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DETAILED PROJECT REPORT (DPR)

FOR REJUVENATION OF RAVI RIVER THROUGH FORESTRY INTERVENTIONS

VOLUME-I

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EXECUTIVE SUMMARY

Introduction

The rivers, particularly, large river systems, constitute one of the most fundamental life support systems that have sustained civilizations, and are projected to be a critical determinant for the future sustenance of human civilizations. River ecosystems have been vital for sustaining life and throughout the history, rivers have attracted oldest civilizations to establish. A river is much more than just the water, comprises of several interdependent components and links, and are influenced by the surrounding terrestrial ecosystems. Rivers link terrestrial, freshwater and coastal marine systems in an open transport and migration route. The most obvious characteristic of river ecosystems is that of unidirectional flow driven by gravity structure patterns and processes in the Riverine Landscape can occur at various time scales. River characteristics show gradients over the longitudinal, lateral (transversal) as well as vertical axis and these gradients also show time - varying characteristics. Rivers have been recognized as integrators or centers of organizations within the landscape as they link terrestrial, freshwater, and coastal and marine ecosystems, and nearly all aspect of human culture from origin to mouth in open transport and migration routes.

The Ravi River is a trans-boundary River crossing northwestern India and eastern Pakistan. It is one of six rivers of the Indus River System. According to ancient history traced to Vedas, the Ravi River was known as Iravati. The waters of the Ravi River drain into the Arabian Sea through the Indus River in Pakistan. It rises in the Bara Bhangal area of District Kangra in Himachal Pradesh, India. The river drains a total catchment area of 11,706.41 km^2 in India after flowing for a length of 341km. The Bara Bhangal comprises of snow covered peaks at heights ranging from 3,000 - 6,000 m amsl. Ravi River is formed by the confluence of Bhadal *Nallah* originating from Bhadal Glacier, Rai *Nallah* originating from Rai Ghar Glacier and Tantgari *Nallah* originating from Tantgari and Karu Glaciers. Flowing westward, it is hemmed by the Pir Panjal and Dhauladhar Ranges, forming a triangular zone. After passing through the Chamba district, it leaves the Himalaya at Basohli and traverse close to Kathua. It makes a sudden westerly bend and enters the Punjab plains near Madhopur. Some distance below Madhopur, it demarks boundary between the two Punjab (West in Pakistan and East in India). It joins the Chenab River at Trimb (Pakistan).

Restoration and Conservation Initiatives

Considering the past use of rivers by mankind over a long period, it can be stated that the present attitude towards River is utilitarian as human think of a river as something to exploit and use for

economic gain rather than for intrinsic ecological values, protection, and conservation. Global scarcity of freshwater has been gearing towards an unsustainable River Basin Management and corresponding services to the humans. It needs a holistic approach, which exclusively focuses on effective River water quality monitoring and quantification, and identification of pollutant sources in order to address the issue of sustainability. These days, rivers are heavily contaminated due to the presence of organic and metallic pollutants released from several anthropogenic sources, such as industrial effluents, domestic sewage, and agricultural runoff. It is astonishing to note that even in many developing countries, most of these contaminants are carried through open drains, which enter river premises without proper treatment. Such practice not only devastates Riverine ecosystem, but also gives rise to deadly diseases, such as minimata and cancer in humans. Considering these issues, the present study develops a novel approach towards simultaneous identification of major sources of pollution in the rivers, along with critical pollutants and locations using an advanced hierarchical cluster and multivariate statistical analysis. The availability and quality of water in the river have been increasingly threatened by over use, misuse and pollution, and both are strongly influenced by the extent and condition of forests in the upstream and downstream areas. More so, climate change is also likely to alter the role of forests in regulating the water flows and influencing the availability of water resources. These strong linkages between forests and water urgently seek high priority attention.

The Ravi River is under the jurisdiction of the Riparian States and UT of Punjab, Himachal Pradesh and Jammu & Kashmir UT and Non-Riparian States of Haryana, and Rajasthan, but the management is presided by the Supreme Court of India and the Ravi-Beas Water Tribunal, set up in 1986 for the purpose. Madhopur Headworks was the earliest project built on Ravi River in 1902 prior to the partition. It is a run-of-the-river project without any water storage envisaged to divert flows through the Upper Bari Doab Canal to provide irrigation in command area of the then unified India. Since 1980s, Baira Siul HEP of 198 MW capacity, the Chamera-I of 540 MW capacity commissioned in 1994, the Ranjit Sagar (Thein) multipurpose project (600 MW) completed in 1999 and the Chamera-II of 300 MW, capacity in the upstream of Chamera-I commissioned in 2004 are functioning.

Conservation Significance

The Ravi River has immense value from the geomorphological, ecological, environmental and economic perspective. It is smallest river of the Punjab and all other trans-boundary rivers of India-Pakistan. In India, it is known as the River of Lahore. The water of Ravi River is allocated to India under Indus Water Treaty (IWT), 1960. Under the IWT, the waters of the Ravi River and five other rivers are divided between India and Pakistan. The Ravi River hosts a large number of National Wetlands of Importance, Important Bird Areas, besides other Important Protected areas.

The River contributes immensely to the Indian economy as the country's agriculture sector is heavily dependent on the fertile plains of Ravi River and its tributaries. The River is endowed with enormous hydro-potential. The majestic snow-peaked Himalayan mountains and various natural ecosystems along the Ravi River and its tributaries, besides wide ranging religious, cultural and historic values, have enormous potential for recreation and tourism industry. The Ravi River and its tributaries form a complex and dynamic system with numerous aspects and dimensions related to them that remain to be explored by the scientific community, and which may provide better insight on the river itself and its management. Healthy river systems safeguard our water and food for the present and future generations.

Forests and Rivers

The forests, water resources, and people are intensely interconnected, and have an intricate relationship among them. Both, quality and quantity of water are strongly influenced by forests. Forests form catchment of streams and rivers, absorb precipitation (i.e., rainfall and snow), slow runoff, reduce soil erosion, improve water infiltration and recharge groundwater and aquifers. Thus, forests have 'Sponge Effect'. Besides this, forests regulate the carbon, oxygen and hydrological cycles. Riparian forests are most complex ecological systems, disproportionately used by wide range of organisms, and are the interface between the terrestrial and aquatic ecosystems. Riparian forests serve as 'Natural Buffers' and 'Biological Filters', and have an ability to act as ecological machinery for self-regulation, self-purification and self-support for the dynamic flow of the river water and its quality. Riparian forest buffers reduce the adverse impact of human activities on rivers. Forests help in sequestration of carbon and its storage and also act as rich repository of biodiversity. Forests are crucial for the sustainable management of freshwater resources, particularly River ecosystems, while water is essential for the sustainability of Forest ecosystems. Humanity is strongly intertwined with forests and rivers, as both offer various ecosystem services to human kind. Since time immemorial, humanity has been using forests as well as rivers for multiple uses, benefits and values. The strong linkages and intricate interdependence between forests and rivers epitomises the significance of managing ecosystems in their entirety with the involvement of stakeholder and cooperation across a multitude of sectors concerned with the cause of land and aquatic resources.

Interactions between Forests and Rivers

Throughout its journey from source to sea, a river integrates all that happens in the Basin/surrounding Landscapes, particularly the impact of human activities. Thus, rivers have been regarded as 'Arteries of the Catchment', 'Life blood', 'Highways', 'Pantries of the world' and even as the 'Sentinels'. Rivers provide early clues as special signals of human impact and

associated risks. Hence, the society can take advantage of early warnings and plan mitigation strategies to deal with adverse human impacts and likely risks. Closer cooperation between the forest and water sectors is a precondition for sustainable development as interactions between forests and water (i.e., flow, yield, and quality) are complex. In recognition, there has been an increasing International action to address 'Forest-Water' interactions.

Integrated Riverscape approach to Restoration

For a long, humans have altered rivers for multiple uses and benefits. The alteration of rivers has been carried out with the best of intention, but without knowledge of the potential implications and repercussions for the diversity, connectivity and ecological integrity of the River ecosystem. The complex subject of 'River Science' has emerged, especially in light of anthropogenic disturbances and regulations which have simplified most rivers and resulted into adverse consequences for structure, composition and functions of a river. The earlier interventions towards river management were mainly small scale interventions, piecemeal, fragmentary in nature, focused on isolationist scientific approaches for management of river degradation and attempted to tackle the symptoms rather than the causative factors.

The complex and dynamic nature of river ecosystems require a comprehensive strategy following a system-based approach, recognizing physical, biological, ecological, socio-economic, and political aspects of the river and human systems which are intricately interconnected. The newer science of river management calls for integration and involvement of allied multidisciplinary subjects *viz*., geomorphology, hydrology, climatology, landscape ecology, hydraulic engineering, forestry, and aquatic and terrestrial ecology besides social sciences. 'River Restoration' is now a common response to declining river health and its importance to water resource management can only be expected to grow. River restoration has been defined as 'Assisting the recovery of the ecological structure and function in a degraded ecosystem by replacing lost, damaged or compromised components and re-establishing the processes necessary to support the natural ecosystem and to improve the ecosystem services it offers'. The concept of River Restoration has been evolved over the time and it is different than other terms *viz.,* 'Rehabilitation', 'Remediation', 'Reclamation', 'Replacement', 'Rejuvenation', 'Mitigation', etc. used in the context of river management.

The rivers are complex mosaic of habitat types and environmental gradients and characterized by spatial complexity and four types of connectivity (i.e., longitudinal, vertical, lateral and temporal). Hence, rivers are increasingly investigated from a landscape perspective, both as 'Landscapes' in their own right and as 'Ecosystems'. A landscape perspective of streams and rivers has emerged and the riverine landscapes are viewed as 'Riverscapes'. The concept of

Riverscape is used to describe the broad scale physical, biological and aesthetic nature of rivers as the Riverscape approach integrates the elements of flowing water and surrounding lands those have been imperilled by human activities. The notion of Riverscape is applied across multiple hierarchical scales as it recognizes a stream or river, its floodplain, and riparian area as an integrated ecological unit.

Preparation of DPR on Forestry Interventions

The Detailed Project Report (DPR) preparation involves recognizing the diversity, complexity and intricacies of forest ecosystems and pivotal multiple functions performed by them and their inter-connectedness with highly dynamic river ecosystem and to adopt a holistic approach for the improvement and management of riverine ecosystem in the entire river basin through forestry interventions. The holistic approach emphasizes appropriate forestry Interventions by the way of protection, habitat management, afforestation, catchment treatment- soil and moisture conservation works, ecological restoration of vital Riparian forest buffer, bio-remediation, improved livelihoods of forest dependent communities and forest dwellers and alternate income generation activities through regulated tourism and community awareness.

The NITI Aayog directed concerned Central Ministries namely MoRD, MoEF&CC, MoA, MoDWS, MoH&UA, MoPR and Chief Secretaries/Administrators of all States and UTs to initiate pilot projects for revitalization of rivers by appropriate convergence of schemes and active involvement of various stakeholders. In response to this and following the pursuit of forestry interventions on Ganga River by NMCG, the MoEF&CC assigned a major task on the Preparation of DPR(s) on Forestry Interventions for Rejuvenation of 13 major Indian rivers (i.e., tributaries of Indus – Jhelum, Chenab, Ravi, Beas and Sutlej; Yamuna, Luni, Narmada, Godavari, Mahanadi, Krishna, Cauvery and Brahmaputra) belonging to nine river systems to the Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, An Autonomous Organization under its control. The ICFRE is an umbrella organization responsible for carrying out forestry research, education and extension activities in the country and an apex body in the National Forestry Research System. The Council has a pan India presence with its nine Regional Research Institutes and five Centre's located in different biogeographic zones of the country. Each Regional Institute has been mandated the task of research, education and extension in the States/UTs under their jurisdiction. The Himalayan Forest Research Institute (HFRI), Shimla, a institute has been entrusted the task to prepare DPR(s) of five tributaries of the Indus River. The present DPR specifically deals with the Ravi River, a major tributary of the Indus River. The ICFRE has allowed HFRI a time frame of 12 months to prepare the DPR envisaging that Proposed Forestry Interventions will immensely facilitate the major goals of accomplishing

Aviral Dhara (i.e., uninterrupted flow), *Nirmal Dhara* (i.e., clean flow) and ecological regeneration of aquatic and terrestrial life/ biota.

Vision, Aims and Objectives

The current project has been envisioned to achieve the larger objectives of management of River ecosystems considering the criss-cross linkages between aquatic, biological and physical environments. The project basically aims at improving the aims of the river flow regime, increase in the environment flow (i.e., e-flows), habitat enrichment, biodiversity conservation, and improvement of the ecological and aesthetic attributes and generation of more avenues and opportunities for sustainable livelihoods. The project is set to adopt a multi-sectoral, multi-pronged, inclusive and holistic approach for Proposed Forestry Interventions to fulfil the twin objectives of maintaining the constant and clean flow of water in the rivers as per the *Aviral Dhara* and *Nirmal Dhara* concepts under *Namami Gange* Programme of NMCG.

Goals and Objectives

a) To review and assess the existing situation of River Basin, past river management and implications and lessons learned
b) To identify and involve stakeholders and build consensus for design and development of strategies and approaches
c) To assess ongoing forestry activities of the States/UT engaged in the River Management programme (s)
d) To assess potential and possibilities for regeneration, improvement, and restoration of forest catchments
e) To assess the conditions of riparian forests and potential of biological filters
f) To examine the possibility of allied and other income generation activities
g) To assess the potential of cultivation of medicinal plants and restoration of conservation areas and identify appropriate species and suitable sites
h) To identify research and monitoring needs and develop a strategy for future research and monitoring
i) To formulate strategies, develop approaches, and plan activities for project implementation

Ravi Riverscape

Nature is complex to comprehend and so are the interrelationships which exist between the different ecosystems. Rivers not only represents the most diverse ecosystems right from their origin up to the merger with the ocean, but also exhibits tremendous heterogeneity and complexity with the surrounding environments all along its course. The Rivers passing through the terrestrial landscape displays longitudinal, lateral, hyporheic and temporal dimensions. Rivers and streams are like long ribbons of aquatic habitat, and inherently difficult to study. It is quite essential to have a continuous view of entire spatially heterogeneous scene of the River environment for effective research and conservation of River ecosystems. Any attempt aiming at the River Conservation and Restoration of river needs to appreciate and comprehend the river ecosystem in its entirety, and also requires to take into consideration the interconnectedness between the river with its surrounding lands as well as impacts of human influences on the river ecosystems. The quantity, function and ecology of water changes as it move from watershed to river. Riverscapes are interactive and open systems which are characterized by high levels of natural disturbances and interconnected ecotones. The Riverscape and river share the sheet of water which covers the land in whole or in part, permanently or intermittently. The Riverscape is that part of a landscape where the runoff water erodes the soil of the catchment and leads to sedimentation in river bed and sea. Thus, Potamology - The science of rivers underpin the various fluvial and ecological processes and emphasize on the riverine landscape perspective of rivers. Thus, the concept of Riverscape indicates a holistic approach linking the rivers and its banks, or the riparian areas. Consequently, the 'Ravi Riverscape' area has been selected on a scientific basis and boundaries of the Riverscape have been delineated for the purpose of planning, assessment and Proposed Forestry Interventions.

The Ravi River is a trans-boundary river crossing northwestern India and eastern Pakistan. It is one of six rivers of the Indus River System. According to ancient history traced to Vedas, the Ravi River was known as Iravati. The waters of the Ravi River drain into the Arabian Sea (Indian Ocean) through the Indus River in Pakistan. The River rises in the Bara Bhangal area of District Kangra in Himachal Pradesh, India. The Ravi River drains a total catchment area of 11,706.41 km^2 in India after flowing for a length of 341km. As far as Himachal Pradesh, Punjab plains and the Union Territory of Jammu and Kashmir are concerned, the Riverscape area of Ravi River and its tributaries is 5041km^2, 11.61.7km^2 and 2970.91km^2, respectively. The entire Riverscape area i.e., 9173.61km^2 of the Ravi River and its tributaries falling in Himachal Pradesh, Punjab and Jammu and Kashmir UT has been included for delineation of the Riverscape. The larger portion of the delineated Ravi River i.e., 54.95% lies in Himachal Pradesh, 32.39 % area in Jammu and Kashmir Union Territory and least falls in Punjab i.e., 12.66% .

Approach for the preparation of Detailed Project Report

The Ravi River originates from Bara Bhangal in the State of Himachal Pradesh and flows through J&K UT and in the plains of Punjab before its confluence with Chenab River in Pakistan. The concerned two States (i.e., Himachal Pradesh and Punjab) and one Union Territory (i.e., J&K) were involved in the extensive consultative process, planning and assessment. The Project Launch Workshop and Sequential Consultative Meetings organized in concerned States and Union territory included policy and decision makers representatives of State Forest Department and various Line Agencies i.e., Agriculture, Horticulture, Animal Husbandry, Mining, Irrigation, Hydro-electric Projects; State/National Level Scientific Or Specialized Organizations i.e., Soil and Water Conservation, Hydrology, Forestry, Wildlife, Environmental Management, Central Water Commission, Groundwater, Remote Sensing and GIS; Universities; Civil Society; and Non-Governmental Organizations besides conservationists and field practitioners. The well planned consultative process and feedback from various stakeholders have been the key step in the formulation of strategies and preparation of present DPR. Constant persuasion, guidance and support at all stages by the Hon'ble Union Environment, Forest and Climate Change Minister, Hon'ble Forest Ministers of concerned States, Senior Officials of the MoEF&CC, ICFRE and SFDs and Team of HFRI were instrumental throughout the process of planning and finalization of the DPR.

Contextual Analysis

All change processes of the exercise formed a part of wider context impinging upon the very objectives of the project itself. As per the issues highlighted, the project on Forestry Interventions for Rejuvenation of Ravi River is constantly influenced by economic, social and political processes otherwise forming an integral part of the society also. The project planners and implementers accordingly sought inputs/information about the overall picture or the Environment, including Technical, National And Sectoral Information. Activities under the said project started with an overall preliminary study (Pre-study), and feasibility study forming its inception phase. The pre-study involved the understanding and assessment of project's external environment by collecting information about various related Sectors, States and organizations involved as well as the primary data that existed about the target disciplines, sectors, themes, etc.

Further, it was also realized that understanding the complex and dynamic nature of a River ecosystem and its linkages with the forests and other surrounding lands requires adequate knowledge of relevant multi-disciplinary subjects and application of various technologies. It is beyond any doubt that there is a lot of literature on the wider subject of River ecology and management besides a long historical perspective on the management of the Ravi River. Thus,

the foremost and key step in the present planning exercise on the preparation of DPR was a systematic review of vast available literature on the subject through internet surfing and library consultations. The websites of prominent International, National, State Level Agencies and Organizations dealing with any of the aspects related to River resources and Conservation approaches were extensively searched, and required information was downloaded for developing the desired insight. The relevant secondary information from related organizations was also collected. The combined efforts on the review of literature and collection of background information immensely helped in the contextual analysis. The contextual analysis also provided desired insight on the Ravi Riverscape and its physical, biological and socio-economic sub-environments.

Consultative Process

The preparatory phase for DPR included review of literature, primary and secondary data collection and analysis, expert consultations and receiving inputs from the wide ranging stakeholders. Accordingly, extensive and exhaustive consultations at the National and State Levels were organized. Two States (i.e., Himachal Pradesh and Punjab) and one Union Territory (i.e., Jammu & Kashmir) forming part of the Ravi Riverscape and State Forest Departments of these States and UT were instrumental in planning and organization of State Level Consultations. The entire process of consultative process was facilitated by the HFRI. Consultation and feedback from various stakeholders have been the key step in the preparation of the present DPR and proposed strategies and actions for its implementation The assignment envisaged stakeholder consultations at the National and State Levels at the time of launch of entrusted task and also after the preparation of draft DPR. Accordingly, prominent consultations for the preparation of DPR held at the National and State Levels, while a broad-based list of Central/ State Government Ministries, Departments, Agencies, Organizations, besides Civil Society and NGOs that were consulted or their representatives participated in the various Meetings.

Situation and Problem Analysis

One of the key steps in the process of preparation of DPR was to delineate the Ravi Riverscape for the purpose of planning, situation and problem analysis thereby, developing an insight on the Riverscape environment and prioritization of areas for proposed Forestry Interventions. The background analysis/ contextual analysis and the consultative process adopted at the National, State and UT and Forest Circle Levels provided the much desired insight on the issues pertaining to Ravi River Basin and its tributaries, terrestrial and aquatic biodiversity, past management, associated States, and developmental activities. A Riverscape within the larger River Basin was delineated. Detailed geospatial analysis of the Riverscape using Remote Sensing and GIS

technologies was carried out. The approach adopted for application of Remote Sensing and GIS for geospatial analysis for the Ravi Riverscape. It provided an understanding on the situation of physical attributes i.e., Land Use and Land Cover, Altitudinal Variation, Slope, Aspect, Soil, Erosion, Forest Types and Forest Cover, Fragmentation, etc. The review of secondary information from a variety of sources (i.e., National/ State Level Agencies/ Departments, Scientific Organizations and Universities) allowed developing an understanding on the Riverscape environment (i.e., Physical, biological, and socio-economic) and identification of challenges, constraints, problems, and threats in River conservation. The Situation Analysis facilitated developing an insight on State specific challenges and threats for the state of Himachal Pradesh, Punjab and Union Territory of Jammu and Kashmir wherein the river flows which depicted contrasting situation owing to large variations in the physical, biological and socio-economic sub-environments. In fact, the extensive consultative process and the sequential Meetings with varied stakeholders definitely helped in the identification and focusing on the main problems in the concerned States and UT in context with Ravi River, besides comprehending the varied reasons/causes, and effects or implications of river degradation on the surrounding lands.

Design of Field Data Formats

The HFRI has adopted and modified five formats earlier developed and prescribed in the context of Ganga River by FRI, Dehra Dun. Five elaborate formats were meant for the collection of primary field data. Various efforts were made for the collection of correct information and data in a uniform template for all the States and UT which comes under the DPR project. The data formats are very useful for preparing the DPR. Details of these five data formats, types of information required, and the procedure to collect desired information were shared with stakeholders, particularly the forest officials and frontline staff during the consultative process and specific training sessions organized. Adequate soft and hard copies of formats were made and widely distributed to forest officials and other stakeholders during the consultative process.

Collection and Analysis of Primary Field Data

The present task on DPR for Forestry Interventions on Ravi River required a better insight and understanding not only of the River and tributaries themselves, but also of the surrounding lands and expanding human prints. Thus, remote sensing and geospatial modeling were used in identification of prioritized and suitable sites for forest plantations. GIS was used to generate different layers within the Riverscape like Land Use Pattern, Soil erosion rates, and slope of the topography.

Expertise has developed various potential plantation and treatment models for the proposed forestry and other conservation interventions in three types of Landscapes visualized within the Ravi Riverscape. These were: (i) Natural, (ii) Agriculture, and (iii) Urban Landscapes. Considering the type of natural ecosystems, native vegetation, soil conditions and agro-climatic zones, potential models of various types of plantations were identified, designed and developed by the HFRI expert team. These suggested models broadly varied for the Himalayas. The purpose of various models planned in the natural landscapes is primarily protection, eco-restoration and conservation.

Plantation and Treatment Models

The multi-disciplinary expertise available at HFRI was used in developing potential plantation and treatment models for the proposed forestry and other conservation interventions in major three type of Landscape components visualized in the Ravi Riverscape. These were: (i) Natural, (ii) Agriculture, and (iii) Urban Landscapes. The purpose of various models planned in the Natural Landscapes is primarily protection, eco-restoration and conservation. Details of potential models were sent to the concerned States and UT for selection and to recommend appropriate modifications, if necessary based on local knowledge, expertise, and experience.

In these multi-level plantations of trees, herbs, shrubs, grasses and important medicinal plants will be included. More and more medicinal plants should be grown in the nurseries of concerned department and it should be on the priority list to cultivate more medicinal plants in Himachal Pradesh, Punjab and J&K UT . While selecting species for planting, ability of plants to tolerate the temperature and other factors of that area should also be considered. In the upper areas of Himalaya, the species which are planted should be useful in conserving soil and also provide the shade for aquatic animals in the river in hot days. Grasses and other ground cover must be kept intact during plantation and other activities. It is important to ensure the planting stock needs and the quality with the help of research nurseries and other quantity planting stock production units of the state forest research institutes or the research wings of the SFDs. Grasses plantation activities for monsoon should be planned carefully, so that, these activities are in harmony with the overall project for which DPR is being prepared. In the three-tier models of plantation emphasis will be given to indigenous species of fodder, fruits, medicinal and other values which would include bamboo, grass, shrub, medicinal plant, tree and horticulture species.

Development of Software and Web Portal

In order to handle a large and voluminous data sets efficiently, better collation, analysis, and synthesis of the required information for report generation and preparation of DPR in a short

time available, development of a desired software and web portal were considered essential. The software was developed in PHP/ Mysql, server Linux based that works on Code igniter Framework basis. It is web based and easily accessed via internet. The software can compute cost calculations according to selected specified models for unlimited created models. In the software, field data can be entered as per the five specified types of models, *viz*., Natural Landscape, Agriculture Landscape, Urban Landscape, Conservation Interventions and Supporting Activities, and can be saved in digital format. The software is capable of generating reports in the desired formats i.e., State and UT-wise, District-wise, Division-wise, Model-wise and Activity-wise, and Annual Consolidated reports can be generated to obtain insight on year-wise areas under different landscapes to be treated and corresponding costs. The FDs of concerned State and UT provided a total of 1157 data sets. The SFD, Himachal Pradesh provided in all 725 formats from to four Forest Divisions while the Forest Department of Jammu region in Jammu & Kashmir UT provided 129 data formats represented by four Forest Divisions, and 303 formats representing three forest Divisions were provided by the Punjab Forest Division.

Objective Analysis and Strategic Planning

The HFRI availed offerings of an Expert on bio-filters and bio-remediation so as to signify capacity remedy fashions and websites for the purpose. A reconnaissance was made to potential field sites and neighboring districts in Himachal Pradesh, Punjab and Jammu & Kashmir UT for the purpose.

The extensive consultative process allowed an understanding to develop the long-term vision and goals that indicate the desired direction or pathways for actions and activities. In the process, it was also understood which changes in the project can contribute to in the longer term and why is the project important for the society, biodiversity and the River ecosystem. In the process, the HFRI team was able to decide the goals, objectives, outputs and outcomes that can be attained. The consultative process gave desired insights on the problems in achieving various objectives and identification of priority actions for restoration of the river. The process also facilitated in formulation of the strategies for programme implementation. Accordingly, it was decided that the programme implementation has to be concurrent in Natural, Agriculture and Urban Landscapes within the Riverscape. Further, a variety of conservation and supporting activities would also be required for effective implementation, knowledge management and sharing, capacity development, monitoring, and adaptive management.

Preparation of Draft DPR – Activities, Resource Planning and Schedule

The aforesaid key steps and the process adopted ultimately helped HFRI in the preparation of draft DPR presenting the details of proposed activities, resource planning and year-wise schedule of operations. Draft DPR (Vol. I and II) was shared with the concerned State and UT, FDs, Line Agencies and other stakeholders in the State and UT through the National Level Consultation Meetings seeking their feedback and valuable inputs. Copies of the draft DPR were also submitted to the ICFRE, Dehra Dun and the MoEF&CC, New Delhi and comments were invited. Necessary presentations were also made at ICFRE, Dehradun and MoEF&CC, New Delhi.

Finalization of DPR, Implementation and Monitoring

The draft DPR was finalized incorporating the feedback and specific comments received from the concerned States and UT, FDs, ICFRE and the MoEF&CC. The Phase I i.e., Project implementation has been planned for duration of five years by respective States and UT and FDs as the Nodal Agencies. A provision for inbuilt, Results-Based Monitoring has been made for continuous monitoring, organizational learning and adaptive management. The Phase II – 'Maintenance Phase' of five years duration would be executed after the implementation of Phase I, primarily with the objective to maintain plantations raised in three types of Landscapes and planning for scaling up replication of the activities in the left over tributaries.

The Organization of DPR

The DPR for Ravi River is presented in two Volumes i.e., Volume I and Volume II. The Volume-I deals with the main DPR while the Volume-II provides Summary of Himachal Pradesh, Punjab and Jammu and Kashmir UT located along the course of the Ravi River.

The Volume-I comprised of total 8 chapters. The first two chapters provide detailed insight about multi-dimensional River ecosystems highlighting the evolving concepts of River ecology, past conservation and management initiatives, existing problems of River ecosystem and needs of River restoration, Riverine Landscape or 'Riverscape', and linkages between forests and water/ river. In addition to this, the chapters also give a broad idea about the basis of DPR preparation, Logical Framework Approach (LFA), vision, goals, objectives, and expected outcomes of the project. The remaining six chapters emphasises upon the policy, legal and institutional context, exhaustive consultative process undertaken during the preparatory phase, role of Implementing Agencies (IAs) and stakeholders, approach and methodologies, Proposed Forestry Interventions, Implementation mechanism, project budget, and potential benefits of envisaged forestry interventions. More precisely, these chapters include detailed account of envisaged forestry interventions by highlighting proposed plantation and treatment models, conservation

interventions and supporting activities; project management, partner organizations and implementation mechanism; project budget outlay, extent of proposed activities and schedule; and potential benefits of planned Forestry Interventions. The Volume II incorporates summary of Himachal Pradesh, Punjab and Jammu and Kashmir UT.

Ravi Riverscape and its Environment

A river is more than just the water inside it and water is only one component of the intricate and dynamic River ecosystem. The overall environment of a river is sum reflection of physical regime-climate, geology, topography and land cover; biological attributes i.e., terrestrial and aquatic biodiversity; and the socio-economic conditions in the surrounding lands of the river or beyond in its catchment.

The ecosystem based approach to river management as a prerequisite seeks appreciation and understanding of the physical, biological and socio-economic sub-environments of the river. The fluvial processes, hydrological regimes, and ecological processes are vital driving forces of the River ecology. Four types of connectivity are of paramount importance for the sustainability of River ecosystem. A dynamic river from source to sea reflects varied interconnectedness, intricacies, heterogeneity, and channel dynamics besides longitudinal changes, vertical interactions, lateral exchange processes, temporal variations, and the resultant spatial patterns in the overall environment in the river and its surrounding lands.

The Ravi Riverscape has been delineated or selected for the purpose of Proposed Forestry Interventions on the basis of consensus emerged from the exhaustive and extensive consultations with various stakeholders. An area of 5041 km^2 falling in Himachal Pradesh, 1161.7 km^2 in Punjab and 2970.91 km^2 in Jammu & Kashmir UT, has been selected for the purpose of Proposed Forestry Interventions. Thus, the area under consideration of this delineated Riverscape constitutes the total catchment area of Ravi River Basin in India.

Presently, the Ravi River reflects fragmentation, decreased connectivity, reduced e-flow, enhanced pollution, and declined aquatic and terrestrial biota, diminished ecosystem services, and overall poor health of the river.

Legislations and Policy Context

The Ravi River flows through Himachal Pradesh, parts of the Jammu region of Jammu and Kashmir UT and Punjab before flowing into Pakistan. Thus, it is not just an inter-state river, but also a trans-boundary river whose waters are shared between India and Pakistan (IWT, 1960). In Himachal Pradesh as well as UT of Jammu and Kashmir, the biggest collective, threat to the

Ravi River Basin is from the hydropower sector. Other threats include sand and boulder extraction and related activities including operation of stone crushing units, road construction, waste and untreated effluents dumping, etc. Real estate and tourism related construction activities have also started to prove disastrous to Basin as floodplains are getting exploited by these sectors increasing flood risk. In Punjab, the issues relate to over extraction of water for the purpose of irrigation, commercial and industrial purpose as well as dumping of industrial waste into the River. Most importantly, the Ravi River Basin has already started witnessing climate change related impacts including glacial melt and increasing threat of Glacial Lake Outburst Floods (GLOFs). Therefore, the law and institutions need to gear itself to the realities of climate change. India's law on natural resources have focused on meeting mostly the developmental needs of the nation to a large extent and meeting local aspirations to a very limited extent. This needs to be changed by focusing on both the sustainability of resources and vulnerability of the resources. The institutional mechanism and legal system must focus on the risk facing the river systems and the dependent communities in view of receding glaciers and hotter climate.

These issues have been dealt with law and policy Chapter, presenting issue wise relevant Legislative, Policy and Institutional Framework in order to achieve the ultimate purpose of the present DPR to restore Ravi River. Owing to the fact that Ravi River also flows through the UT of Jammu and Kashmir, a separate section in the present Chapter also looks into the legal impact of the Jammu and Kashmir Reorganization Act, 2019.

Implementing Agencies and Institutional Context

The preceding chapters and the forgoing sections have given ample idea about the wide array of Government and Non-Governmental Agencies at the Centre and State Levels besides diverse stakeholders and the Civil Society those are involved with the prominent disciplines/ sectors of forest management, wildlife conservation, environmental management, water resource management, river development and restoration of rivers in the country. The Chapter on the Ravi Riverscape and its environment has appropriately highlighted the intricacies of the physical, biological and socio-economic sub-environments in the context of river besides numerous sectors and agencies directly connected and responsible for the maintenance of uninterrupted e-flows and clean water of Ravi River. In general, the Union Ministry of Jal Shakti and the Ministry of Environment, Forest and Climate Change (MoEF&CC) at the Centre are the two prominent ministries those are directly concerned with the rivers, its environment, and much desirable restoration process. From the perspective of proposed forestry interventions, details of the implementing agencies at the National and State levels are much desirable. Hence, the following section provide details on the MoEF&CC as the Nodal Agency for overseeing and steering the programme implementation; the ICFRE, Dehra Dun and its institute i.e., the HFRI,

Shimla as the National Partner Organization for Capacity Development and Monitoring; and the pivotal role of the concerned Forest Department in Himachal Pradesh , Punjab and J&K UT as the Implementing Agencies.

The Civil Society represents the collective group of individuals, Non-Governmental Organizations and Institutions in a society that mark interests and will of citizens, and also referred as the 'Third Sector' of the society, distinct from the government and corporate. Since, the Ravi River flows through cities and towns and the River and its tributaries throughout their journey from origin to confluence are surrounded by densely populated human habitations. The Civil Society can play vital role in creation of mass awareness, protection of river and river resources, and allied activities. The religious bodies (e.g., village devtas, temples, gurdwaras, Radha Soami, Satsang, etc.) can also play vital role in efforts towards river restoration. Likewise, numerous organizations and institutions (e.g., Panchayats, JFMCS, Eco-development Committees, Biodiversity Management Committees – BMCs, Aanganwari Workers, Nehru Yuva Kendras (NYKs), National Service Scheme – NSS, etc.) can be of utmost importance and they can be involved in awareness campaigns, cleaning drives for river and surrounding lands, protection and monitoring, and also implementation of proposed forestry interventions.

River Conservation and Restoration

The subject of River Conservation and Restoration is multifaceted. Broadly, two types of monitoring have been envisaged during the project execution phase These are; (a) monitoring of project performance in terms of project goals/ objectives, activities, targets, outputs, outcomes and impact; and (b) Ecological and socio economic monitoring in terrestrial as well as aquatic ecosystems.

Research and monitoring activities are vital to develop the information base, setting goals and objectives and evolving strategies besides facilitating policy and decision making. It is evident from the foregoing description on the physical, biological and socio-economic environment in the context of Ravi River and the Riverscape, a large number of interrelated variables and factors from the origin to mouth of the River come into play. The subject of River ecology and management is therefore multi-faceted, intricate and elaborate. Considering the complex and dynamic nature of river ecosystem, and the fact that the vast area is covered within the Riverscape and much of the area is in difficult terrain and inaccessible, it is essential to adopt various concurrent monitoring mechanisms and relevant tools for carrying out envisaged monitoring activities. Thus, concurrent monitoring mechanisms include: (a) IT enabled monitoring, (b) RS and GIS based monitoring, (c) Online monitoring through web portal, (d) On ground monitoring, and (e) Participatory monitoring. In recent times, increasingly mobile app

based monitoring on real time basis in a much more transparent manner is possible. Thus, it is proposed to incorporate IT/ mobile app based monitoring. Since large, difficult and inaccessible areas form the major part of the River Basin/ Riverscape, optimal use of RS and GIS technologies, particularly for monitoring glaciers; sedimentation in reservoirs; and changes in channel morphology, land use and land cover, snow cover, forest cover, wetlands, cropping pattern, etc.

Over the years, HFRI has developed as a Knowledge Management Centre in the field of ecology (Himalayan and Trans-Himalayan regions) and conservation of diverse temperate forest ecosystems and privilege to have essential ingredients: (a) Professionals and expertise, (b) State of the art laboratories and other physical infrastructure, and (c) Processes and innovative technologies. Since its establishment, HFRI has made significant contributions towards the forestry research, development of suitable nursery techniques, propagation of native plant species and eco-restoration of mined areas and cold desert and having long experience in dealing with cumulative environmental impact assessments of Himalayan Rivers and well-laid infrastructure has been proposed to undertake the major responsibility as the National Level Partner Organization for effective implementation of this priority project on river restoration (forestry and conservation interventions aiming for *Aviral Dhara* and *Nirmal Dhara*, ecological integrity and restoration of river health), liaisoning with Central Nodal Ministry and Implementing Agencies at the State level, concurrent research and development, science and technology based back-stopping, capacity development, monitoring, and evaluation.

The HFRI, Shimla with its long standing, multidisciplinary team, well laid infrastructure and expertise in the field of Himalayan environment, forestry, natural resource management, climate change, etc. is suitably placed and visualized to develop as the Knowledge Management Centre for the above stated purpose.

Project Components and Proposed Interventions

In the broad sense, the proposed Implementation Plan aims to contribute towards clean Ravi River, besides maintenance of ecological and geological integrities. Based on extensive consultative process carried out as a part of this DPR, the following shared vision emerged for the Implementation Plan.

(a) Riverscape Management: Aiming a holistic Riverine Landscape (Riverscape) approach for sustainable management of Ravi River, its banks, or its riparian areas, within its fluvial system.

(b) ***Aviral Dhara, Nirmal Dhara,*** **Ecological Rejuvenation and Biodiversity Conservation:** Aim to address the drivers and stressors of River ecosystem and promote sustainable use by balancing ecological requirements with the needs of sustainable livelihoods.

(c) Improved Ecosystem Services and Sustainable Livelihoods: This goal aims to specifically seek enhanced ecosystem services so as to maintain sustainable livelihoods.

(d) Effective Implementation, Knowledge Management, and Innovative Approaches: This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches (i.e., nursery techniques, afforestation, bio-filters and bio-remediation), and adoption of appropriate modern technologies.

The Logical Framework Approach has been adopted for the formulation of DPR. It is important tool thinking for relating inputs to the implementation of activities, activities to the production of outputs, outputs to the achievement of a defined purpose, and purpose to a high-level goal or impact. The LFA summary is a living document consulted and altered through the project's lifecycle based on the new information, monitoring and lesson learnt; besides, it facilitates efficient communication mechanism between decision makers, practitioners and other stakeholders involved in the project.

Strategies

The understanding on the Riverscape environment has amply revealed that the Riverscape is a mosaic of varied land uses and it includes the: (a) Natural ecosystems, (b) Rural system predominated by agro-ecosystems, and (c) built-up urban environment represented by cities and towns. Each of these broad land use category represents significant area of the Riverscape with unique conditions and situation, and varied use patterns, ownerships and management needs. Hereafter, three broad land use categories within the Riverscape are being referred as the 'Natural', 'Agriculture', and the 'Urban' Landscapes. These three landscapes immensely influence the intricate and vibrant nature of Ravi River ecosystem, especially the environmental flow, water quality, and aquatic biota besides terrestrial biodiversity in surrounding lands, and the various ecological and fluvial processes of the lotic system. Hence, in view of the prominence of three types of Landscape elements within the Riverscape, a multipronged strategy for proposed forestry interventions addressing specific requirements of each of the Land Use type/ Landscape category has been planned for the execution as a part of the implementation plan during the Phase I (5-year duration). The Phase I will be followed by Phase II (Maintenance Phase). As a part of the broader strategy, zoning within the Riverscape is visualized keeping in view three distinct Landscape categories and specific targeted Forestry Interventions those are being planned in each of the zone.

Zoning and Lower Order Zone Plans

As elaborated above, three broad and distinct Landscape types or 'three zones' have been deciphered within the Riverscape for the purpose of Proposed Forestry Interventions. The following section presents an elaborate account of specific Forestry Interventions in each of the zone or represents the self-contained 'Lower Order Zone Plan' for the Natural, Agriculture And Urban Landscapes, respectively within the Riverscape.

Natural Landscapes

Total 44 models in three types of Landscapes i.e., Natural, Agriculture And Urban Landscapes were selected and incorporated in the present DPR. Altogether, 13 models were selected for Natural Landscape in the hilly region of Himachal Pradesh was numbered from RV/HP/NL/01 to RV/HP/NL/13. 13 models were selected for Natural Landscape in the hilly region of Jammu and Kashmir UT and named as RV/JK/NL/1 to RV/JK/NL/13 while 02 models for Natural Landscape in alluvial plains of Punjab, numbered from RV/PB/NL/01 to RV/PB/NL/02 were included. Details of these models in Natural Landscape relevant to hills and alluvial plains along with incorporated abbreviations/ code are summarized in chapter 5.

Agriculture Landscape

The Agriculture Landscapes Second lower order zone largely in the rural environment constitutes the matrix of the Riverscape. The activities in this zone mainly seek enhanced agricultural production. Within the Ravi Riverscape, in terms of extent the Agriculture Landscape was widely distributed. It is along the altitudinal gradient in Himachal Pradesh and Jammu and Kashmir UT and in the vast expanse of alluvial plains of Punjab along the main channel. The primary activity in this zone is agriculture and horticulture production. A wide range of agricultural and horticulture crops are being undertaken by farmers on their private lands. The purpose of this lower order zone (i.e., Agriculture Landscape) is to enhance productivity of agricultural lands by appropriate soil and moisture conservation measures and planting of economic and fruit trees so as to support the overall conservation values and other expected ecological functions and ecosystem services. 2 models for the Agriculture Landscape in Himachal Pradesh are proposed. These are: (a) Model RV/HP/AL/01, and (b) Model RV/HP/AL/02 relevant to boundary plantations and Planting of Economic Trees in Block plantation, respectively. In case of Jammu and Kashmir Union Territory, 2 models: RV /JK/AL/01 and RV /JK/AL/02 are proposed. In alluvial plains of Punjab, 2 models (RV/PB/AL/01 and RV/PB/AL/02) specifically designed for plantations along the boundaries of crop fields and plantations in blocks, respectively have been proposed.

Urban and Peri-Urban Landscape

Proposed Forestry Interventions in the third lower order zone i.e. the Urban Landscapes, the built up environment represented by the Land Use and Land Cover category of 'Settlement' of the Riverscape. This category of Land Use and Land Cover was widely distributed throughout the Riverscape, predominantly all along the main channel and its tributaries and formed the third lower order zone referred as the 'Urban Landscape (UL)'. Under this lower order zone, altogether 3 models (RV/HP/UL/01 to RV/HP/UL/03) focusing on riverfront development, plantations in Institutional and Industrial estates, Eco-Park development, have been proposed in the mountainous tract of Himachal Pradesh. Likewise, for Jammu and Kashmir UT, 3 models have been proposed viz., Riverfront development (RV /JK/ UL/01), Institutional and Industrial Estate Plantations (RV /JK/ UL/02) and Eco-Park Development (RV / JK/UL /03). Within the alluvial plains of Punjab, 4 models *viz*., Bio-remediation and Bio-filtration (RV/PB/UL/01), Riverfront development (RV/ PB/UL/02), Institutional and Industrial Estate Plantations (RV/PB/UL/03), Eco-Park development (RV/PB/UL/04) are proposed in Urban Landscape.

Theme Plans

In addition to the Forestry Interventions and specific treatment models included for three lower order zone plans, additional 'Conservation Activities' and 'Supporting Activities' those are common to two or all the three zones are referred as important themes have been proposed. Theme based activities or 'Theme Plans' are grouped under the name of: (i) 'Conservation Interventions' such as; (a) Soil and Water conservation, (b) Riparian Wildlife Management, and (c) Wetland Management (Natural and Artificial), and (ii) 'Supporting Activities' such as (a) Policy Interventions, (b) Concurrent action research, (c) Capacity building, (d) Awareness, (e) Participatory monitoring, and (g) Evaluation. These theme based activities (i.e., Conservation Interventions and Supporting Activities) have been planned at the State and Local Field Levels i.e., for Himachal Pradesh,Punjab and J&K UT in the present context.

Implementation Mechanism

The Programme Implementation has been planned in two phases of five years duration each. The Phase 1 deals with Project Implementation while the Phase II primarily focuses on the maintenance of plantations established during the Phase 1. The project visualizes constitution of two Programme Steering Committees (PSCs), one at the National level in the Central Nodal Ministry being referred as the 'National Programme Steering Committee (NPSC)' while the other one at the State and UT level in the concerned FD/ IA, and being referred as the 'State Programme Steering Committee (SPSC)'. The NPSC and SPSC would be responsible for the

efficient execution of the project at the National, State and UT levels, respectively. The NPSC would be responsible for approving the APOs submitted by participating State and UT and a National Level Partner Organization (NPO) in addition to primary functions of overseeing and steering the execution of the Implementation Plan. The NPMU at the Central Nodal Ministry will be responsible for the release of funds to IAs and the NPO once the APOs have been approved by the NPSC. The Project Facilitation Unit (PFU) at the NPO will follow its own mechanism of governance and will constitute its own Monitoring and Steering Committee for overseeing the project.

Project Budget

The DPR envisages two phases: (a) Phase 1- Project Implementation, and (b) Phase II Maintenance Phase. Each phase is of 5-year duration. Thus the project activities planned and incorporated in the DPR spread over a period of 10-years. The total financial outlay for phase I and phase II for detailed project report of Ravi River through forestry intervention is Rs. **498.77** Crore. The projected financial outlay of the Phase 1 on Project Implementation of five-years duration is Rs. **395.95** Crore. The projected budget outlay of Phase II (Maintenance Phase) of five-year duration is Rs. **102.81** Crore. As mentioned above, the project includes four broad based components. Accordingly, financial cost of each of these four components is summarized below:

Project Outlay: Component and Activity Wise

The Principal Component-A: Implementation of Forestry Interventions in Ravi Riverscape

An amount of Rs 359.33 Crore, which is 72.04 % of the overall project budget, is provisioned for principal component A. This includes total Rs. 333.69 Crores for forestry interventions in three landscapes (Sub-component A.1) and Conservation intervention (Sub-component A.2) and Rs. 25.64 crore provisioned for supporting activities (Sub-component A.3).

Component -A: The Component - A on plantations and various treatment models in three types of landscapes within the riverscape is the largest in terms of its spread, extent and quantum of funds provisioned. The component A, being the predominant component of the overall project have envisaged three sub-compenents.

Sub-Component –A.1 the predominant sub-component (A.1) emphasizes on extensive plantation in three types of Landscape (Natural, Agriculture, Urban and Plantations under Eco-Task Force (ETF) within the riverscape. Among three landscapes, the highest predominance of proposed activity is in Natural Landscapes within the riverscape i.e., Rs. 105.47 Crores. Two Battalions of Eco-Task Force with also carry out plantation (2,000 ha) activities in the Natural

Landscape in Hiamchal Pradesh and Jammu & Kashmir UT at projected cost of Rs. 45.34 Crores. Plantations and other appropriate treatment models have also been planned for Agriculture Landscape and Urban Landscape within the riverscape and budget provision to the tune of Rs. 4.81 Crores and Rs.67.22 Crores respectively of the sub-component (A.1) have been made.

The second Sub-component on 'Conservation Interventions' (**A.2**) includes three major types of interventions/activities. These are: (a) soil and moisture conservation measures, (b) riverine and riparian wildlife management, and (c) wetland management. Rs. 110.85 Crores are provisioned for this subcomponent, which is 22.22 % of total budget outlay. Out of this, the budget outlay for SMC is Rs. 73.21 Crore, which is 20.37 % allocation of the funds provisioned for Component A. Budget outlay provisioned for Riverine, Riparian Wildlife Management and Wetland Management is Rs. 37.64 Crore, which is 10.48 % of total budget of component A.

The third Sub-component (**A.3**) pertaining to 'Supporting Activities' is to be executed by concerned States/UT level IAs. This Sub-component includes seven broad based activities viz., (a) policy and legal interventions, (b) participatory monitoring, (c) adaptive research, (d) capacity development, (e) awareness, (f) project management, and (g) evaluation. A budget of 25.64 Crore or 5.14% of total budget proposed to the concerned States/UT has been provisioned for carrying out various supporting activities for five-year period.

The Component-B: The component B specifically pertains to the National Partner Orgnization (NPO) responsible for carrying out priority activities relevant to the strengthening of knowledge management, enhacement of capacity for forestry interventions and river conservasion. Strengthening Knowledge Management and enhancement of national capacity for forest hydrology, forestry interventions, and conservation and restoration of rivers would require a sum of Rs. 18.53 Crore or 3.72% of the overall project outlay. The highest budget amounting Rs. 4.89 Crore has been provisioned for cost of PFU, while budget of Rs. 3.93 Crore has been provisioned for Research and Development, while Rs. 1.12 Crores, Rs. 1.69 Crore, Rs. 2.25 Crore, Rs. 0.92 Crore, Rs. 0.42 Crore and Rs. 0.29 have been envisaged for policy level interventions, capacity development, Scientific exchange, awareness, Monitoring and Evaluation respectively.

The Component – C on the Phase II of the project of five-year duration for maintenance of plantations raised during Phase I of the project has also been planned. The Phase II would also include limited activities related to replication of efforts in additional tributaries/areas and scaling up of the planned effort. A sum of Rs. 102.81 Crore or 20.61 % of the total project financial outlay has been envisaged specifically for the Component – C on 'Maintenance Phase'.

The Component – D pertains to project management at the national level which would include the establishment of National Project Management Unit (NPMU) at the Central Nodal Ministry

with the responsibility to oversee, steer and manage this priority project. A sum of Rs. 18.09 Crore, representing 3.63 % of the overall budget over a period of five-year during the Phase I has been provisioned. Year-wise proposed budget for Project Management Unit at Central Nodal Ministry for Ravi River is presented in Table 7.6. Thus, it is clear that the major portion of project budget outlay is meant for field level activities incorporating proposed forestry interventions, conservation interventions and supporting activities to be implemented in concerned States/UT.

A total of 12 Territorial Forest Divisions and 4 Wildlife Divisions in Ravi Riverscape, will carry out proposed activities relevant to forestry interventions within the Riverscape. A total of 6401.54 ha area of three landscapes, 421 ha area of Riverine and Riparian wildlife management and wetland management and 452920.5 m^3 extent of soil and moisture conservation in Ravi Riverscape is envisioned to be treated under the various forestry interventions.

Project Schedule

The execution period of Phase I and Phase II of the project has been designed and incorporated in the present DPR is of 5-years duration in each case. Thus, the total duration for programme implementation including the maintenance phase is of 10-years. At this juncture, it is not clear when the project would commence and which will be the first year of programme implementation during Phase I. The Government of India may take its own time to decide the Central Nodal Ministry responsible for the implementation of the project and to allocate required funds for the execution of plan. Various proposed activities have been staggered over five years of the Phase I. The experience illustrates that once the Government of India has accorded its approval for the project and earmarked required funds, the first year by IAs would be largely devoted for project initiation, preparatory works, particularly the establishment of nurseries and commencement of various activities related to conservation interventions and supporting activities. The planting material meant for high altitude Himalayan part of the riverscape would be ready in nurseries and earliest available by the end of second year of project implementation. Thus, the earliest effective establishment year of plantations would be the third year of Phase I in high altitude areas. Establishment of plantations is proposed in third, fourth and fifth years of Phase I. The Phase II of five years duration is specifically designed and incorporated for the purpose of maintenance of plantations and other activities. Considering the fact that most proposed activities are time bound and seasonal in nature, ideally the project initiation after all approvals, budget allocation, etc. should commence in April–May so as to allow adequate time for preparatory works, establishment of nurseries, development of planting material for Afforestation/ Reforestation in lower reaches of the riverscape before the onset of monsoon season in the month of June or so in the next year. Thus, careful scheduling of project

commencement would be vital for the overall success and effective implementation of envisaged activities. The quantum of activities is expected to be at its peak in third and fourth years of Phase-I. The Mid-Term Review (MTR) is proposed in the last quarter of third financial year of the project execution while the Terminal Evaluation (TE) is being envisaged in the third year of the Phase II.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACF	- Assistant Conservator of Forests
AGB	- Above Ground Biomass
AIBP	- Accelerated Irrigation Benefit Programme
AIG	- Alternate Income Generation
AL	- Agriculture Landscape
ALOS-DEM	- Advanced Land Observing Satellite based digital elevation model (ALOS-DEM
APO	- Annual Plan of Operations
AYUSH	- Ayurveda, Yoga and Naturopathy, Unani, Siddha, and Homeopathy
BADP	- Border Area Development Programme
BBMB	- Bhakra-Beas Management Board
BCM	- Billion Cubic Meters
BCRLIP	- Biodiversity Conservation and Rural Livelihood Improvement Project
BGB	- Below Ground Biomass
BMC	- Biodiversity Management Committee
BOD	- Biological Oxygen Demand
BPL	- Below the Poverty Line
BRO	- Border Roads Organization
BSI	- Botanical Survey of India
CAMPA	- Compensatory Afforestation Fund Management and Planning Authority
CAPF	- Central Armed Police Forces
CAT	- Catchment Area Treatment
CBD	- Convention on Biological Diversity
CBO	- Community based Organization
CC	- Completion Certificate

CCA	- Cultivable Command Area
CIFRI	- Central Inland Fisheries Research Institute
CITES	- Convention on the International Trade in Endangered Species of Wild Flora and Fau
CIWSA	- Centre of Inland Waters in South Asia
CMS	- Convention on Migratory Species
COD	- Chemical Oxygen Demand
CPCB	- Central Pollution Control Board
CPIC	- Circle Project Implementation Committee
CSD	- Commission on Sustainable Development
CSO	- Civil Society Organization
CSS	- Centrally Sponsored Schemes
CWC	- Central Water Commission
CGWB	- Central Ground Water Board
DC	- Debris-covered
DEM	- Digital Elevation Model
DFO	- Divisional Forest Office
DIC	- District level Implementing Committee
DFID	- Department for International Development
DO	- Dissolved Oxygen
DOM	- Dead Organic Matter
DPR	- Detailed Project Report
DRDA	- District Rural Development Agency
DSMIS	- Decision Support and Management Information System
EAP	- Externally Aided Projects
EC	- Eco development Committees

EI	- Ecological Integrity
EIA	- Environment Impact Assessment
EFA	- Environmental flow assessment
EFR	- Environmental Flow Requirement
ESA	- Environmental and Social Analysis
ESCAP	- Economic and Social Council for Asia and Pacific
ESMF	- Environmental and Social Management Framework
ESZ	- Eco-Sensitive Zones
ETF	- Eco Task Force
FAO	- Food and Agriculture Organization
FDA	- Forest Development Agency
FDC	- Flow Duration Curves
FPC	- Flood Pulse Concept
FREEP	- Forestry Research, Education and Extension Project
FRI	- Forest Research Institute
FSI	- Forest Survey of India
GAP	- Ganga Action Plan
GBPNIHESD	- G. B. Pant National Institute of Himalayan Environment and sustainable Development
GEF	- Global Environment Facility
GHG	- Green House Gas
GIM	- Green India Mission
GIS	- Global Information System
GLOF	- Glacial Lake Outburst Floods
GLIMS	- Global Land and Ice Measurements from Space
GoI	- Government of India

GPC	- Good Practices Guidance
GPG	- Good Practices Guidance
GPS	- Global Positioning System
GRBEMP	- Ganga River Basin Environment Management Plan
GREF	- General Reserve Engineer Force
HCC	- Hyporheic Corridor Concept
HEP	- Hydroelectric Project
HFF	- Himalayan Frontal Fault
HFL	- High Flood Level
HFRI	- Himalayan Forestry Research Institute
HIMCOSTE	- Himachal Pradesh Coucil for Science Technology and Environment
HKH	- Hindu Kush Himalaya
HoFF	- Head of Forest Force
HNA	- Himalaya Niti Abhiyan
HP	- Himachal Pradesh
HPSIRD	- H.P. State Institute of Rural Development
IA	- Implementing Agency
IAFs	- Indian Armed Forces
IARI	- Indian Agriculture Research Institute
IBA	- Important Bird Area
IBIS	- The Indus Basin Irrigation System
ICFRE	- Indian Council of Forestry Research and Education
ICIMOD	- International Centre for Integrated Mountain Development
IDA	- International Development Agency
IFS	- Indian Forest Services

IGB	- The Indus, Ganga and Brahmaputra
IIIM	- Indian Institute of Integrative Medicine
IIRS	- Indian Institute of Remote Sensing
IISWC	- Indian Institute of Soil and Water Conservation
IIT	- Indian Institute of Technology
IMD	- Indian Meteorological Department
IP	- Implementation Plan
IPCC	- Intergovernmental Panel on Climate Change
IPH	- Irrigation and Public Health Department
ISFR	- India State of Forest Report
ISRO	- Indian Space Research Organisation
ITBP	- Indo Tibetan Police Force
IUCN	- International Union for the Conservation of Nature and Natural Resources
IWDP	- Integrated Watershed Development Project
IWMP	- Integrated Watershed Management Programme
IWRM	- Integrated Water Resources Management
IWT	- Indus Waters Treaty
JBIC	- Japan Bank of International Cooperation
JICA	- Japan International Cooperation Agency
JFM	- Joint Forest Management
JFMC	- Joint Forest Management Committee
J&K	- Jammu and Kashmir
KVK	- Krishi Vigyan Kendra
LCS	- Low Cost Sanitation
LFA	- Logical Framework Approach

LULC	- Land Use Land Cover
MAPs	- Medicinal and Aromatic plants
MAR	- Mean Annual Runoff
MAAT	- Mean annual air temperature
MBT	- Main Boundary Thrust
MCM	- Million Cubic meters
MDF	- Moderately Dense Forest
MoEF&CC	- Ministry of Environment, Forest and Climate Change
M.ha	- Million hectares
MMs	- Mahila Mandals
MNNREGs	- Mahatma Gandhi National Rural Employment Guarantee Scheme
MoA&FW	- Ministry of Agriculture and Farmer's Welfare
MoD	- Ministry of Defense
MoEF&CC	- Ministry of Environment, Forest and Climate Change
MoH	- Ministry of Home
MoH&UA	- Ministry of Housing and Urban Affairs
MoJS	- Ministry of Jal Shakti
MoPR	- Ministry of Panchayati Raj
MoUD	- Ministry of Urban Development
MoWR, RD& GR	- Ministry of Water Resources, River Development and Ganga Rejuvenation
MSR	- Mean Seasonal Runoff
MoDW&S	- Ministry of Drinking Water and Sanitation,
MW	- Mega Watt
MoRD	- Ministry of Rural Development
MoS	- Ministry of Shipping

MT	- Metric Ton
MTR	- Mid Term Review
MoT	- Ministry of Transport
MoYA&S	- Ministry of Youth Affairs and Sports
MSR	- Mean Seasonal Runoff
NAP	- National Afforestration Programme
NAPCC	- National Action Plan on Climate change
NBM	- National Bamboo Mission
NBSS&LUP	- National Bureau of Soil Survey and Land Use Planning
NCC	- National Cadet Corps
NGRBA	- National Ganga River Basin Authority
NIDM	- National Institute of Disaster Management
NLCP	- National Lake Conservation Plan
NMCG	- National Mission for Clean Ganga
NP	- National Park
NPCA	- National Plan for Conservation of Aquatic Ecosystems
NPSC	- National Project Steering Committee
NRCD	- National River Conservation Directorate
NRCP	- National River Conservation Plan
NSS	- National Service Scheme
NTCA	- National Tiger Conservation Authority
NAP	- National Afforestration Programme
NAPCC	- National Action Plan on Climate change
NBA	- National Biodiversity Authority
NBFGR	- National Bureau of Fish Genetic Resources

NBM	- National Bamboo Mission
NBSS & LUP	- National Bureau of Soil Survey and Land Use Planning
NCC	- National Cadet Corps
NCIWRDP	- National Commission for Integrated Water Resource Development Plan (NCIWRDP
NERIL	- North Essex Resource and information Line
NGO	- Non-Government Organisation
NGRBA	- National Ganga River Basin Authority
NGRBP	- National Ganga River Basin Project
NGT	- National Green Tribunal
NHB	- National Horticulture Board
NIDM	- National Institute of Disaster Management
NIH	- National Institute of Hydrology
NIT	- National Institute of Technology
NL	- Natural Landscape
NLCP	- National Lake Conservation Programme
NMCG	- National Mission for Clean Ganga
NMPB	- National Medicinal Plant Board
NP	- National Park
NPK	- Nitrogen Phosphorus Potassium
NPSC	- National Project Steering Committee
NRCD	- National River Conservation Directorate
NRCP	- National River Conservation Plan
NRSC	- National Remote Sensing Centre
NSS	- National Service Scheme
NTCA	- National Tiger Conservation Authority

NTFP	-	Non-Timber Forest Product
NWCP	-	National Wetlands Conservation Programme
NWIA	-	National Wetland Inventory and Assessment
NWM	-	National Water Mission
NYKS	-	Nehru Yuva Kendra Sangathan
OF	-	Open Forest
PA	-	Protected Area
PAU	-	Punjab Agriculture University
PBR	-	Peoples' Biodiversity Register
PCB	-	Pollution Control Board
PCCF	-	Principal Chief Conservator of Forest
PD	-	Project Director
PED	-	Project Executive Director
PF	-	Protected Forest
PFU	-	Project Facilitation Unit
PID	-	Photo Interpretation Department
PLM	-	Programme Logic Model
POM	-	Particulate organic material
Ppm	-	Parts per million
NWRC	-	National Water Resources Council
PMU	-	Project Management Unit
PSC	-	Project Steering Committee
QPM	-	Quality planting material
RBM	-	Results-Based Management
RBDPM	-	River Basin Development and Planning Management

RCC	-	River Continuum Concept
RF	-	Reserved Forests
RFA	-	Recorded Forest Area
RFD	-	River Front Development
RfR	-	Rally for Rivers
RO	-	Range Offices
SAARC	-	South Asian Association for Regional Cooperation
RS	-	Remote Sensing
SACEP	-	South Asia Cooperative Environment Programme,
SBT	-	Sea buck thorn
SGRCA	-	State Ganga River Conservation Authority
SDC	-	Serial Discontinuity Concept
SDG	-	Sustainable Development Goals (SDGs
SF	-	Scrub Forest
SFD	-	State Forest Department
SFDA	-	State Forest Development Agency
SFM	-	Sustainable Forest Management
SDM	-	Soil Organic Matter
SEAC	-	State Expert Appraisal Committee
SEIAA	-	State Environment Impact Assessment Authority
SoI	-	Survey of India
SKUAST	-	Sher-e Kashmir University of Agriculture Science and Technology
SMEs	-	Small and Micro Entrepreneurships
SOM	-	soil organic carbon
SPCB	-	State Pollution Control Board

SPMU	- State level Project Management Unit
SPSC	- State Project Steering Committee
SRP	- Sulphate Removal Package
STP	- Sewage Treatment Plants
TDS	- Total Dissolved Solids
TK	- Traditional Knowledge
TOFs	- Trees Outside Forests
UBDC	- Upper Bari Doab Canal
UC	- Utilization Certificate
UDF	- Un-demarcated Forest
UFs	- Unclassed Forests
UL	- Urban Landscape
UNCBD	- United Nations Convention on Biological Diversity
UNCCD	- United Nations Convention to Combat Desertification
UNCED	- United Nations Conference on Environment and Development
UNDP	- United Nations Development Programme
UNEP	- United Nations Environment Programme
UNFCC	- United Nations Framework Convention on Climate Change
UNRISD	- United Nations Research Institute for Social Development
USA	- United States of America
USAID	- United States Agency for International Development
UT	- Union Territory
VDF	- Very Dense Forest
VFPC	- Village Forest Protection Committees
VFDS	- Village Forest Development Society

VFDC	- Village Forest Development Committee
VSS	- Van Sanrakshan Samiti
WII	- Wildlife Institute of India
WLS	- Wildlife Sanctuary
WMS	- Web Map Service
WPA	- Wildlife Protection Act
WRIS	- Water Resources Information System
WRR	- Water Resources Regions
WWF	- World Wildlife Fund
YAP	- Yamuna Action Plan
ZSI	- Zoological Survey of India (ZSI

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Chapter-1

Introduction

1.1 Natural Ecosystems – Human Well Being and Sustainable Development

Eco-systems are the planet's life support systems for the human being and all other forms of life (WHO, 2005). Natural ecosystems like forests, grasslands, wetlands, coastal and marine systems provide a variety of goods and services upon which people depend. Amongst varied natural ecosystems, freshwater ecosystems (lakes, ponds, groundwater, springs, streams, rivers and some others wetlands) make up the smallest percent of the earth's aquatic ecosystems but are vital for sustaining life on the earth. Living organisms form the basis of a multitude of ecosystems and these ecosystems considerably influence the exchange of energy and cycling of water, carbon, nitrogen and other elements within and between the Earth's atmosphere, biosphere, hydrosphere (e.g. oceans, rivers and lakes), cryosphere (e.g. permafrost, snow and ice) and lithosphere (e.g. soils, mountains and seabed).

Although, humanity has always depended on the services provided by the biosphere and its ecosystems but humans have used, exploited or even modified almost all natural ecosystems for their own benefits (WRI, 2003; MEA, 2005). Anthropogenic activities have adversely impacted the earth's ecosystems. Natural ecosystems are vulnerable, limited and require balance to thrive. When one element increases or decreases, the ecosystem must adapt to the change. Human activities are important in almost all type of ecosystems. Although, humans exist and operate within ecosystems, their cumulative effects are large enough to influence ecosystem functioning and even the external factor like climate. Owing to the rapid development, communication, industrialization, urbanization, globalization and technological advancements, the world is fast changing and transforming. However, the transition to global sustainable development has not been successful yet. Further, in the process of unplanned rapid development and due to various activities either biotic or abiotic, the environmental problems have become even more acute and global. Today's, development challenges from climate crisis to rising inequalities and protracted conflict cannot be dealt within isolation. It is essential that three dimensions of sustainable development (economic, social and environmental) are integrated in a coherent and balanced manner. Freshwater is essential to inclusive, equitable and sustainable development and is embedded in all the sustainable goals.



Plate 1.1- Ravi River

1.2 Rivers – Complex and Dynamic Ecosystems

Water is the basis of life and probably the most essential requirement for economic and social development of mankind. Over 70 percent of the earth's surface is covered with water, but freshwater resources accessible for direct human use account for less than 1 percent (Asaeda *et al*., 2009). Amongst, varied freshwater ecosystems, running waters, particularly rivers are globally significant as they provide a plethora of utilities for humankind, including a source of water for domestic, industrial, and agricultural purposes, a means for power generation, routes for navigation, and sites for the religious pursuit, cultural, recreational, and adventurous activities (Malmqvist and Rundle, 2002). Rivers have served as area for settlement, infrastructure and production for several thousand years (Bock *et al*., 2018). Running waters (streams and rivers) are most complex and dynamic ecosystems as they encompass a wide array of habitats from their origin to confluence with other rivers or up to their mouth besides they incorporate a number of processes during their journey. The relative narrowness of the flowing systems means that they have intimate contact with their surrounding catchment and the terrestrial ecosystems they contain (Hynes, 1975). In addition to their linear form, streams and rivers are unique and fascinating amongst aquatic ecosystems in their unidirectional flow. This feature shapes the morphology of river channels, makes running waters extremely variable in space and time and

has led to a biota that is highly adapted to dynamic conditions (Giller and Malmqvist, 1998; Malmqvist and Rundle, 2002). Rivers are an integral part of the natural landscape and the intricate river system involves a large number of basin-scale processes that influence river flow, water quality, structure of the river channel, and aquatic and riparian biota (Speed *et al.*, 2016). Rivers have been recognized as integrators within the landscape as they link terrestrial, freshwater, coastal and marine ecosystems and nearly all aspect of human culture from origin to mouth in open transport and migration routes (Naiman and Bilby, 1998; Wampler, 2012). The susceptibility of running water is aggravated by their linear and unidirectional nature as almost any activity within a river catchment has the potential to cause environmental change and any pollutant entering a river is likely to exert effects for a large distance downstream. van der Velde *et al.* (2004) has described five unifying characteristics of river *viz*., unidirectional flow, a state of continuous physical change, a high degree of spatial and temporal heterogeneity at all scales, high variability between *lotic* systems, and specialized biota to inhabit matching to flow conditions of a river. River in the process of its flow from source to sea provide one temporal and three spatial dimensions of river connectivity viz., longitudinal, vertical and horizontal (Seliger and Zeiringer, 2018). The longitudinal connectivity is exhibited from origin to mouth. The vertical connectivity represents mixing of free flowing surface water with the ground water below through the river bed. The river has strong linkages with its surrounding lands and this linkage has been referred as the lateral connectivity.

A river acts as a source as well as a sink. River as a source contributes energy, materials, organisms to the surrounding landscape and also acts as a sink for water or sediments during flooding besides pollutants and waste. Rivers play vital role in the hydrological cycle and at the same time being primarily influenced by the cycle.

1.3 River Ecosystem – Human Use and Disturbance

Rivers, especially large river systems are one of the most basic life support systems that sustain civilizations, and are considered an important determinant for the future livelihood of human civilizations (Sinha *et al*., 2013). For centuries, human populaces have settled near rivers to gain the flexibly of water for drinking and irrigation, the prolific soils of the encompassing floodplains to bear farming, accessibility of freshwater fish and the advantages of river as mode for transport (Speed *et al*., 2016). The direct extraction and consumption of freshwater is the most obvious benefits derived from rivers. According to Carpenter *et al.* (2011) surface freshwaters supply about 75% of the water withdrawn for the human use. Agriculture is the bigger client of freshwater, representing around 70% of freshwater withdrawal and over 90% of consumptive use (Hoekstra and Mekonnen, 2012). Rivers are also a major source of food. Inland fisheries including aquaculture contribute about 33% of total global fish catch and provide more than 6% of the worlds' annual protein supplies for human (FAO, 2007). According to Helfman (2007), recreational fishing alone is estimated to have value of US $ 116 billion per year. For

over 5,000 years, humans have exploited rivers more than any other type of ecosystems (Boon *et al*., 1992 and Speed *et al*. 2016). While this relationship with rivers has brought several benefits to human society, it has also had significant impacts on the rivers, in some instances fundamentally changing the way they function (Nienhuis and Leuven, 2001). Human induced changes over the last century were exceptionally large and consequently such impacts are threatening the capacity of river ecosystems to provide the services for human societies have come to depend on, as well as capacity of rivers to meet new demands.

In ecology, disturbance is defined as 'any relatively discrete event in time that removes organisms and open space which can be colonized by individuals of same or different species' (Sousa, 1984; Begon *et al*., 1990). Natural disturbances and stochastical events are observed in almost all ecosystems. In case of rivers, natural disturbances could be due to tectonic movement, avalanche, landslide, cloud burst, storm, flood, drought, forest fire, etc. and they may occur randomly while human disturbances are the dominant ecological factor impacting the river ecosystem. River ecosystems experience a wide array of human disturbances *viz*., changes in land use and land cover in surrounding lands, deforestation, agriculture expansion, livestock grazing, engineering measures or physical barriers and diversion of water, road network, construction near shorelines or river banks, pollutants and industrial effluents, sand mining and boulder collection, excessive fishing, etc. The recovery of energy from rivers and streams through the construction of dams comes at a cost of ecosystems and the function of river systems. Dam construction can result in changes to sediment transport, aquatic ecosystems and fish migration (Collier *et al*., 2000). The capture of sediment behind dams can have profound impacts on the geomorphology and function of the river downstream from the dam. The water released below the dam has been termed 'hungry water' because it has sufficient energy to transport sediment but the sediment has been captured behind the dam (Kondolf, 1997). The hungry water consumes the bed and banks of the river below the dam, resulting in entrenchment and armoring of the bed. As a result of such disturbances, very few rivers retain their original integrity, degradation of rivers and riverine landscapes become a serious concern for all nations. Increasingly, natural disturbances are altered by human disturbances. Likely implications of climate change are expected to adversely impact rivers and other associated natural ecosystems and surrounding land. Most rivers in India, now suffer on the account of fragmentation, soil erosion and sedimentation, altered and reduced environmental flow, waste and sewage disposal, industrial effluents, excessive extraction of water, and chemical pollutants from agriculture. The exploitation of rivers by humans has led to widespread degradation of their natural character, resulting in a loss of characteristic habitat, biodiversity and the benefits on which the society rely on. As a result, rivers and their tributaries show signs of siltation, nutrient enrichment, loss/decline of habitat and biodiversity, and loss of vital longitudinal, vertical, and lateral connectivity. Undoubtedly, most rivers now provide much reduced ecosystem services than what they used to offer. Some of the rivers are even on the brink of dying or losing the ecological integrity.

1.4 The Rivers – Past, Present and Future

Rivers provide ecosystem services that have attracted humans for millennia (Haidvogl, 2018). Archeological and other written evidence provide sufficient proof that river uses and necessary technical infrastructure existed already in ancient times, especially in arid zones. Major rivers such as the Nile, the Euphrates, the Indus and the Yangtzekiang enabled cultures to develop and shaped their economy and culture (Haidvogl, 2018). Since, perhaps as much as 7,000 years ago, riverine ecosystems have been systematically modified on increasingly large scale since the invention of irrigation (Mays, 2008; Schmutz and Sendzimir, 2018). Hence, rivers are among the most threatened ecosystems of the world and the river science has evolved in the past century so as to define the threatening trends and the mechanisms that cause them. The Historical degradation of rivers has been accelerated by surges of economic and/or technological power as empires and technologies erupted and expanded. The historical evolution of river uses and resulting ecological impacts exhibit clear temporal patterns. The pre-industrial effects were mostly local and regional, and human practices such as passive flood protection were designed to adapt to, not control the dynamics of river. Industrialization had large scale effects on the river uses and their impacts on morphology, hydrology and aquatic biota. Geo-engineering of rivers has systematically channelized river for transport and to increase drainage during high water events and separated the channel from the floodplain and dammed rivers for hydropower (Zarfl *et al*., 2014). According to Likens (2010), rivers currently store the equivalent of 15% of global annual river runoff. As a result, 48% of rivers in term of volume globally are moderately to severely impacted by either flow regulation, fragmentation or both (Grill *et al.*, 2015). During the twentieth century, deteriorating water quality and hydro-morphological degradation were perceived as a necessary evil to foster economic development. Riverine impairment peaked in response to a combination of intensifying factors such as enhanced resource exploitation and use, exponential growth in number of machineries in industries, intensified agriculture driven by an ever increasing number of modern tools and machines, as well as fertilizers and pesticides. As a response in the late 1980s and 1990s, river restoration projects were planned and implemented (Haidvogl, 2018; Schmutz and Sendzimir, 2018). In the context of Ravi River, residential and Industrial wastes are the key problems. Although, NGT has imposed a ban on throwing garbaze on the riverbed, but no proper waste management is deteriorating the river water quality. Silt and clay are the worsening agent of Ravi River in monsoon period. There has been drastic changes in Ravi River course over the past 20 years due to the ongoing human activities. The river has diverted its course towards India as the geography is at odds with it. It is estimated that large structures could divert the river route to India at least 1 to 5 km from the Punjab border (Thomas and Sharma, 1998).

1.5 Need for Scientific Management

Rivers are a dynamic combination of water, sediment, aquatic organisms, and riparian vegetation, all participating in a complex system from the point of origin, or headwaters, toward the ocean or basin where the journey ends (Wampler, 2012). Rivers provide a multitude of services *viz*., water supply, waste assimilation, fisheries, energy production, flood attenuation, spiritual, cultural and recreational benefits, and the habitat that supports a wide range of ecosystems (Pegram *et al*., 2013). During 1970s and 1980s, it became evident that engineering solutions alone are unable to provide solutions for the multifaceted problems of river management, particularly the trades-off between competing interest and values but soon it was realized that an integrated approach to managing rivers and their river basins is required (Pegram *et al*., 2013). The approaches and practices of river basin management and planning have evolved over time in response to changing and competing demands on river systems by societies as well as the significantly altered conditions of rivers. During the past four to five decades, the evolution in practices of river management and basin planning has witnessed a profound shift in focus from a narrow, engineering-focused approach, to a more complex process incorporating environmental sustainability, demand management, institutional development, economic and social analyses and trades-off. The scientific discipline dealing with the study of rivers known as Potamology is the interdisciplinary branch of hydraulics, hydrology and fluid dynamics concerning surface streams and their regimes. The discipline generally focuses on issues of fluvial erosion, transport and sedimentation, fluvial dynamics and river metamorphosis or change through time. The need for new perspective of multi-disciplinary (geology, climatology, soil science, hydrology, ecology, forestry, engineering, environmental management, social sciences, etc.) and holistic approach to planning, assessment and management of river ecosystems arises due to the strong linkages between ecological interconnectedness of river basins and the hydrology, upstream and downstream, and river and surrounding lands. The newer perspective of river management and basin planning requires consideration of the following four broad groups of benefits (Grey and Sadoff, 2005):

a) environmental benefits to the river i.e. enhanced environmental flow, improved water quality, conserved biodiversity and increased productivity
b) enhanced economic benefits from the river like food, energy and manufacturing production
c) reduced costs of management through flood control
d) benefits beyond the river i.e. eliciting wider cooperation and economic integration

The emerging need emphasizes to adopt a comprehensive approach to river management so as to understand the complex physical, chemical, biological and even socio-economic processes that drive river health and for identifying the most effective and efficient restoration measures (Speed *et al*., 2016). Further, recent approaches to river management stress upon adoption of the

strategic approach focusing on the riverine landscape perspective, ecosystem based approach recognizing running waters are open ecosystems well connected with human systems. Their complex biotic and abiotic functions, processes and structures are largely the result of a system-inherent, dynamic genesis and development (Jungwirth *et al*., 2002; Speed *et al*., 2016).

1.5.1 River Ecology

The dendritic river patterns are the foundation of most topography on the planet and decide the linkages among terrestrial and aquatic ecosystems. These patterns are progressively sorted out from smaller scale living spaces to the size of entire catchments (Frissell *et al*., 1986; Trautwein and Pletterbauer, 2018). Hence several processes of *lotic* ecosystems are determined by the hierarchically nested structure of river networks and their interlinkages.

The conditions of a river catchment and the flows of energy, materials and organisms in the river as a dynamic ecosystem are interwoven in a complex, cross-linked relationships of ecosystem functioning (Trautwein and Pletterbauer, 2018). Catchments are hydrologic units defined as the area collecting the water within a given drainage divide or watershed. All the catchments for all the tributaries of a river are lumped together to form a river basin (Seliger and Zeiringer, 2018). According to Naiman *et al*. (1992), streams and rivers are integrators of broader environmental conditions as they reflect the conditions of the surrounding landscape. Besides water flow, water quality is an important aspect of the stream and river ecology. Water quality includes physical, chemical and biological constituents affecting a stream's physical conditions and chemical constituents, together characterizing the stream quality. High-elevation streams have less acid neutralizing capacity, hardness, total ions, nutrients and metals than the lowland waters. Deforestation, removal of riparian vegetation, inputs of organic material and storm water runoff caused by agricultural activities and urbanization not only result in enhanced stream temperature but also reduced levels of dissolve oxygen (DO). Low DO in the interstitial spaces of the stream substratum adversely affects fish embryos and benthic invertebrates. Stream periphytons are responsive to changes in water quality and habitat (Naiman and Bilby, 1998). The river flow and water quality significantly influence the distribution and abundance of these biological communities (Benda *et al*., 1998).

In the context of rivers, four dimensions need to be considered when studying and managing rivers (Ward, 1989). These four dimensions are*:* (a) longitudinal dimension – rivers change from source to mouth, both in physical characteristics of the channel and in associated biological communities; (b) vertical dimension – rivers are tightly linked to ground water including hyporheic habitats; (c) lateral dimension – rivers are not limited to the channel but also include their margins and floodplains; and (d) temporal dimension – rivers are in the state of constant change, including short lived flood pulses, seasonal variations in habitat characteristics, long term migration of channel and so on. Maintenance of this multiscale temporal variation is vital

for river health (Ward, 1989). Further, Meyer (1997) adds another relevant dimension that of the social and human context.

Thus, it is evident from the above description that rivers are complex and dynamic ecosystems as they are directly or indirectly affected by multiple human activities. Therefore, river conservation must take into account the needs and interest of people living along their banks and within the drainage basin (Sabater and Elosegi, 2014).

1.5.2 Rivers – Ecological Concepts and Connectivity

The 'ecological connectivity' refers to the spatial and temporal extent to which living organisms and associated ecosystem services, processes and functions can move between different habitat patches. The science of ecological connectivity or landscape connectivity has evolved considerably in the last two decades or so (Huber *et al*., 2018).

The connectivity has both structural and functional components. 'Structural connectivity' describes the physical characteristics of a landscape that allow for movement, including topography, hydrology, vegetative cover and human land use patterns. 'Functional connectivity' describes how well genes, propagules, individuals, or populations move through the landscape (Rudnick *et al*., 2012). Connectivity can influence a wide range of processes within a landscape and thus, has direct relevance to: (a) species persistence, (b) behavioral ecology, (c) community structure and (d) the challenge of climate change.

In the context of a river, connectivity refers mainly to exchange pathways of water, resources and organisms between the channel, aquifer and the floodplain, although interactions with adjacent uplands also need to be considered (Ward and Stanfold, 1995). While natural disturbance generally allows maintaining high connectivity and associated habitat heterogeneity, productivity and biodiversity of river ecosystems, but anthropogenic influences often disrupt the intensity, frequency and timing of the natural disturbance regime that is responsible for maintaining the ecological integrity of these dynamic ecosystems.

The foregoing section has already highlighted the four dimensions relevant to river ecosystem in relation to one temporal and three types of spatial connectivity (Ward, 1989; Weins, 2002; Rudnick *et al*., 2012; Seliger and Zeiringer, 2018). With the growing interest and development of the discipline of river science and river conservation, in the past three to four decades, several well-known ecological concepts in the context of running waters have evolved which includes 'River Continuum Concept (RCC)', 'Serial Discontinuity Concept (SDC)', 'Hyporheic Corridor Concept (HCC)' and 'Flood Pulse Concept (FPC)'. Zhou *et al*. (2014) stated that several stream/river ecologists have long observed that rivers are influenced by the surrounding terrestrial ecosystems (Leopold and Marchand, 1968; Cummins, 1974; Wallace *et al*., 1997). The concept of riverscape (or river landscape) was proposed in the 1960s when Leopold and

Marchand (1968) used the term to describe the broad-scale physical, biological and aesthetic nature of rivers. After it 'Riverine Productivity Model', 'Riverine Ecosystem Synthesis' concept and 'River Wave Concept' in the context of running water have evolved.

1.5.3 The Riverscape

Recognizing that rivers are complex mosaic of habitat types and environmental gradients, characterized by high connectivity and spatial complexity, riverine landscapes increasingly are viewed as 'Riverscape' (Fausch *et al*., 2002; Schlosser, 1991; Allen, 2004) a unit that amenable to study over a wide scale of range from braided river and its valley to smaller habitat patches (Palmer *et al*., 2000; Tockner *et al*., 2000). According to Sullivan *et al*. (2007) a riverscape is an interactive, open system, characterized by high level of human and natural disturbances and interconnected ecotones. In view of this, the riverscape approach aims to provide an integrated, holistic perspective of patterns and processes occurring within the *lotic* as well as in the surrounding landscape. The riverscape level planning and assessment are now considered pivotal for effective river management and river restoration programmes as it facilitates development of understanding and appreciation of the complex and dynamic interactions among running water, disturbance regimes, spatial heterogeneity and biodiversity.

1.5.4 The River – Ecological Integrity

'Ecological Integrity (EI)'refers to the ability of an ecosystem to support and maintain ecological processes and a diverse community of organisms (Karr *et al*., 1986; Jungwirth *et al*., 2000; Schallenberg *et al*., 2011). EI integrates a wide range of ecological values related to the structural and functional processes of ecosystem, making it particularly appealing for management applications. The concept of EI has been widely adopted by ecologists, policy makers, resource manager and the broader community. Over the years, various concepts *viz*., ecological integrity, biological integrity, and ecosystem health have evolved.

Water of sufficient quality and quantity is critical to all life. Degradation of water resources, particularly river ecosystems has been a long concern of human society (Karr, 1991). Thus, assessing the EI and ecological health of rivers and streams is fundamental and increasingly important water management issue worldwide (Bunn and Davies, 2000). The measurement of river health and its response to variety of environmental stressors, including land use, requires well-tested indicators of EI.

1.5.5 River Restoration

Human induced degradation of river ecosystems and loss of aquatic biodiversity are continuing and widespread. Most of India's rivers are in varying degrees of decline and distress. Human impacts, often involve changes in hydrologic activity and flow regimes. Deteriorating flow regimes and the discharge of organic and toxic effluents combine to affect a river's health adversely. Further, deterioration aggravates and occurs when 'river organs' – tributaries, riparian vegetation, floodplain, bed and biota are damaged and mutilated. Thus river restoration is at the forefront of applied hydrologic science (Wohl *et al*., 2005).

Ecological restoration has become an important aspect of river management (Petts and Kalow, 1996; Downs *et al*., 2002; Adams *et al*., 2005). The term 'Restoration' usually implies the act of restoring to a former/original state or position or to an unimpaired or perfect position. Thus, restoration has two implications: firstly, returning to an original state; and secondly, returning to a state that is perfect or healthy (Bradshaw, 1987a, b, c and 1996). Earlier, much work towards river management has primarily focused on habitats and species within the stream or a river. However, in the 1990s concern broadened to the restoration of ecosystems outside the river channel, i.e. catchments, riparian zones, river corridors and floodplains (Brookes, 1990). These ecosystems have a role in water harvesting and capturing of runoff, protecting river water quality, storing floodwater and flood protection, and providing habitats for wildlife, etc. Thus, river restoration has evolved overtime from one dimensional responses aimed at addressing a single issue (e.g., water quality) to sophisticated approaches that involve active restoration (physically changing the river or landscape) and passive restoration (policy measures to change human behavior) (Speed *et al.*, 2016).

The US National Research Council defines restoration as 'the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and functions of the ecosystems are recreated. The goal is to emulate a natural functioning and self-regulating system that is integrated with the ecological landscape in which it occurs' (NRC, 1992). According to Bradshaw (1996), restoration is distinguished from 'Rehabilitation' which describes measures that address only some elements of change within a degraded system, but still aims to return the ecosystem closer to its original condition. In contrast, the term 'Remediation' may refer to changing an ecosystem to an alternate condition which differs from both its current and original state, albeit with some improved values or functions (Fig. 1.1).

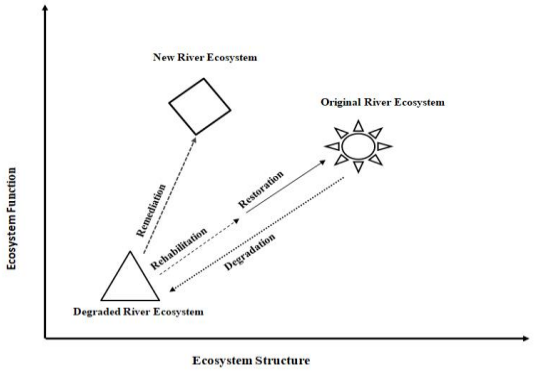


Fig. 1.1 - One Example of an Approach to Distinguishing between Restoration, Rehabilitation, and Remediation

(Source: Bradshaw, 1996)

The concepts of rehabilitation and remediation recognize that, in most instances, the extent of alterations caused by humans over a longtime, along with the impacts associated with ongoing human activities, make restoring ecosystem to their natural condition either unrealistic or undesirable (Bradshaw, 1996; Speed *et al*., 2016). Others have taken a broader approach to define ecological restoration. The Society of Ecological Restoration defined restoration as 'the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed' (SER, 2004). The Society of Wetland Scientist defined wetland restoration as 'actions taken in converted or degraded wetland that result in the re-establishment of ecological processes, function, and biotic/abiotic linkages and lead to a persistent, resilient system integrated within its landscape' (SWS, 2000). Over time, definitions for both 'Ecological Restoration' and 'River Restoration' have evolved and shifted from a somewhat idealized notion of returning ecosystems to a natural or pristine state, to a more pragmatic and utilitarian approach to viewing and managing river ecosystem. Wohl *et al.* (2005) defined river restoration as 'assisting the establishment of improved hydrologic, geomorphic and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system'. 'Ecological River Restoration' is specifically defined as 'assisting the recovery of ecological integrity in a degraded watershed system by re-establishing the processes necessary to support the natural ecosystem within a watershed (Speed *et al.,* 2016).

The Indian Charter for Rivers – 2014 or Delhi Declaration envisages rivers flows shall be *Aviral* (uninterrupted, continuous), and *Nirmal* (unpolluted). This over-riding principle shall govern all uses and interventions in rivers. Further, the ecological and hydrological integrity of the river systems shall not be compromised.

The broad array of activities labeled as river restoration has accelerated during the past three decades or so, particularly in the USA (Bernhardt *et al*., 2005 and 2007), Europe (Brookes, 1990;

Sear, 1994; McDonald *et al*., 2004; Clifford, 2007) and Australia (Brierley and Fryirs, 2005). Within the last decade, different types of process based restoration have increased in prominence, in concert with numerous calls from researchers to prioritize river function or process in restoration, rather than only river form (Kondolf, 1998; McDonald *et al*., 2004; Bernhardt and Palmer, 2007). This has included restoration that has emphasized promoting channel-floodplain connectivity (Tockner *et al*., 1999; Shields *et al*., 2011; Gumiero *et al*., 2013), longitudinal connectivity and partial restoration of water and sediment fluxes (Shafroth *et al*., 2010; Konrad *et al*., 2011), and ecological productivity (Lepori *et al*., 2005; Palmer *et al*., 2010a and b). The results of these restoration approaches are increasingly evaluated with respect to biotic response (Helfield *et al*., 2007; Walther and Whiles, 2008; Lorenz *et al*., 2009). Simultaneously, the scope of river restoration has expanded to encompass a broader range of river types, beyond the prototypical mid-order, pool-riffle meandering river. These span headwater streams in diverse settings, rivers altered by dams, large lowland rivers, and large drainage networks where restoration may involve broad, multidisciplinary efforts.

River restoration involves a wide range of stakeholders from the public and private sector including policy makers, practitioners, scientists and non-governmental organisations, as well as all citizen groups, potentially impacted. By actively drawing these various stakeholders into the process, visions can be shared and tuned towards each other. This makes for different interests to be met, and increases support for restoration efforts.

1.6 Rivers-Concern for Conservation

The complex, dynamic and inter-related nature of river and human systems demands that isolationist approaches and temporary measures are unlikely to respond to the challenges of basin–scale river management and restoration. Rivers have been dramatically reshaped to accommodate extensive and intensive agriculture, industrial uses as well as high density habitations. Historical degradation of river ecosystems was accelerated periodically by surges of economic and technologic power. Dendritic stream-river networks are the backbone of the most landscapes and determine the linkage between terrestrial and aquatic ecosystems. In most instances catchment has been severely impacted by human activities. Effective river management requires a greater understanding of interactions between landscape conditions over large spatial extents and in stream responses.

Geo-engineering of rivers by way of creation of sequential physical barriers like reservoirs and barrages for hydropower generation and irrigation has not only altered the river flow but also channelization of rivers for transport also separated channels from their floodplains. In several instances, water has been diverted to other river system by linking rivers. Alteration of river flow and influence on aquatic fauna, particularly migratory fishes upstream are prominent concerns for river ecological integrity.

Considering the past use of rivers by mankind over a long period, it can be stated that the present attitude towards river is utilitarian as humans think of a river as something to exploit and use for economic gain rather than for intrinsic ecological values, protection, and conservation. Water is the main variable in the context of the rivers as water runs the river and thus, flow regimes are of paramount importance in maintaining the structure, functions, and processes of riverine ecosystems. The flow determines the essentially required dynamics of the four dimensional connectivity of the river as described earlier. Land use changes and various pollutants from different sources have imperiled rivers. Thus, connectivity and pollution issues remain two important concerns related to the degradation of river ecosystems.

The scale and complexity of river conservation and restoration is challenging the present capacity of scientists and field practitioners about their understanding of rivers to identify when and what actions are necessary to best address declining river health. At the same time, scientists and practitioners are being required to demonstrate, with the high degree of certainty, the benefits that can be expected from the significant investments of public funds. Despite the significant advancement of restoration science, challenges remain to ensure how river ecosystem function improves. Certainly, inadequacies in the present scientific information base, understating and support in the context of Indian rivers and their restoration are major concerns.

In most instances, the river basin spreads over two or multiple States and often resulting into interstate disputes for water sharing. With increasing water crisis arising due to maximum water utilization by the States in the upstream area, interstate disputes are on rise. Likewise, the Himalayan Rivers originating or traversing from India or in the case of trans boundary rivers, there is a growing concern arising due to international disputes among the countries sharing water resources of a river.

In highly developed basins, with competing users, river restoration is now much needed to achieve many and sometimes conflicting goals (Palmer *et al*., 2014). Corresponding objectives i.e., improved water quality, improved urban development support or recreational activities, flood protection, biodiversity promotion, advanced navigation and competing needs require balancing river ecosystem services and individual needs, and may require trading in the planning process (Speed *et al*., 2016).

The river ecosystem operates at multiple hierarchical scales. Often, restoration projects have failed as a result of addressing issues at the wrong spatial scale. If the drivers of the river degradation are at the basin scale, responses need to be designed accordingly, and local restoration projects are unlikely to be successful. Operating at larger scale requires engaging with a wide-array of stakeholders and essentially seeks inter-agency cooperation. The implementation of holistic approaches at the river basins or a riverscape level involving multiple agencies and varied stakeholders is generally a protracted and cumbersome process.

The various earlier river restoration initiatives had a goal of returning rivers to a 'pre-development' or 'natural' state. Definitely, in most situations, returning to natural state is not feasible. Moreover, it is a tall order of ambitious nature as rivers have been altered by human development over centuries. Thus, water resource managers need to change their aims and the way they approach the restoration works, particularly in setting restoration targets. Restoration projects are not only required to consider just the historical conditions and past trends, but in order to succeed, it is also essential to plan for potential stresses and risks in future, so as to ensure resilient rivers after restoration to such stresses and risks. Moreover, there is uncertainty owing to changes in climate, land use, population growth and urban development. Restoration also needs to accommodate the likely implications due to shift in human values and belief systems.

Restoration projects are not just single time efforts as seldom restoration projects are maintenance free. Thus, funds may be required for ongoing maintenance cost over a longer time frame. From the perspective of sustainability, it is also essential that future activities within the basin do not undermine the restoration gains. Sustainability also requires that a river ecosystem has the adaptive capacity to maintain its restored condition and it is self-sustaining by maintaining a dynamic equilibrium (Speed *et al*., 2016).

1.6.1 Indian River Systems

Rivers of India play an important role in the lives of Indian people. Rivers also form the basis for domestic and industrial water supply, generation of hydro-electricity, inland fishing and are responsible for deposition of fertile soil in the plains as well as formation of deltas. Some river basins are also responsible for trapping of oil and natural gas which also contribute to the list of usefulness of these rivers. Most of the rivers in India either flow into the Arabian Sea or the Bay of Bengal, which is determined by the watershed and the physical features of the country (Balasubramanian, 2007).

India is privileged to have four large river systems *viz.*, Indus, Ganga, Brahmaputra and Godavari (FAO - AQUASTAT, 2011; Balasubramanian, 2007). The rivers of India have been broadly categorized into the following four groups:

The Himalayan Rivers: Himalayan Rivers are fed by melt of snow and glaciers and flow throughout the year. During the monsoon season, these rivers assume alarming proportions as they carry enormous sediment and cause frequent floods. The Indus, Ganga and Brahmaputra along with their tributaries form the most important River systems.

The Deccan or Peninsular Rivers: The prominent rivers originating from varied mountain ranges namely, Satpura and Vindhyas in the Deccan or peninsular region of the country are

rainfed and fluctuate in volume. Several of them are non-perennial. Important rivers *viz.*, Mahanadi, Godavari, Krishna, Pennar and Cauvery drain into the Bay of Bengal in the east while westerly flowing Narmada and Tapti Rivers flow into the Arabian Sea.

The Coastal Rivers: Short rivers arising either from the Western Ghats or the Eastern Ghats with limited catchment area, especially on the west coast, south of Tapi and non-perennial are included in this category. Prominent rivers in this category are in parts of Gujarat, Goa, Maharashtra, Karnataka, Kerala, Tamilnadu, Andhra Pradesh, Odisha and West Bengal. Important rivers are: (a) Machhu, Bhadar, Hiran , Shingoda, Machhundri and Raval in Gujarat; (b) Vashishti, Savitri, Ulhas, Mithi, Tansa, Dahisar and Vaitarna in Maharashtra; (c) Terekhol, Mandovi, Baga, Zuari, Colval, Saleri, Mandre, Harmal, Sal, Talpona and Galjibag in Goa; (d) Netravati, Sharavathi, Aghanashini and Palar in Karnataka; (e) 44 rivers in Kerala including Chalakkudy, Neiyyar, Pampa and Periyar; (f) Thamirabarani, Vaigai, Vellar, etc. in Tamilnadu; (g) Vamsadhara, Nagavali and Sharada in Andhra Pradesh; and (h) Subernarekha, Budha Balanga, Baitarani and Brahamani in Odisha.

Inland Drainage Basin Rivers: A few small rivers originate from Aravalli hills do not drain into sea instead they drain into salt lakes and get lost in sandy desert or the Rann of Kutch. These are Luni, Sarasvati and Banas Rivers.

(A) River Basins

India is a land of several rivers and numerous mountain ranges (Himalayas, Satpura, Vindhyas, Aravallis, Western Ghats, etc). India's geographical area of about 329 million hectares (M ha) is criss-crossed by large number of rivers. Ganga, one of the Indian rivers are figuring amongst the most notable rivers of the world. The rivers and mountains have a greater significance in the history of Indian culture, economy, development, religious and spiritual life (Balasubramanian, 2013). Rivers, with their tributaries, are the main channels of drainage of the land surface and at the same time are also the chief agents of land erosion, and the main lines for transport of waste products of the land to the sea. Drainage basin is the area drained by the main river including all its tributaries.

On the basis of the area drained, the river basins of India have been classified into three categories: (i) river basins with catchment area of >20,000 km^2 as large river basins; (ii) river basins having a catchment area between 2,000 km^2 to 20,000 km^2 as medium river basins; and (iii) the rivers having a catchment area <2,000 km^2 as minor river basins (Rao, 1979). The major river basins of India in descending order of area are: the Ganga, Indus, Godavari, Krishna, Brahmaputra, Luni, Mahanadi, Narmada, Cauveri, Tapi, Pennar, Brahmani, Mahi, Sabarmati, Barak and Subarnarekha (Fig. 1.2). India is endowed with many rivers and twelve of them are classified as major rivers whose total catchment area is 252.8 million hectares (M ha). Of the

major rivers, the Ganga - Brahmaputra Meghana system is the biggest with catchment area of about 110 M ha which is more than 43 percent of the catchment area of all the major rivers in the country (Fig. 1.3) The other major rivers with catchment area more than 10 M ha are the Indus (32.1 Mha.), Godavari (31.3 Mha.), Krishna, (25.9 M ha.) and Mahanadi (14.2 M ha). The catchment area of medium rivers is about 25 M ha and Subernarekha river has catchment of just 1.9 Mha. (Kumar *et al.,* 2005). Accordingly, the Indian geographic extent has been divided into 113 river basins including 14 large, 44 medium and 55 minor basins. Concerned government agencies *viz.*, Central Water Commission (CWC), Central Ground Water Board (CGWB), Government of India Web Portal, and River India - Water Resources Information System (India-WRIS) by CWC and National Remote Sensing Centre (NRSC) have described varied number of basins due the fact that various agencies have either bifurcated larger basins into smaller one or clubbed smaller ones as single entity (Chatterjee and Sinha, 2014).

For a properly integrated management of the basin's waters and their quality, the setting up of comprehensive river basin organizations has been recommended (Chitale, 1994). The Indus, Ganga and Brahmaputra (IGB) River basins support the lives and livelihoods of some 700 million people to the south of the Hindu Kush Himalayan Ranges (Eriksson *et al*., 2009). The water resources in these basins have been widely utilized for drinking, irrigation, navigation, industry and hydropower, and provide the basis for local livelihoods (Mirza *et al*., 2003). 1,44,900 ha of land is irrigated in the Indus Basin; 1,56,300 ha in the Ganga Basin and 6,000 ha in the Brahmaputra Basin (Immerzeel *et al.,* 2010).

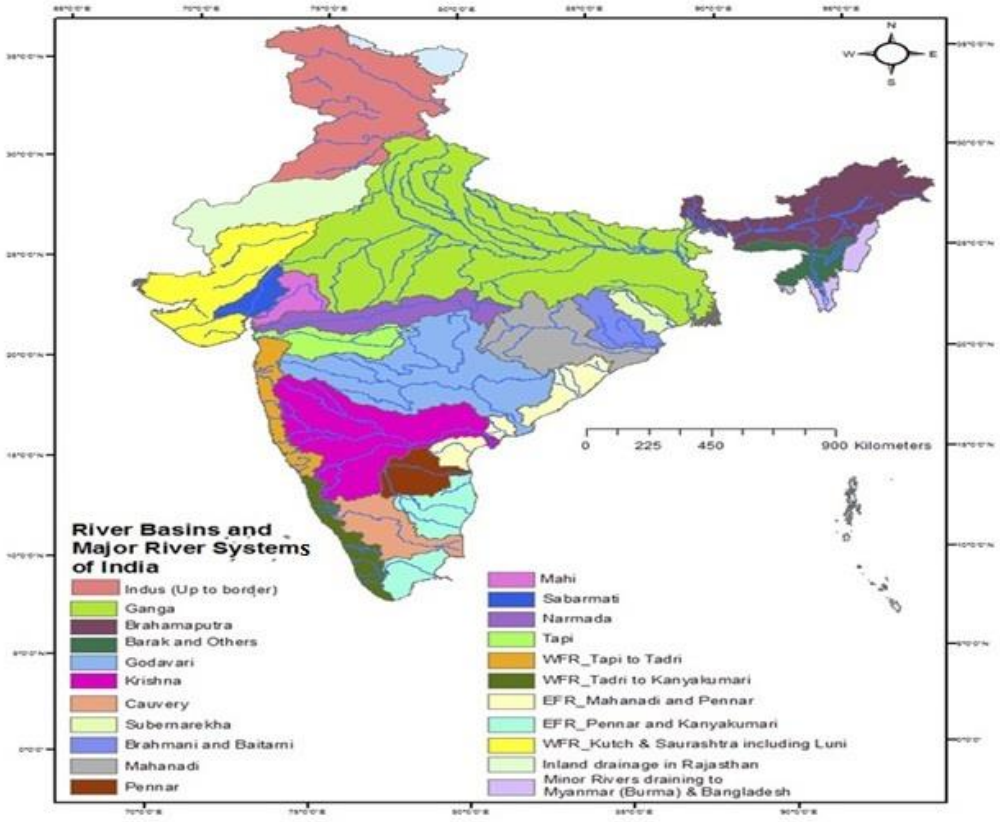


Fig. 1.2- River Basin and Major River Systems of India
(Source: CWC, 2019)

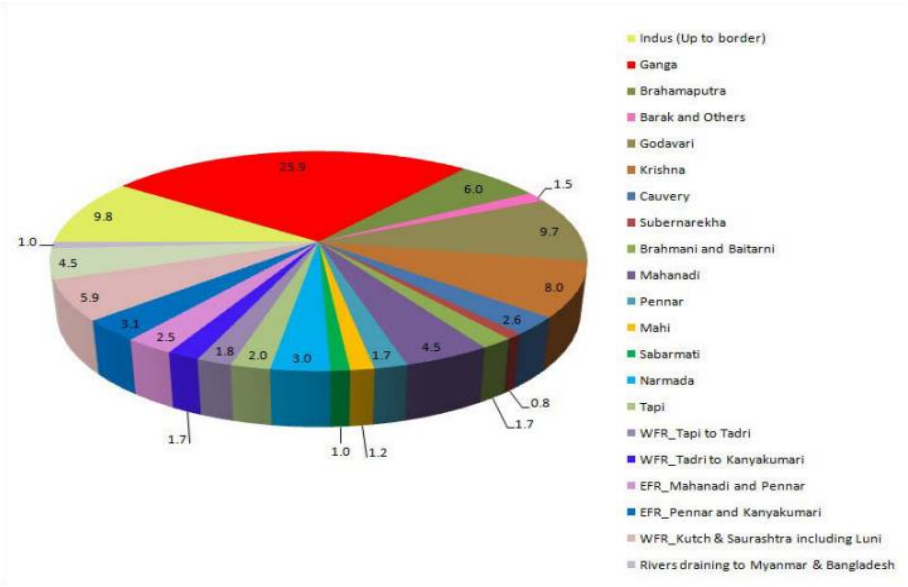


Fig. 1.3- Percentage of Geographical Area in Each Basin

(Source: CWC, 2019)

(B) Hindu Kush Himalaya – A Global Asset and a Major Source of Freshwater Supply

The Hindu Kush Himalayan region extends between latitudes 15.95° - 39.31° N and a longitudes of 60.85° - 105.04° E, covering an area of about 4.2 million km^2 and extends to all or part of eight countries in Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan (Bajracharya and Shrestha, 2011). There is heavy snowfall and glaciers in the mountains of the region. Melting ice water and glaciers feed the ten largest river systems in Asia viz., Amu Darya, Indus, Ganga, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze, Yellow and Tarim (Immerzeel *et al*., 2010; Kaser *et al*., 2010) (Table 1.1). Ten major river basins of Hindu Kush Himalaya are described in Fig. 1.4.

Table 1.1 – Area and Population of the Major River Basins Originating in the HKH

River Basin	Area (km^2)	Population in 2010 (million)	Population in 2015 (million)
Amu Darya	6,45,870	27.1	30.18
Brahmaputra	5,28,083	64.63	68.07
Ganges	10,01,090	539.43	580.09
Indus	11,16,350	244.31	268.42
Irrawaddy	4,26,393	40.18	42.87
Mekong	8,41,337	74.58	77.31
Salween	3,63,898	18.19	17.88
Tarim	9,29,254	10.65	11.37
Yangtze	20,66,050	600.92	604.94
Yellow River	10,73,440	192.86	198.02
Total	**89,91,765**	**1,812.95**	**1,899.14**

(Source: CWC, 2019)

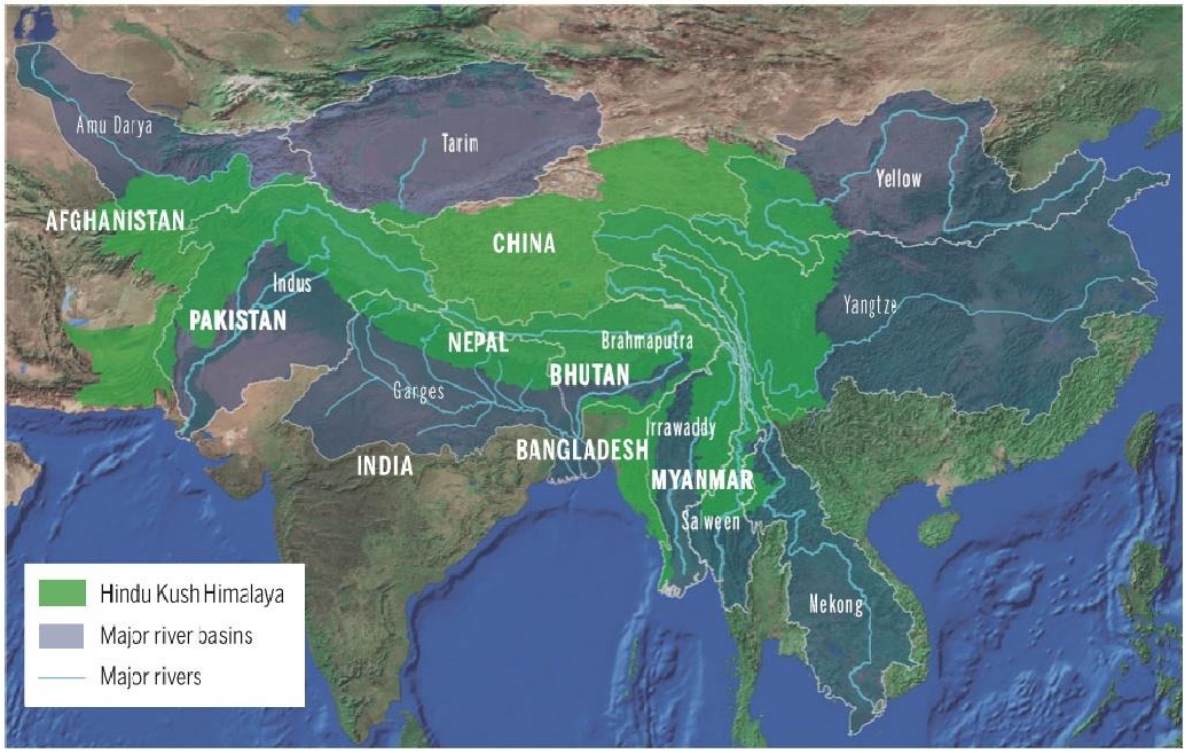


Fig. 1.4 – 10 Major River Basins of Hindu Kush Himalaya

(Source: Sharma *et al*., 2019)

The Hindu Kush Himalayan Region (HKHR) is known as South Asia freshwater tower (Fig. 1.4). It has a great extent of snow and glaciers outside the polar region, so it is called Third Pole (Dyhrenfurth, 1955). Melting of snow and glacier play a vital role in bringing water to the river basin of dry riverbed, especially where there are large irrigation systems which are dependent on surface water sources. Mountains are very sensitive to climate change and the HKH region is no exception. Changes in ice caps can have a profound effect on the amount and timing of water availability (Rabatel *et al*., 2013). A complete understanding of the extent and nature of glaciers change will support water flow planning and water resource management (Rankl *et al*., 2014).

There are significant variations in snow response to the region due to the different terrain, climate and weather conditions. There is a transition from cold to dry and wetter (monsoon dominated) to warmer climates from west to east and north to south. Comprehensively, in this region due to climate change, glaciers are shrinking or retreating (Kaser *et al*., 2006; Zemp *et al*., 2009; Fujita and Nuimura, 2011; Kargel *et al*., 2011; Scherler *et al*., 2011). Some studies reported different behaviour of glaciers in the Karakoram (Hewitt, 2005 & 2011; Scherler *et al*., 2011) which may be explained by a positive trend in winter precipitation and limited

warming during the melt season (Archer and Fowler, 2004; Tahir *et al*., 2011). Climate change also give rise to the enlargement and formation of glacial lakes, which in turn can lead to an increase in Glacial lake outburst and flooding (GLOF). Many such floods have already been reported in the region (Richardson and Reynolds, 2000; Bajracharya *et al*., 2007; Bajracharya and Mool, 2010).

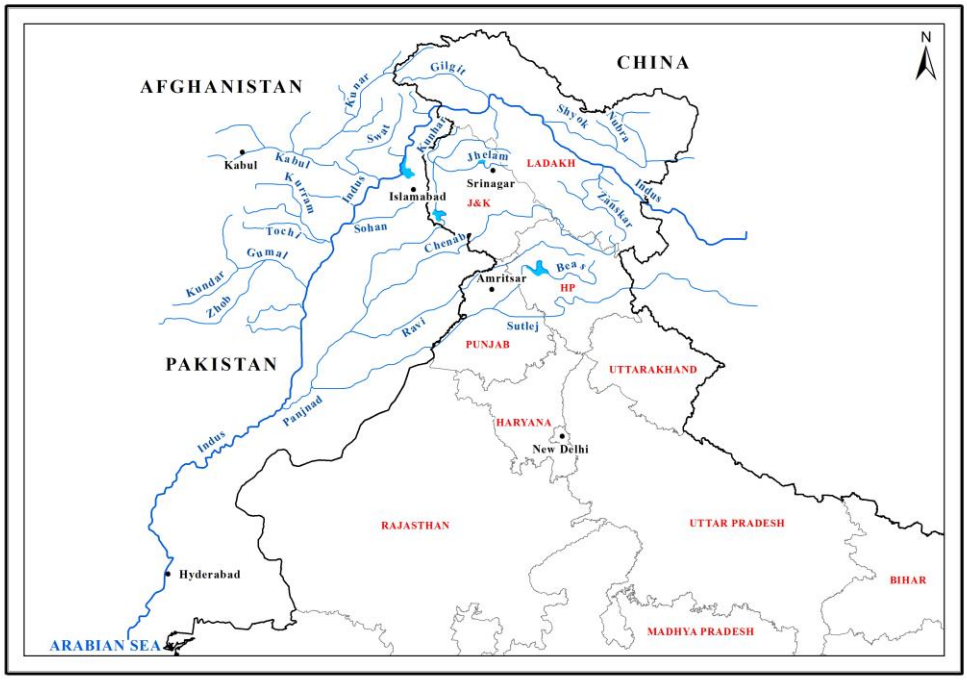


Fig. 1.5 – Indus River and Its Tributaries
(Source: wikipedia.org)

Despite the importance of the HKH region, there is a lack of consistent and homogeneous glacier data. Most studies focus on small areas and present a regional overview. Several interlinked global glacier inventory initiatives exist, such as the World Glacier Monitoring Service (Haeberli *et al*., 1989), Global Land and Ice Measurements from Space (GLIMS) (Raup *et al*., 2007), the Glob Glacier Project (Paul *et al*., 2010) and the Randolph Glacier Inventory (Pfeffer *et al*., 2014). However, none of these initiatives has resulted in a consistent and complete glacier inventory for the HKH region. Such a regional glacier database, based on a standardized method, is therefore urgently needed as a benchmark against which changes can be assessed. Recently, an inventory of glaciers, including debris-covered (DC) glaciers, has been developed for the entire HKH region using remote-sensing data (Bajracharya and Shrestha, 2011; Bolch *et al*., 2012). Amongst the 10 major river basins in the HKH region, the Indus River is one of the longest rivers in Asia and its basin is shared by China (Tibet), India, Pakistan and Afghanistan. It constitutes the second largest drainage with 11,16,350 km^2 area. Certainly, the Indus River and

its tributaries have immense significance for the two human dominated nations i.e., India and Pakistan. River Basis and Major River Systems of India are given in Fig.1.2.

(C) The Indus River System

The trans-boundary Indus River Basin with the approximate area of 1.12 million km^2 is located in four countries, of which the largest part is distributed in Pakistan (47%), and substantial upstream parts in India (39%), China (8%) and Afghanistan (6%) (FAO – AQUASTAT, 2011). In India, the basin spreads over the Ladakh and Jammu and Kashmir Union Territories (J&K UT), Himachal Pradesh, Punjab, Rajasthan, Haryana and Chandigarh Union Territory. Ladakh and J&K UTs share the highest extent of basin area, being 1,93,762 km^2 (60%), followed by Himachal Pradesh (51,356 km^2 or 16%) and Punjab (50,304 km^2 or 15.96%). Rajasthan and Haryana States contribute 5% and 3% extent of the basin, respectively. Chandigarh UT has a minuscule extent of 114 km^2 or just 0.04% of the total basin area (India-WRIS, 2012). Out of the total irrigated area (228 694 km^2, 21 % of basin area) about 60.9 % is located in Pakistan, 37.2 % in India, 1.9 % in Afghanistan and 0 % in China. The Indus Basin Irrigation System (IBIS) is the largest irrigation system in the world. Water demands are thus by far the highest in Pakistan followed by India (Laghari *et al*., 2012). The Indus catchment area is unique in the sense that it contains seven of the world's highest peaks after Mt. Everest including K2 (8,600 m), Nanga Parbat (8,100 m) and Rakaposhi (7,800 m) and the world's highest motorable passes *viz.*, Umling La (19,300 ft) and Khardung La (17,580 ft). Nearly 55% area of the Indus River basin within India lies above 3,000 m elevation (India-WRIS, 2012). The land use and land cover mapping undertaken in the Indian part of Indus River Basin by India-WRIS revealed that agriculture land accounts to 35.8% of the total area, diverse forests covered 15.09% area while snow and glaciers covered 12.46% area. Wastelands occupied as high as 28.53% area of the basin within India. Grasslands and water bodies represented 4.19% and 1.85% area, respectively while built up land covered just 2.09% area.

In India, 5 rivers namely Sutlej, Ravi, Beas, Chenab and Jhelum are the major tributaries of Indus River (Fig 1.5). In conjunction with the rivers Chenab, Jhelum, Sutlej, Ravi, Beas and two tributaries from the Afghanistan and Khyber Pakhtunkhwa, the Indus creates the Sapta Sindhu (Seven Rivers) delta of Pakistan. It is also a lifeline for millions of Indians who live along its course and depend on it for their daily needs.

Physiography of Indus Basin

The geographical extent of the basin is between latitude N 29°08' to 36°59' and longitude E 72°28' to 79°39' with a maximum length and width of 756 km and 560 km, respectively. The basin is bounded by the Himalayas on the east, by the Karakoram and Haramosh Ranges on the north, by Sulaiman and Kirther Ranges on the west, and by the Arabian Sea on the south (India-WRIS, 2012). The Indus Basin is characterized by diversified relief features. It has all the

majestic high mountain ranges of the sub-continent, surprising valleys, deep gorges, rugged plateaus and the alluvial plains. The Indus basin is divided into two physiographic divisions i.e. Upper Basin (Mountainous Belt) and Lower Basin (Alluvial Plain). Upper basin is mainly dominated with rugged and high mountains including the cold desert regions of Tibet and Ladakh while the Lower basin is dominated by the alluvial plains of Punjab and Sindh (Pakistan).

Climatic condition of the basin plays significant role in the water runoff in the basin. The lower basin is a single climatic division with arid to semi-arid climatic conditions and receives maximum rainfall from summer monsoon. These monsoon rains increase the flow of Indus basin from the summer until autumn. While the upper basin covers the mountainous belt that mainly lies under snow and glaciers. These glaciers and snow cover peaks of the upper basin and plays a significant role in water discharge of the Indus Basin.

Origin

The Indus also known as the Sindhu, originates from a glacier near *Bokhar Chu* latitude N 31°15' and longitude E 81°40' in the Tibetan region at an altitude of 4,164 m in the Kailash Mountain range. In Tibet, it is known as *'Singi Khamban' or Lion's mouth*. After flowing in the northwest direction between the Ladakh and Zaskar Ranges, it passes through Ladakh and Baltistan. It cuts across the Ladakh Range forming a spectacular gorge near Gilgit in Jammu and Kashmir, Union Territory (UT). It enters into Pakistan near Chillar in the Dardistan region. The Indus originates in the northern slopes of the Kailash Range in Tibet near Lake Manasarovar. It follows a north-westerly course through Tibet. It enters Indian Territory in Jammu and Kashmir, UT. It forms a picturesque gorge in this part. Several tributaries - the Zaskar, the Shyok, the Nubra and the Hunza join it in the Kashmir region. It flows through the regions of Ladakh, Baltistan and Gilgit and runs between the Ladakh Range and the Zaskar Range. It crosses the Himalayas through a 5,181 m amsl deep gorge near Attock, lying north of the Nanga Parbat and later takes a bend to the south west direction before entering Pakistan. It is the only river that can claim to have the unique distinction of being identified with a five thousand years old civilization, culture and traditions, of the people. The people living across it were called Sindhu-Putras or Hindus since the Greek pronounced it Sinthus and Latin Sindus, Pliny writes Indus in Sindhus appellatus. The Indus River is the twelfth largest river in the world and its total length is 2,880 km out of which only 1,114 km flows through India (Ojeth, 2006).

The Indus River in Pakistan receives five important tributaries on its left bank from India. The Jhelum River originates from Varinak in the Kashmir Valley, Jammu and Kashmir Union Territory of India, and flows westerly and enter into Pakistan. Chenab, Ravi and Beas Rivers originate in Himachal Pradesh. Chenab River originates from Chandertal in Lahaul-Spiti of

Himachal Pradesh. (FAO- AQUASTAT, 2011b). The Chenab River first flows northwesterly through J&K, UT and later in the Punjab province of Pakistan. The Jhelum River ends in a confluence with the Chenab River at Trimmu in District Jhang of Pakistan. Ravi River after its origin in Kangra District, Himachal Pradesh flows through the plains of Punjab, India and finally enter into Pakistan. The Beas River originates in Kullu Himachal Pradesh, flows southwesterly before its confluence with Sutlej River at Hari-Ke-Patan, Punjab, India. The Sutlej River originates in western Tibet, China in Mt. Kailash range and adjacent to the origin points of rivers Indus, Ganga and Bharmaputra. It enter in India from the estern part of Himachal Pradesh state at Shikpi La at the Indo-China border and flows westerly through the hilly state of Himachal Pradesh before entering into the plain of Punjab state, India. Finally, the Sutlej River out flows into the plains of Punjab Province of Pakistan till its confluence with joint waters of Trimab, Jhelum, Chenab and Ravi. The meeting point of the combined Sutlej, Beas, Ravi, Chenab and Jhelum is called 'Panjnad'. Below about 70 km to Panjnad, the combined waters of fiver rives join the Indus River at Mithankot in west Punjab Pakistan. The Panjnad is flow resulting from the five main rivers (literally Punjab means 'five waters'). The Jhelum and Chenab rivers known as the western rivers, and the Ravi, Beas and Sutlej, known as the eastern rivers join the Indus River.

In Indian context, many tributaries of Indus River has been the source of physical and spiritual sustenance of Indian civilization for millennia. Thus, Indus River has significant geographical, ecological, environmental, religious, cultural, spiritual and economic significance in India with these values transcending the boundaries of the basin. The Indus is one of the handfuls of rivers in the world that display a tidal bore.

The Indus Water Treaty

Post-independence of India and Pakistan in 1947, the two independent political entities India and Pakistan, the sharing of Indus waters resulted in a dispute and became an International issue. About 8 years of discussion and negotiations between the Governments of India and Pakistan, carried out under the auspices of the World Bank, resulted in 'Indus Waters Treaty (IWT), 1960'. Under this treaty, the waters of the three eastern rivers (the Ravi, the Beas and the Sutlej) would be for the exclusive use of India and waters of the three western rivers (the Indus, the Jhelum and the Chenab) for the exclusive use of Pakistan. Under the IWT (1960), the following rules apply:

Western Rivers

Chenab and Jhelum Rivers were recognized as the western rivers. Pakistan shall receive all those waters of the western rivers for which India is under obligation to let flow, except for restricted uses, related to domestic use, non-consumptive use, agricultural use and generation of hydro-

electric power of which the amount are set out in the Treaty. Total inflow from China to India in the Indus River Basin is 181.62 km^3 it is estimated that flow generated within India is 50.86 km^3, resulting in a flow from India to Pakistan of 232.48 km^3, of which 170.27 km^3 is reserved for Pakistan and 62.21 km^3 are available for India (FAO – AQUASTAT, 2011).

Eastern Rivers

The Ravi, Beas and Sutlej Rivers are the eastern rivers and all their water from India will be available for unrestricted use by India. Pakistan will be under obligation to allow flow, and not allow any influence, by the water (while flowing in Pakistan) of any streams on its natural side that joins the Sutlej Main or Ravi Main before these rivers eventually flow into Pakistan. The average annual flow in India before crossing the border is estimated at 11.1 km^3. All the water, while flowing into Pakistan of any rivers where in its natural course joins the Sutlej main or Ravi main after these rivers cross into Pakistan will be obtained through the unrestricted use by Pakistan (FAO, 2011).

Groundwater Resources and Water Quality

The Himalaya is famous for their fresh water body, high mountains, spring meadows and mountain forests. However, the most interesting character given by nature is its freshwater bodies that are not only important to the environmental, social and economic and cultural significance of the region, but also serve as a major source of local economic growth as there are many Hydro-Power projects in these water bodies. Most of these water bodies are key tourist attractions. The monitoring of water quality in the Indus River and its many tributaries is carried out by the State Pollution Control Boards of Himachal Pradesh, Punjab, Haryana and Rajasthan, the Central Water Commission, the Central Water Supply Board and the Central Pollution Control Board. The observation of water quality is divided into two categories, surface water quality and groundwater quality. Surface water is measured by CWC and CPCB and groundwater quality is measured by CGWB, CPCB and other Government Departments.

Water quality of the Indus River and its tributaries is excellent. Water quality deteriorates downstream but remains well within permissible limits (FAO-AQUASTAT, 2011). The Central Pollution Control Board observes quality parameters at various locations and the water quality parameters observed in rivers of Indus Basin are Beas, Sutlej, Ravi, Sirsa, Swan, Largi, Parvati, Tawi, Chuntaol, Jhelum, Chenab, Gawkadal, Baspa, Binwa, Neugal, Siuel, Spiti and Suketi Khad. The river water quality in the Himalayan Segment and the Diluted Segment is comparatively good. However, due to heavy abstraction and discharge of pollutants into the river system, the lower segments are highly polluted.

The Indus River Basin represents a large area of artesian covering a large command area of 16.2 million ha. Generally, the water quality according to the Total Dissolve Solids (TDS) of the

Indus River and its streams is between 60 ppm and 374 ppm, which is very safe for most uses (FAO-AQUASTAT, 2011). TDS at a maximum ranges between 60 ppm during high flow and about 200 ppm during low flow. The water quality declines below the river, but remains well within the permitted limits. The Indus River Basin has its roots in irrigated agriculture since the time of the ancient Indus Civilization and since then water-related development in the trenches, especially during the last century or so has greatly increased. A large number of dams, bridges, hydro-electric projects and road networks are already in place. The total irrigation area along the Indus River is estimated at 26.3 million hectares, with Pakistan weighing about 19.08 million ha. or 72.7 %, India at 6.71 million ha or 25.6 %, Afghanistan at 0.44 million ha or 1.7 % and China at 0.03 million ha or 0.1%. The most irrigated area is estimated at 24.5 million hectares. The resource area irrigated by surface water accounts for 53% while groundwater makes up 47% (FAO-AQUASTAT, 2011).

Natural Diversity

The Indus River Basin has been bestowed with enormous diversity of mountain ranges, snowcapped peaks, large extent of glaciers, diverse forests, grasslands/alpine pastures, high altitude wetlands, and a network of streams and rivers besides archeological sites of old civilizations and rich and diverse cultural heritage. Thus, the entire basin area is exceptionally rich and diverse naturally, biologically, ecologically and socio-culturally. The higher reaches are home to threatened flagship species i.e., the Snow Leopard (*Panthera uncia*), its co-predator (Himalayan Wolf - *Canis himalayensis*), and prey species (*Ibex* - *Capra ibex*, Bharal - *Pseudois nayaur*, Himalayan Tahr - *Hemitragus jemlahicus*, Himalayan Marmot - *Marmota himalayana*, Himalayan Pika - *Ochotona himalayana*). In some parts of the Indus River Basin, particularly in the middle and lower reaches there is high abundance of Common Leopard (*Panthera pardus*). Other associated species are: Himalayan Brown Bear - *Ursus arctos isabellinus*, Asian Black Bear – *Ursus tibetanus*, Markhor – *Capra falconeri*, Himalayan Musk Deer – *Moschus leucogaster* and Himalayan Goral - *Naemorhedus goral*.

The Basin of Indus River harbours enormous diversity of birds including spectacular pheasants, reptiles and amphibians while the river and its tributaries have a high diversity of freshwater fishes besides endangered aquatic mammals *viz.,* the Indus River Dolphin - *Platanista indicus minor* and two other species: the Eurasian Otter – *Lutra lutra* and the Smooth Coated Otter – *Lutrogale perspicillata*.

The Indus River Basin and its tributaries are the most important supplier of freshwater resources for densely populated regions in India and Pakistan, and it forms the backbone of agriculture and food production and make significant contribution towards hydropower generation and industrial development. Especially, the river is critical since rainfall is meager in the cold desert and lower Indus Valley regions. The Indus River Basin sustains a substantial human population of about 268 million (Sharma *et al.,* 2019). The Indus River Basin is one of the regions in the world that is

faced with major challenges for its water sector, due to population growth, rapid urbanization and industrialization, environmental degradation, unregulated utilization of the resources, inefficient water use and poverty, all aggravated by climate change (Laghari *et. al.*, 2012).

1.6.2 The Ravi River – Its Uniqueness or Statement of Significance

The Ravi River originates in the Lesser Himalayas in India. The river is 880 km long with a catchment area of 24, 960 km^2. It runs almost along the India-Pakistan border. The Ravi River has five major tributaries *viz.*,Ujh, Bein, Basantar, Deg and Hudiara, the upper catchments of which lie in India. The largest tributary is *Deg Nallah* river, which is 256 km long with a catchment area of 730 km^2 (FAO-AQUASTAT, 2011; NDMA-UNDP, 2010). But according to Moza (2014) and Iqbal *et al.* (2018), total length of the Ravi River, both in India and Pakistan, is about 720 km, out of which 320 km is in India of which 158 lies in Himachal Pradesh and 162 km within Punjab. According to GIS data, length of Ravi River is 340.69 km is in India, of which 167.67 km lies within Himachal Pradesh, 63.38 km in Jammu & Kashmir, UT and 109.64 km within Punjab. In India, flowing westward, it is hemmed by the Pir-Panjal and Dhauladhar Ranges, forming a triangular zone (Moza, 2014). The Ravi River is smallest river of all other Trans boundary rivers of India and Pakistan. In India, it is known as the River of Lahore. The Ravi River originates in the Bara Bhangal area in the Multhan tehsil of Kangra district of Himachal Pradesh. The Bara Bhangal comprises of snow covered peaks at heights ranging from 3,000 m to about 6,000 m elevation. Ravi is formed by the confluence of *Bhadal Nallah* originating from Bhadal glacier, *Rai Nallah* originating from Rai Ghar glacier and *Tantgari Nallah* originating from Tantgari and Karu glaciers. The waters of Ravi are allocated to India under Indus Water Treaty, 1960. Flowing in north-westerly direction from its source, it drains between the Pir-Panjal and Dhauladhar Ranges through narrow valleys and enter the Chamba district of Himachal Pradesh. After passing through the Chamba district, it leaves the Himalayas at Basohli and traverse close to Kathua. It makes a sudden westerly bend and enters the Punjab plains near Madhopur. Some distance below Madhopur, it demarks boundary between the two Punjabs (West in Pakistan and East in India). It joins the Chenab River at Trimb (Pakistan). The Ravi River has 34293 streams of different orders are found in this basin in Himachal Pradesh (HPSFD, 2014). Besides mythological, religious and cultural significance, the Ravi River has immense value from the geomorphological, ecological, environmental and economic perspective. The statement of significance of Ravi River Basin based on diverse conservation values is presented below in the Box 1.1

Ecological Significance

The Ravi River is one of the five major tributaries of the Indus River in the Indian Territory. It is an integral part of the Indus River Basin and forms the headwaters of the Indus basin. The

Catchment area of the Ravi River Basin in Himachal Pradesh is about 5,450 km^2 and is elongated leaf shaped. A good part of the Ravi catchment i.e. about 890 km^2 lies above the snow line i.e. 4,000 m, which receives moderate to heavy snowfall during winter (HPSFD, 2014). The river has its origin in Bara Bhangal in Kangra district which comprises of snow covered peaks ranging from 3,100 m to 5,800 m. Bhadal and Tantgiri are the two major glaciers in Bara Bhangal which make the river perennial. The river's catchment on the left is enclosed by Dhauladhar, the high peaks of which separate it from the Beas. These peaks remain snow covered for about eight months in a year. The catchment of the river on the left is comparatively narrow which makes the slope steep. On the right side of the river, catchment is wide and separated by high hills of the Pangi Valley from the catchment of the Chenab. The Ravi River Basin lying within Indian Territory is generally rocky and passes through gradient of Himalayan Ranges. After crossing the Shivaliks in Chamba district of Himachal Pradesh, the river enters Punjab at Madhopur and then enters Pakistan. The river catchment is bounded by the Dhauladhar on the left and by Pir-Panjal Ranges on the right. The entire catchment comprises of mountainous terrain with steep hill slopes and is very thinly populated. Some area in the upper catchment of the basin remains frozen throughout the year. The main river as well as the tributaries are fed from snow/glaciers which makes these rivers perennial. The average rainfall in the basin varies from 600 mm to 1,600 mm. Intensity of the rainfall is maximum in the region between the confluence of Siul and Thein dam. While the upper reaches of Ravi River have low intensity of rainfall, the water availability due to snow/glacier contribution is generally even. Due to high altitude and cold climate, there is hardly any vegetation in the upper reaches of the basin. The area is not inhabited and the cultivation appears to be only on limited scale. Vegetation is mainly tropical, sub-tropical, temperate, sub-alpine and alpine types with a thick cover of reserve forests. The important species are Oak (*Quercus* spp.), Chestnut (*Aesculus indica*), Deodar (*Cedrus deodara*), Kail (*Pinus wallichiana*), Juniper (*Juniperus spp*.), The Himalayan Yew *(Taxus wallichiana*) and Birch (*Betula utilis*).The habitat areas of musk deer (*Moschus* spp.), Snow Leopard *(Panthera uncia*), Himalayan tahr (*Hemitragus jemlahicus*), Ibex (*Capra ibex*) and Serow (*Capricornis* spp.) are restricted to the upper reaches of Ravi River catchment (2,800 – 4,000 m) and occupy the upper cold desert layer (Himdhara Report, 2016). *Naemorhaedus goral* (Goral) and *Muntiacus muntjak* (Barking deer) are most common ungulates in this region. These animals are distributed in the temperate to sub-alpine forests in elevations between 2,400 and 2,800 m. Among the Primates, *Macaca mulatta* (Rhesus macaque) and *Presbytis entellus* (Langur) apart from other animals like squirrel (*Sciuridae* spp.), jackal (*Canis* spp.), leopard (*Panthera pardus*) and porcupine (*Hystrix indica*) etc. are found to inhabit the same ecological niche from the lower parts to upper parts of the hills (1,400 -3,400 m). Among all the faunal elements found in this area, birds show the maximum diversity area is a paradise for avian fauna. A total of 13 fish species are known to inhabit the Ravi River. In addition to these a few species, viz., *Barilius* spp. and *Puntius* spp. are found in different *khads* of Ravi River (Himdhara Report, 2016). Wildlife plays a vital role in balancing the environment. It

provides stability in a variety of natural processes. Wildlife and nature are closely associated with humans for emotional and social reasons. Animals have been very helpful to human being in providing food, clothing and a source of income. Wildlife helps to maintain the balance of nature. Animals are big hunters, which is the main reason for the evolution of nature. Therefore, when equity and stability are disrupted, it leads to many problems. Wild plant products such as food, medicine, timber, fibers, etc. have economic value and wildlife products such as meat, medicine, leather, ivory, lac, silk, etc. have great economic value.

Geologically, major portion of the basin is composed of Jutogh group/Vaikrita group/Central gneiss formations while Blaini/Infra-Krol formations are found in the bed of Ravi River. The soil of Ravi River Basin is Cryorthents and Lithic Udorthents type. The Ravi River Basin represents two biogeographic zones viz., The Himalayas and Punjab Plains.



Plate 1.2- General View of Ravi Riverscape

Two states Himachal Pradesh and Punjab and one Union Territory (J&K) which come under Ravi River Basin contributes 3,28,271 km^2 (9.99%) of total geographical area of India. These states collectively harbour 60,347 km^2 diverse forests (Recorded Forest Area (RFA)) or about 7.86% forests (RFA) of the country (FSI, 2019).

Further, these two states and one Union territory have altogether 746.71 m cum growing stock of forests that constitute 12.75% of the total growing stock of the country. Forests in above mentioned states and union territory harbor 6,55,899 million tonnes of carbon stock which contribute 9.206% of total estimated carbon stock of country which sequester carbon and also help in reduction of Greenhouse gas emissions (FSI, 2019).

The Ravi Basin is home to many threatened and sensitive ecosystems, *viz.*, glaciers, alpine meadows, grasslands, riparian forests, etc. along with a large variety of rare, endangered and threatened species that inhabit them. The Ravi River Basin across two states (Himachal Pradesh and Punjab) and J&K union territory harbours altogether seven Wildlife Sanctuaries (WLS). These are Gamgul, Tundah, Kugti, Kalatop-Khajjiar, Dhauladhar, Jasrota and Kathlour Kushlian WLS. In Ravi River Basin, two wetlands of National importance Khajjiar Wetland and Ranjeet Sagar Wetland occurs. The prominent peaks in Ravi Riverscape are Pir-Panjal (5,972 m), Barakanda (5,860 m), Manimahesh Kailash (5,660 m) and Thamsar (5,080 m).

Economic Significance

The Ravi River Basin is exploited for its rich timber. However, the valley has large, fertile plains, and is known as the 'GARDEN OF CHAMBA'. The crops grown in the basin supply grains to the capital and Dalhousie region. Tree species such as *Morus alba*, *Ilex* spp., *Juglans regia*, *Cedrus deodara*, *Pinus roxburghii*, *Pinus wallichiana*, etc. are growing along the Ravi River. Locally grown dried fruits are exported to nearby towns, cities, and sold locally. Ravi River offers its dwellers various activities such as fishing, skiing, river camping and retreating.

The Chamba district of Himachal Pradesh is considered as one of the richest areas of traditional and potential medicinal wealth which comes under Ravi River Basin. *Jurinea dolomiaea, Gentiana kurroo, Valeriana jatamansi, Morchella esculenta, Viola serpens, Carum carvi* and *Picrorhiza kurroa* are high valued medicinal plants found in Holi and Bharmour area of Ravi River Basin (Thakur *et al.,* 2016). Three plant species i.e., *Gentiana kurroo, Carum carvi* and *Picrorhiza kurroa* are reported endangered whereas one species *Jurinea dolomiaea* is vulnerable. Moreover, *Jurinea dolomiaea* is the highest extracted plant followed by *Gentiana kurroo* with harvested yield of 1,600 kg/yr and 900 kg/yr. Most of the species are disappearing at faster rate because of its excessive extraction and impact due to forest fires and over grazing. Some important fodder plants with high fidelity value (100%) grown in the area were *Acer caesium, Aesculus indica, Ailanthus altissima* and *Quercus semecarpifolia (*Rana *et al.,* 2019*).*



Plate 1.3- Agriculture Landscape in Ravi River Basin



Plate 1.4 - Catchment Areas of Ravi Riverscape

The Ravi River provides subsistence fishery thereby nutritional security especially to people dwelling in interior areas along the International border and is a means of livelihood to local fisherman. The minor minerals (sand, boulders and concrete) are extracted in massive quantities from the river beds of Ravi and its tributaries. This basin has been heavily targeted for the hydro-electric power development since 1980s with the installation of NHPC's first hydro-electric power generation plant with the name of Baira-Siul Hydro-electric power project. Hydro Electric Projects (Commissioned, Under Construction & Planned) on Ravi River in HP are 167 projects having hydropower potential of 2835.12 MW and having the potential capacity of 3237 MW (Himdhara, 2016, HIMURJA, 2015).

Cultural Significance

According to ancient history traced to Vedas, the Ravi River was known as Iravati (also spelt Eeraveti). The river was known as Parushani or Iravati to Indians in Vedic times and as Hydraotes to the Ancient Greeks. The part of the legendary battle of the ten kings was fought on the banks of the Parushani River, later inferred by MacDonell and Keith as the Ravi River. When the Indian National Congress changed it goals to 'Purna Swaraj' or Total Independence, President Jawaharlal Nehru unfurled the tricolor on the banks of Ravi River in the midnight hours of 31st December, 1929 amidst the slogans of 'Inquilab Zindabad' and 'Vande Mataram'. The Manimahesh peak and the lake, which feeds the Budhil River - a tributary of the Ravi, in Chamba, has several myths associated with it. It is believed that Lord Shiva resides with Goddess Parvati in Manimahesh Kailash. A rock formation in the form of a 'Shivling' on this mountain is considered as the manifestation of Lord Shiva and the field at the base of the mountain is called by the local people as Shiva's Chaugan. The local Gaddi community considers this region as Shiva Bhoomi. Legend says that before Shiva married Goddess Parvati at the Mansarovar Lake and they became universal parents, Shiva created Mount Kailash in Himachal Pradesh and made it his abode. The Manimahesh Ganga River originates in a cascade from the lake and joins the Budhil River on its left bank (Kotwal, 2016). Another popular festival held in Chamba is the 'Minjar Mela' which marks the triumph of the Raja of Chamba over the ruler of Kangra, in 935 AD. The festival also celebrates the paddy and maize crops grown at this time of the year. On the last day of the festival (Minjar Mela), a parade is held from the Akhand Chandi Palace to Ravi River, where offerings are made to the river. This commemorates an event in which Raja Sahil Verman changed the course of the river, to make the Hari Rai temple accessible to all devotees.



Plate 1.5- International Minjar Fair at Chamba

The Ravi was witness to the epic battle mentioned in the Rig Veda in which the tribal kingdom of Bharata had emerged victorious. Not long after, the river saw the sage Valmiki compose the Ramayana while sitting on its banks, narrating the story of the ideal king Ram. The river was witness to the last seventeen years of Guru Nanak's life, and how he performed ashnan (bath, as a purification process) every day before working in his fields. The river also cleansed the body of Guru Arjan after he was tortured on the orders of Emperor Jahangir, and it accepted the guru in its embrace, providing him salvation from the Mughal forces. The majestic snow-peaked Himalayan Mountains and various natural ecosystems along the Ravi River and its tributaries, besides wide ranging religious, cultural and historic values, have enormous potential for recreation and tourism industry. The natural beauty around this river is worth seeing and gives a great view at summer time. Moreover, the river is a great attraction for tourists and gives a notable place to local visitors. Water sports adventure (rafting and boating) and pilgrimage (Manimahesh) are major attraction and constitute several circuits of tourism. Festivities and events like International Minjar Mela are associated with the worship of Ravi River.



Plate 1.6 - Manimahesh Lake

1.7 Problems of Ravi River Basin

The Ravi River Basin in Indian Territory is spread over Himachal Pradesh, Jammu and Kashmir UT and Punjab and covers an extent of 11706.41 km^2 in India . The natural and anthropogenic problems of Ravi River encompasses heavy rain that leads to flash flood, silt and clay deposition that makes water highly turbid, Harsh climatic conditions due to erratic and changing patterns of snowfall, rainfall, and temperature, fragility of the Himalayan environment owing to increased seismic activity and active landslides, shallow soil depth, low soil fertility and faulty land use pattern. The rivers are under threats due to the five major developmental activities, hydro-power projects, Industrialization and Urbanization along riverscape leads to water pollution and waste dumping in riverbanks, Sand Mining i.e., sand mining rampant in Punjab plains, Deforestation that steer to quick runoff leading to floods and soil erosion and also loss of biodiversity. But in the present project on forestry interventions, afforestation and reforestation activities along with soil and water conservation measures in identified priority areas besides various conservation and supporting activities are envisaged so as to seek *Aviral* Dhara intervention activities to maximize silt retention and surface water absorption.

The above developmental activities are being carried out in the absence of proper planning, impact assessment and carrying capacity studies and adequate monitoring. The key threats that the Himalayan Rivers face are the burgeoning pollution from sewage, industrial effluents and reduced e-flow. These are the prominent problems that have several ecological, social, cultural and economic impacts that are becoming irreversible. The rhitherone zone of Ravi within the Himalayas has been maneuvered extensively for generation of power by formulation of many dams, Chamera I, II, III and Ranjitsagar/Thein.

1.8 Past and Present River Conservation Initiatives

1.8.1 Conservation of Major Indian Rivers

Conservation of Ganga River: In recognition of the conservation significance of the Ganga River and also appreciating growing national concerns about environmental degradation of the river and its basin the GoI declared the Ganga River as India's National River in 2008 and constituted the National Ganga River Basin, Authority (NGRBA) on 20 February, 2009 under the Section 3 (3) of the Environment (Protection) Act, 1986. The NGRBA entrusted the consortium of seven Indian Institute of Technology (IITs) with the task of preparing the Ganga River Basin Environment Management Plan (GRBEMP) and launched World Bank assisted National Ganga River Basin Project (NGRBP). In addition, the MoEF&CC has been implementing two separate Central Sponsored Schemes (CSS): (i) the National Wetlands Conservation Programme (NWCP), and (ii) the National Lake Conservation Programme (NLCP). Further, the Union Cabinet approved National Water Mission (NWM) in April, 2011. The Union Budget of 2014-15 announced the setting of an integrated Ganga Conservation Mission named as 'National Mission for Clean Ganga (NMCG)' or 'Namami Gange' while recognizing the multi-sectoral, multi-dimensional and multi-stakeholder nature of rejuvenation challenges in the context of Ganga River and entrusted the central key Ministries including: (a) MoWR, RD&GR, (b) MoEF&CC, (c) Ministry of Shipping - MoS, (d) Ministry of Transport – MoT, (e) Ministry of Urban Development - MoUD, (f) Ministry of Drinking Water and Sanitation – MoDW&S , and (g) Ministry of Rural Development – MoRD to work together so as to arrive at an action plan. The Namami Gange aimed for: (a) *Aviral Dhara* (uninterrupted flow), (b) *Nirmal Dhara* (clean water), (c) ecological rejuvenation by way of conservation of aquatic life and biodiversity, (d) promotion of tourism and shipping, and (e) knowledge management on Ganga. Based on modern scientific study and a more holistic understanding of rivers and their ecosystems, the GoI has recognised the comprehensive definitions of a river (Isha Foundation, 2017) as a river is wholesome if it has the characteristic of '*aviral dhara*' (continuous flow), '*nirmal dhara*' (unpolluted flow), geologic entity, and ecologic entity, across the basin in all seasons.'

The MoWR, RD&GR and NMCG implemented a wide range of projects during past five years or so involving various Ministries, State Governments, Departments and Agencies. In the financial year 2015-16, the Ministry entrusted a major task to the Forest Research Institute (FRI), Dehra Dun on the preparation of Detailed Project Report (DPR) on Forestry Interventions for Rejuvenation of River Ganga. Accordingly, the FRI prepared the DPR which was one of its kinds. The DPR adopted a holistic riverscape approach with a focus on forestry interventions, aiming for improvement in quantity and quality of water. Implemented by five states located along the course of Ganga River. Meanwhile, the present Union Government on its re-election in May, 2019 took an immediate step to launch a new Ministry named as the Ministry of Jal Shakti (MoJS) indicating a visible thrust on water. The MoJS is now the umbrella ministry in which all water- related ministries have been integrated. Thus, the MoWR, RD&GR and MoDW&S have been merged into the new Ministry. The NRCD under the purview of MoEF&CC is also being brought under the MoJS. Parallel to various concerted efforts to restore the mighty Ganga River, the GoI has initiated several different programmes to manage and conserve various major rivers of the country.

Yamuna Action Plan: In case of Yamuna River, a tributary (1,376 km) to Ganga River, the Yamuna Action Plan (YAP), a bilateral project between the GoI and Japan was initiated in 1993. It is one of the largest river restoration projects in India. The Government of Japan, through the Japan Bank of International Cooperation (JBIC), has provided financial aid of ¥ 17.7 billion to carry out the project. The project is being executed by the NRCD, MoEF&CC.

River Valley Project Development in the Indus River Basin

Brahmaputra Board: On the lines of BBMB, the GoI constituted a statutory body named as the Brahmaputra Board in 1980 in order to regulate and develop inter-state Brahmaputra and Barak River Valley and utilization of water resources of Brahmaputra and Barak River and their tributaries for irrigation, hydro-power, navigation and flood management. The jurisdiction of the Board covers all the states of the North-Eastern Region, Sikkim and part of West-Bengal falling in Brahmaputra of basin.

Conservation of Narmada River: The Government of Madhya Pradesh has initiated a campaign to conserve the Narmada River. The campaign primarily focuses on creation of public awareness and their involvement besides promoting activities such as soil and water conservation, afforestation, pollution control and organic farming. As a part of the campaign, a *Yatra* or pilgrimage that run for 148 days during 2016-17 began and ended at Amarkantak, the origin of the Narmada River. The campaign also included planting 16 million trees along the riverbank.

Rally for Rivers: Rally for Rivers (RfR) is a campaign launched by Isha Foundation in 2017, a non-profit, spiritual organisation found in 1992 by Sadhguru Jaggi Vasudev based at

Coimbatore. RfR aims to instil awareness protecting rivers so as to tackle the water scarcity across rivers in India and brought out a document entitled 'Revitalization of Rivers in India Draft Policy Recommendation' and submitted to the Hon'ble PM, India on 03 October, 2017. The document recognized rivers as a 'National Treasure' and envisaged that the protection of the rivers should encompass: (a) ensuring full ecological/environmental flows; and (b) preserving biological, chemical and physical characteristic of water that protects the gene pool (Isha Foundation, 2017). The PMO formed an expert group to look into the policy recommendations made by RFR under the chairmanship of CEO, NITI Aayog. Six states i.e., Karnataka, Assam, Chhattisgarh, Punjab, Maharashtra, and Gujarat signed a MoU with Isha Foundation to plant trees along river banks.

NITI Aayog – The NITI Aayog has also come out with a detailed document on the India - Three Year Action Agenda (2017-18 to 2019-20) including a chapter on sustainable management of water resources. This document has been prepared on the basis of an extensive discussion with inputs from the Central Ministries and State Government. The NITI Aayog has also developed a Strategy for New India@75, and has focused on the current situation of water resources and the way forward for various dimensions of management of water resources in the country (NITI Aayog, 2018).

River and Water Conservation as a National Movement: In the past decade or so, the GoI has realised the growing water crisis is the main impediment in the country's development and in the process of nation building. Despite growing water crisis, India is not only committed to fulfill its international obligations towards biodiversity conservation, environmental management, climate change mitigation, human rights, social justice, equity as well as peace, but at the same time country is fully geared for planned accomplishments essential for nation building and meaningful contribution towards global agenda on sustainable development (Savita, 2019). In short, management of scarce and precious water resources and river conservation adopting a holistic approach have become a national movement.

Realizing the growing water crisis in the country mainly due to the anthropogenic activities with far reaching consequence on quality and quantity of the rivers, the river cleaning programme of major river in the country initiated with the launching of the Ganga Action Plan (GAP) in 1985. The Ganga Action Plan was expanded to cover other rivers under the National River Conservation Plan (NRCP) in the year 1995. The pollution abatement works are implemented on a cost sharing basis between the Centre and State Governments. The works include collection, transportation and treatment of municipal sewage, river front development (RFD), low cost sanitation (LCS), electric crematoria, improved wood based crematoria, etc. Prevention and control of industrial pollution is being addressed by the Central and State Pollution Control Boards/Pollution Control Committee. The objective of NRCP is to improve the water quality of the rivers, which are the major water sources in the country, through the implementation of pollution abatement works.

Ravi Project: The waters of the Ravi River are allocated to India under the IWT (1960). The river is under the jurisdiction of the riparian states of Punjab and Himachal Pradesh, and non-riparian states/UT of Haryana, Jammu & Kashmir and Rajasthan, but the management is presided by the Supreme Court of India and the Ravi, Beas Tribunal, set up in 1986 for the purpose. Madhopur Headworks was the earliest project built on Ravi in 1902 prior to the partition. It is a run-of-the-river project without any water storage envisaged to divert flows through the Upper Bari Doab Canal to provide irrigation in command area of the then unified India. Since 1980s, Baira Siul HEP of 198 MW capacity, the Chamera-I of 540 MW capacity commissioned in 1994, the Ranjit Sagar (Thein) multipurpose project (600 MW) completed in 1999 and the Chamera-II of 300 MW capacity in the upstream of Chamera-I commissioned in 2004 are functioning. The post-independence, the Madhopur-Beas Link was built during 1955-57 linking Ravi River with Beas at Harike. The Rajasthan canal is a capacity of 18,500 Cs, off taking from Harike Headworks was constructed during 1958-1961, for supply of Ravi- Beas waters to Rajasthan.

Various past and present conservation schemes, programmes and projects have been launched in concerned States i.e., Himachal Pradesh and Punjab and UT i.e., Jammu & Kashmir of Ravi Riverscape which are as follows.

(A) Watershed Development Programmes

The Watershed Development Programmes aims at integrated development of natural resources like land, water, vegetation, etc. by taking up watershed development projects. Under this states funded scheme, new plantations are raised and the old plantations are maintained besides carrying out research and extension activities and promotion of information technology. From the year 2013-2014 to 2015-2016, 3097 ha area has been afforested besides maintaining 3600 ha old plantations in Punjab.

(B) National Afforestation Programme (NAP)

The National Afforestation Programme was initiated in the year 2002-03 by National Afforestation and Eco-Development Board (NAEB) of the Ministry of Environment and Forests (MOEF), Govt. of India (GOI) with a broad objective of regeneration and eco-development of degraded forests. National Afforestation Programme is a 100% Centrally Sponsored Scheme. The main objectives of the scheme as envisaged in the Revised Operational Guidelines 2009 were; (a) Sustainable Development and Management of Forest Resources, (b) Increase and/or improve Forest and Tree cover, (c) Rehabilitation of degraded forests and other areas by institutionalizing decentralized / participatory forest management and supplementing livelihoods improvement processes, and (d) Development of Eco-Tourism facilities.

(C) Joint Forest Management

The Joint Forest Management is a National program through which communities have been involved in forest management since the 1990s. There are over one hundred thousand Joint Forest Management Committees (JFMCs) that are protecting and managing over 22 million hectares of forest lands in the country. Although, initially JFM was supported through projects and initiatives of individual Officers and NGOs, it was subsequently institutionalized through the National Afforestation Programme (NAP), a flagship scheme of the National Afforestation and Eco-Development Board (NAEB), MoEF&CC, Government of India. In Punjab, the concept of JFM is applicable to all the reserved, protected and unclassed forests. The JFM process is now intended to adopt a three pronged strategy to involve local through Forest Protection Committees, NGO, Voluntary Agencies/ Religious Bodies/ Institutions and farmers

(D) River Valley Projects and Flood Prone Rivers (RVP & FPR)

The Himachal Pradesh Forest Department has been carrying out soil and water conservation activities under Centrally Sponsored Schemes of RVP and FPR to prevent soil loss and conserve water and improve moisture regimes in the State. All types of lands viz., Agriculture, waste and forest are treated with suitable package of treatments i.e., construction of contour vegetative hedges, contour graded bunding, horticulture plantations, contour/staggered trenching, sowing and planting of plants, silvi-pasture development, pasture development, afforestation , farm pond, percolation tank and drainage line treatment. The Forest Department has carried out the Soil and Water Conservation works under RVP & FPR schemes up to 2013-14, after which the scheme was discontinued due to merger of various Centrally Sponsored Schemes by the Government of India. Out of 874 micro-watersheds of very high and high priority, 333 No. were treated under the scheme and 541 are yet to be treated. The main objectives of the scheme were; (a) Prevention of land degradation by adopting appropriate need based soil and watershed approach in an integrated manner in the Inter-State catchments, (b) Improvement of land capability and moisture regime in the watersheds, (c) Promotion of land use to match the land capability, (d) Prevention of soil erosion and runoff, from the watershed with a view to prevent pre-mature siltation of multipurpose reservoirs and to reduce flood peaks and volumes of runoff.

(E) Compensatory Afforestation Fund Management And Planning (CAMPA)

Himachal Pradesh State CAMPA, constituted vide GoHP Notification dated 03.08.2009, receives funds from Central Adhoc CAMPA. It functions through a Governing Body, a Steering Committee and an Executive Committee. A series of plantation programmes have been launched by the Government of India with the purpose of increasing forest cover and regenerating degraded forests.

(F) Punjab Compensatory Afforestation Fund Management and Planning Authority (PUNCAMPA)

According to the Forest (Conservation) Act, 1980 and the Rules made there under, to compensate the adverse effects of any forest area diverted, compensatory plantation equal in extent of area diverted has to be done in land provided by the user agency or in double the degraded forest area. To carry out compensatory plantation, the user agency has to deposit the net present value of the area diverted as well as the cost of raising plantation. These funds earlier used by the Forest Department at its own will, however in pursuance of the guidelines of the Ministry of Environment and Forest vide letter NO. 1-58/09- MoS (1/C), dated 15-07-2009, Punjab compensatory Afforestation Fund Management and Planning Authority was to reconstitute as a registered society under the Society Registration Act, 1860.

(G) Catchment Area Treatment (CAT) Plan

To address various environmental issues arising out of construction of HEPs, Himachal Pradesh Forest Department has formulated Comprehensive Catchment Area Treatment Plans (CCPs) for all the four major River Basins *viz*., Sutlej, Beas, Ravi and Chenab in the State. These CCPs emphasized on the integrated approach for the treatment up to watershed level and also beneficial for socio-economic upliftment of the local communities through livelihood support.

(H) Secure Himalaya Project

Project "Secure Himalaya" was launched in January 2017 aided by Government of India and United Nations Development Programme, with support from the Global Environment Facility. It entitled "SECURE Himalayas - Securing Livelihoods, Conservation, Sustainable Use and Restoration of High Range Himalayan Ecosystems", to ensure conservation of locally and globally significant biodiversity, land and forest resources in the high Himalayan ecosystem, while enhancing the lives and livelihoods of local communities. The project is spread over three States and one Union Territory i.e., Jammu & Kashmir UT, Himachal Pradesh, Uttarakhand and Sikkim.

(I) WWF Initiatives-2009

In 2009, Nokia India CSR (Corporate Social Responsibility) team in collaboration with WWF-India and the Department of Forests and Wildlife Preservation of Punjab Government initiated the 'River Watch Project', a programme for the Bio-monitoring of freshwater biodiversity in the Sutlej–Beas–Ravi Rivers in Punjab, which covers the Harike Wetland, a Biodiversity Hotspot.

(J) Green India Mission in Jammu and Kashmir and Punjab

Green India Mission is based on a holistic view of greening and focuses on carbon sequestration and multiple ecosystem services, especially, biodiversity, water, biomass, etc. along with climate adaptation and mitigation as a co-benefit. Green Punjab Mission was constituted in September

2012, with the objective to give an impetus to the activities related to conservation and development of existing forest and tree cover and its further enhancement in forest land as well as non-forest land in villages, urban and peri-urban areas such as panchayat lands, focal points markets, hospitals, institutional land, etc. It also aims to raise nurseries including purchase of seeds, seedlings, fertilizers and other material for raising for nurseries and other related activities for the purpose of creation of good quality planting stock for Greening Punjab Mission Activities.

(K) Integrated Forest Protection Scheme

The Integrated Forest Protection Scheme was launched for implementation during 10th Five Year Plan (FYP). The three main components of Intensification of Forest Management Scheme are: Forest fire control and management, Strengthening of Infrastructure and Survey demarcation and working plan preparation. Main objectives of the scheme were to (a) maintain environmental stability through preservation and where ever necessary, restoration of ecological balance, (b) preserve the natural heritage of the country by protecting and conserving the remaining natural forests, (c) improve productivity of forests to meet essential needs, (d) ensure management of forests by preparing and implementing good quality Working Plans, and (e) protect forests against forest fires by adopting improved and modern management practices.

During the 12th five year plan, the Integrated Forest Protection Scheme (IFPS) has been revised and re-named as Intensification of Forest Management (IFM). Four new components have been added to make it broader based i.e., Protection & Management of Sacred Groves. The main objectives of the scheme were, (a) Conservation of Restoration of unique vegetation and eco-system, (b) Control and eradication of Forest invasive species, (c) Preparedness for meeting challenges of Bamboo flowering and improving management of Bamboo Forests.

(L) Sub-Mission on Agro-Forestry in Punjab

The Sub-Mission on Agro-Forestry (SMAF) is a scheme started by Ministry of Agriculture and Farmers Welfare, Government of India under National Mission for Sustainable Agriculture (NMSA) in year 2016-17 with a focus to enhance income of farmers and also to diversify land use from agriculture to agro-forestry to certain extent. The objectives are to; (a) encourage and expand tree plantation in complementary and integrated manner with crops and livestock to improve productivity, employment opportunities, income generation and livelihoods of rural households, especially the small farmers, (b) ensure availability of quality planting material like seeds, seedlings, clones, hybrids, improved varieties, etc. (c) popularize various Agro-forestry practices/models suitable to different agro-ecological regions and land use conditions, (d) create database, information and knowledge support in the area of agro-forestry, and (e) provide extension and capacity building support to agro-forestry sector.

(M) Medicinal Plants Projects in Punjab

To support JFMCs for setting up clusters for value addition of medicinal plants, the Ministry of AYUSH has sanctioned a special project for six Forest Divisions of Punjab i.e., Douay, Hoshiarpur, Pathankot, Mukstar, Patiala and Bathinda in the year 2016-17. The Schemes will promote sustainable collection, value addition and warehousing of high traded medicinal plants besides establishing school herbal gardens in Patiala, Mukstar and Bhatinda districts.

(N) Conservation, Management and Development of Wildlife Schemes in the Punjab

This is a State Plan Scheme for the development and management of wildlife in the State and is the only scheme of the Department which deals with all wildlife conservation and development related issues. The Department has been implementing this scheme with components for conservation and protection of wildlife in the State. Objectives of the scheme are; (a) Provision for in-situ conservation in Protected Areas and outside Protected Areas, (b) Provision for ex-situ conservation – Upkeep feed fodder maintenance and up gradation of zoos, (c) Provision for rescue of animals and other expenditure including administrative expenditure and contingency, (d) Provision for providing compensation for man-animal conflict.

Some of the other prominent schemes apart from the above mentions are National Mission On Sustainable Agriculture - 2014, Himachal Pradesh Mid-Himalayan Watershed Development Project, CM's Participatory Afforestation Scheme, Artificial Ground Water Recharge Schemes, Solid Waste Management Schemes, and National Bamboo Mission along the Ravi Riverscape.

1.8.2 Ravi River Basin Management

Under Indus Waters Treaty i.e., signed between India and Pakistan, Ravi River is allocated to India. The river is under the jurisdiction of the riparian states of Punjab and Himachal, and non-riparian states of Haryana, Jammu & Kashmir and Rajasthan, but the management is presided by the Supreme Court of India and the Ravi Beas Tribunal, set up in 1986 for the purpose. Madhopur Headworks, is the earliest project built in 1902 on Ravi River. It is a run-of-the river project (no storage envisaged) to divert flows through the Upper Bari Doab Canal (UBDC) (also known as Central Bari Doab Canal) to provide irrigation in the command area of the then unified India. The hydropower potential developed since the 1980s is through installation of Baira Siul Hydro-elelectric Power Project of 198 MW capacity, the Chamera-I of 540 MW capacity commissioned in 1994, the Ranjit sagar Multipurpose Project of 600 MW capacity completed in 1999 and the Chamera-II of 300 MW capacity in the upstream of Chamera-I commissioned in 2004.

Transfer of surplus water from one basin to another, termed as interbasin water transfer has been effectively implemented on the Ravi River. The surplus waters of the Ravi River have been transferred directly first to the Beas River through the Ravi-Beas Link. A further link from Beas

River to the Sutlej River by the Beas-Sutlej Link augments storage of the Bhakra reservoir in India.

1.9 Legal Policy and Institutional Context in term of Management of River

A sparate Union Ministry of Environment and Forests was created in 1980's to conserve rivers and fresh water resource by realizing the growing demands on these precious natural resources. Even much before this, the Wildlife Protection Act, 1972 was enacted by the Government of India (GoI) which provided equal emphasis on all natural ecosystems i.e., terrestrial, aquatic, coastal and marine. Accordingly, a large number of protected areas (National Parks and Wildlife Sanctuaries) were established. A large number of protected areas that focus specifically on freshwater resources i.e., glaciers, rivers, estuaries, lakes, swamps floodplains etc. were designated as either National Parks or Wildlife Sanctuaries so as to ensure effective conservation of such ecosystems and habitats and their associated biota.

In past five decades or so the Central and State Governments have enacted various legislations related to forests, wildlife, environment, river, etc. and formulated relevant policies. The DPR enumerates and reviews various legal and policy foundations relevant to river ecosystem and conservation those exist in the country and also highlights that how various prominent judgments, directives and other interventions by different Hon'ble Courts including the National Green Tribunal have helped in safeguarding interests of forests, wildlife, rivers and wetlands besides protection of the environment.

Certainly, the Indian Forest Act, 1927; Wildlife (Protection) Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act, 1986; and Biological Diversity Act, 2002; Forest Rights Act, 2006; Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; The Compensatory Afforestation Fund Act, 2016; Indus Water Treaty, 1960; Jammu and Kashmir Reorganisation Act, 2019 besides some of the provisions - Article 48 A and Article 51 A (g) of the Constitution of India are pertinent from the perspective of river conservation. The National Forest Policy, 1988; Environment Impact Assessment Notification, 2006; Municipal Solid Waste (Management and Handling) Rules, 2000; National Water Policy, 2012; and Wetland (Conservation and Management) Rules, 2017; Guidelines on Sustainable Sand- mining, 2015; MoUD Guidelines on Urban Greening, 2014; Himachal Pradesh Participatory Forest Management Regulations, 2001; Himachal Pradesh Non-Biodegradable Garbage (Control) Act,1995; Forest (Conservation) Amendment Rules, 2014 are some of the prominent policies and legal instruments applicable in case of river conservation. The agreement made and provisions incorporated as per the Indus Water Treaty, 1960 are of utmost importance in the context of Ravi River from the perspective of river water settlement, use and obligations as it is one of the 'Eastern Rivers' listed under the Treaty.

1.10 The Present Task – Forestry Interventions for Ravi River

The previous description has amply illustrated the realization of degrading quality and quantity of rivers in the country and the need for its restoration through holistic approach. Since there is a global appreciation of the strong linkages between forests and water; therefore, multi-sectoral and holistic approach emphasizes upon forestry interventions in river restoration. Detailed Project Report preparation involves recognizing the diversity, complexity and intricacies of forest ecosystems and pivotal multiple functions performed by them and their inter-connectedness with highly dynamic river ecosystem and to adopt a holistic approach for the improvement and management of riverine ecosystem in the entire river basin through forestry interventions. The holistic approach emphasizes appropriate forestry interventions by way of protection, habitat management, afforestation, catchment treatment-soil and moisture conservation works, ecological restoration of vital riparian forest buffer, bio-remediation, improved livelihoods of forest dependent communities and forest dwellers and alternate income generation activities through regulated tourism and community awareness.

1.10.1 Forests – Multiple Functions, Uses and Values

Forests are an integral part of complex land-use systems with many function. They constitute an essential natural heritage and are important economic assets, and they are vital for sustaining the global environment. Since ancient times, man has depended on forests for diverse goods and services for its survival. Forests provide a wide range of goods, such as food, wood and fibre, and ecosystem services, such as climate regulation, water catchment protection, poverty reduction, spiritual fulfillment and aesthetic enjoyment. Everyone depends on these goods and services, and many millions depend on forest-based employment for their livelihoods, yet over the past 50 years humans have changed forest ecosystems more rapidly and extensively than in any other historical period. The conversion of forests into agricultural and grazing land and the general transformation of forest ecosystems have contributed to economic development, but not all regions and groups of people have benefited and many have suffered in socio-cultural, economic and environmental terms. Moreover, the full costs of deforestation and forest degradation are becoming apparent through, for example, biodiversity loss, increased floods and drought, climate change and loss of soil fertility. Forests are part of landscapes and attract many tourists in search of recreation. Multiple functions of forests are: (a) watershed functions (b) risk mitigation (c) biodiversity and food security (d) air quality (e) fuel wood and timber (f) land use (g) cottage tourism and recreation (Hofer *et al*., 2003).

1.10.2 Riparian Forest Buffers as 'Biological Filters' – Ecological Machinery for Self - Purification and Bioremediation in River Ecosystems

The term riparian refers to the biotic communities and the environment on the shores of streams, rivers, ponds, lakes, and some other wetlands. In this chapter, the phrase riparian forest refers to vegetation directly adjacent to rivers and streams. The riparian forest extends laterally from the active channel to the uplands, thereby including active floodplains and the immediately adjacent terraces. Riparian areas are also rich in aesthetic appeal. Riparian buffers as 'Natural Buffers' and 'Biological Filters' are the single most effective protection mechanism for major water resources such as Ravi River, which is under severe pressure of waste and pollutants. Riparian forest buffers are designed combinations of trees, shrubs, grasses, forbs and bioengineered structures adjacent to, or within, a stream channel targeted to mitigate the impact of land use on the stream. By developing an understanding of the interactions between a riparian buffer (trees, shrubs and grasses), the stream, and the adjacent upland area, its layout can effectively meet the goals for which it has been established. Riparian buffers also have a role in reducing nutrient losses to streams in upland forests. Retention of phosphate is particularly important to prevent nutrient enrichment and algal problems in standing waters after aerial applications of rock phosphate.

Natural buffers (riparian forest) are complex ecosystems in themselves as they provide habitat and improve the stream communities they shelter. These natural buffers as functional filters are: (i) direct water filtering by aquatic organisms that are 'filter feeders'; (ii) the filters are mainly represented by aquatic organisms; (iii) the filter represented by benthic organisms; and (iv) the filter represented by microorganisms attached to suspended particles in water provides microbiological treatment of water column.

Biological filters help catch and filter out sediment and debris from surface runoff. Biological filters consist of some solid media that serves as a surface on which bacteria can attach and live. Water containing ammonia and/or nitrite flow over this media and the bacteria attached to it. The bacteria remove the ammonia from the water and use it as an energy source to drive their life processes. Biological filters are designed to maintain the various forms of inorganic nitrogen (e.g., ammonia, nitrite, and nitrate) at levels that are healthy for the fish being cultured. Biological filters have inbuilt mechanism for bioremediation that includes the removal of both hazardous and non-hazardous contaminants from the liquid, solid, and gas phase using biological processes.

The water in the landscape tends to draw people because of its visibility, movement, reflection, color, and its consequent contrasts to adjacent earth surfaces. Conclusion is that the aesthetic appeal of a stream is a function of its topography, relief, form, vegetation types and arrangement, water variability and pattern, and human use and impacts (Litton, 1977). Streams that are more

sinuous are often more interesting because a hidden view contributes to a sense of mystery to the experience. Other features, such as the presence of rapids or large scenic vista will also increase the appeal of the stream (Leopold, 1969; Kuska, 1977; Brown and Daniel, 1991). However, the presence of litter, man-made features (utilities, roads, dams, etc.) and evidence of poor water quality (discoloration, turbidity, odor, algae) can distract from the aesthetic appeal (Leopold 1969; Hoover *et al*., 1985).

1.10.3 Forest Ecosystems – Fragmentation and Degradation

The term "fragmentation" has been defined as simultaneous reduction of forest area, increase in forest edge, and subdivision of large forest areas into smaller non-contiguous fragments (Laurance, 2000). Deforestation is the conversion of forested areas to non-forest land use such as arable land, urban use, logged area or wasteland. According to Tejaswi (2007), deforestation is the conversion of forest to another land use or the long-term reduction of tree canopy cover below the 10% threshold. Deforestation can result from deliberate removal of forest cover for agriculture or urban development, or it can be an unintentional consequence of uncontrolled grazing (which can prevent the natural regeneration of young trees). The combined effect of grazing and fires can be a major cause of deforestation in dry areas. Deforestation implies the long-term (>10 years) or permanent loss of forest cover. Deforestation defined broadly can include not only conversion to non-forest, but also degradation that reduces forest quality - the density and structure of the trees, the ecological services supplied, the biomass of plants and animals, the species diversity and the genetic diversity. Narrow definition of deforestation is the removal of forest cover to an extent that allows for alternative land use. The United Nations Research Institute for Social Development (UNRISD) uses a broad definition of deforestation, while the Food and Agriculture Organization of the UN (FAO) uses a much narrower definition (Tejaswi, 2007). In a more general sense, forest degradation is the long-term reduction of the overall potential supply of benefits from the forest, which includes wood, biodiversity and any other product or service (Tejaswi, 2007).

1.10.4 Forests and Water - Strong Linkages

Water is a vital element of all natural resources and essential to life. Forests have a close relationship to our water resources. Sustainable forest management is of vital importance for supply of good-quality freshwater, protection against natural hazards like floods or soil erosion, and for combating desertification. Forested basins and catchments provides high proportion of freshwater to meet the basic requirements of domestic, agricultural, industrial and ecological needs in both upstream and downstream areas (Calder *et al*., 2007).

To address challenges related to water security there is an urgent need for a better understanding of the interactions between forests/trees and water, for awareness raising and capacity building in

forest hydrology, and for embedding this knowledge and the research findings in policies. Similarly, there is a need to develop institutional mechanisms to enhance synergies in dealing with issues related to forests and water as well as to implement and enforce action programmes at the national and regional levels. In the past, forest and water policies were often based on the assumption that under any hydrological and ecological circumstance, forest is the best land cover to maximize water yield, regulate seasonal flows and ensure high water quality. Following this assumption, conserving (or extending) forest cover in upstream watersheds was deemed the most effective measure to enhance water availability for agriculture, industrial and domestic uses, as well as for preventing floods in downstream areas. Forest hydrology research conducted during the 1980s and 1990s (Calder, 2007) suggests the role of upstream forests in maintaining water flows during the dry season, and water-quality preservation.

1.10.5 From 'Isolationist' to 'Holistic' Approaches to River Conservation

Water is the most vital element to life on earth, which can be a limited resource in an expanding global economy and population. The river water, a major source of surface water, finds multiple uses in irrigation, navigation, hydropower generation, flood management, etc., thereby increasing the degree of complexity regarding its distribution among the users. The planning and management of river basin have gradually evolved over time with the change in water demand and also the river condition. Since last few decades, it has started moving towards a more scientific and technical approach consisting of integrated practices and management. India, being the second most populous nation of the world, its limited water resources is increasingly constrained by growing demand for irrigation and industrialization, which in turn has raised the level of pollution in many holy rivers along with interstate water disputes. To deal with all these conflicts, the river basin planning requires a sustainable holistic modeling of the entire basin for the socio-economic development of the country. The forgoing description has amply highlighted that there are strong and intricate linkages among forest, water, watershed, river, climate and people while these sectors have been seen in isolation for a long time and isolationist approaches were adopted for management. The isolationist, centralized, top-down, sectoral approaches to river conservation have not yielded much desired success as the holistic, multi-disciplinary, multi-stakeholder, decentralized, bottom-up approaches to river basin or riverscape management were ignored. The vital aspects *viz.*, the complexity and dynamic nature of the river, connectivity, e-flow, ecological integrity, river health, biota, biodiversity conservation, and socio-economics of dependent people were overlooked from the perspective of inter-connectedness and entirety. The increasing national and international momentum and action now seeks to move from a sectoral to an integrated and cross-sectoral approach to environmental, economic and social planning at local, national and international levels in the context of river conservation and management of vital river resources. The holistic approach also advocates to promote effective and equitable collaborative arrangements and partnerships among

governments, local communities, scientific organizations, private sector, civil society, forests and water managers and other stakeholders besides facilitating knowledge sharing, capacity development, science-based policy development and tangible improvements in forests and water management (FAO, 2013). In view of the emerging scenario and to fulfill the urgent requirements of national agenda and global commitments, the Government of India has also launched several new initiatives relevant to river rejuvenation and conservation as narrated in the section 1.7. Amongst them, the *Namami Gange* programme initiated by the MoWR, RD & GR (Now Ministry of Jal Shakti) as a part of the National Mission on Clean Ganga (NMCG) focuses on the rejuvenation of the National River i.e., the Ganga River and adopted a comprehensive, multi-sectoral, multi-dimensional and multi-stakeholder strategy including 'forestry interventions' as an important and vital component. The Forest Research Institute (FRI), Dehra Dun on behest of the MoWR, RD & GR has prepared a Detailed Project Report (DPR) on forestry interventions for rejuvenation of Ganga River in the year 2015. From the financial year 2016-17, the 5-year project on forestry interventions prepared by FRI is being implemented by five concerned states Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal lying along the main river course. The NMCG has supported implementation of plantation activities in Natural, Agriculture and Urban Landscape within the delineated Ganga Riverscape besides other interventions as proposed in the DPR.

1.10.6 Current Task – DPR Preparation on Forestry Interventions for Rejuvenation of Ravi River

Realising the current plight of all major Indian rivers, the Government of India, NITI Aayog prepared a programme for action which details how the recommendations made by Rally for Rivers (RfR) will be implemented on the ground. The programme for action was prepared by the Department of Rural Development and it was decided to launch a major mission on revitalization of rivers utilizing the existing schemes and programmes of the Government with community lead efforts. Accordingly, the NITI Aayog directed concerned Central Ministries (MoRD, MoEF&CC, MoA&FW, MoDWS, MoH&UA, and MoPR) and Chief Secretaries/Administrators of all States and UTs to initiate pilot projects for revitalization of rivers by appropriate convergence of schemes and active involvement of various stakeholders. In response to this and following the pursuit of forestry interventions on Ganga River by NMCG, the MoEF&CC assigned a major task on the preparation of DPR(s) on forestry interventions for rejuvenation of 13 major Indian rivers (tributaries of Indus – Jhelum, Chenab, Ravi, Beas and Sutlej; Yamuna, Luni, Narmada, Godavari, Mahanadi, Krishna, Cauvery and Brahmaputra) belonging to nine river systems to the Indian Council of Forestry Research and Education (ICFRE) Dehradun, An Autonomous Organisation under its control. The ICFRE is an umbrella organisation responsible for carrying out forestry research, education and extension activities in the country and an apex body in the national forestry research system. The Council has a pan India presence with its nine Regional Research Institutes and six Centres located in different biogeographic zones of the

country. Each Regional Institute has been mandated the task of research, education and extension in the States/UTs under their jurisdiction. The Himalayan Forest Research Institute (HFRI), Shimla, a regional institute has been entrusted the task to prepare DPRs of five tributaries of the Indus River. The present DPR specifically deals with the Ravi River, a major tributary of the Indus River. The ICFRE has allowed HFRI a time frame of 12 months to prepare the DPR envisaging that proposed forestry interventions will immensely facilitate the major goals of accomplishing *Aviral Dhara* (uninterrupted flow), *Nirmal Dhara* (clean flow) and ecological regeneration of aquatic and terrestrial life/ biota.

1.10.7 Funding Agencies Initiatives

The rivers are essential for sustaining human life as they provide potable water, transportation, electricity and the livelihood for many people nation-wide. Besides, rivers are vital for ecology and environment. In India, Rivers have spiritual connectivity and hence considered sacred. However, the state of major Indian rivers is in deteriorating stage due to anthropogenic activities though the magnitude of which is of varied degree at various segments of the rivers all along the length. The catchments of rivers are under serious threats leading to deforestation and degradation and this has serious implications on quality and quantity of flow of rivers and its tributaries. Realizing the gravity of situation, Government of India took initiative to restore the deteriorating health of major Indian Rivers. Earlier, a Detailed Project Report on Forestry Interventions for Ganga River under *Namami Gange* Programme of Ministry of Jal Shakti, Government of India (GoI) was prepared by Forest Research Institute, Dehradun, an nstitute of Indian Council of Forestry Research and Education (ICFRE), Dehradun in 2016. Appreciating the successful implementation of forestry interventions of Ganga River, GoI had entrusted ICFRE to prepare Detailed Project Report (DPR) for Rejuvenation of Major Rivers of the Country through Forestry Interventions on the line of Ganga River DPR. The HFRI, Shimla a regional Institute of ICFRE had been entrusted to prepare DPRs of 05 major Himalayan Rivers *viz*., Jhelum, Chenab, Ravi, Beas and Sutlej of Indus River Basin flowing in the western Himalayan region. The present DPRs of 05 rivers and its tributaries of Indus River Basin may either be implemented by MoEF&CC at its own or may request the Ministry of Jal Shakti to provide required funds to execute or implement as a joint venture in collaboration with any other Central Ministry/National or International Agency. Alternatively, the MoEF&CC may decide to implement the specific component(s) of the project and implement the whole programme in partnership with other Ministries/Agencies.

Among the National funding agencies, National Medicinal Plant Board (NMPB) can play important role in implementation and funding of medicinal plants component as proposed in the DPR. The NMPB is responsible to develop proper mechanism for co-ordination between various Ministries/Departments/Organizations and implementation of support policies/programmes for conservation, cultivation, trade and export of medicinal plants sector. The NMPB assesses

demand/supply position relating to medicinal plants both within the country and abroad and inventorisation and quantification of medicinal plants. It also promotes *in-situ/ex-situ* conservation and cultivation of medicinal plants and co-operative efforts among collectors and growers and assisting them to store, transport and market their produce effectively. NMPB also provides fund for organizing training programs to build the capacity of stakeholders on medicinal plants.

1.10.8 The Himalayan Forest Research Institute (HFRI) – A Knowledge Management Centre

The Himalayan Forest Research Institute (HFRI), Shimla is one of the nine regional Institutes under the umbrella of ICFRE. It was initially established as the High Level Conifer Regeneration Research Centre in 1977 specifically to carry out research on problems associated with natural regeneration of Silver Fir and Spruce. The HFRI has successfully been providing services based on sound scientific and technological basis, with a multidisciplinary approach to various forestry sectors through its scientists and distinguished practicing forests. In 1998, the Government of India appreciating the environmental problems of Temperate Forests Ecosystems and high altitude ecology in the Himalayan States, particularly Himachal Pradesh and Jammu & Kashmir decided to develop this Centre to a full-fledged research Institute at the time of reorganization of forestry research in ICFRE. The Institute has been mandated to carry out forestry research, education and extension activities in one Himalayan States (Himachal Pradesh) and two UTs-J&K and Ladakh with a focus on eco-rehabilitation of cold desert, sub-tropical and temperate regions, regeneration of coniferous and broad-leaved forests, insect pest management and popularization of agro-forestry. HFRI is well equipped with state of the art laboratories and other facilities in its own campus at Panthaghati, Shimla. The institute has established experimental field research stations and model nursery in different parts of Himachal Pradesh, J&K and Ladakh. The Institute has a team of multidisciplinary scientists working in six divisions and supported by technical staff. Since its establishment, HFRI has made significant contributions towards the development of suitable nursery techniques, propagation of native plant species and eco-restoration of mined areas and cold desert. Over the years, HFRI has developed as a knowledge management centre in the field of high altitude ecology (Himalayan and Trans-Himalayan regions) and conservation of diverse temperate forest ecosystems and privilege to have essential ingredients: (a) professionals and expertise, (b) state of the art laboratories and other physical infrastructure, and (c) processes and innovative technologies.

1.10.9 Project Development Phase and Preparation of DPR – The Approach

As directed by the MoEF&CC and ICFRE, the HFRI has followed the broad framework of DPR as adopted in the context of forestry interventions for rejuvenation of Ganga River. Long field

based experience, existing scientific knowledge and multi-disciplinary expertise available at the institute have been optimally utilized for planning, assessment and development of suitable approach, and strategies in the case of Ravi River. The Ravi River originates in Himachal Pradesh and flows in the plains of Punjab before its confluence with Chenab River in Pakistan. In short, concerned two States namely, Himachal Pradesh and Punjab and one Union territory (J&K) were involved in the extensive consultative process, planning and assessment. The Project Launch Workshop and sequential Consultative Meetings organized in concerned States and Union territory included policy and decision makers representatives of State Forest Department and various line agencies – Agriculture, Horticulture, Animal Husbandry, Mining, Irrigation, Hydroelectric Projects; state/national level scientific or specialized organizations – Soil and Water Conservation, Hydrology, Forestry, Wildlife, Environmental Management, Central Water Commission, Groundwater Board, Remote Sensing and GIS; Universities; Civil Society; and Non-Governmental Organizations besides conservationists and field practitioners. The well planned consultative process and feedback from various stakeholders have been the key step in the formulation of strategies and preparation of present DPR. Constant persuasion, guidance and support at all stages by the Hon'ble Union Minister for Environment, Forest and Climate change Hon'ble Forest Ministers of Himachal Pradesh, Jammu & Kashmir and Punjab, senior officials of the MoEF&CC, ICFRE and SFDs were instrumental throughout the process of planning and finalisation of the DPR.

1.10.10 The Logical Framework Approach

Freshwater ecosystems, particularly rivers and its resources are used for a wide variety of purposes and by various agencies. Thus, people interact with river resources in different ways which impact the water environment. Managing a river basin or river ecosystem or a riverscape is a challenging task due to conflicting and competing needs such as drinking water, industrial supply, irrigation, power generation, waste dumping, navigation, sand mining, fish harvest, water sports and recreation, and flood mitigation besides the development of the basin in terms of water resources, urbanisation and wetland protection (Bong and Putuhena, 2008; Puranik and Dhadwad, 2015). In view of the conflicting demands and in order to protect, conserve and utilize river resources sustainably, it is essential to take into consideration the diverse and complex relationship with other components of environment while planning whether it is for river basin development or river conservation. Hence, Riverscape level planning and conservation require integration of physical, biological and socio-economic sub-environments of river ecosystem adopting participatory approaches and active involvement of stakeholders.

Most developmental projects, irrespective of the sector focus on complex socio-ecological systems in which ecological, social and economic processes are closely intertwined. The developmental agencies rightly emphasize on 'pathway to change' or 'impact chain' or 'Results-Based Management (RBM)'. The Theory of Change stress upon the 'process' through which

change will occur and specifies the ways in which all the required outcomes and desired long-term change (impact) will be brought about. RBM as a broad management strategy aims at achieving improved performance and demonstrable results (UNDP, 2009).

In the past, the holistic and results-based project approaches to planning and management of various developmental projects were ignored. Over the years, various international agencies working in the development sector have evolved various approaches *viz.,* Logical Framework Approach (LFA), Programme Logic Model (PLM) and Results-Based Management (RBM) those offer analytical tool for systematic and logical approach for designing projects with inbuilt mechanism for distinct performance review or evaluation so as to enhance the efficiency of such developmental projects and to ensure accomplishment of desired outcomes and goals (Framst, 1995; Cummings, 1997; Puranik and Dhadwad, 2015; Örtengren, 2016). The LFA was developed in late 1960s and its use became a requirement for the projects funded by USAID. The RBM is an evolution of a standardized budgeting system i.e., Results-Based Budgeting introduced within UN Agencies in the late1990s. Cummings (1997) has described role and use of LFA, PLM and RBM and pointed out their similarities and differences. The paper also noted that the approaches are perhaps not so much distinctive and suggested that practitioners could benefit from increasing cross-fertilization of ideas emerging from these resembling approaches.

LFA since its origin in 1960s has been under continuous development. Increasingly, LFA is employed in wide array of projects and sectors. LFA is an extensive, participatory and integral method that delivers a well-structured plan with clearly measurable objectives and well-defined, relevant activities and indicators (Örtengren, 2016). The approach facilitates the planning, monitoring and management of 'change processes' so that they can achieve positive and sustainable results. The LFA approach has proven to be a useful and effective tool when following the principles of RBM. The approach is an aid to the logical thinking and ensures that the basic premises are probed extensively and the interrelated key elements are analysed systematically. Considering the recognition of LFA as one of the most efficient tools for designing, implementation, monitoring and evaluating developmental projects, this approach has been used in the process of preparation of present DPR. According to the LFA methodology, the cyclic project planning process includes the nine steps: (a) the contextual analysis, (b) situation and problem analysis, (c) analysis of stockholders, (d) activity planning, (e) resources planning, (f) monitoring result, indicators and means of verifications, (g) risk analysis and management, and (h) analysis of assumptions. The logical framework or log frame developed in the process has been elaborated in Part II, Chapter 5 of the DPR.

The entrusted task on the preparation of DPR includes one year duration 'Project Preparation Phase' while 'Project Implementation Phase' has two phases. Phase-1 deals with project implementation and the phase-II (Maintenance phase) has been envisaged for maintenance of plantations raised in phase I. So, The Logical Framework Approach has been adopted for the formulation of DPR. It is important tool thinking for relating inputs to the implementation of

activities, activities to the production of outputs, outputs to the achievement of a defined purpose, and purpose to a high-level goal or impact. The LFA summary is a living document consulted and altered through the project's lifecycle based on the new information, monitoring and lesson learnt; besides, it facilitates efficient communication mechanism between decision makers, practitioners and other stakeholders involved in the project.

1.10.11 Aims, vision and Objectives of the Project

In the broad sense, the proposed Implementation Plan aims to contribute towards restoration of Ravi River by way of ensuring *Aviral Dhara* and *Nirmal Dhara,* besides maintenance of ecological and geological integrities. Based on extensive consultative process carried out as a part of this DPR, the following shared vision emerged for the Implementation Plan:

Vision: Conservation and sustainable use of biodiversity of Ravi River ecosystem is fundamental to ecologically sustainable development. Biodiversity is an integral part of human lives and livelihoods and constitute resources upon which families, communities, nations and future generation depend.

Mission: The mission is to accomplish the above shared vision by adopting multi-pronged strategy and pursue of five specific strategic priorities: (a) address drivers of environmental degradation and arrest biodiversity loss, (b) adopt integrated, innovative and nature based solutions, (c) enhance resilience and adaptation, (d) build alliances and foster synergies, and (e) opt for the right influential models and interventions so as to achieve reduced pressure on biodiversity, restore degraded ecosystems, promote sustainable use of biological and water resources, enhance capacities, mainstream biodiversity, augment policy and law support, and facilitate science based efficient decision making.

The following objectives were set forth for achieving the aim of the entrusted assignments:

i. To review and assess the existing situation of river basin, past river management and implications and lessons learned
ii. To identify and involve stakeholders and build consensus for design and development of strategies and approaches
iii. To assess ongoing forestry activities of the states engaged in the river management programmes
iv. To assess potential and possibilities for regeneration, improvement, and restoration of forest catchments
v. To assess the conditions of riparian forests and potential of biological filters
vi. To examine the possibility of allied and other income generation activities
vii. To assess the potential of cultivation of medicinal plants and restoration of conservation areas and identify appropriate species and suitable sites

viii. To identify research and monitoring needs and develop a strategy for future research and monitoring

ix. To formulate strategies, develop approaches, and plan activities for project implementation

1.10.12 Expected Outcome of the Project

The proposed efforts towards river restoration are confined exclusively to forestry interventions aiming for enhancement of forest cover, grassland and wetland management, reduction in soil erosion, riparian management, and instream/aquatic habitat and species management. Generally, a well-developed tree cover has positive effects on water quality (Calder, 2007) and can prevent surface erosion and shallow land sliding, especially by reducing surface runoff (Bruijnzeel, 2004; Sidle *et al*., 2006). The overall impact on water yield largely depends upon the extent of the catchment planted and the spatial configuration of the trees. The preceding Chapters and foregoing description have amply highlighted the strong interconnectedness between forests and rivers and how both these natural ecosystems have been impacted by humanity in spite both ecosystems offer a wide range of ecosystem services for human well- being, prosperity and sustainable development. Proposed forestry interventions involving extensive plantation activities in three landscapes i.e., Natural, Agriculture and Urban within the Ravi Riverscape besides execution of planned conservation interventions and supporting activities. Likely potential benefits of proposed interventions in terms of increased availability of water; enhanced e-flow; reduced soil erosion and sedimentation; augmented forest cover; and improved water quality, terrestrial and aquatic biota, ecosystem services and rural livelihoods besides significant contribution towards climate change mitigation by way of sequestration and storage of carbon. However, potential benefits and outcomes in quantitative terms are computed and summarized in chapter 8.

1.10.13 The Organization of DPR

The present DPR is prepared in two Volumes. Volume I deals with the main DPR while the Volume II contains summaries of two States and one Union Territory along the course of the Ravi River. The Volume I consist of eight chapters dealing with the existing situation of the Ravi Riverscape and the proposed plans. Chapter 1 - 'Introduction highlights the complexity and dynamic nature of rivers and its linkages with forests, other lands, and human well-being, past and present river management, evolving concepts and holistic approach of basin management and riverscape, current task on forestry interventions, logical framework, and the organization of the DPR. Chapter 2 highlights the existing environment (physical, biological, and socio-economic) in the broader context of Ravi River Basin, in particular the riverscape under consideration along the course of Ravi River. This Chapter emphasizes the details of biodiversity

in terms of diverse forests, grasslands, wetlands, and associated threatened species besides the physical and the socio-economic environment. Chapter 3 describes the riverscape, i.e., the planning and assessment area for DPR and the approach adopted. Chapter 4 deals with the details of various Central and State Government-level agencies and organizations that are directly responsible for the policy and decision making, over-seeing and implementation of various activities relevant to water resources, environment, forest management, biodiversity conservation, river management, etc. This Chapter critically examines the existing policies, conventions, treaties and laws pertaining to the themes of the DPR, identifies gaps, imperatives and future needs from the perspective of various users and those who either influence/impact or are responsible for the management of water resources. Chapter 4 also provides an insight into various civil society organizations Nehru Yuva Kendra Sangathan (NYKS) and Indian Armed Forces (Eco-Task Force), Central Armed Police Forces (Indo-Tibetan Border Police-ITBP that can either undertakes activities relevant to forestry interventions or assists and facilitates in various supporting activities. Chapter 5 under Part II describes the goals and objectives of forestry interventions and the adopted strategies for implementation. This is followed by Chapter 6 which specifically narrates institutional arrangements and mechanisms for project implementation besides aspects of sustainability. The Chapter-7 provides details on the overall project budget, cost tables and the schedule of operations. The last Chapter-8 describes the potential benefits of proposed forestry interventions. References are provided at the end. As already stated, Volume II deals with the summary of concerned two States (Himachal Pradesh and Punjab) and one UT (Jammu & Kashmir) relevant to the Ravi Riverscape that have been included for implementation during the Phase-1 and phase-II of the Project

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Chapter -2

Ravi Riverscape and its Environment

2.1. River Environment

Ecosystems are mainly two types i.e., aquatic and terrestrial. The water based ecosystem is called aquatic environment while land based ecosystem is known as terrestrial ecosystem. On the basis of physical, chemical and biological characteristic of water, the aquatic ecosystems can be further categorized into freshwater and marine ecosystems. Water is an essential requirement of life because most of human civilization are also originated near water courses, especially along the major rivers. Freshwater is widely used for domestic, agricultural and industrial use due to its quality and purity as drinking. Freshwater biological system regulates the running and stable water bodies and their health. Lentic biological systems and lotic sites refer to static and circulating water conditions, respectively. Pragmatically, all biological variables such as temperature, light, pH, gases, water salts, humidity, alkalinity, salinity, density and areal distribution play an important role in regulating the location of these environments (Balasubramanian, 2005). Natural riverine ecosystems are part of larger watershed networks or catchments, where small headwaters streams drain between medium-sized streams, which flow continuously into major river networks. For most people, a river means the water that flows from mountains to the sea. However, flowing water is important part of a living body called the 'River' (Mihov and Hristov, 2011). A river is a large natural course of flowing water obtained from precipitation. The river ecosystem is a complex mosaic of interaction and interrelationship of the biotic i.e., flora and fauna and abiotic i.e., hydrological, geomorphic, etc. components in dynamic equilibrium (Shekhar and Prasad, 2009; Das, 2014). The ecological function of a river is linked to the hydrological variations in the river flow (Jain and Kumar, 2014). Therefore, flow is the most important and significant variable of the river system/ecosystem. Apart from supporting the environment, and performing its geomorphic functions namely, erosion, sediment transport, recycling, etc., during floods, the river adds nutrients to the soil. The river is the last sink of flow to the top of its basin. Due to diversion of river water used for agriculture, industry and domestic use, natural and river water have been used. Excessive use of river resources is exemplified by the lack of long, backward and direct connections to the river system and poor river flow. River pollution by domestic and industrial liquid wastes leads to the deterioration of river health. The encroachment on river space, obstruction of water ways in the drainage basin, excessive sand mining and deforestation in the catchment has further aggravated the problem. The poor health of rivers has adversely impacted the complex dynamic equilibrium in the river basin. It raises question about sustainable use of river resource (Shekhar, 2016).

Four types of connectivity viz., lateral i.e., connectivity of river to floodplain, longitudinal i.e., connectivity throughout the river length, vertical i.e., connectivity to the underlying groundwater and aquifers and temporal i.e., connectivity of river overtime in a river have been recognized for better understanding of the complex nature of a river ecosystem. These four types of connectivity are of paramount importance as they ensure natural processes to continue to occur in a river. Connectivity also ensures flow of energy and nutrients between and within aquatic and terrestrial environments. Due to the above importance of rivers of the countries in the world countries including India have recognized the significance of adopting comprehensive river basin approach or riverscape specific interventions for restoration of major rivers. Thus, the present chapter attempts to study, examine, and understand the nitty-gritty of three sub-environments in the context of Ravi River Basin and the Ravi Riverscape in particular. The present synthesis is based on the review of secondary information for the preparation of present DPR. Thus, synthesis on the environment of the River Basin/Riverscape is solely based on review and an effort has been made to summarize and highlight the vital aspects of three sub-environments from the perspective of DPR and Restoration of Ravi River through Forestry Interventions.

The entire Ravi River Basin in the Indian Territory spreads over an extent of 11,706.41 km^2. Out of this, the delineated Ravi Riverscape includes an extent of 9173.61 km^2 and represents 78.36% of the Basin area (Table 2.1). Details of the area incorporated in the Ravi Riverscape, the rationale, and proportion constituting state/UT-wise have been provided in the Chapter 3.

Table 2.1 - Area Coverage under the Ravi Basin and the Ravi Riverscape

Sr. No.	Consideration Unit	Area Covered (km^2)	Coverage Area (States/UTs)
1.	Ravi Basin	11,706.41	Himachal Pradesh, Punjab and Jammu & Kashmir.
2.	Ravi Riverscape	9,173.61	Himachal Pradesh, Punjab and Jammu & Kashmir.

(Source: Micro-watershed Atlas of India; SLUSI)

As stated earlier, the drainage area of the Ravi River Basin lies in two States, viz., Himachal Pradesh and Punjab, and Union Territory of Jammu & Kashmir. The State and UT-wise distribution of the riverscape area is presented in Table 2.2. The total catchment area of Ravi River in Himachal Pradesh is 5041 km^2 and the entire area has been included in the riverscape. A small sub-set (1,161.7 km^2) of total catchment in Punjab was included as a part of the riverscape. Thus, the larger portion, being 54.95% of the riverscape, lies in Himachal Pradesh while 12.66% area of the riverscape falls in Punjab. Nearly 32.40% area of riverscape lies in the Jammu and Kashmir Union Territory.

Table 2.2- State wise Distribution Area of the Ravi Riverscape

Sr. No.	State	Covered Area in Riverscape (km^2)	Representative Area in the Riverscape (%)
1.	Himachal Pradesh	5,041	54.95
2.	Punjab	1161.7	12.66
3.	Jammu & Kashmir UT	2,970.91	32.39
	Ravi Riverscape (Total)	**9173.61**	**100**

2.2 Ravi River - Headstreams, Main Stem and Tributaries

The Ravi River is one of the five major rivers of the Indus River Basin within the Indian Territory. It is an integral part of the Indus River Basin and forms the headwaters of the Indus River Basin. In Indian Territory, the Basin lies within the States of Himachal Pradesh (HP) and Punjab, and Union territory of Jammu and Kashmir. Ravi River originates from Bara-Bhangal at an elevation of 4,229 m amsl, approximately 150 km north-east of historical Chamba town. It flows in steep gradient with series of loops and bends. In between main tributaries like Kalihan, Budhil, Tundah, Siul and Sewa contributes lot of run off to the Ravi River. Bara-Bhangal comprises of snow covered slopes between 3,050 - 5,800 m amsl. The total length of the course of the Ravi River is about 720 km. from its origin in India to till it debouches into the Chenab River in Pakistan. The basin represents some remarkable features such as, water is clear, transparent, alkaline and well oxygenated. The river flows in a north-west direction for most of its course, rises in Baira-Bansu and continues through Trehta and Chanota to Ulhansa, where it is joined by two of its major tributaries in the head reaches *viz*., Budhil and Tundah. Beyond this up to Chhatrari, river flows through a narrow gorge where after it opens out. After passing through Churi, Bagga, Mehla, Chamba and Udaipur, the river approaches Rajnagar, and then flows in narrow gorge, to Sherpur. The Siul River, its largest tributary joins the Ravi River upstream of Chamera Stage-1 dam site. The Sewa River flowing from the north joins the Ravi River near Khairi. It then bends to the southwest and striking the terminal spurs of the Dhauladhar Range, separates Chamba district from Jammu and Kashmir UT and finally leaves the territory of Himachal Pradesh upstream of Ranjit Sagar Dam Punjab.

Budhil *Nallah* has its origin on the slopes of the mid Himalayas near Kugti Pass, at Harsar. It receives on its left bank the small stream from sacred Lake of Mani-Mahesh, situated beneath the peak called the Mani-Mahesh, Kailash at an elevation of 3,952 m amsl. It passes village Bharmour downstream and soon afterwards meets the Ravi River near village Kharamukh. Tundah *Nallah* rises at Kalicho Pass, flows through Tundah Valley and joins the Ravi River near

Kharamukh. The right bank, tributaries are bigger, and have more discharge as compared to the left bank tributaries except Kalihan, which originates in Dhauladhar Range on the left bank and contributes a good discharge. Both Budhil and Tundah *Nallah* are about 54 km in length (ICFRE, 2011).



Plate 2.1 - The View of Ravi River at Chamba, HP

There are total 34,293 streams and out of this 27,701 streams of first order, 5,162 of second order streams, 1,094 of third order, 253 of fourth order, 62 of fifth order, 17 of sixth order, 3 of seventh order and 1 of eighth order streams in Ravi River Basin in Himachal Pradesh. The Siul River is one of the major tributaries with a catchment area of about 1500 km^2 and contributes a large amount of water to Ravi River. *Ujh* and Sewa *Nallah* are major tributaries which originate in J&K UT and forms part of the catchment lying in Punjab. Deg *Nallah* which is 256 km long with a catchment area of about 730 km^2 is another major tributary of the river that originates in J&K UT, but joins the main Ravi River in Pakistan. The river enters Punjab near Pathankot, forms International boundary while passing through Gurdaspur and Amritsar districts of Punjab and finally leaves Indian Territory at Goina/Kakarmani village some 80 km away from Lahore city. Ravi River join the Chenab River in Pakistan and the ultimately drains into the Arabian Sea. It is one of the rivers which still has good drinking water. The rhithron zone of Ravi River within the

Himalaya has been maneuvered extensively for generation of power by establishment of many dams, Chamera I, II, III and Ranjitsagar/Thein. Ravi Riverscape, its catchment and major Tributaries are given in Fig. 2.1 and length of main stem and its tributaries are described in Table 2.3.

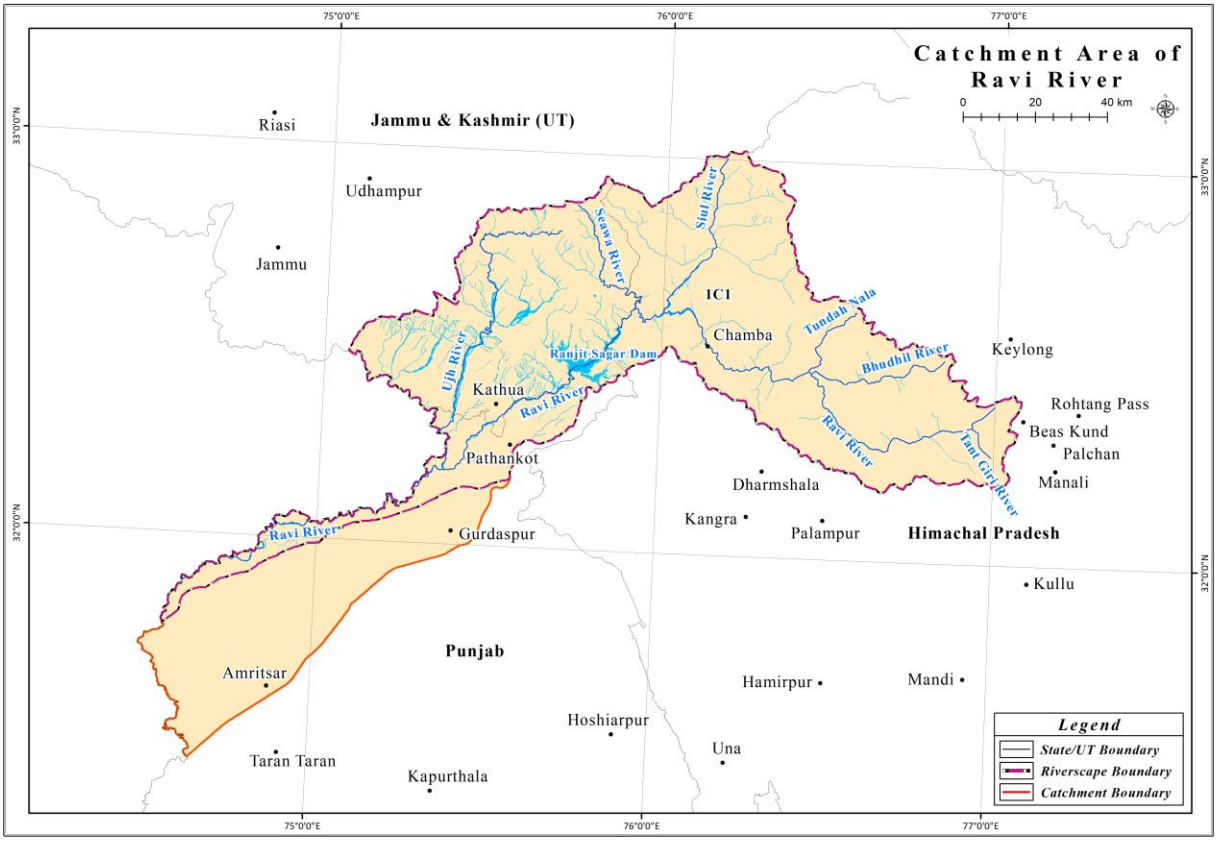


Fig. 2.1 - Ravi Riverscape, Catchment and Major Tributaries

Table 2.3 - Length on Ravi River Main stem and its Major Tributaries

Sr. No.	River Name	State	River length (km)
Ravi main stem			
1.	Ravi River	Himachal Pradesh	**167.67**
2.	Ravi River	Jammu and Kashmir UT	**63.38**
3.	Ravi River	Punjab	**109.64**
4.	**Total Length**		**340.69**

Major Tributaries			
1.	Bhudhil River	Himachal Pradesh	**45.19**
2.	Sewa River	Himachal Pradesh, Jammu & Kashmir UT	**67.55**
3.	Siul River	Himachal Pradesh	**55.27**
4.	Tant Giri River	Himachal Pradesh	**10.55**
5.	Tundah *Nallah*	Himachal Pradesh	**26.6**
6.	Ujh River	Jammu & Kashmir UT and Punjab	**116.78**



Plate 2.2- Loose Strata During Construction of Road

(a) **Siul River:** It rises from the tract between the Dhauladhar and Pir Panjal Ranges near Jammu & Kashmir UT and Himachal Pradesh border. Thereafter, this river flows towards East, takes a U turn and attains a south-westerly course before flowing into the Ravi River downstream of Chamba. This river is fed by both snow melt waters and spring waters.

(b) **Tant Giri River:** Covering a length of 10.55 km, this river rises as a small stream from the slopes of an off-shoot of the Pir Panjal Range in the area East of Bharmaur in Chamba district. The Tant Giri Valley is 'U' shaped. Its bottom is strewn with boulders and morainic deposits laid down by the glaciers in the past.

(c) **Budhil and Dhona (Nai) River:** These tributaries join the Ravi River about 64.37 km downstream from the source. The Budhil River starts off from the Lahaul Range at an elevation of 4,080m amsl and both are Hindu pilgrimage sites, and is fed by the glaciers of Manimahesh Kailash Peak and Manimahesh Lake. The Nai on the other hand takes its course from Kali Debi Pass and after flowing a length of 48.28 km joins the Ravi River at Triloknath (colloquial called Trilokinath). The entire length of Budhil is 72 km where it has a bed slope of 314 feet per mile (59.5m/km). It flows through the ancient capital of Bharmwar, now known as Bharmour in Himachal Pradesh. During 1858–1860, the Raja of Bharmour had considered the Budhil Valley as an excellent source of Deodar trees for supply to the British Raj. However, a part of the forest surrounding the temple was considered sacred and declared as a reserved area.

(d) **Ujh River:** The Ujh River flows through the Kathua district in the Union Territory of Jammu and Kashmir, covering a length of 116.78 km. The source of the Ujh River lies in the snow bound hills of the Bhadarwah town at an altitude of 4,300 m amsl in Jammu province. Ujh-sub basin mainly comprises of hilly and rugged terrain with altitude varying from 510 - 4,300 m amsl. Orographic influences affect the pattern of rainfall distribution in space and time. There are three meteorological stations near the catchment viz., Pathankot, Jammu and Dalhousie.

(e) **Sewa:** The Sewa river originates from Sartha Hill Range and traverses a short course of 67.55 km down to its junction with Ravi River at an altitude of 578 m amsl. The length of the river in the district is 125 km and the average width is about 250 meter. The famous Sewa Hydel Project is being constructed on this river at Village Sewa. The water of Sewa River is utilised for drinking purpose. The Sewa River feeds a number of small canals and Kuhls and its water is utilized for irrigation of agricultural land of the district. It also helps in transportation of timber from hills to plains in bulk and also provides construction material like sand, stones, etc.

(f) **Tundah *nallah*:** The Tundah River flows northeast to southwest and meets the Ravi River near Tundah village of Chamba district, Himachal PradeshApart from the above tributaries, other minor tributaries of Ravi River are Bhadal, Baira, Basantar, Devak and Saki.



Plate 2.3 - Budhil Tributary of Ravi River



Plate 2.4 – Tundah *Nallah* of Ravi River

2.3 The Physical Environment

The concept of environment is quite enormous in scope, ranging from the physical to biophysical and from the natural to the social environments. In a system analysis approach or ecosystem management, the focus is on interactions and inter-relationships between different parts of the environment. The term 'Environment' is simply means 'Surroundings' (Environs). Hence, the environment of an individual, object, element or system includes all entities with which it is surrounded, this means, the abiotic (non-living) and biotic (living) components of the environmental systems.

The Ravi River Basin is the biggest sub-micro region in the Chamba district. Ravi River is rugged and covered with the spurs of the right ranges. The Dhauladhar Range separates the basin of Ravi Beas from that of the Ravi River and the Chenab River and Zanskar snowy ranges, constituting the main topographical features of the area. The Dhauladhar Range running in north-west direction forms the boundary between Mandi and Kullu districts, at the point where it gives off Bara-Bhanghal branch to join the mid Himalaya. It makes a sudden bend westward and for the first time touches the boundaries of district Chamba, on the southern border, from this point, it continues for about 50 km, forming the boundary between Kangra and Chamba districts. The Zanskar range is the most direct continuation of the main Himalaya axis (ICFRE, 2011).

The Ravi Riverscape represents two major physiographic divisions: (a) The Himalayan Mountainous zone in Himachal Pradesh, and some area in Union Territory of Jammu and Kashmir, and (b) Indo-Gangetic Plains in Punjab State. These two prominent physiographic and geomorphological divisions have a direct bearing on the characteristics of Ravi River Basin, the riverscape and the river hydrology in particular. Noticeably, the physical environment of the Ravi riverscape is fascinating owing to the natural grandeur of Himalayan Mountains and vastness of the alluvial plains; incessantly evolving evolutionary and environmental processes, and expanding human imprint by way of developmental projects and intensification of agriculture. Thus, it is of paramount importance to first develop an insight on the physical environment in the context of Ravi Riverscape, specifically with regard to above mentioned two prominent physiographic and geological formations that have experienced continuous change since their creation.

2.3.1 Himalayan Mountains in Himachal Pradesh and Jammu & Kashmir Union Territory

The term 'Himalaya' is derived from the Sanskrit word *Hima* meaning snow and *Alaya* being dwelling, thus the Himalaya is the abode of snow. The Hindus believe it as the symbol of divinity, an abode of the Lord Shiva. Nonetheless, it protects India, in security point of view, from its two neighbouring states i.e.,Pakistan from the northwest and China from the north and northeast, regulate the climatic condition of the Ganges Valley and the Central India and

supports livelihood for over 50 % of the total population of India. The Himalaya also protects the mainland of India from the severe cold waves that origin from the Tibetan Plateau (Sati, 2016). The Himalayan range encompasses enormous variations in elevation, precipitation, biodiversity, and pattern of human livelihoods. These mountains modify the regional climate in complex ways and the ecosystem services they provide influence the lives of almost 1 billion people in 8 countries (Singh and Thadani, 2015). The Himalaya are the highest mountains of the world, also called as the Water Tower of Asia (Schild, 2008). High biodiversity and species endemism make these mountains of significant conservation importance (Dhar *et al.*, 2000; Xu *et al.,* 2009). Forest productivity is high, and the Himalayan forests are important repositories of carbon (Singh and Singh, 1992; Singh and Thadani, 2013). Out of two States, one State i.e., Himachal Pradesh and one UT Jammu & Kashmir represent mountainous part of the riverscape. Himachal Pradesh has the total geographical area of 55,673 km^2 and lies between 30°22'40" to 33°12'40" N latitudes and 75°45'55" to 79°04'20" E Longitudes. Jammu & Kashmir UT lies between 32.7266°N and 33.7782°N Latitudes and 74.8570°E and 76.5762° E Longitudes. The western Himalayan province nestled at the top of Himalayan Range are Himachal Pradesh and Jammu & Kashmir and Ladakh UTs. The larger part of the Ravi Riverscape is primarily constituted by the Himalayan Mountains, within Himachal Pradesh. The Ravi River Basin is flanked by the Chenab River Basin in its north while on the south by the Beas River Basin, both also being the major rivers of the Indus River. Geologically, Himalaya, the youngest folded mountains, still undergoing the mountain-building process (Saxena, 1970).

The Himalayan arc extends from the Indus Trench below Nanga Parbat (8,125 m) amsl in the west to the Yarlung Tsangpo – Brahmaputra gorge below Namche Barwa (7,756 m) amsl in the east, a distance of about 2,500 km and a width of 200 km – 300 km (Singh, 1971; Ives and Messerli, 1989; Rao and Saxena, 1994; Ives, 2004; Khawas, 2008) divided the Himalaya on the basis of geological and geo-morphological characteristics into the three physiographic divisions i.e., (a) Shivaliks, (b) Himanchal, and (c) Himadri, extending almost uninterrupted throughout its length.

(a) **Shivaliks or Outer Himalaya (Sub- Himalaya**): The Shivalik region is located between the Himalaya and the Indo-Gangetic plains of northwestern India. However, its area is reported to range from 2.14 to 8.00 m ha in northwestern India by various workers. In terms of geology and physiology, Shivalik region (3.33 m), covering hills (1.79 m) and its piedmont plains or foot hills (1.54 m ha) in Jammu and Kashmir UT (Currently), Himachal Pradesh, Uttarakhand, Punjab, Haryana, Uttar Pradesh and the Chandigarh UT area between 217 - 2332 m amsl was demarcated. A detailed map showing the Shivalik region will help conserve the region's natural resources without conflict over its location (Yadav *et al.*, 2015)

(b) **Himachal or Lesser Himalaya:** The Himachal Pradesh with an average height of 3,900 - 4,500 m, amsl and width varying from 32 - 80 km forms the central chain and composed

mainly of highly compressed altered rocks from Algonkian or Pre-Cambrian to Eocene in age. These low grade sediments are thrust over the Shivaliks along the MBT. Prominent ranges of the middle Himalaya include the Nag Tibba, the Dhauladhar, the Pir Panjal and Mahabharat.

(c) **Himadri or the Great Himalaya (High Himalaya):** The Great or Inner Himalaya transcends 6,060 m, amsl and incorporate pinnacles like the Everest, K2 (Godwin Austen), Kangchenjunga, Dhaulagiri, Nanga Parbat, and so on, it shapes the foundation of the Himalayan Orogeny. The width of this zone is around 24 km. To the north of Great Himalaya stretch out several ranges such as Zanskar, Ladakh, and the Kailash (Saxena,1970; Khawas, 2008).



Plate 2.5 - General View of Himalayan Mountains of Ravi River Catchment

Apart from the above tectonic/ longitudinal sub-divisions, the Himalayas also exhibit notable regional geographical characteristics. Eight regional divisions on the basis of regional heterogeneity have been described (Singh, 1971; Khawas, 2008). This includes: (a) Western Himalaya regional division i.e., Kashmir Himalaya and Himachal Himalaya sub-divisions; (b) Central Himalaya regional division i.e.,Uttarakhand Himalaya and Nepal Himalaya subdivisions; and (c) Eastern Himalaya regional division i.e., Sikkim, Darjeeling, Bhutan and Arunachal

Himalaya sub-divisions. However, the biogeographic classification of India by Rodgers and Panwar (1988) divides the Himalayan Biogeographic Zone–2 in four biotic provinces viz., 2A North-Western Himalaya, 2B Western Himalaya, 3B Central Himalaya, and 2D North-Eastern Himalaya and the vast region of the Trans Himalaya as a separate Biogeographic Zone-1 having two biotic provinces i.e., 1A-Ladakh Mountains and 1B-Tibetan Plateau. The Himalayan Mountains in Himachal Pradesh have representation of 1A-Trans-Himalaya Ladakh Mountains, 2A-North- Western Himalaya and 2B-Western Himalaya biotic provinces.

Himachal Pradesh, Jammu & Kashmir UT and Punjab form the catchment of four major Himalayan Rivers *viz*., Chenab, Ravi, Beas, and Sutlej feeding to the Indus River System. These main rivers are fed with numerous small first–and higher–order streams and rivers from both sides. Glaciers, snow-capped peaks, headstreams and their tributaries, lakes, waterfalls in the Himachal Himalayan region along with diverse forests in the Outer, Lesser, and Great Himalaya, and the Trans Himalaya play a crucial role. In view of their importance to the basin and the riverscape, the following section attempts to provide an insight on them from the perspective of the physical environment. A large number of International, National and State Level Government Organizations/ Agencies have been carrying out long term researches on varied aspects of the Himalayan Mountains *viz*., their formation and structure, geological characterization, tectonic movements, seismicity, glaciers, snow cover, glacial hazards, hydrology, surface and groundwater resources i.e., springs and aquifers, Erosion and sedimentation, environmental flow, water quality, pollution, climate change, irrigation and hydroelectric projects (HEPs), vulnerability, etc., and have made significant contributions to the relevant literature. A voluminous body of literature highlighting past trends on above themes is available and optimally used to provide a brief synthesis and insight in the context of management of Ravi Riverscape and proposed forestry interventions for rejuvenation of important river like Ravi River.

(A) Glacier, Snow Cover, Glacial Hazards and Vulnerability

Glacier

Glaciers are formed due to the recrystallization and metamorphism of naturally fallen snow on land surface. It is estimated that glaciers cover about 16.3 million km^2 of the globe and hold nearly 77% of world's fresh water resources (Srivastava, 2012). Himalayan region of India is home of some of the most notable glaciers in the world. After the polar ice caps, the Himalaya has the largest amount of glaciers. The glaciers and snow cover of the Himalaya–Karakoram (H–K) region play significant roles in the regional climatic system. The H–K region has the largest concentration of snow cover and glaciers outside the polar regions, with a total glacier cover of ~40,800 km^2 (Bolch *et al.*, 2012) involving 9,575 glaciers in the Indian Himalaya (Raina and Srivastava, 2008). The glaciers and snow cover of the H–K region influence the overall runoff in lowland rivers, recharge river-fed aquifers, provide water for hydro-power, agriculture,

ecosystems and eventually contribute to regional/global sea-level (Dyurgerov and Meier, 2005; Thayyen and Gergan, 2010). Glaciers being physically complex and dynamic systems are sensitive to climate changes (Benn and Evans, 2010). These ice bodies are key indicators for assessing climate change in the Himalayan region, especially areas without having climatic observations instrumentation facility (Barry, 2006; Bolch *et al.*, 2012). Since the end of the Little Ice Age (LIA) (~1850s), Himalayan glaciers have been in a general state of recession (Mayewski and Jeschke, 1979; Bhambri and Bolch, 2009). Himalayan glaciers studies indicate that many glaciers show an increased, receding-trend over the past few decades (Kulkarni *et al.*, 2007; Bolch *et al.*, 2008), and many glaciers have stable fronts since 2000 (Bhambri *et al.*, 2013; Bahuguna *et al.*, 2014). The Ravi River Basin comprises of 198 glaciers. The total area covered by these glaciers is 235.21 km^2 with an ice reserve of 16.88 km^3. The maximum number of glaciers is found to be either oriented towards South (43), followed by North West (31) and North east (29). The largest glacier, Ravi glacier 121, has an area of 18.65 km^2, and is located at 32°25'15.27" N Latitude, and 77°00'10.61" E Longitude. The glaciers in the Ravi River Basin are classified mainly into mountain and mountain basin glaciers, out of which mountain glaciers are dominant in terms of number. There are 98 mountain glaciers and 39 mountain basin glaciers. Of the total ice reserves in the basin the mountain glaciers and mountain basin contain 29.77 and 43.98%, respectively.



Plate 2.6 - Snow-clad Mountains in Ravi River Basin

Bhadal Glacier of Ravi River

It is located in the south-western slopes of the Pir-Panjal range in the Bara Bhangal area of the Kangra district. It feeds the Bhadal River which is a tributary of Ravi River. Bhadal River's catchment is made up of U- shaped valleys, waterfalls, morains, cirques and towering peaks. The size of the Bhadal glacier suddenly grows up because of rapid and heavy snowfall. Glacier inventory of the Ravi River Basin, North-Western Himalaya has been generated for the year 2002 using Landsat ETM + and ASTER Global DEM (GDEM V2) as the baseline data for the change analysis (Chand and Sharma, 2015). Glacier area decreased from 125.8 ± 1.9 km^2 (1971) to 119.9 ± 4.8 km^2 (2010/13), a loss of 4.7 ± 4.1% or 0.1 ± 0.1% a− 1. The glacier recession rate has decreased, to a minimum for the recent decades (2002–2010/13). The debris-covered glacier area increased by 19.2 ± 2.2% (0.5 ± 0.05% a− 1) in the Ravi River Basin. However, there were significant variation in its sub-basins i.e., in Budhil and Upper Ravi sub-basin, where the debris-covered area increased by 28.6 ± 3.1% (0.7 ± 0.1% a− 1) and 14 ± 1.6% (0.3 ± 0.04% a− 1) respectively, between 1971 and 2010/13 (Chand and Sharma, 2015). Glacier retreat rates in the Ravi River Basin were lower than previously reported for selected glaciers in the similar basin and other basins (e.g., Chenab, Beas, Parbati, Baspa and Tirungkhad) of the Himachal Himalaya (Chand and Sharma, 2015).

Snow Cover

Snow cover is the second largest component of the cryosphere and covers 40-50% of the Earth's land surface during the Northern Hemisphere winter. In addition, snow precipitation plays an important role in feeding the glaciers. Annual precipitation of snow feeds the accumulation zone of the glaciers, and is considered an important aspect for glacier mass balance. The Himalaya being the loftiest mountains is an abode of snow (Brown, 2000; Lemke *et al.*, 2007). The snow capped mountainous region is about 80% of the total area of the Himalaya. In the Himalaya, the western part gets more snow than the entire Himalayan area. The snowline, the lowest point on the snow-covered mountain, is about 5,490 m in the equator and 610 m in Greenland. In temperate zones, it is about 3,050 m (Jain *et al.,* 2006). Snow is a dynamic natural element, the distribution of which is largely controlled by latitude and altitude. Snow is especially important for the hydrological cycle, as large amounts of the water Supply come from seasonal snowmelt at high latitudes and in mountainous basins (Barnett *et al.*, 2005). This is particularly true for the Indus River Basin, where snowmelt from the Hindu Kush–Karakoram–Himalaya (HKH) ranges provide the first water available after a long dry period October– March (Immerzeel *et al.,* 2010) that is mainly used for irrigation and power generation (Hasson *et al.,* 2013). Immerzeel *et al.* (2009) have reported the snowmelt contribution to the Upper Indus River Basin (UIB) flows to be around 40%.

In the tropical country like India, snow distribution is mostly controlled by altitude. Aspect has a major impact on snow accumulation in the lower elevations in all the basins as compared to higher elevations. Ravi River has 33% snow cover and the minimum elevation from where snow

covered area appears is 1,058m amsl for Ravi River. Satluj River has the lowest rate of change of snow cover with elevation (1.3% per 100m), Chenab River 1.8% per 100 m, followed by Ravi River 2% per 100m and Beas River (2% per 100m) (Jain *et al.*, 2009). In Ravi River Basin, snow accumulation and ablation are the continuous processes throughout winter. Maximum snowfall occurs from December to March, mostly due to western disturbances (Dobhal *et al.*, 2008). Even in middle of winter, large snow area was observed melting. In January, snow area was observed to be reduced from 90% to 55% suggesting depletion of snow cover between 1800 - 3000 m amsl. This is a significant reduction in snow extent in winter season. The assessment of seasonal snow cover variation during 2015 in Himachal Pradesh using space data was done by the Himachal Pradesh State Centre on Climate Change under the aegis of State Council for Science, Technology, and Environment. The report said that basins on the northern side of the Pir-Panjal showed comparatively better results than the southern basins, but the overall area under snow during peak winter months in these basins was also less than previous years (2010-14). The Ravi River Basin, which is on the southern side of the Pir Panjal also shows less snowfall area during 2015-16.



Plate 2.7 - Cirque formed in Ravi River Basin

Consistent with the unprecedented global warming, the Himalaya has experienced significant warming during recent decades (Shrestha *et al*., 1999; Diodato *et al.,* 2012). Consequently, the annual average snow cover decreased by 16% over the entire Himalaya from 1990 to 2001 (Menon *et al.,* 2010). A similar snow cover trend has also been observed from 2000 to 2008 (Immerzeel *et al.,* 2009) though some regional anomalies do exist. Similarly, most of the Himalayan glaciers have been retreating and losing mass since the end of the Little Ice Age, where current observations show on average, an acceleration of such responses since the mid-1990s (Bolch *et al.,* 2012).

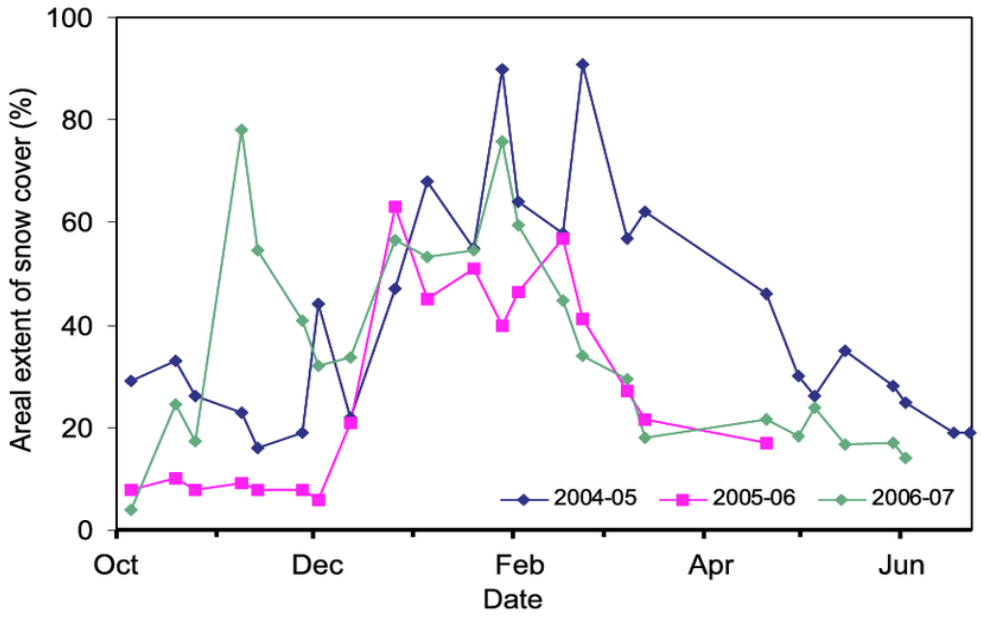


Fig. 2.2- Snow Accumulation and Ablation Curves of Ravi River for 2004, 2005 and 2006

(Source: Kulkarni, 2010)

In Ravi River Basin, a positive trend has been observed during November 2015 which indicates an increase of about 30% in the snow cover area in comparison to the period 2010-14, whereas in October, a decreasing trend has been observed. The peak winter months (December-February) and the late winter or early summer month March shows comparatively more reduction in the snow cover area in this basin which is by about 37%, 48%, 48% and 38%, respectively in comparison to the period 2010-14 (Randhawa *et al.,* 2016). Snow accumulation and ablation curves for Ravi River Basin are given in Fig. 2.2.

Glacial Hazards

The GLOF is characterized by sudden release of huge amount of lake water that rushes along the channel downstream in the form of dangerous flood waves. GLOF surges trigger landslides and bank erosion that temporality blocks the surge waves and result in a series of surges as the landslide dam is breached. Glacial Lake Outburst Floods (GLOF), avalanches and flash floods are considered as primary hazards while rock fail/debris fall can be considered as a secondary hazard. Out of 7 major lakes, of Ravi River Basin, only one lake is characterized as potentially dangerous lake i.e., Ravi – glacial (gl) 13 lake. It has the association with the glacier Ravi_gr 184 at a distance of 76 m distance (Bhagat *et al*., 2004). The Himalaya in Himachal Pradesh is also prone to avalanches that trigger downward movement of rock mass, ice blocks and snow. The high Himalayan valleys close to glaciers are susceptible to avalanches.

Vulnerability

Vulnerability has been defined as the degree to which a system or part of it, may react adversely during the occurrence of a hazardous event (Proag, 2014). Ravi River Basin is vulnerable to earthquakes, Glacial Lake Outbursts Floods (GLOFs), cloud bursts, avalanches, landslides, hailstorms, and flash floods. The fragile and steep hills in the Himachal Pradesh are witnessing massive construction activities and development of infrastructure i.e., roads, bridges, dams, airports, etc. and concrete townships despite the State falls in the high Seismic Zone IV and V. Earthquake, poses biggest threat to the concerned States/UT. Himachal Pradesh has been shaken by more than 80 times by earthquakes having a magnitude of 4 and above on the Richter Scale as per the recorded history of earthquakes. As per the BIS seismic zoning map, five districts of the State namely, Chamba (53.2%), Hamirpur (90.9%), Kangra (98.6%), Kullu (53.1%) and Mandi (97.4%) have 53 to 98.6% of their area liable to the severest design intensity of MSK IX or more. Much of the Ravi River Basin, particularly areas of Kangra and Chamba Districts fall in the seismic Zone V. Ravi River catchment area of Kathua district in Jammu & Kashmir UT comes under seismic zone IV (J&K SDMA, 2016 ; J&K SDMP Draft, 2011). In Punjab most earthquakes are shallow though a few earthquake of intermediate depth have been recorded. The district Pathankot falls in zone IV and earthquake of intensity VIII on the seismic scale corresponding to MMI (Modified Mercalli Intensity) making it prone to earthquake. April 1905 earthquake of Kangra (Himachal Pradesh) is the deadliest earthquake till date in Punjab. Close to 30,000 people were killed in the Kangra Valley and the adjoining parts of northern India and Pakistan. Shocks from the temblor were experienced as far as Puri, on the Mahanadi Delta in Orissa. Damage from the earthquake extended into many parts of the Punjab including Pathankot district (EIA-EMP Report, 2016).

Floods are another form of natural disaster which the state experiences every year. Due to the diverse topography of the area, the flood problems in the state is largely isolated in Nature. High monsoon rains in the area of the Shivalik and lower and mid Himalayan ranges cause extensive

floods during rainy season. In the upper reaches of the Ravi valley, the main problems are flash floods and bank erosion because of the steep slopes of river and high river flows due to heavy rains. The 1955 flood was the highest on record for the Ravi River with peak discharges of 17,840 cubic meters per second ($m^3\ s^{-1}$) at Madhopur Headworks,18,661 $m^3\ s^{-1}$. Due to floods in Ravi River since last so many years, the left bank of the river has been heavily eroded away at many places. Although the Ranjit Sagar Dam has been completed in 2001 and chances of flash floods in Ravi River have been consequently reduced to some extent, but the area downstream Madhopur Head Works is prone to flooding. These flashy torrents sometimes carry high floods during monsoon with heavy rainfall in their catchments areas. In Punjab State districts Amritsar, Jalandhar and Gurdaspur, villages are inundated by Ravi River floods.

The Himachal Pradesh is prone to various hazards caused by landslides. Kahlon *et al.* (2014) have provided a summarized comprehensive account on landside hazards in different districts of Himachal Pradesh.

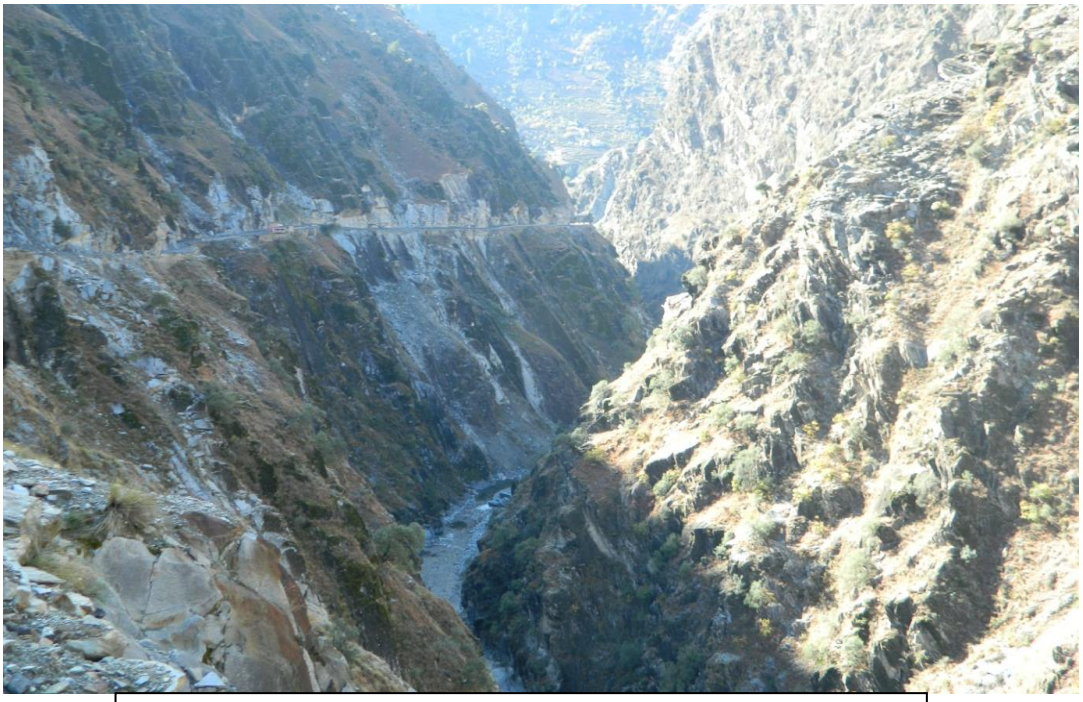


Plate 2.8 - Ravi River Flowing in Deep Gorge

In Chamba district, 6370 km^2 area is Landslide Prone Area, out of which 2120 km^2 area comes under Severe to very High zone area (HPSDMA, 2018). Location of past landslides coincide with Major River Systems of Himachal Pradesh are represented in Fig. 2.3.

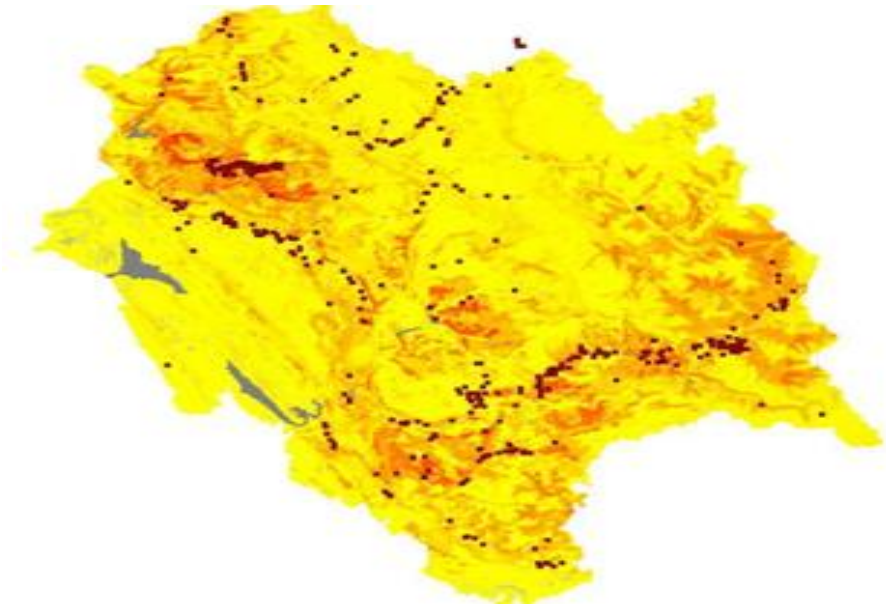


Fig. 2.3– Location of Past Landslides Coinciding with Major River Courses in Himachal Pradesh

(Source: TARU, 2015)

(B) Hydrology – Surface and Groundwater Resources, Sedimentation, Environmental Flows and water Quality

The Ravi River like any other Himalayan River has a typical Himalayan Basin comprising broadly of three parts: (a) Upper glacier-fed basin (> 4,000 m amsl), (b) Middle snow-fed basin (2,000 m - 4,000 m amsl), and (c) Lower rain-fed basin (below 2,000 m amsl). Annual variation in climatic conditions, particularly precipitation i.e., snowfall and rainfall has greater influence on the availability of surface water, runoff, and groundwater recharge. The waters of the Ravi River are allocated to India under the Indus Waters Treaty signed by India and Pakistan. Within India, the river is under the jurisdiction of the riparian States of Punjab and Himachal, and non-riparian states of Haryana, Jammu & Kashmir UT and Rajasthan, but management is presided by the Supreme Court of India and the Ravi-Beas Tribunal, set up in 1986 for the purpose. The hydrology of the Ravi River is controlled by spring snowmelt and the South Asian monsoon that brings heavy rains from June to September. The Ravi River has flood discharges in excess of 600,000 cubic feet (17,000 m^3) per second during the summer monsoon season, but during the winter, the flow is substantially reduced together with the suspended sediment load. The average annual rainfall for the Ravi River Basin is 1370 mm and the highest amount of rainfall is received in the month of August i.e., 20% of the average annual value. Significant amount of rainfall occurs during winter month of January to March i.e., 26% of the average annual value, which reflects the significant contribution of Western Disturbances (EIA, 2010). Various hydrological aspects of the Ravi River from the perspective of availability of surface and

groundwater resources, its use for agriculture by way of irrigation and groundwater exploitation, power generation by creation of dams, reservoirs and hydroelectric projects, river fragmentation i.e., barriers - water storage in dams,

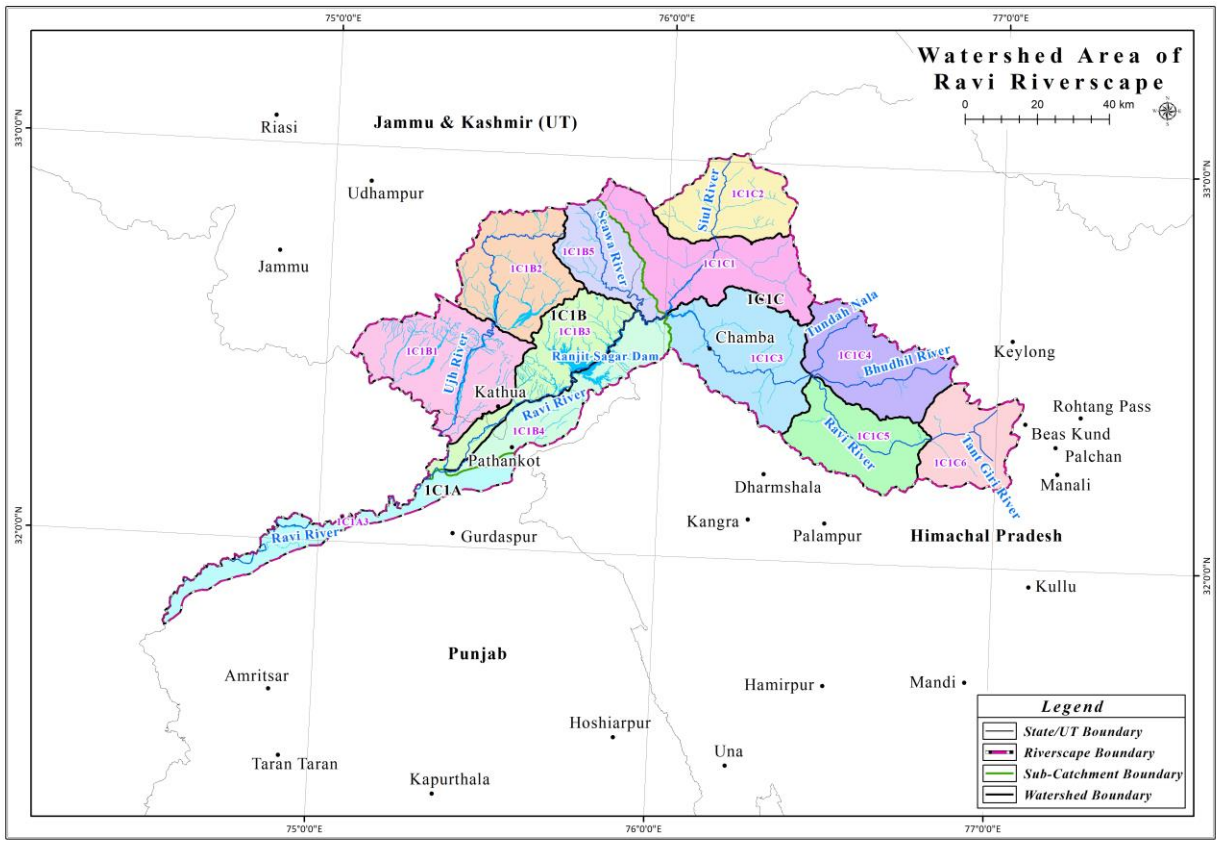


Fig. 2.4 – Ravi Riverscape with Tributaries and Watershed

reservoirs and diversion of water by tunnels and canals, pollution i.e., dumping waste and sewage into the river have been important aspects of study.

Surface Water

The water resources potential of the country, which occurs as a natural runoff in the rivers is about 1869 Billion Cubic Meters (BCM). Ravi River terrain is made up of mainly basaltic rock

and exhibits dendritic and Herringbone drainage pattern is classified as highly sloping and high runoff zone which give rise to high drainage discharge (Sharma, 2018). Sub-basins could be sub-divided into smaller hydrological units namely, watershed for water resources management at larger scale (Micro level). Size of the watershed is governed by the size of stream and its boundaries. Ravi River has 20 number of watersheds in its basin whose size ranges from 390 - 1303 km^2 (Fig. 2.4). However, due to various constraints of topography and uneven distribution

over space and time, only about 1123 BCM of the total annual water potential can be put to beneficial use. This can be achieved through 690 BCM of utilizable surface water and 433 BCM through ground water. While water for drinking purpose has been accorded top most priority in water use, irrigation is the major consumer of water. Ultimate irrigation potential which can be created through major and medium irrigation projects is assessed as 58.47 Mha. Irrigation potential created in the country from major and medium irrigation projects, which stood at 9.7 Mha. in 1951, has risen to 47.97 Mha by the end of XI Plan. Besides this, an additional irrigation potential of about 35 Mha can be created by taking up long distance inter basin transfer of water from surplus to deficit basins. The irrigation potential of Himachal Pradesh, J&K and Punjab is 50,250 and 3,000 Thousand (ha.) respectively (CWC, 2017). A significant portion of the discharge from the Ravi River comes from the Himalayan mountain system, primarily glaciers, snowmelt and rainfall and runoff during the monsoon season. The hydrological cycle in the Ravi River Basin is governed by the south-westmonsoon. About 84% of the total rainfall occurs in the monsoon from June to September. Consequently, water flow in the Ravi River and its tributaries is highly seasonal.

Surface water bodies have traditionally played an important role in the lives of common people in India by way of irrigation, drinking water supply, ecology, tourism and domestic uses. In Ravi River Basin in Himachal Pradesh, the drainage density is categorized into 10 categories. In Ravi River Basin the drainage density is very high in lower stream orders areas because of dissected topography and due to this the erosion processes are also very high. It is observed that the canopy areas of Dhauladhar and Pir Panjal, the drainage density is very high of > 9 kms per square kilometer. It is also observed that in Ravi River and its major tributaries bed areas, the drainage density is low. It is found out from drainage density map that in Glacier covered areas; the drainage density is also low. It is also found out that with the increasing of stream order the drainage density is decreasing (Sharma, 2018).

Annual Flows of the Ravi River and Water Balance

The hydrological aspects in the case of Ravi River could be appreciated by understanding the integrated operation of the Beas-Sutlej-Ravi System as the Beas-Sutlej link, comprising a diversion dam at Pandoh across the Beas River was created to transfer 4,727 million m^3 of water to Bhakra Reservoir on the Sutlej River through tunnels and open channels (Rao and Ramasheshan, 1985). Likewise, water from the Ravi River is transferred by a diversion at Madhopur Headworks through the Madhopur-Beas Link to the Beas River, Sutlej, Beas, Ravi and their main canal network is shown in Fig. 2.5. The interconnected surface water budget system of the Beas, Sutlej, and Ravi Rivers was shown diagrammatically by Lamba and Prem (1975) and adopted by Rao and Ramasheshan (1985).

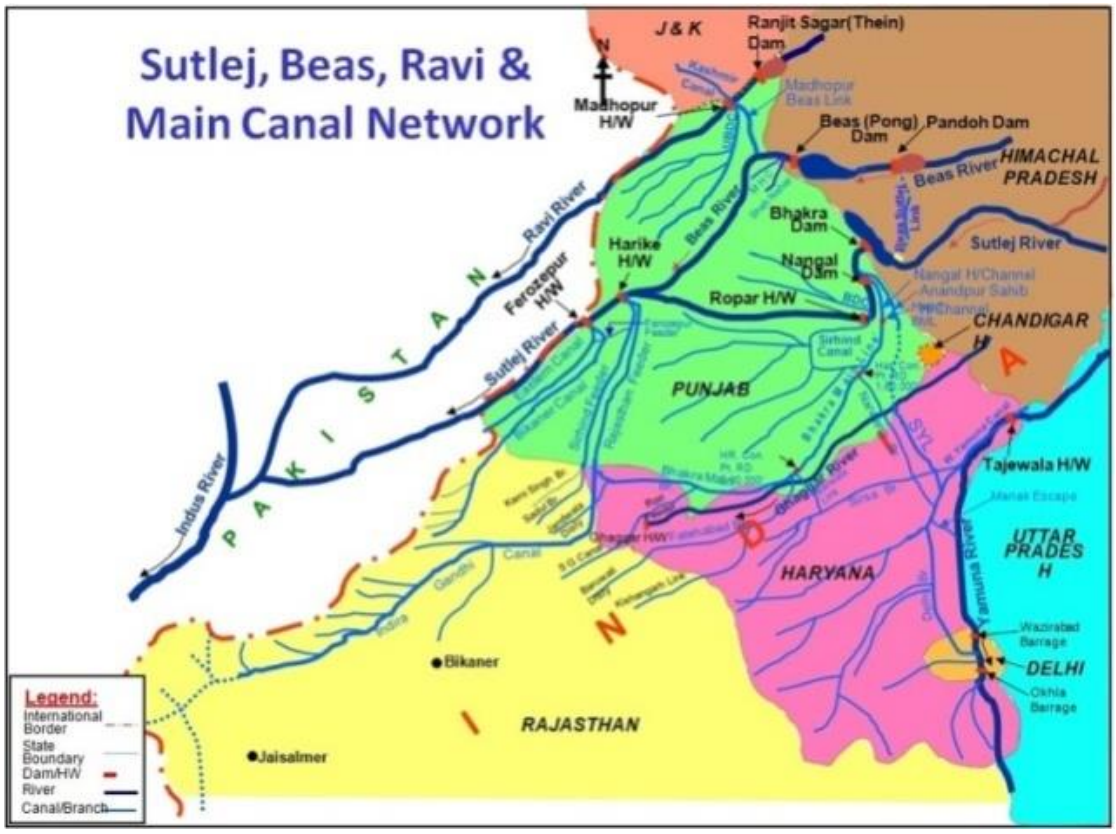


Fig. 2.5 – Sutlej, Beas and Ravi Rivers and Main Canal Network
(Source: cwc.gov.in)

Water Use and River Fragmentation

The term water use, while common, can mean many different things, referring at times to consumptive use and at times to withdrawals of water. Withdrawal usually refers to water removed from a source and used for human needs. Some of this water may be returned to the original source with changes in the quantity and quality of the water, but some may be used consumptively. The term consumptive use or consumption typically refers to water withdrawn from a source and made unavailable for reuse in the same basin, such as through conversion to steam, losses to evaporation, seepage to a saline sink, or contamination (Gleick, 2003). Ravi River and its tributaries have been used for irrigation since ancient times. The two states and one Union Territory have varying intensity of irrigation and the values of net irrigated ranged from 21% (HP), 42.831% (J&K) to 98% (Punjab) (DAC&FW, 2015). The gross irrigation potential of HP is estimated to be 3.35 lakh hectare, while the irrigation potential created has reached 2.56 lakh hectare by September 2013. Total replenishable groundwater resources of Himacha Pradesh is 0.036 m ham/yr. The ground water uses for irrigation activities for Himachal Pradesh computed as a whole was to the tune of 0.029 m ham/yr. In addition, 0.007 m ham/yr of ground water is drafted for the purpose of domestic, industrial and other uses in Himachal Pradesh. The cropping intensity and irrigation potential have already been fully exploited in Punjab and the

growth in productivity has also reached at a saturation point. Therefore, agriculture sector is showing slow growth trend over a period of time. Besides, farmers are not ready to take risk due to assured returns of wheat and paddy, and very few advances have taken place in Research and Development in this sector. Most of the growth is generally due to increase in the MSP of Wheat and Rice every year than due to increase in production (GoPES, 2018). Interconnected Surface Water Budget System of three rivers namely Beas, Sutlej and Ravi has been given in Fig. 2.6.

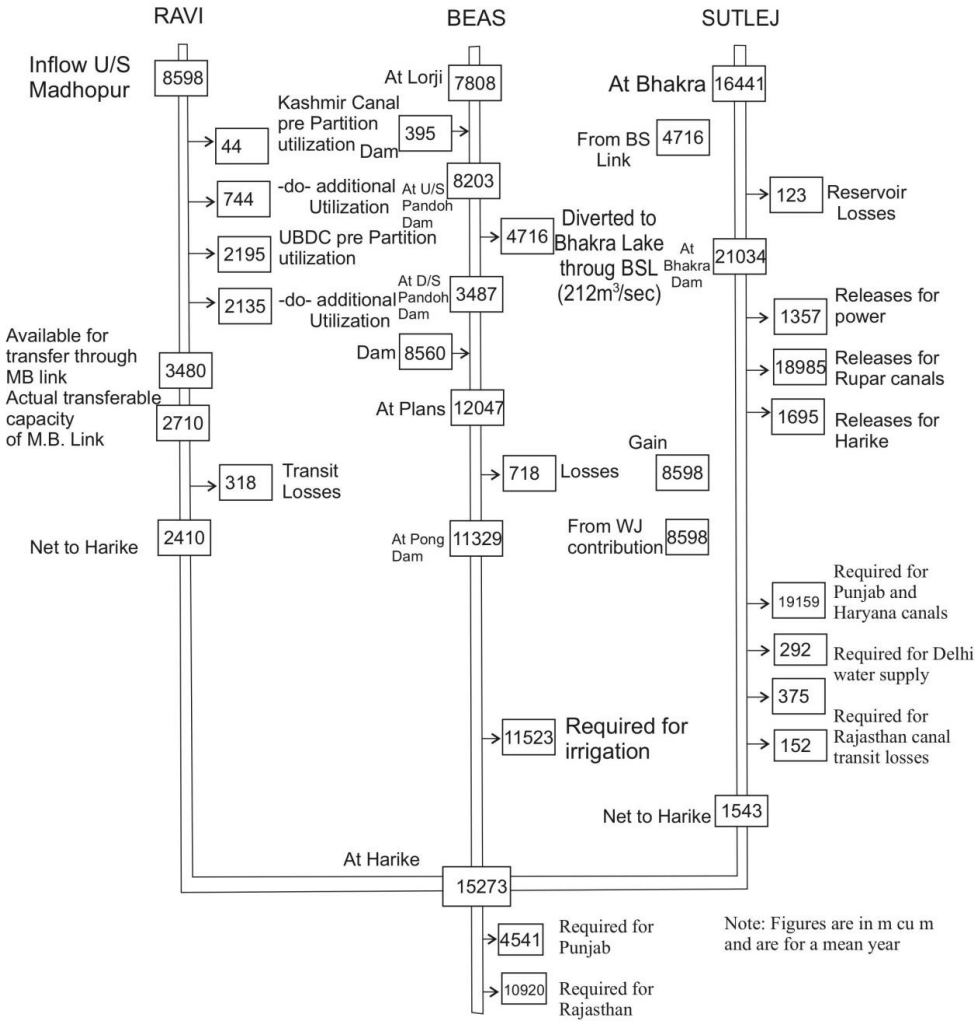


Fig. 2.6 – Interconnected Surface Water Budget Systems of Beas, Sutlej and Ravi Rivers
(Source: Lamba and Prem, 1975)

Agriculture in Punjab has a heavy requirement of water for irrigation and there is an excellent network of surface and ground irrigation facilities serving this purpose. About 99 % of net sown area in the State is irrigated. Punjab has an organised irrigation distribution set up through canals, branch canals and minor distributaries and field channels or water courses. The cultivation of

high water demanding crops particularly paddy is an important factor accountable for decline in underground water levels in Punjab. Annual availability of surface and ground water in the State is 3.48 million hectare meters (M ha-m). However, the annual demand for State agriculture is 4.76 mhm. as given in Table 2.4. The annual deficit to the tune of 1.28 mhm every year is met through the overexploitation of underground water by tube wells leading to serious problem of deteriorating underground water resources. Overtime, tube well irrigation has been increased and about 73 % of the total irrigated area is irrigated by underground water pumped out by about 14.05 lakh tube wells in the State. This is mainly due to availability of cheap credit and free supply of electricity in the State. As, for the last many years, the Punjab farmers are getting free electricity supply for the use of tube wells as well as canal water irrigation (Grover *et al*., 2017).

Table 2.4- Status of Water Resources in Punjab

Status of water resources in Punjab	
Annual canal water available at H/w	1.79 M ha-m
Annual canal water available at outlets	1.45 M ha-m
Annual canal water available	2.03 M ha-m
Total annual available water resources	3.48 M ha-m
Annual water demand	4.76 M ha-m
Annual water deficit	1.28 M ha-m

(Source: Jain (2012), Department of Soil & water Engineering, PAU, Ludhiana)

In J&K UT, the irrigation projects are classified into three categories viz., major, medium and minor irrigation projects. A Project which have a Cultivable Command Area (CCA) of more than 10,000 hectare is termed as major project. A project which has a CCA of < 10,000 hectare, but > 2,000 hectare are termed as medium projects and those which have a CCA of 2,000 hectare or less are known as minor projects. Minor irrigation projects have both surface and ground water as their sources, while major and medium projects mostly exploit surface water resources. In J&K UT, irrigation potential is created under funding through Accelerated Irrigation Benefit Programme (AIBP), Border Area Development Programme (BADP) and State Sector/District Sector Schemes (including NABARD loan assistance). Presently, 9 major/medium irrigation schemes are under implementation in the State, out of which, 5 are funded under AIBP, 3 in the State Sector and remaining 1 scheme under loan raised from NABARD.

River Fragmentation

The obstruction of a river's flow by dams, barrages and inter-basin transfers is known as River Fragmentation. Fragmentation of river systems is pervasive and growing, and is a large, but underappreciated threat to freshwater biodiversity (Benke, 1990). As per India-Water Resources Information System (WRIS) database, Ravi River sub-basin has fair number of water resource assets and large waterbodies as compared to other sub-basins. There are mainly 7 dams, 3 barrages, 1 weir, 2 lift irrigation schemes and 9 power houses. Himachal Pradesh has got 4 dams namely Baira Siul, Chamera I, Chamera II and Chemera III. All are on Ravi River and falls in Chamba district. Two dams namely Sewa St II Dam on Sewa River, Ranjit Sagar Dam on Ravi River fall in Kathua district of Jammu and Kashmir UT. The Shahpur Kandi Dam (in construction) on Ravi River falls in Gurdaspur district of Punjab. Ujh Level Crossing Barrage (Ujh River) and Sewa - III Barrage (Ravi River) are constructed in Kathua district of Jammu & Kashmir UT.

Ravi-Tawi Irrigation Complex

The Ravi-Tawi Irrigation Complex is a conglomerate of two canals namely, Ravi Canal and Tawi Lift Canal. The Ravi Canal was envisaged for construction in early 1970s to draw J&K UT's share of 1150 cusecs water of Ravi River through gravity to irrigate the arid Kandi lands of Kathua and Jammu districts. In the beginning, the canal was to take off from the right bank of Thein Dam (now called Ranjit Sagar Dam), but because of a subsequent agreement reached between the states of Punjab and J&K UT, it had to take off from the right bank of Shahpur Kandi Barrage. This Barrage, which was tornment, still has not been taken up in full swing despite the lapse of around 30 years after signing of the said agreement. The expansion and intensification of agriculture in the plains of Punjab coincides with the development of irrigation potential on account of expansion of canal network and reservoirs and also with the advent of technologies related to agriculture and irrigation. Post-independence agriculture expansion in the country for food self-sufficiency and efforts to boost activities under the programme of green revolution resulted in the loss of forests and other natural vegetation besides reclamation of swamps and marshes.

Madhopur Barrage lying on Ravi River is situated in Gurdaspur district of Punjab. Siul is on Baira River is situated in Himachal Pradesh. Two lift irrigation schemes running in Jammu & Kashmir UT part of sub-basin are Lakhanpur Lift Irrigation Scheme and Basantpur Lift Irrigation Scheme. Ravi River water is used for irrigating large areas of land along its course. The Ravi River is subjected to maximum manipulation along the Himalayan zone at several places resulting in Chamera I, II and III rock-fill dams of 950, 180 and 135 ha area, respectively and at village Thein resulting in Thein/Ranjitsagar Reservoir, again an earth-cum-gravel shell dam of 87 to 90 km^2 area having maximum height of 160 m, storage capacity of 3,280 million cusecs and live storage capacity of 2,344 million cusecs. Along plains its resources (water) are

abstracted almost fully at Madhopur for irrigation purposes leaving river basin almost dry below barrage for approximately 30 km distance between Madhopur to Kathlour. The Basin in the zone is sustained by leakage water from barrage. Diverted resources are canalized into 3 main canals, Kashmir, UBDC (Upper Bari Doaba Canal) and Hydel. Amongst the three, Kashmir Canal has a capacity of 900 cusecs and is carved out before the barrage, UBDC having capacity of 11,200 cusecs and Hydel with capacity of 6,900 cusecs, originate below barrage. It provide irrigation in the command area of unified India. Doabas formed by the Ravi River are known as the Rechna Doab i.e., between the Chenab and Ravi Rivers, and the Bari Doab or Majha i.e., between the Ravi and the Beas Rivers. Its resources are diverted into Beas River also via Ravi-Beas Link Canal (offshoot of UBDC) 15 km long earthen Canal which puts its resources into the Beas river via *Chaki* Nallah at Malikpur (Distt: Gurdaspur). The Ravi River although devoid of its basin flow, nonetheless is sustained by influx of many perennial and seasonal tributaries joining along its course making it a full fledged river from Kathlour onwards, draining almost 60 km of Punjab along the border; it irrigates a large area east of the Ravi River in India, and its distributary canals extend into Pakistan.

Six major hydroelectric power storage i.e., hydroelectricity generation – Chamera-I, II, III, Ranjit sagar dam, baira siul, and sewa projects along the course of the Ravi River exsist in concerned States/UT and Shahpurkandi Dam is under construction (India-WARIS webGIS). The Hydropower potential of Ravi River System has been assessed at 2294 MW. The hydropower potential developed since the 1980s is through installation of Baira Siul HEPs of 198 MW capacity, the Chamera-I of 540 MW capacity commissioned in 1994, the Ranjitsagar Multipurpose Project (600 MW) completed in 1999 and the Chamera-II of 300 MW capacity in the upstream of Chamera-I commissioned in 2004. As the Ravi River is located at lower level, Indus, Jhelum and Chenab Rivers water can be diverted to this river for harnessing huge hydro power potential.

The physical barriers by way of dams, barrages and other man-made structures block or constrict the river, thereby interrupting the flow of water, sediments and aquatic species (UNEP, 2008). The river fragmentation by such man-made structures not only interrupts or changes the flow rate that causes physical imbalance in the river, the other alterations in sediment load and seepage inflow/ outflow could also be easily upset.

Ground Water Availability

Ground water is an essential and vital component of our life support system. Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. The diverse physiographic, climatic, topographic and geology conditions in the Ravi River Basin have given rise to diversified ground water situation. The rock formations ranging in age from Archean to Recent occupy the mountainous State and control the occurrence and movement of ground water depending upon aquifer

composition, structure and deposition. Hilly and mountainous parts with steep slopes mainly constitute the run off areas and thus, have low ground water potential. However, in valleys and low lying areas, unconsolidated/ semi-consolidated formations form potential aquifers. The Central Ground Water Board (CGBW) has assessed the ground water resources. Accordingly, for the year 2017, the Total Annual Ground Water Recharge of the State was 0.51 BCM and the Annual Extractable Ground Water Resources was 0.46 BCM. The Current Annual Ground Water Extraction for all uses was 0.39 BCM and the Stage of Ground Water Extraction was 86%. Out of 8 assessment units, four have been categorized as 'Over-exploited', one as 'Semi-critical', and three as 'Safe'. Further there was no saline assessment unit in the State. In comparison to estimates of 2013, there was marginal reduction in the Total Annual Ground Water Recharge and the Annual Extractable Ground Water Resources. However, the Ground Water Draft had increased from 0.27 BCM to 0.39 BCM in 2017 (CGWB, 2019). The Northern Himalayan Regional Station of the Central Ground Water Board (CGWB) based at Dharamshala provides district-wise information on groundwater resources i.e., the distribution, utilization/exploration, water quality and current status on a regular basis.

The major part of the basin is mainly covered by hilly/mountainous areas and has no appreciable ground water potential other than the Punjab. In Jammu & Kashmir UT and in Himachal Pradesh, the majority portion does not contain appreciable ground water data, yet Kathua district of Jammu & Kashmir UT and Kangra district of Himachal Pradesh shows rise of greater than 4 meters in ground water level due to recharge. Punjab is occupied by Quaternary alluvial deposits of Indus River Basin. In major part of the State, ground water levels are in the range of 10 to 20 meters. The longterm water level fluctuation data indicates that water levels in major parts of the state have declined drastically. As per the ground water assessment carried out, net dynamic ground water resources of Punjab are 21.443 MCM (Million Cubic meters), whereas net draft is 31.162 MCM, leading to ground water deficit of 9.719 MCM. The stage of ground water development for the State as a whole is 145% and the State falls under "Over- exploited" Category (Gupta, 2009; Jha and Sinha, 2009). Net Annual Ground Water Availability of Amritsar and Gurdaspur Districts of Punjab are 246120 ham and 185256 ham, respectively. 1500 km^2 area has been identified for artificial recharge for surface water availability in Ravi River Basin in Punjab (Gupta, 2009).

Environment flow

Flow regime has been recognized as one of the most important drivers of river health. Increasingly, E-flows are seen as a device to ensure healthy river ecosystems. E-flows is a key component of an Integrated Water Resources Management and accounts for the volume of water allocated for ecosystem functioning. As in return ecosystems provide services to people, an E-flows is not exclusively a matter of sustaining a healthy ecosystem, but also a matter of supporting riparian livelihoods (Maasri, 2013). Since the "Birth" of the E-flows concept in the

nineties, many efforts were engaged to establish E-flows standards. European countries were among the first to engage in establishing such standards and after two decades of research a broad consensus on main key elements to consider was reached. Those key elements include, (a) Adapting flow standards for each river basin, (b) Accounting for the use of the Basin, and (c) Accounting for the Eco-regional characteristics of the basin by establishing environmental flows that mimic natural flow regimes. The concept of environmental flows is relatively new, dating to the last decades (early 1990s), and is defined as "The water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits" (Dyson *et al*., 2003).

In the past, the natural flow in India was often understood as a small flow that would be released at the bottom of dam as compensation for harvesting rights, without considering the impacts on river ecosystem. Indian rivers have been heavily influenced by anthropogenic activities over the past 60 years, and have great social and religious significance for many people. Natural flow is necessary for the aquatic environment to remain healthy and for sustainable use of water resources. The main areas of focus for the development of Environmental Flow Assessment (EFA) study in India are the construction of a shared database of hydrological, ecological and socio-economic data, improved hydrology-ecology relationships, environmental services testing, tackling pollution due to anthropogenic activities and the promotion of Environmental Flow Assessment (EFA) Research. At the same time, efforts will be needed to develop new methods or refine existing Indian methods (Jain and Kumar, 2014).

The development of environmental flow assessment (EFA) methodologies began in the USA in the late 1940s, mainly as a result of new environmental and freshwater legislation accompanying the rapid expansion of modern dam-building (Poff and Matthews 2013). Later, Australia, the UK and South Africa also emerged as countries leading development and application of EFA methodologies (Tharme, 2003; Acreman and Dunbar, 2004). Despite advances worldwide (Acreman *et al.,* 2014), the status of E-Flows science in India can be characterized as in its infancy because of the limited knowledge and experience base. A report of the National Commission for Integrated Water Resource Development Plan (NCIWRDP, 1999) stated that it was not possible to estimate the amount of water needed for environmental purposes, as the knowledge base for making any approximate calculation of this requirement was very limited. The very seasonal nature of rainfall in India, tropical monsoon followed by a dry season, a very large number of storage dams, barrages and river diversions have been constructed to regulate river flows to supply water for domestic use, irrigation, industrial demand, hydropower generation and control floods. To further control floods, floodplains have been isolated by embankments along rivers at some places. Meanwhile, land-based infrastructure development activities continue to increase sediment loads of rivers. In addition, because of urbanization, industrialization and agricultural intensification, rivers receive large discharges of untreated or partially treated domestic and industrial effluents, fertilizers and pesticides. Out of the 30 world river basins identified as global level priorities for the protection of aquatic biodiversity

(Groombridge and Jenkins, 1998), nine are in India and were singled out due to their extensive and continuing development. These basins are the Cauvery, Ganges-Brahmaputra, Godavari, Indus, Krishna, Mahanadi, Narmada, Pennar and Tapi. Except for the Ganges-Brahmaputra, all these basins have also been categorized as "Strongly affected" by flow fragmentation and regulation (Nilsson *et al.,* 2005). In India, E-Flows has usually been understood as a flow that is to be released downstream from dams for environmental maintenance, similar to the definition of Krchnak *et al*. (2009). Such releases have often been minimal to allow maximum abstraction upstream. For the majority of dams in India, there is no obligation for a certain amount of the water to be released downstream for aquatic ecosystems. After river water has been stored/diverted, stretches of rivers remain nearly dry and polluted, acquiring a substantial flow only during the rainy season. Overall, there has been limited appreciation of the nature of rivers as ecosystems that provide important services, livelihoods and human well-being, and whose ecological integrity depends upon their physical, chemical and biological characteristics, as well as interactions with their catchment (Jain and Kumar, 2014).

Iyer (2005) has highlighted the importance of instream flows in India for different purposes. Flows are needed for maintaining the river regime, making it possible for the river to purify itself, sustaining aquatic life and vegetation, recharging groundwater, supporting livelihoods, facilitating navigation, preserving estuarine conditions, preventing the incursion of salinity, and enabling the river to play its role in the cultural and spiritual lives of the people.

In the absence of clear insight on the complex nature of e-flow, long term researches, and field data, various studies, national/ state governments and concerned agencies, and even the Hon'ble Courts/National Green Tribunal (NGT) have given different recommendations for maintaining the minimum flow. Accordingly, the Central Water Commission (CWC) recommended different minimum flow criteria for the Himalayan and other rivers in the country. The CWC recommended that the minimum flow in the case of Himalayan Rivers must not be less than 2.5% of the 75% dependable annual flow, expressed in cubic meters per second (m^3/s) along with one flushing flow during the monsoon period, with a peak flow of not less than 250% of the 75% dependable annual flow. In case of other rivers, the CWC recommended the minimum flow in any 10-day period must not be less than the observed 10-day flow, with 99% exceedance. Where 10-day flow data are not available, this may be taken as 0.5% of the 75% dependable annual flow. In addition, one flushing flow would be required during the monsoon season with a peak flow of not less than 600% of the 75% dependable annual flows.

In view of the large number of HEPs in Himachal Pradesh, the State Water Policy expresses that 'In ventures for hydropower generation including appropriating of water, sufficient water is required to be discharged around the year to address the issues of downstream users'. Recently, the Department of MPP and Power, Government of Himachal Pradesh vide letter no. MPP-F (2)-16/2008 dated 29th January, 2009 frame the policy regarding ensuring minimum flow of water in Hydro-Electric Projects (HEPs) and decided that 'henceforth the hydroelectric project company

in Run of the River (RoR) Project shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean months i.e., from December to February shall be considered. This minimum discharge is required keeping in mind the serious concerns of the State Government on account of fragile ecology and environment and also to address issues concerning riparian rights, drinking water, health, aquatic life, wildlife, fisheries, silt and even to honor the sensitive religious issues like cremation and other religious rights, etc. on the banks. However, the companies are at liberty to install mini-hydel projects to harness such water for their captive use for their utilities, systems and colonies subject to prior approval of the State Government (RSET, 2019).

The Hon'ble NGT in its judgment order dated 09 August, 2017 has clearly directed that all rivers in the country shall maintain minimum 15% to 20% environmental flow of their average lean season flow and directed that whichever State is unable to adhere to this average percentage can approach to the MoEF&CC with justification. The MoEF&CC will dispose the representation by the State in consultation with the Union Ministry of Water Resources. Hence, it is evident from the forgoing description that the Government of India has lately recognized the merit of maintaining environmental flow throughout the year in the country's rivers so as to balance between the essential ecological requirements of the river ecosystem and the demands of various developmental sectors. This way, the goal of healthy river with multiple objectives relevant to the maintenance of uninterrupted flow, clean water, aquatic biota, ground water recharge, and sediment movement besides supporting livelihoods and allowing the river to be used for other multiple values and benefits can be achieved.

Erosion Processes

It is evident that for a very long time, the geological processes have been persistently changing the face of the Earth, but extremely recent second type of process of change, if considered at the geological time scale is caused due to permanent activities by humans (Gupta *et al.,* 2012). Human activities such as deforestation, forest degradation and mineral extraction are also responsible for erosion processes. Mineral extraction includes quarries, and underground mines, contribute to erosion and sedimentation. Wasson, 2003 identified the major source regions of erosion in the Himalaya into the Tethyan, High and Lesser Himalaya. The Shivalik foothills are also identified. These major source regions are topographically and lithologically distinct and some erosion and transport processes are confined to particular regions. The major features and erosion processes are given in Table 2.5.

Table 2.5 - Major Features and Erosion Processes

Source Region	Major Features	Major Erosion
Tethyan Himalaya	Sedimentary and volcanic rocks, moderate to high relief; grazing	Sheet and rill erosion, channel erosion, glaciation and landslides
High Himalaya	Crystalline rocks, steep slopes; high relief; little forest; extensive grazing	Landslides, glaciation, channel erosion, sheet and rill erosion, GLOFs and Landslide Lake-Burst Floods (LLFs)
Lesser Himalaya	Sedimentary and meta sedimentary rocks; steep slopes; moderate to high relief; forested in part; cultivation, grazing and forestry.	Landslides, sheet and rill erosion, channel erosion, and LLFs
Shivaliks	Sedimentary rocks, often partly lithified steep slopes, moderate to low relief forested in part; cultivation, grazing, and forestry	Landslides, sheet and rill erosion, and channel erosion
Plain	Unconsolidated alluvium and aeolian deposits; very gentle slopes and very low relief except along incised rivers; cultivation and grazing	Sheet and rill erosion, channel erosion, and wind erosion

(Source: Wasson, 2003)

The Ravi River like other Himalayan River systems such as the Indus, Ganga and Brahmaputra exhibit unique fluvial processes as they operate in three zones, viz., (i) Source area in the high mountainous zone, (ii) Vast alluvial plains, and (iii) Deltaic plain (Sinha, 2004). Thus, the fluvial system is commonly conceptualized in three process-dominated zones i.e., (i) Upper source zone, (ii) Middle transfer zone, and (iii) Lower accumulation zone (Schumm, 1977).

The upper and middle parts of the Ravi River Basin, entirely located in the Himalayan region, represented by above three erosion source regions are under the enhanced influence of human activities in past 100 years or so. These regions are afflicted with a serious problem of soil erosion. The riverscape form generally flows in westerly direction depicts large altitudinal variation from 159 m to very high altitude of 6076 m amsl. Altitude plays an important role in the physical characteristics, biological diversity and its distribution, socio-economic uses and

consumption patterns. In particular, higher altitudes greatly influence river flow, rate of sedimentation, vegetation, wild animal use and even human settlements and their uses. Since inception, the Himalayan Mountains have been undergoing intense erosion. According to Milliman and Meybeck (1995), the estimate of global sediment discharge is to the tune of 15-16 X 10161 year$^{-1.}$

Sediment Transport

Sediment relocation is one of the most necessary and important processes involved in the carving earth's surface, and thus have a fundamental interest to geomorphologists. Existing landforms are carved and changed by erosion of weathered sediments, and deposition of those sediments produces new landform suits in some areas (Sherman *et al.,* 2013). Sedimentation is a major process by which particulate material is removed from the water column and an important determinant accounting for the stability of aquatic ecosystems (Hakanson and Jansson, 1983; Bloesch, 2004). The intense erosion process is undergoing in the Himalayan Mountains since their formation and Himalayan Rivers have been removing and transporting large amount of sediments to the Arabian Sea i.e., Indus River, Bay of Bengal i.e., Ganga and Brahmaputra Rivers, and Andaman Sea i.e., Irrawaddy River as these mighty rivers have been forming large deltas. A large number of studies have been carried out relevant to sediment transfer, sediment budget, deltaic accretion, and formation of deep sea fan (Milliman and Meade, 1983; Abbas and Subramanian, 1984; Milliman and Syvitski, 1992; Milliman and Meybeck, 1995; Subramanian, 1996; Wasson, 2003)

Sediment Budget

The sediment budget is defined as the calculation of resources, sinks and methods of redistribution of sediments in a unit region over a unit time. Although in geomorphological literature, the calculated sediment is mainly clastic, and often excludes bedding material, it is clear that such limited use is very damaging to the concept (Slaymaker, 2003). The Indus Fan is the second largest deep-sea fan and is, therefore one of the largest sediment bodies in the modern ocean basins. The fan principally comprises material eroded from the Western Himalaya, Karakoram and Hindu Kush (Clift *et al*., 2002). The Indus Fan has been accumulating since at least the middle Eocene (~45 Ma; Clift *et al*., 2001), and as such, contains a record of orogenic erosion dating from the start of the India-Asia collision. Gupta *et al*. (2012) evaluated that Indian peninsular rivers transports around 83 Mt of sediment every year. The Ganga-Brahmaputra and Indus Rivers contribute 850 Mt and 13 Mt of sediments, respectively to the oceans. Their estimate suggested that presently the large rivers of East, Southern and Southeast (ESSE) Asian countries i.e., China, Taiwan, Vietnam, Myanmar, Thailand, India, Pakistan and Bangladesh collectively depositing ~2,150 Mt of sediment annually to the oceans. Further, they documented that ESSE Asian countries host about 250 mega dams and several tens of thousands of large and small reservoirs and observed that despite the increase in the annual

flux of inland sediment due to enhanced human activities, the annual flux of sediment reaching to the world's coast has been drastically reduced because of the retention within mega dams and other reservoirs. Thus, existing, ongoing and planned dam construction activities across ESSE Asia may further reduce the annual sediment fluxes (Gupta *et al*., 2012).



Plate 2.9 - Sediment, Silt and Muck accumulation at Chamera Hydro-electric Project (HEP)

Dams and Reservoirs are important infrastructures, particularly for the countries like India with strong seasonal variation in flow pattern as well as rapid growth of economy and population leading to increasing water and energy demand. Reservoir sedimentation is one of the major issues to be earnestly considered in dam improvement and rehabilitation efforts. The global net amount of reservoir storage has been decreased in recent years because the sediment management was not a standard practice in the past. As per the finding of International Commission of High Dams (ICOLD), 50% of the storage would be lost globally by 2050 and 100% within 200 to 300 years due to sedimentation. Such situation would be endangering water security and livelihood. (CWC, 2019) Sediment-induced problems induce a number of adverse impacts not only within reservoirs, but also in both upstream and downstream areas of river systems with dams. Some of the adverse effects, induced by sedimentation and erosion processes in river system with reservoirs are; (A) Reduction of storage volume in reservoirs due to sediment deposits; (B) Flood level increase in upstream of the reservoir (higher than estimated

during design) due to changed river slope; (C) Erosion and shifting of river banks and bed incision in downstream areas; and (D) Adverse effects on agricultural activities in downstream areas due to lack of fertile silt and nutrient supply (CWC, 2019).

Ranjit Sagar, an earth core cum gravel shell dam was constructed in 1999, mainly fed by Ravi River and Thein creating a reservoir of 87 km^2 in district Kathua (32°17' N to 32''55' N Latitudes and 75°32' E to 75''76'E Longitudes) of Jammu & Kashmir UT and adjoining territories of Punjab and Himachal Pradesh. The area of different States falling under Reservoir is Jammu & Kashmir UT, 5339.2 ha, Punjab, 332.8 ha, and Himachal Pradesh, 400 ha. The Reservoir has a catchment area of 6,086 km^2, mainly fed by Ravi River and Thein. The minimum and maximum water levels of the Reservoir recorded are 493'8m (March, 2001) and 578.6m (September, 2001). Sediment texture showed that sand was the major fraction (44.7%), followed by clay (31.3%) and silt (18.7%). Accumulation of clay and silt in the stagnant portion of Reservoir was also observed. The sediment is poor in available nitrogen and available phosphorus. The sediment differs considerably in different zones with respect to physical and chemical features. The basin soil seems to have little impact on water quality as the later derives nutrients mainly from the catchment area. As most of the rivers and tributaries are flowing, there is minimum probability of siltation and water quality remains more or less the same round the year (Gupta and Das, 2005).

Chamera - I is a medium size reservoir with a gross storage of 412.8 Mm^3 (at FRL) and submergence area of 9.5 km^2 and Reservoir length is 15 km. Total catchment area for Chamera-I is 4725 km^2 . Chamera-II is a small size reservoir with a gross storage of 2.25 Mm^3 (at FRL) and length of the reservoir is 3.6 km. Total catchment area for -II is 2593 km^2 (Dayal *et al*., 2016). Losses in live storage capacity are still insignificant so far. This may be owing to regular sediment management as mentioned thereafter (CWC, 2019). The sediment management practices and operation guidelines for Chamera-I and Chamera-II are reported by Dayal *et al*., (2016). Despite sediment management in Chamera-I, the reservoir storage capacity is decreasing. Nevertheless, the sediment management seems to be effective enough to maintain the reservoir storage to some extent as well as to avoid the sediment related problem near the intake area in a highly sediment laden river. The sediment management in Chamera-II is carried out by maintaining the lower reservoir level during flood season, which is synchronized with Chamera-III (upstream reservoir) as well.

Water Quality

As per ancient history, almost all the civilizations have developed on the banks of rivers due to their fertile land and pure water indicating that rivers play a vital role for our survival. In India, Himalayan range is the greatest source of pure water in the form of snow that melt and transverses through 45,000 km long riverine networks (Bhardwaj 2005; Suthar *et al*., 2009). There are thirteen major river basins in India which occupy around 83% of total drainage basin area with 85% of total surface flow and about 80% of Indian people reside in this area (Bhardwaj

2005; Manoj and Padhy, 2015). As per National Commission for Integrated Water Resource Management, out of about 1913 km^3 average annual flow of Indian rivers around 690 Km^3 i.e., about 36% of the total flow of the rivers are utilized (Kumar *et al*., 2005). But, in the present scenario of population explosion and the consequent demand for better quality of life, river water is under continual stress condition and loses their self purifying capacity. Moreover, river water gets contaminated through industrialization, urbanization and changes in land use pattern (Sanchez *et al*., 2007; Dasmohapatra, 2011; Jindal and Sharma 2011; Suratman *et al*., 2015). Due to these activities, water chemistry reflects plenty of deviations in environmental status. During last few decades, increase in industrialization, urbanization and intensive agriculture have been affecting the basic river water quality and is of great environmental concern worldwide (Kumar and Mukherjee, 2016). The State Pollution Control Board (SPCB) is the primary agency responsible for monitoring the water quality in a State as the monitoring is a pre-requisite to ascertain the impact on water quality and planning of type and extent of pollution control measures required to mitigate the situation.

The Ravi River is subjected to minimum pollution load in India compared to other two main rivers of the system, i.e., Sutlej and Beas Rivers (Moza, 2014), thus the comparative account of 3 main rivers of the system will give insight to the changes in biotic diversity have occurred due to pollution and will give insight to the bio-indicators for the system as a whole. The pollution load as assessed by Biological Oxygen Demand (BOD) (0.78-1.17 mg/litre) and Chemical Oygen Demand (COD) (2.6 to 3.75 mg/litre) indicate that Ravi River water does not carry much organic load as well as chemical pollutants especially in upper Shahpur Madhopur stretch as the values for former are below 1mg/litre and for latter below 3 mg/litre. The same is substantiated by low values of specific conductivity (166-166.87 μmhos/cm) in the stretch. BOD and COD values do not exhibit much seasonal variation as river is not subjected to major effluent load. The slight increase in BOD (1.05 mg/ litre to 1.75 mg/litre) and COD (1.2 mg/litre to 3.4 mg/litre) during monsoon to post monsoon in lower stretch is under the impact of Saki and other tributaries which is rich in nutrients and biotic components (Moza, 2014).

The river water quality assessments are best analyzed when they are based upon a comprehensive picture of physical, chemical, and biological assessments. Over the years, various National and International agencies have provided the guidelines for the standards of water quality from the perspective of inland surface water, ground water resources, and drinking water as a number of agencies are involved in water quality monitoring (Kumar *et al.*, 2017). The MoEF&CC, Government of India, has provided the guidelines for standards of inland surface water under the Environmental (Protection) Rules, 1986 (MoEF&CC, 1993). The Bureau of Indian Standard (BIS) has also provided guidelines for drinking water (BIS, 2012). However, in order to optimize and rationalize the monitoring programme, the Central Pollution Control Board (CPCB), MoEF&CC, Government of India, an apex body in the field of water quality management in India has issued 'Water Quality Protocol' of surface water which is being

followed by the SPCBs (CPCB, 2007). The tolerance limits for inland surface waters provided by the CPCB under five categories is provided in Table 2.6 and water quality standards prescribed for drinking water are presented in Table 2.7.

Table 2.6- Tolerance Limits of Inland Surface Water

Sr. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1	Colour (Hazen Units)	10	300	300	-	-
2	Odour	**Un-objectionable**	-	-	-	-
3	Taste	Tasteless	-	-	-	-
4	pH (maximum) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5	Conductivity (μS/cm)	-	-	-	1,000	2,250
6	DO (mg/L) (minimum)	6	5	4	4	-
7	BOD (3 days at 27°C) (mg/L)	2	3	3	-	-
8	Total Coliforms (MPN/100 mL)	50	500	5,000	-	-
9	TDS (mg/L)	500	-	1,500	-	2,100
10	Oil and Grease (mg/L)	-	-	0.1	0.1	-
11	Mineral Oil (mg/L)	0.01	-	-	-	-
12	Free Carbon Dioxide (mg/L CO_2)	-	-	-	6	-
13	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-
15	Phenol (mg/L C_6H_5OH)	0.002	0.005	0.005	-	-
16	Total Hardness (mg/L as $CaCO_3$)	300	-	-	-	-
17	Chloride (mg/L as CI)	250	-	600	-	600
18	Sulphate (mg/L as SO_4)	400	-	400	-	1,000
19	Nitrate (mg/L as NO_3)	20	-	50	-	-
20	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21	Calcium (mg/L as Ca)	80	-	-	-	-
22	Magnesium (mg/L Mg)	24.4	-	-	-	-
23	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24	Iron (mg/L as Fe)	0.3	-	50	-	-
25	Manganese (mg/L as Mn)	0.5	-	-	-	-
26	Zinc (mg/L as Zn)	15	-	15	-	-

Sr. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
27	Boron (mg/L as B)	-	-	-	-	2
28	Barium (mg/L as Ba)	1	-	-	-	-
29	Silver (mg/L as Ag)	0.05	-	-	-	-
30	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31	Mercury (mg/L as Hg)	0.001	-	-	-	-
32	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-
35	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-

(Source: CPCB, 2007)

Class-A : Drinking water source without conventional treatment, but after disinfection.
Class-B : Outdoor bathing.
Class-C : Drinking water source with conventional treatment, followed by disinfection.
Class-D : Fish culture and wildlife propagation.
Class-E : Irrigation, industrial cooling and controlled waste disposal.

Table 2.7 - Drinking Water Quality Standards

Sr. No.	Parameters Desirable	Acceptable Limit*	Permissible Limit**
1	Color (Hz)	5.0	25
2	Odour	Unobjectionable	-
3	Taste	Agreeable	-
4	Turbidity	5.0	10
5	pH	5.0-8.5	No relaxation
6	Total Coliforms (MPN/100 ml)	0	-
7	TDS (mg/l)	500	2,000
8	Total hardness (mg/l) as $CaCO_3$	300	600
9	Total alkalinity (mg/l)	200	600
10	Chlorides (mg/l)	250	1,000
11	Sulphates (mg/l)	200	400
12	Flourides (mg/l)	1.0	1.5
13	Nitrate (mg/l)	45	100
14	Calcium (mg/l)	75	200
15	Magnesium (mg/l)	30	100

Sr. No.	Parameters Desirable	Acceptable Limit*	Permissible Limit**
16	Manganese (mg/l)	0.05	0.5
17	Copper (mg/l)	0.05	1.5
18	Zn (mg/l)	5.0	15.0
19	Iron (mg/l)	0.30	1.0
20	Lead (mg/l)	0.05	No relaxation
21	Cadmium (mg/l)	0.01	No relaxation
22	Chromium (mg/l)	0.05	0.05
23	Phenolic compounds as phenol (mg/l)	0.001	0.001
24	Anionic detergents as MBAS (mg/l)	0.001	0.002
25	Arsenic as As (mg/l)	0.05	0.05
26	Selenium as Se (mg/l)	0.01	0.01
27	Mercury total as Hg (mg/l)	0.001	0.001
28	Cyanide (mg/l)	0.05	0.05
29	Mineral oil (mg/l)	0.01	0.3
30	Polynuclear aromatic hydrocarbons (PAH) (μg/l)	0.02	0.02

(Source: CPCB, 2007)

*The values indicated under the column 'Acceptable' are the limits up to which water is generally acceptable to the consumers.

**Values in excess of those mentioned under 'Acceptable render the water not acceptable, but still may be tolerated in the absence of alternative and better source, but up to the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.

Water quality monitoring of the Ravi River is carried out at 2 different locations i.e., (i) At Madhopur upstream (U/S), (Punjab) and (ii) at Lakhanpur, downstream (D/s), Madhopur (Jammu and Kashmir UT) of the interstate boundary of J&K UT/Punjab. The water Quality of Ravi River at Madhopur U/S, (Punjab) is monitored by Central Pollution Control Board (CPCB) for year 2009-13 having 07 Number of observations at the interstate boundary of Punjab and Jammu & Kashmir (CPCB, 2015). The BOD and DO concentration are within the prescribed standards at the location whereas Total coliform count is exceeding at said locations (CPCB, 2015).

The water Quality of Ravi River at Lakhanpur, downstream D/s Madhopur (Jammu & Kashmir UT) was monitored for year 2010-12 having 04 Number of observations at the interstate boundary of Punjab and Jammu & Kashmir UT.

Rivers are central to many of the environmental issues that concern society, and they are studied by a wide range of specialists including hydrologists, engineers, ecologists, geologists and geomorphologists. Riverine water quality is an important issue for each stakeholder as it affects human uses as well as plant and animal life (Kumar and Dua, 2009). A water quality index is a

means to summarize large amounts of water quality data into simple terms (i.e., good) for reporting to management and the public in a consistent manner. Similar to the Ultra Violet (UV) Index or an Air Quality Index, it can tell us whether the overall quality of water bodies poses a potential threat to various uses of water, such as habitat for aquatic life, irrigation water for agriculture and livestock, recreation and aesthetics, and drinking water supplies (Kumar and Dua, 2009). The concept of WQI was developed by the Washington State Department of Ecology, Environmental Assessment Programme. The values of WQI were computed using the formula provided by Thukral *et al.* (2005). The WQI used is a unit less number ranging from 1 to 100. A higher number is indicative of better water quality. For temperature, pH, Coliforms and dissolved oxygen, the index expresses result relative to levels required to maintain beneficial uses. Water quality index is a 100-point scale that summarizes results from a total of 9 different parameters listed as; (a) pH; (b) Dissolved Oxygen (DO) Saturation; (c) Turbidity; (d) Temperature Change; (e) Total Coliforms (MPN/100 ml); (f) Biochemical Oxygen Demand (BOD) (mg/L); (g) Total Phosphate (mg/L); (h) Nitrates (mg/L); and (i) Total Suspended Solids (TSS) m/L. The water quality can be designated as 'Excellent', 'Good', 'Medium', etc. as per the range of WQI, given in Table 2.8.

Table 2.8 - Water Quality Index

Range	**Quality**
90 – 100	Excellent
70 - < 90	Good
50 - < 70	Medium
25 - < 50	Bad
0 - < 25	Very bad

The index produces a number between 0 (worst water quality) and 100 (best water quality)

(Saffran *et al*., 2001).

2.3.2 The Alluvial Plains

The Ravi River after traversing a distance of about 167 km in Himachal Pradesh and 63 km in the Union Territory of Jammu and Kashmir, descends into the alluvial plains in Punjab. The Punjab Plain is a part of the vast Indo-Gangetic Plain (IGP) shaped due to flexing of Indian lithosphere during continent to continent collision of Indian Plate against the Asian Plate. The Indo-Gangetic Plains (IGP) ranks as one of the most extensive fluvial plains of the world. The deposit of this tract represents the last chapter of earth's history. It came into existence due to the collision of the Indian and Chinese plates during Middle Miocene (Parkash and Kumar, 1991). The Indian plate is still moving at the rate of 2–5 cm/yr towards the north and forming the world's highest mountain range on its border. The north-south compression generated throughout the plate ensures that it is continuously under stress and provides the basic source of

accumulating strain in the fractured zones (Gaur, 1994). The fluvial deposits and landforms of the IGP have been influenced by the stresses directed towards north and northeast. The major rivers of the IGP have changed their courses and at present, are flowing in southeast and easterly directions with convexity towards the southeast, which is strikingly similar to the arcuate pattern of the major thrusts bordering the IGP (Prakash *et al*., 2000). Thus, the IGP shows a series of terraces, bars and meandering scars resulting in microhigh and microlow areas on the apparently smooth topography (Pal *et al*., 2003; Singh *et al*., 2006)

The IGP is still tectonically active and the major sedimentation is taking place from large river systems of the IGP. The IGP developed mainly by the alluvium of the Indus, Yamuna, Ganga, Ramganga, Ghagra, Rapti, Gandak, Bhagirathi, Silai, Damodar, Ajay and Kosi Rivers. Geophysical surveys and deep drilling by the Oil and Natural Gas Commission of India (Sastri *et al.*, 1971) suggests that the IGP is a vast asymmetric trough with maximum thickness of 10,000 m. that thins out to the south. The IGP covers about 43.7 m ha and represents eight Agro-Ecologial Regions (AERs) and 14 agro-ecological sub-regions. The nature and properties of the alluvium vary in texture from sandy to clayey, calcareous to non-calcareous and acidic to alkaline. Though the overall topographic situation remains fairly uniform with elevations of 150 m amsl in the Bengal Basin, and 300 m amsl in the Punjab plain, local geomorphic variations are significant (Shankarnarayan, 1982).

The Indo-Gangetic Alluvial Plains (IGP) is among the most extensive fluvial plains of the world and cover several states of the northern, central and eastern parts of India. The Indo Gangetic Plain (IGP) occupies a total area of approximately 43.7 m ha and represent eight agro-ecological regions (AER) and 14 agro-ecological sub regions. The area of the IGP is nearly 13% of the total geographical area of the country, and it produces about 50% of the total food grains to feed 40% of the population of the country. Thus the sustainability of the present cropping system and also the health of the soils demand a review on the historical development of the soils and their management that remained associated with the tectonic, climatic and geomorphic history of the IGP since it came into existence due to collision of the Indian and Chinese Plates during the Middle Miocene.

The Indo-Gangetic Plain is drained essentially by two major river systems, namely the Indus System, which drains into the Arabian Sea, and the Ganga System which drains into the Bay of Bengal. The Indo-Gangetic Plain has been divided into: (a) Punjab-Rajasthan Plain, (b) Ganga Plain, (c) Bengal Plain, and (d) Brahmputra Plain (Singh, 1987; Singh and Ghosh, 1994). The Punjab-Rajasthan Plain comprises the Indus Plain in the west and the Punjab-Haryana Plain in the east. The Punjab-Haryana Plain occupies a unique position, located in the water divide area of two river systems i.e., the Indus River System and the Ganga River System.

Punjab-Haryana Plain is part of the vast Indo-Gangetic Plain formed due to flexing of Indian lithosphere during continent to continent collision of Indian Plate against the Asian Plate. The collision formed the Himalayan mountain chain, where the Indian Plate is still under-thrusting

the Asian Plate (Molnar and Tapponier 1977; Seeber *et al*., 1981; Molnar 1984; Ni & Barazangi 1984; DeCellers and Giles 1996; Wesnousky *et al*., 1999). It created the Indo-Gangetic peripheral foreland basin, formed on the flexed Indian plate lithosphere (Lyon-Caen and Molnar, 1985; Singh, 1987) in early Miocene, which expanded in middle Miocene where the sediments from the Himalaya started depositing mainly through fluvial processes (Singh, 1996). The rocks of Siwalik succession i.e., middle Miocene to early Pleistocene are the uplifted sediments of the northern margin of this foreland basin, thrusted along the Himalayan Frontal Thrust (HFT). The thrusting events in the Himalaya, making the Siwalik Hills, caused southward shift of the present Indo-Gangetic Foreland Basin (Ghosh and Singh, 1988; Singh and Bajpai, 1989; Singh, 1996). The tectonic activity is continuing in the Himalaya and its manifestations are recognizable in the quaternary alluvial deposits of the Indo-Gangetic Plain (Srivastav, 2014).

Few studies have been carried out in parts of the Punjab-Haryana Plain to reconstruct the shallow subsurface sand bodies representing ancient channel systems and provide OSL dates to the buried channels (Saini *et al*., 2009; Saini and Mujtaba, 2010; Kshektrimayum and Bajpai, 2011). Giosan *et al*. (2012) studied the fluvial landscape development in Punjab Plain during Holocene and its impact on the Harappan Civilization.

Geomorphology of Punjab-Haryana Plain

The Punjab-Haryana Plain is a vast alluvial plain, bounded by Siwalik Hills of Himalaya in the north and Aravalli-Delhi Massif in the south, formed by essentially fluvial processes. Several distinct regional geomorphic surfaces have been identified. They are characterized by their location, type of sediment, slope and pattern of drainage. These surfaces were formed during changing climatic conditions in late Quaternary, however, they have been partly modified later and are undergoing changes in the present day. The geo-morphological map of Punjab-Haryana Plain is given in Fig. 2.7.

(a) Himalayan Piedmont Zone

The Himalayan Piedmont Zone is located at the base of Shivalik Hills, and has developed due to coalescing of fans near the hill front. The zone is generally confined between 300 - 350 m amsl and makes a 10 to 15 km wide belt along the Shivalik Hills. The Himalayan Piedmont Zone forms a continuous surface drained by parallel and radiating drainage where the individual channels are ephemeral, shallow and braided.

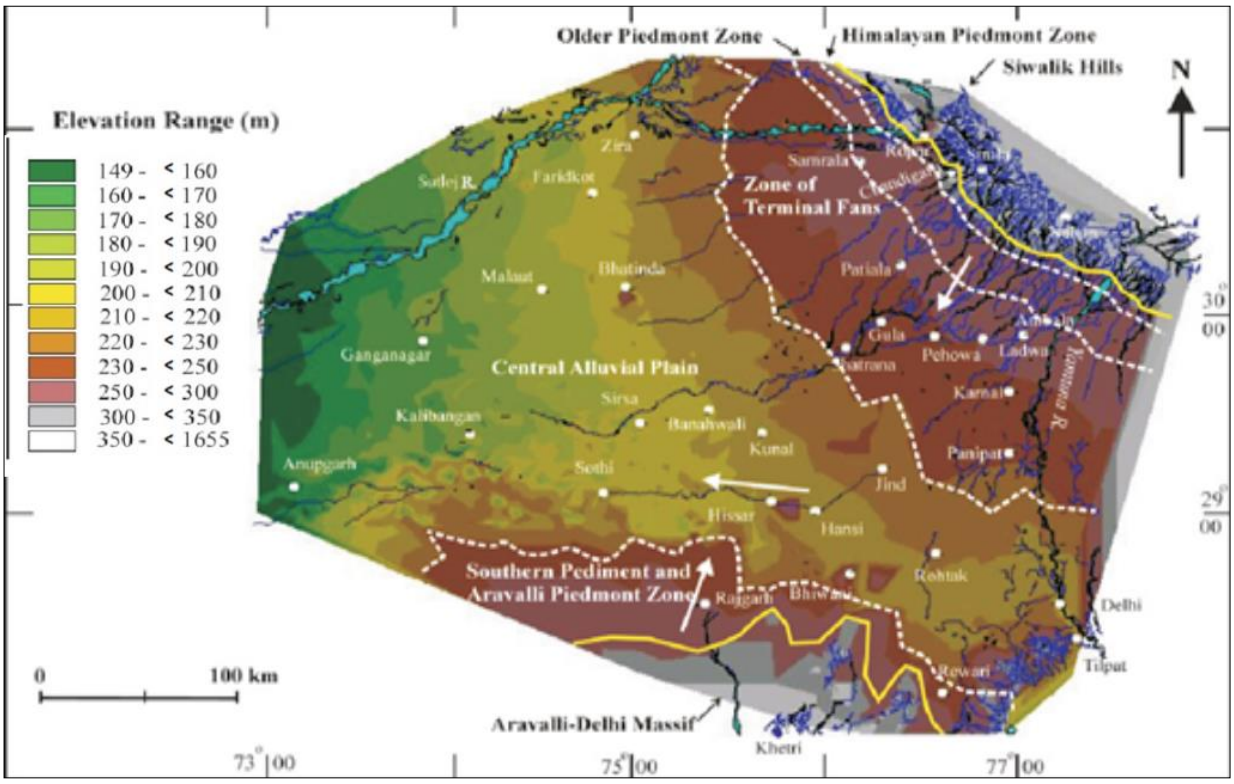


Fig. 2.7 - Geomorphological Map of Punjab-Haryana Plain
(Source: Srivastava *et al*., 2014)

(b) Older Piedmont Zone

To the south of the Himalayan Piedmont Zone, the Older Piedmont Zone is approximately 20 km wide with a gradient of about 1.3 to 1.5 m/km. This area is usually covered with muddy to sandy sediments, but it shows gravel and coarse sand below. It stretches between 270 - 300 m amsl and shows many temporary streams. Currently, there is fine layer of sediments formed in this area.

(c) Zone of Terminal Fans

One of the most prominent feature of the Punjab-Haryana Plain and marks approximately 80 km wide south of the Older Piedmont Zone. Typically, it shows an entrance to the slope where it touches the Old Piedmont area and meets south of the Central Alluvial Plain. A terminal fan assembly stretches, ranging from 270 m - 200 m amsl. In the closest part, the gradient is 70-85 cm/km, and in the central part, it is 30-35 cm/km. In the distal part, the gradient is 20-30 cm/km, and usually indicates recurrence of interesting channels (Parkash *et al*., 1983; Singh and Ghosh, 1994).

(a) Central Alluvial Plain

This is a flat area south of the Zone of Terminal Fans, located between 180 m southwest to 228 m northeast. This zone is characterized by a flat area with a limited zone of a gentle western slope occupied by the dry alluvial low area.

(b) Southern Pediplain

This small zone is confined between the Aravalli Piedmont Zone and the Central Alluvial Plain and made up of sediments derived from the Aravalli Mountain front and consists of brownish mud and silt, with granules of pedogenic calcrete.

(c) Aravalli Piedmont Zone

A narrow belt along the Aravalli-Delhi Massif comprising of brownish coloured clays, silts and sand.

Alluvial Stratigraphy

Rivers entering sedimentary basins distribute their sediment and water in major sediment fans which have been recognized in stratigraphic records around the world (DeCelles and Cavazza, 1999; Leier *et al*., 2005; Hartley *et al*., 2010; Weissmann *et al*., 2010). The development of alluvial stratigraphy is controlled by river avulsion, sedimentation rate, and the stacking pattern of fluvial channel-belt sand bodies (Allen, 1978; Leeder, 1978; Bridge and Leeder, 1979). This alluvial stratigraphy, in turn, determines the characteristics and productivity of groundwater aquifers in terms of; (a) the percentage of sand-rich aquifer bodies in the subsurface, (b) the geometry and dimensions of the aquifer bodies, (c) their hydraulic conductivity and specific yield, and (d) their connectivity (Renard and Allard, 2013). Understanding the stratigraphic architecture of large alluvial aquifer systems is particularly critical because these systems are major repositories for groundwater, and are a primary source of fresh water in large parts of the world. Traditionally, geological studies focused mainly the rock succession. However, studies of vast alluvial plains were ignored (Singh, 1996). The extreme flatness of the vast region and geomorphologically monotonous character also did not attract the geomorphologist to undertake detailed investigations of alluvial plains or flood plains. Some systematic geomorphic studies were carried out on the vast Indo-Gangetic Plain, particularly the Ganga Plain (Geddes, 1960; Mukerji, 1963; Singh, 1996). The vast alluvial plain of IGP was classified into Older Alluvium (Bhangar) and Newer Alluvium (Khadar), each with different sediments (Pascoe, 1973). The Older Alluvium makes the higher interfluve areas while the Newer Alluvium forms deposits of major river channels and their valleys. Khadar land lies next to a river while Bhangar land has greater elevation and lies away from the river. Bhangar soils are poor in fertility as they are above flood levels whereas Khadar soils are fertile as they are found at relatively below the flood level. The former soils are full of kanker (Lime Module) while latter soils are composed of fine silt and clay. The area lying below the mountains is referred as Kandi. The Himalayan Rivers divide the plains into doabs (i.e., the region between two rivers) or it is land lying between two

converging or confluent rivers. The Punjab Plains owing to flowing of multiple river from the Himalaya and several confluent rivers/tributaries created varied doabs. Hence, they were named differently. The Bari Doab lies between the Ravi and Beas Rivers, the Bist Doab refers to the land between the Beas and Sutlej Rivers, and the Rechna Doab lies between the Chenab and Ravi Rivers. The Bari Doab tract of Punjab is an agriculturally important region as it lies between two important rivers (i.e., Beas and Ravi). Since alluvial plains of the Ganges symbolizes the life line of one of the world's largest population. Consequently a number of studies have been carried out on the morphology, Hydrology including flooding history and sediment transport behavior of the river system. The alluvial stratigraphy of the large valleys and interfluves in the plains has provided insight about the sediments pattern (Sinha, 2004). However, the insight on alluvial stratigraphy in the context of Punjab-Haryana Plains is relatively poorer. The scarcity and the lack of integrated geomorphologic, stratigraphic, sedimentological, mineralogical, and geochemical approaches have precluded a comprehensive insight (Sinha *et al*., 2005). It was quite evident in the case of Punjab Plains.

2.3.3 Climate

The climatic conditions of Ravi Riverscape which is spread over the mountainous Himalayan State of Himachal Pradesh and Jammu & Kashmir UT and alluvial plains in Punjab State are influenced significantly by various driving variables *viz.*, solar radiation, precipitation (i.e., snowfall and rainfall), temperature, humidity and wind. The notable altitudinal variation from plains to the high mountains of the Great Himalaya in the riverscape plays significant role in maneuvering varied climatic conditions. The extent of snowfall and spatio-temporal pattern of rainfall have a direct bearing on the hydrological regime of the Ravi River and its tributaries. The influx of solar radiation and diurnal temperatures, particularly in the Himalayan stretch of the riverscape also has an important role to play in the process of formation of glaciers ablation, glacier and snow-melt, plant transpiration and evaporation of surface water from open water bodies (i.e., lakes, rivers, and reservoirs). Wind direction and velocity also influence the humidity, evaporation and transpiration. Cumulatively, above stated climatic attributes of the mountainous stretch and the Punjab plains have profound implications on weather, micro-climate, hydrology, water flow, diversity and productivity of forests, grasslands and maintenance of wetlands, cropping pattern, and agricultural productivity besides several aspects of livelihood.

Physiographically, the entire basin is mountainous with an altitude ranging from 559-6,162 m amsl. The habitation is found only up to 3,000 m amsl. The climate is found varying from semi-tropical to sub-alpine. In the lower part of Bhattiyat tehsil, the climatic conditions are similar to those of Kangra and the Shivalik area of Kangra district, while in higher altitude the climate is of temperate, sub-alpine and alpine type. The soil types of this region as classified by the N.B.S.S. & L.U.P. (I.C.A.R.). Forests have great importance in the economy of the Himachal Pradesh as a

whole and Ravi River Basin in particular. In the Ravi valley the climatic conditions vary with altitude. In the lower portion of the basin vegetation is semi-tropical. Rainy season is well marked while winter is mild. In Bharmour, Holi and Bara Bhangal areas, summer is exceedingly mild and pleasant. Owing to the scarce rainfall, the percentage of humidity is always low. The winter is very severe and snowfall starts in October and continues till March and April. The district is having rainy season from middle of June to the middle of September, and has vastness of the rainfall during this season. Snow may fall as early as the beginning of October. The snowfall on the Dhauladhar and Pir-panjal Range is heavy and in severe winter it lasts from the early November to late March (Sharma, 2019).

The Ravi River Basin experiences tropical monsoonal climatic environment with the onset of southwest monsoon occurring in late summer season i.e., around the second fortnight of June month. Monsoon usually lasts for three months from July to September. The climate in Himachal Pradesh is also influenced by northeast rains and the occasional western disturbances. The State thus experiences three marked seasons *viz.,* (a) summer season (April-June), (b) rainy Season (July to September), and (c) winter season (October-March). Overall, Himachal Pradesh is known for its salubrious climate. Precipitation declines from west to east and south to north with the average annual rainfall of 1,100 mm. District-wise rainfall relevant to the riverscape in Himachal Pradesh is presented in Table 2.11.

The geological structure is mostly formed by Jutogh group/Vaikrita group and Central Gneiss types besides other groups like Granites (unclassified), Blaini/Infra-Krol formations, Shimla group, Panjal traps and Shivalik formations. It has also shale types of rocks, slate, sand stone, lime stone, conglomerates and quartzites. The soil of the area depends upon altitude aspects, climate and vegetation type. The soil is young and thin. Profiles are channery and are diffused between genetic horizons.

Low Hill Zone

It is found up to altitude of 900 m. The soil is shallow and alluvial in low hill soil zone. The soils are neutral, the nutrients status ranges from low to medium.

Mid Hill Zone

It extend up to altitude of 900-1500 m amsl. The soils are loam to clayey loam and greyish brown colour. The soil is acidic in reaction and also neutral in some locations.

High Hill Soil Zone

It is found between 1500-2100 m amsl. The soil is silty loam to clayey loam. The soil are deep and acidic to neutral in reaction organic matter is high with available nitrogen ranges from medium to very light. The potassium is medium. The available phosphorus in the soil is low to medium.

Mountainous Soil Zone

It extends between 2000-3000m amsl altitudes. The soils of region are silty loam with light brown to dark brown in colour. The soil is not deep in high hill soil zone. The soil is slightly to moderate acidic. Organic content range from 2.5 – 3.5 and available nitrogen is medium to high. The soil of mountainous soil zone are not used for agriculture production.

The soil under conifer are acidic and podzols and, whereas in oak forest have brown soil. The fairly soil is found in marshy area (Singh and Sharma, 2006).

Table 2.9 - District-wise Trends in Rainfall in Ravi River Basin of Himachal Pradesh

Sr. No.	District	Years			
		1990	2000	2014	2017
1	Kangra	2,490.0	1,353.4	1,058.2	1,595.9
2	Chamba	1,532.2	1,414.2	469.4	1,051.8

(Source: IMD website)

It is evident from the Table 2.11 that values of rainfall in two districts in different years have varied remarkably. The values showed that upper region of the basin (Kangra) receive more rain fall as compared to lower region (Chamba). The rainiest months are July and August. The months of December and January recorded minimum rainfall .

The climatic conditions in alluvial plains of Punjab mainly vary from semi-arid to dry sub-humid while experiencing the tropical monsoonal climate. Owing to much lower altitudinal areas in Punjab Plains, except in the northeastern part of the State i.e., bordering with the Outer Himalaya or *Kandi* area of Shivaliks, generally, temperatures are higher. Broadly, the region of alluvial plains of the riverscape experiences four seasons: (a) monsoon (July to September), (b) post-rainy season (October to November), (c) winter (December to February), and (d) summer (March to June). The maximum temperature rises up to 48° C in month of May-June while winter months are generally colder experiencing lower temperature reaching to 0° C. Frost is common in winter season. Generally, temperature starts rising slowly from the month of February and increases rapidly February to June with hottest days in June. In July, when monsoon sets in, the temperature subsides and keeps falling till January. The sunshine is abundant except for a brief period in December and January. The amount of rainfall in plains varies from 250 - 1,100 mm, the maximum is near the Shivalik Range and the minimum in the southwestern extreme of the plains. Over 70% of the rainfall is received during the period of July to September. Some time, the monsoon begins to retreat in the middle of September. Broadly, the climatic conditions in the alluvial plains part of the riverscape can be divided into two categories: (a) Less Hot and Humid

Northeast Zone – This zone is spread over Pathankot and Gurdaspur Districts. The region is not very hot and for eight months of the year, monthly temperature remains below 20° C. Being located in the Shivalik Ranges, this climatic zone enjoys more than that 800 mm of average annual rainfall; and (b) Hot and Semi-Dry Central Zone - This zone is spread over Amritsar, Districts. Annual average temperature of this zone is higher than that of the Less Hot and Humid Northeast Zone. In the months of December and January, ground frost and mist are the common phenomenon. This region receives average annual rainfall of 400 - 800 mm and the amount of average rainfall received gradually increases as one moves towards the northern parts.

Effects of global warming and climate change are evident. Villagers, farmers, fishermen and populace in general do realize changes in rainfall and snowfall pattern in terms of total amount of rainfall/ snowfall, number of rainy days, delayed onset of monsoon, longer dry spells, early withdrawal of monsoon, etc. Hence, the close scrutiny of climatic variables generally provides an insight on large scale variation in monthly values, mean values and even annual average values of precipitation. These changes are obviously bringing changes in cropping pattern, shift in distributional range of a particular crop/ horticulture species, frequent drought or floods, etc. Greater variability and extremities in climatic attributes are of serious concern in the context of Himachal Pradesh and alluvial plains in Punjab from the perspective of maintenance of surface and ground water resources, river ecosystems, other natural ecosystems, agro-ecosystems, and sustainable livelihoods.

2.4 The Biological Environment

Man is an essential part of an environment whether it is forest, grassland, wetland or marine ecosystem. Since time immemorial, nature and humidity have consistently had a complex and symbiotic relationship as natural ecosystems are the planet's life support system not only for human well-being but also for all other forms of life *viz*., macro and micro-organism. Enhanced human imprint, particularly in the last century and increase in human disturbance by way of conversion of natural ecosystems, livestock grazing, forest fires, over harvests of natural resources, introduction of invasive and alien species, and incompatible land use in surrounds of delicate ecosystems has caused habitat fragmentation, decline of biodiversity, reduced ecosystem services, and even impairment of natural functioning of complex and dynamic ecosystems. It has been lately realized that the maintenance of 'Natural capital' is essential for the human well-being and to accomplish varied goals of sustainable development. Decline in fresh water ecosystems and looming water crises in a considerable part of the world has attained the significance as one of the global challenges that is strongly linked with other challenges faced by the humanity. The importance of a river's flow regime for sustaining biodiversity and ecological integrity is well established (Poff *et al*., 1997; Hart and Finelli, 1999; Bunn and Arthington, 2002). Stream flow is viewed as a 'Maestro' (Walker *et al*., 1995) or 'Master variable' (Power *et al*., 1995) that shapes many fundamental ecological characteristics of riverine ecosystems. From

a basic ecological perspective, extreme events such as high flows and low flows exert selective pressure on populations to dictate the relative success of different species, and patterns of variation in 'Sub-lethal' flows can influence the relative success of different species and regulate ecosystem process rates (Resh *et al.*, 1988; Hart and Finelli, 1999). The range and variation of flows over recent historical time, referred to as the natural flow regime (Richter *et al*., 1996; Poff *et al*., 1997), sets a template for contemporary ecological processes (Resh *et al*., 1988; Doyle *et al*., 2005), evolutionary adaptations (Lytle and Poff, 2004) and native biodiversity maintenance (Bunn and Arthington, 2002). Flow regime varies geographically in response to climate (precipitation and temperature) and catchment controls on runoff i.e., topography, geology, land cover, position in network. All flow regimes may be considered unique in some measure of their details; however, many authors have stressed the need to characterise the similarity among flow regimes to provide typologies that can support a priori predictions (e.g., ecological and evolutionary convergence under geographically disjunct selection regimes) and development of general principles for flow regime management (Arthington *et al*., 2006).

The biological environment in Ravi Riverscape is constituted by diverse forests, alpine pastures, grasslands and wetlands in Himachal and J&K UT and Punjab plains. The biological environment of the Ravi River Basin is described below.

2.4.1 Biogeographic Representation

The Ravi Riverscape along concerned two Indian States i.e., Himachal Pradesh and Punjab and one Union Territory i.e., Jammu and Kashmir represents two biogeographic zones: (i) 2-Himalaya, and (ii) 4-Semi Arid. These two biogeographic zones are further represented by two biotic provinces, namely (a) 2A- Northwestern Himalaya, (b) 4A-Punjab Plains (Rodgers and Panwar, 1988). These two biogeographic zones and two biotic provinces cover a wide range of natural ecosystems and associated rare, endangered and threatened floral and faunal species. The biogeographic zone, 2 Himalaya with two biotic province is represented in Himachal Pradesh and Union Territory of Jammu and Kashmir, while the Punjab State falls in one biogeographic province of a single zone i.e., 4 A-The Punjab Plains of the Semi-Arid zone.

2A-Northwestern Himalaya Biotic Province: The Himalayan Mountain Ranges covering a region of around 2, 36,300 km^2 in India spread across five States (i.e., Uttarakhand, Himachal Pradesh, Sikkim, West Bengal, and Arunachal Pradesh) and one Union Territory (i.e., Jammu and Kashmir). A noteworthy segment of the nation's population other than human population in Nepal, Bhutan, Bangladesh, Myanmar, China, and Pakistan rely upon water for different uses. Himachal Pradesh embodies the full range of Himalayan ecosystem from the arid cold desert of the Trans-Himalaya (Zone 1) across the main Himalayan Range (Zone 2) to the semi-arid foothills (Zone 4). The State has representation of two biotic provinces (2A-North Western Himalaya and 2B-Western Himalaya). These two biotic provinces (2A and 2B) are divided by

the Sutlej River which acts as a barrier for species like the Himalayan Ibex (Rodgers and Panwar, 1988).

The 2A-Northwestern Himalayan biotic province is characterized by high snowcapped peaks, steep slopes, unconsolidated soils, and intense rainfall and represented by the Great Himalaya, Lesser or Middle Himalaya, and the Outer Himalaya or Shivaliks. Varied landforms, notable altitudinal gradient, and harsh climatic conditions make the environment in this zone of extreme fragility. The area of this biotic province harbors a considerable chunk of glaciers, snow covered areas, diverse forests, alpine pastures, high altitude wetlands, and rivers and tributaries besides spectacular Pir-Panjal and Dhauladhar Himalayan Ranges. In spite of rugged terrain, one can find wide spread human habitations, high densities of livestock, expanding agriculture/ horticulture, and growing mountain tourism and adventure activities on steep slopes. The natural environment in this biotic province has greatly suffered under ever mounting human pressure and developmental activities (i.e., linking of rivers and diversion of water, hydroelectric projects, widening of road network, and ever increasing tourism and hospitality industry). Despite human pressure and impact of developmental activities, the biotic province harbors a large number of endangered faunal taxa *viz*., Snow Leopard (*Panthera uncia*), Bears (*Ursus thibetanus*), Wolves (*Canis himalayensis*), Tahr (*Hemitragus jemlahicus*), Bharal (*Pseudois nayaur*), etc. The biotic province is represented by a wide range of galliforms and other avifauna. The biotic province harbors broad leaved forests, temperate forests, sub-alpine and alpine vegetation dominated by conifers, oaks, spruce, fur, rhododendron spp. etc. The biotic province is rich in lichens, bryophytes, orchids, bamboos, grasses, medicinal herbs, and shrubs. The Ravi Riverscape in this biotic province, harbours the Tundah Wildlife Sanctuary, Kugti Wildlife Sanctuary, Kalatop Wildlife Sanctuary, part of Dhauladhar Wildlife Sanctuary, besides others smaller protected areas.

Jammu & Kashmir Union Territory: Kathua and Samba districts of J&K UT falling the Ravi Riverscape. The whole tract lies at the confluence of the Shivalik belt with the Outer Plains. The southern and south-western parts of the Division are covered by gentle terrain whereas the northern and north-eastern parts are covered by high hills. The major part of the division falls in *Kandi* area which is characterised by rugged, highly dissected terrain and harsh climate. The entire Division lies in the sub-tropical region and therefore, the vegetation here is that characteristic of sub-tropical climate. The associates of Chir pine forest are Indian Ash Tree (*Lannea coromandelica*), *Wendlandia heynei*, *Mallotus philippensis*, etc. The major area is heavily infested by *Lantana camara* (Punj-phulli) which is a major threat to the natural vegetation of the Division. The biotic province is represented by the Jackal (*Canis aureus*), Jungle Cat (*Felis chaus*), Indian Fox (*Vulpes benghalensis*), Indian Crested Porcupine (*Hystrix indica),*Leopard (*Panthera pardus*) ,Grey Himalayan Goral (*Nemorhaedus goral)* and Barking Deer (*Muntiacus muntjak*). Ravi riverscape in this biotic province, harbours the Jasrota Wildlife Sanctuary, besides others smaller protected areas.

4A-Punjab Plains Biotic Province: According to Rodgers and Panwar (1988), the entire Punjab lies in a single biotic province i.e., 4A-The Punjab Plains of the Semi-Arid Biogeographic Zone. Climatically, much of the Punjab fall in the Arid Desert Biogeographic Zone (<400 mm rainfall), but the great extent of irrigation by Himalayan Rivers (i.e., Ravi, Beas and Sutlej) has removed virtually all true desert elements. Thus, the State is placed in the Semi-Arid Indus drainage area. The entire biotic province can be recognized in three regions viz., (a) the north Shivalik Hill system, the Indus Alluvial Plains, and a fragmented region of wetlands-natural and artificial. The Shivaliks have a dry deciduous forest cover, but much has been severely eroded and reforestation has largely used exotic tree species. The Shivalik forests still has Sambar (*Cervus unicolor*), wild pig (*Sus scrofa cristatus*), barking deer (*Muntiacus muntjak*), etc. The alluvial plains have fragmented relict populations of Nilgai (*Boselaphus* spp.) which together with wild pig (*Sus scrofa cristatus*) cause considerable crop damage. A few smaller and isolated populations of Black Buck (*Antilope cervicapra*) and Chinkara (*Gazella bennettii*) also occur. The wetlands have an important migratory water fall avifauna. The Ranjit Sagar of Ravi River forms an important wetland site.

2.4.2 Diverse Forests

Forests cover nearly 6% of the planet, but they harbor up to 90% of the world's terrestrial biodiversity. Forests and trees make vital contributions to both people and the planet, bolstering livelihoods, providing clean air and water, conserving biodiversity and responding to climate change (FAO, 2018). According to FAO, the world's total forests area is just over 4 billion hectares, with forests covering 31% of total land area and legally established protected areas covering an estimated 13% of the world's forests. The Global Forest Resources Assessment (GFRA), coordinated by FAO revealed that the world's forest area decreased from 31.6% of the global land area to 30.6% between 1990 and 2015, but the pace of loss has slowed down in recent years. The livelihoods and food security of many of the world's rural poor depend on world's diverse and vibrant forests and trees. Evidence shows that around 40% of the extreme rural people–250 million people–live in forests. Nearly, three-quarters of the globe's accessible freshwater comes from forested watersheds and about 40% of the world's 230 major watersheds have lost more than half of their original tree cover. While the importance of forests and trees to a healthy, prosperous planet is universally recognized, the depth of those roots is much greater than imagined. The quantitative evidence now suggests that forests and trees also make significant contributions to the sustainable development goals through the informal sector, agro-forestry, opportunity to empower women, sustainable water management, tourism, sustainable cities, climate change adaptation and tackling land degradation and biodiversity loss (FAO, 2018). Forests also influence the nature's capacity to cope with natural hazards.

Forest biological diversity results from evolutionary processes over thousands and even millions of years which, in themselves, are driven by ecological forces such as climate, fire, competition

and disturbance. Forest biological diversity can be considered at different levels, including the ecosystem, landscapes, species, populations and genetics. Complex interactions can occur within and amongst these levels. In biologically diverse forests, this complexity allows organisms to adapt to continually changing environmental conditions and to maintain ecosystem functions. Despite the vital role that trees play, the forest diversity is severely threatened by over exploitation, land-use change, fragmentation of populations, climate change, invasions of exotic species and over-grazing by domestic livestock.

(A) Forests of Himachal Pradesh

Himachal Pradesh represents diverse forests due to varied altitudinal gradient and climate. Broadly, on the basis of altitudinal zones, four vegetation zones can be deciphered *viz*., (a) Lower Montane Zone in the Outer Himalaya or Shivaliks (<1,000 m amsl); (b) Middle Montane Zone in the Lesser Himalaya (1,000 -<2,000 m amsl); (c) Temperate Zone in the Greater Himalaya (2,000 -<3,000 m amsl); and (d) Sub-Alpine and Alpine Zone in the Great Himalaya (≥3,000 m amsl). About one third of the state is permanently under snow, glaciers and cold deserts where tree growth is minimal due to harsh conditions. Forests vegetation of the state is broadly grouped in different categories based largely on the altitude, rainfall, humidity and species composition. Major forest types in the Himalayan part of the riverscape as per the revised classification of forest types by Champion and Seth (1968) represent seven Major Groups, and four Sub-Groups, and 23 Forest Types (Table 2.10).

The forests in Ravi River Basin come under the administrative control of Chamba Territorial Circle and Dharamshala (N) Wildlife Circles with their Head Quarters located at Chamba and Dharamshala, respectively. There are four territorial divisions namely; Bharmour, Chamba, Churah and Dalhousie (part) and two wildlife divisions namely, Chamba and Hamirpur (part). The Protected Area Network comprises 4 WLS in Chamba WL Division i.e., Gamgul WLS, Tundah WLS, Kugti WLS and Khajjiar-Kalatop WLS and one WLS i.e., Dhauladhar WLS under Hamirpur wildlife Division. The major forest types as per the revised classification of Champion &Seth (1968) are described below.



Plate 2.10 - General view of Forests of Ravi River Basin Along Ravi River

Table 2.10 – Forest Types in the Ravi Riverscape of Himachal Pradesh

Major Group	Type Group	Sub-Group	Forest Types
Dry Tropical forests	5- Tropical Dry Deciduous Forests	5-B: Northern Dry Mixed Deciduous Forests	5B/C2 Northern Dry Mixed Deciduous Forests
Montane Sub- Tropical forests	9-Sub-Tropical Pine Forests		9C1a: Himalayan Sub-Tropical Pine Forests
			9/C1b: Upper or Himalayan Chir Pine Forests
			9/C1/DS1: Himalayan Sub-Tropical Scrubs
			9/C1/DS2: Sub -tropical *Euphorbia* Scrubs

Major Group	Type Group	Sub-Group	Forest Types
Sub-Tropical Dry Evergreen Forests	10-Sub-Tropical Dry Evergreen Forests		10/C1a: *Olea ferriginea* Trees Forest
Montane Temperate Forests	12-Himalayan Moist Temperate Forest	12-C1:Lower Western Himalayan Temperate Forests	12/C1a: Ban Oak Forests (*Quercus oblongata*)
			12/C1b: Moru Oak Forest (*Q. floribunda*)
			12/C1c: Moist Deodar Forests
			12/C1d: Western Mix Coniferous Forests
			12/C1e: Moist Temperate Deciduous Forests
			12/C2a: Kharsu Oak Forests (*Quercus semecarpifolia*)
			12/C2b: Himalayan Upper Oak-Fir Forests
		C2: Upper West Himalayan Temperate Forests	12C/DS1: Oak Scrub
			12/DS3: Himalayan Temperate pastures
			12/C1/DS2: Himalayan Temperate Secondary Scrubs
			12/1S1: Alder (*Alnus nitida; A. nepalensis*) Forests
			12/1S2: Riverine Blue Pine (*Pinus wallichiana*) Forests
			12/2S1: Low level Blue Pine Forests
Sub-Alpine Forest	14-Sub-Alpine Forest	14-C:West Himalayan Sub-Alpine birch/fir Forest *(Betula/Abies*)	14C1b: West Himalayan Sub-Alpine Birch/fir Forests
			14/DS1: Sub-Alpine Pastures
Alpine Scrubs	15-Moist Alpine Scrubs		15C1: Birch-Rhododendron Scrub Forests
			15C2: Deciduous Alpine Forest
			15/C3: Alpine Pastures

(Source: Champion & Seth, 1968)

Group 5 - Tropical Dry Deciduous Forests

This Group is represented by one Sub-Group and one Forest Type.

(a) Sub-Group 5B - Northern Tropical Dry Deciduous Forests

The dry deciduous forest, in which the upper canopy is light, but probably fairly even and continuous in the climax form. The canopy is formed of mainly deciduous trees. The undergrowth is thin represented mainly by shrubs including some xerophytic evergreen species.

5B/ C2 - Northern Dry Mixed Deciduous Forests

This type is represented by small strips and patches along the Ravi River and its tributary Siul River ranging from 800 - 1000 m amsl rarely extending up to 1200 m amsl. The width of area under this type goes on decreasing with altitude. Draber, lower portion of Sultanpur, Parel, Kalaban CA, Talota, Thari, Mahual, DPFs of Masroond and Lower Chamba ranges, and Rakh DPF of Upper Chamba range represent this type. *Dalbergia sissoo, Albizia* spp., *Pistacia integerrima, Mallotus philippensis* and *Celtis australis* are among the main tree species of this type. Undergrowth consists of *Murraya koenigii, Justicia adhatoda, Colebrookea oppositifolia, Carissa opaca, Woodfordia fruticosa,* etc.

Group 9 - Sub-Tropical Pine Forests

This is a forest dominated by Chir pine (*Pinus roxburghii*) in the top canopy. Broad-leaved, especially evergreen Oaks increase with increasing altitude and leaving the pine on the warmer and drier ridges. Towards the lower limit of this forest there is an increase in the trees of the dry deciduous type. Climbers and bamboos are usually absent. The important forest types that form a part of this forest are described below.



Plate 2.11 - Sub-Tropical Pine (*Pinus roxburghii*) Forest in Ravi Riverscape

(i) 9C/1B Upper or Himalayan Chir Pine Forests

This type of forests occur between 800-1800 m amsl on northern aspects and 1000-1800 m amsl on South East and West aspects overlapping the tropical dry deciduous forests at lower elevations and temperate forests at higher elevations. The forests lie on both banks of Ravi River and on the left bank of Siul River. This type is mostly confined to Masroond and Lower Chamba ranges of Chamba Division and Bakloh and Dalhousie ranges of Dalhousie Division.

(ii) 9/C1/DS1 - Himalayan Sub-Tropical Scrubs

At places in the zone of Himalayan Chir Pine forest, the tree cover is unable to come up due todry /shallow soil, excessive grazing pressure or frequent fires. In such places scrub formation takes place. Lower part of Masroond and Lower Chamba ranges of Chamba Forest Division and Bhalei range of Chaurah Forest Division represent this type. The vegetation is mostly zerophytic, thorny and non-palatable. The common shrubs found are *Plectranthus rugosus, Dodonaea viscosa, Woodfordia fruticosa, Rhus parviflora, Lantana camara,* etc. There is immense scope to improve upon this type of forest to better usable for fodder, fuel and small timber.

(iii) 9/C1/DS2 - Sub-Tropical Euphorbia Scrubs

This type occurs up to 1200 m amsl in small patches. Lower parts of Baranda, Kiani, Rajpura, Dhar–II DPF of Masroond range, Sarol, Chaundi-Da-Phat, Banu-ka-rakh, DPFs of Lower Chamba range and lower parts of Bhalei range represent this type. The soil is very shallow at

someplaces rocky where *Euphorbia royleana* (Thor) found studded here and there which can survive better than other scrub spp.

10 Sub-Tropical Dry Evergreen Forests

10/C1a: *Olea ferruginea* Forests

This type occurs between 800 - 1400 m amsl. Annual rainfall averages 1200 mm. *Olea ferruginea* is seen in pure patches in most of the forests of Masroond and Lower Chamba ranges of Chamba Forest Division, near Manjir on aspect draining into Siul, at places on eastern aspect along *Baira Nallah* scattered in Chir Pine Forest in Churah Forest Division and in the tract mainly on the left bank of Ravi River in Chaned block of Dalhousie Forest Division. Elsewhere, it is found scattered and decreases proportionally with altitude. This species provides very good fodder and fuel to the local People. Other associates of this species are *Pistacia integerrima, Dalbergia sissoo, Albizia* spp., *Toona ciliata, Lannea coromandelica*, *Mallotus philippensis*, etc.

Group 12 - Himalayan Moist Temperate Forests

These are rich and diverse forests comprised of conifers and broad-leaved species found in the moist temperate regions of the Himalaya. The top canopy is comprised of conifers or broad-leaved species or their mixture. These forests extend along the whole length of the Himalaya above the sub-tropical forests and towards higher elevations they give way to sub-alpine forests. The altitude ranges from 1,500 - 3,300 m amsl depending on the latitude, aspect and configuration of the ground. These forests are of the following types.

(i) 12/C1a - Ban Oak Forests (*Quercus oblongata*)

This type of forest occurs between 1,200 – 2,000 m amsl on northern aspects and 1,450 – 2,450 m amsl on South and South West aspects. The sub-type also interludes in Chir zone in low elevations down to 1,000 m amsl but occupies depressions on northern aspects. These forests occupy large tract in Masroond, Pukhri and Saho blocks of Chamba Forest Division. The Ban Oak forests are also found in pure stands in Churah Forest Division, on the left bank of Ravi River from Kharamukh to Holi and left bank of *Budhil Nallah* in Bharmour Forest Division and Banikhet and Dalhousie ranges of Dalhousie Forest Division. Because of its high utility as fuel, fodder and for agricultural implements, it occupies a unique position in the fabric of agricultural economy in the Ravi catchment. Unfortunately the biotic interference over the area has always been of an increasingly high order which has resulted in the retrogression of this climax species. This can be seen in the vicinity of habitations where these trees face a ruthless lopping thus rendering the natural regeneration and propagation impossible. Many areas have simply bush type of this important Oak due to indiscriminate lopping. It is frequently associated with Deodar and Kail at higher elevations and Chir pine at lower limits mostly confined to depressions. Other

common associates of Ban Oak are *Rhododendron arboreum, Quercus floribunda, Lyonia ovalifolia, Neolitsea pallens, Persea duthiei, Pyrus pashia* and *Rhus chinensis*. There is generally a good deal of shrubby growth consisting of *Myrsine africana, Rubus ellipticus, Desmodium elegans, Viburnum cotinifolium, Berberis lycium, B. aristata, Deutzia corymbosa* and *Lonicera quinquelocularis*. Among climbers *Parthenocissus semicordata, Clematis* spp., *Hedera nepalensis, Ficus* spp., etc. are the most common.



Plate 2.12 – *Quercus oblongata* (Oak) forests in Ravi River Basin

(ii) 12/C1b Moru Oak (*Quercus floribunda*) Forests

These forests are found in small patches and in shady portions of deodar and spruce between 2,100 – 2,700 m amsl sometimes descends to 1,900 m amsl. It occurs in Bara Bhangal area, tracts of Bharmour, Chamba and Churah Forest Divisions and Chamba (WL) Division. It favours moist situations and grows gregariously in deep and well drained soil. Moru is found in association with *Rhododendron arboreum, Neolitsea pallens, Cedrus deodara* and *Picea smithiana*. The undergrowth consists of *Sarcococca saligna, Viburnum cotinifolium, Berberis* spp., *Prinsepia utilis, Rubus* spp., *Girardinia heterophylla, Daphne papyracea, Lonicera* spp.,

Deutzia spp., etc. The trees are generally tall and clean bowled except near habitations where they are subjected to heavy lopping for fodder.

(iii) 12/C1c - Moist Deodar Forests

This important forest type occurs between 1,600 – 2,400 m alms and the most beautiful and valuable deodar forests are situated between 1,800 – 2,200 m alms. These forests are almost pure with some Kail and little Spruce. Deodar occurs on all geological formations but avoids badly drained stiff soil. Deodar grows mixed with *Picea smithiana* and at some places with *Abies pindrow*. These forests descend to Chil and Ban oak zones at lower elevations. Other associates are *Quercus floribunda, Neolitsea pallens, Toona ciliata, Populus ciliata, Carpinus viminea, Ulmus villosa, Cornus macrophylla, Prunus cerasoides, Aesculus indica, Juglans regia, Ulmus wallichiana,* etc. The most frequently distributed undergrowth species are *Viburnum cotinifolium, Indigofera heterantha, Desmodium elegans, Rubus ellipticus, Berberis lycium, Prinsepia utilis, Rosa moschata, Rosa macrophylla, Myrsine africana, Sarcococca saligna, Daphne papyracea, Hedera nepalensis,* etc.



Plate 2.13 - *Cedrus deodara* (Deodar) forests in Ravi River Basin

(iv) 12/C1d - Western Mixed Coniferous Forests

These forests occur above Deodar forests between 2,000 – 3,500 m amsl and occupies a considerable tract of the catchment. These mixed coniferous forests are mainly of Silver Fir and Spruce with some occasional admixture of Kail and Deodar. In depressions Fir constitutes more proportion along with some broad leaved species whereas Spruce is more on gentle /moderate slopes with fairly good exposure. This type mostly fits in Moru Oak zone, but ascends to Kharsu zone. The deciduous associates interspersed in these forests are *Aesculus indica, Juglans regia, Acer* spp., *Prunus cerasoides, Ulmus wallichiana, Fraxinus micrantha, Persea* spp., *Neolitsea pallens, etc*. On the cooler northern aspects *Taxus wallichiana* forms the under storey. The undergrowth and herbaceous flora is generally fairly thick and comprises of *Berberis* spp., *Lonicera quinquelocularis, Artemisia* spp., *Viburnum cotinifolium, Indigofera* spp., *Viola* spp., *Angelica glauca, Fragaria vesca, Valeriana jatamansi, Ainsliaea aptera, Heracleum* spp., etc. The common climbers are *Parthenocissus semicordata, Clematis* spp., *Hedera nepalensis* and *Ficus* spp.

(v) 12/C1e - Moist Temperate Deciduous Forests

These are is found between 1,800 – 2,750 m amsl along *Nallah*, in moist hollows and depressions of the whole tract. Due to extreme moist conditions, these sites are unfit for conifers, but on comparatively better drained sites Silver Fir and Spruce on upper zones and Kail in lower zone occur. Ban oak is present on various spurs in some places. The chief species existing in these forests are *Aesculus indica, Corylus jacquemontii, Acer pictum, Acer caesium, Juglans regia, Prunus cornuta, Rhododendron arboreum,* etc

(vi) 2C/DS1- Oak Scrubs

Because of heavy biotic interference, most of Ban oak and Moru oak forests of the area have been reduced to mere scrub formation. The dwarfish stunted growth of oaks is attributed to indiscriminate lopping and excessive grazing. Other unpalatable species like *Lyonia ovalifolia, Rhododendron arboreum* also grow in abundance. Invasion of weeds like *Sorbaria tomentosa* and *Parrotia jacquemontiana* is quite common.

(vii) 12/C1/DS2 - Himalayan Temperate Secondary Scrubs

An irregular or dense scrub cover with a few predominating and scattered residual trees of the Oak-deodar forests occur on excessively grazed and lopped areas of the temperate forests. *Berberis lyceum, Indigofera heterantha, Prinsepia utilis, Plectranthus rugosus,* etc. are the important secondary nature of scrub communities which occur especially on the southern aspect.

(viii) 12/C2a - Kharsu Oak (*Quercus semecarpifolia*) forests

These forests are dominated by Kharsu oak (*Quercus semecarpifolia*) and forms a dense crop. The main tree species found in the first storey are *Abies pindrow*, *Acer caesium*, *Picea smithiana*, *Pinus wallichiana*, and *Quercus semecarpifolia*. Second storey consists of *Betula utilis*, *Ilex dipyrena*, *Prunus cornuta*, *Rhododendron arboreum*, and *Sorbus foliolosa*. Understorey consists of few tall spreading shrubs like *Cotoneaster bacillaris*, *Ribes glaciale*, *Rosa macrophylla*, *Rhododendron campanulatum*, *Viburnum cotinifolium*, etc.

(ix) 12/C2b - West Himalayan Upper Oak-Fir Forests

These occur between 2,600 – 2,900 m amsl. The characteristics feature is the presence of Kharsu and Fir /Spruce together as stand to stand mixture and the forest gives look of a two storied forest. The common shrubs are *Viburnum* spp., *Rosa* spp., *Berberis* spp., *Lonicera* spp., etc. Natural regeneration is scanty. These are the summer grazing grounds of locals and Gujjar graziers.

(x) 12/DS3 - Himalayan Temperate Pastures

Such portions are particularly near halting ground of Gujjars. The tree cover is unable to establish due to shallow soil and only grasses cover the area. Such lands are reduced to pasture status and are of this degradation type. They are found between 1,500 – 3,100 m amsl on all aspects. These Himalayan grasslands occur on ridges and slopes especially where moist or wet conditions are present. The common grasses in the mixed coniferous forest zone are *Agrostis* spp., *Calamagrostis* spp., *Dactylis* spp., *Arundinella nepalensis*, *A. pumila*, *Bothriochloa* spp., *Chrysopogon gryllus*, *Cymbopogon* spp., *Festuca* spp. and *Poa* spp., etc.

(xi) 12/1S1 - Alder Forests

Alder (Piak) forests occur along streams and extends into tributaries. It also extends further into landslides and occurs generally pure. At places, *Populus ciliata*, *Pyrus pashia*, *Ficus palmata* and *Toona ciliata* trees are also found. Shrubs are occasional and *Indigofera heterantha*, *Colebrookea oppositifolia*, *Berberis* spp., *Prinsepia utilis*, *Desmodium elegans*, etc. are common between 1,100 – 1,800 m amsl.

(xii) 12/1S2- Riverine Blue Pine (*Pinus wallichiana*) Forests

The only forest which can be allotted to this seral type is Bhalu DPF in Churah Forest Division where Kail occurs on new alluvial deposits with Piak. The elevation is about 1,350 m and the aspect is north-east.



Plate 2.14 – *Pinus wallichiana* (Kail) forests in Ravi River Basin

(xiii) 12/2S1- Low level Blue Pine Forests

This seral type occurs between 1,400 – 2,500 m amsl on northern aspects and 1,600 – 2,700 m amsl on south/eastern/Western aspects. Kail forms almost pure forest. At places, it is however mixed with some deodar and spruce trees. *Pyrus pashia* and *Rhododendron arboreum* are usually second storey trees. *Indigofera heterantha, Berberis* spp., *Desmodium elegans, Sarcococca saligna,* and *Prinsepia utilis* are shrubs generally met with.

Group 14 - Sub-Alpine Forests

These forests are a typically dense growth of small crooked trees or large shrubs with patches of coniferous over wood. These forests are the top most tree forests of the Himalaya forming the tree line between 3,000–4,000 m amsl. The forests of this group include the following types.

(i) 14/C1b - West Himalayan Sub-Alpine Birch/ Fir Forests

These forests are found between 3,000 – 4,000 m amsl. The associated trees are mostly *Betula utilis, Prunus cornuta, Abies spectabilis* and *A. pindrow*. The shrubs found in association are *Cotoneaster acuminata, Rosa sericea, R. macrophylla,* and *Ribes glaciale, Smilax vaginata, Spiraea bella, Syringa emodi, Salix* spp., *Rhododendron* spp., *Juniperus* spp., *Lonicera* spp., *etc*

(ii) 14/DS1- Sub-Alpine Pastures

In Sub-Alpine zone where tree cover cannot exist due to shallow soil or heavy snow fall, grasses, forbs and / shrubs occupy the ground. Many important medicinal herbs such as *Viola canescens* (Banafsha), *Sinopodophyllum hexandrum* (Bankakru), *Salvia moorcroftiana* (Thuth) *Valeriana jatamansi*, (Muskbala), *Jurinea macrocephala* (Dhoop), *Selinum* spp., etc occur in these areas.

Group 15 - Moist Alpine Scrubs

This type of forest consists of the alpine zone vegetation found just below the snowline and usually above the tree line in the moister tracts. Arctic climatic conditions are experienced in this tract of vegetation. The vegetation of this group consists of the following forest types.

(i) 15/C1 - Birch-Rhododendron Scrub Forests

This is low evergreen forest dominated by *Rhododendron* and also including other deciduous species. The trunks of trees are short and may be bent at the base. This type of forest is found in the alpine areas. The main species in the first storey are Scrubs *Betula utilis*, *Rhododendron campanulatum* and *Sorbus foliolosa*. Undergrowth constitutes *Berberis* spp., *Gaultheria trichophylla*, *Lonicera* spp., *Salix* spp., *Rosa* spp., *Rhododendron* spp., and *R. anthopogon*, etc. This is an alpine xerophytic formation in which dwarf shrubs predominate.

(ii) 15/C2- Deciduous Alpine Vegetation

This formation is not a tree type and lies between the sub-alpine forests and alpine pastures. It is characterized by low deciduous shrubs usually of one meter height. Patches of dwarf *Rhododendron* spp., *Juniperus* spp., *Salix* spp., *Lonicera* spp., etc. form this type of forests, Grasses, sedges and forbs are found frequently growing under this vegetation type.

(iii) 15/C3 - Alpine Meadows

These are found below the snowline all along the higher Himalaya. They are composed of perennial mesophytic herbs, sedges and few grasses. The important herbs are species of *Aconitum*, *Anemone*, *Fritillaria*, *Gentiana*, *Festuca*, *Iris*, *Kobresia*, *Primula*, *Ranunculus*, *Rheum*, *Euphrasia*, *Artemisia*, *Primula*, *Potentilla*, *Meconopsis*, *Bistorta*, *Oxyria*, *Rumex*, etc.



Plate 2.15 – Alpine meadows in Ravi River Basin

Table 2.11 - The major species in forest types according to Champion and Seth (1968) are classified as follows.

Forest Types	**Major species**
G-3 Tropical Dry Deciduous Forests	*Senegalia catechu, Anogeissus latifolia, Aegle marmelos, Mallotus philippensis, Dendrocalamus strictus, Carissa opaca, Justicia adhatoda,* etc.
G-5 Tropical Moist Deciduous Forests	*Mallotus philippensis, Terminalia bellirica, Terminalia arjuna, Bauhinia vahlii, Anogeissus latifolia, Buchanania lanzans, Lannea coromandelica, Alstonia scholaris, Syzygium cumnii,* etc.
G-9 Sub-Tropical Dry Deciduous Forests	*Pinus roxburghii, Terminalia chebula, Mallotus philippensis, Pyrus pashia, Albizia chinensis, Senegalia catechu, Murraya koenigii, Rubus ellipticus, Syzygium cumini, Dalbargia sissoo, Senegalia catechu, Cordia* spp., etc.
G-12 Himalayan Moist Temperate Forests	*Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow, Quercus oblongata, Q. floribunda* and *Q. semecarpifolia*
G-13 Himalayan Dry Temperate Forests	*Pinus gerardiana, Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow* and *Populus ciliata*

G-14 Sub-Alpine Forests	*Viburnum* spp., *Salix* spp., *Acer acuminatum, Prunus cornuta, Abies spectabilis, A. pindrow, Betula utilis, Rhododendron* spp., etc.
G-15Moist Alpine Scrubs	*Rhododendron* spp., *Berberis* spp., *Juniperus* spp., *Rosa* spp., *Lonicera* spp., *Salix* spp., etc.
G-16 Dry Alpine Scrub	*Juniperus* spp., *Lonicera* spp., etc.

(Source: Modified after Champion & Seth, 1968)



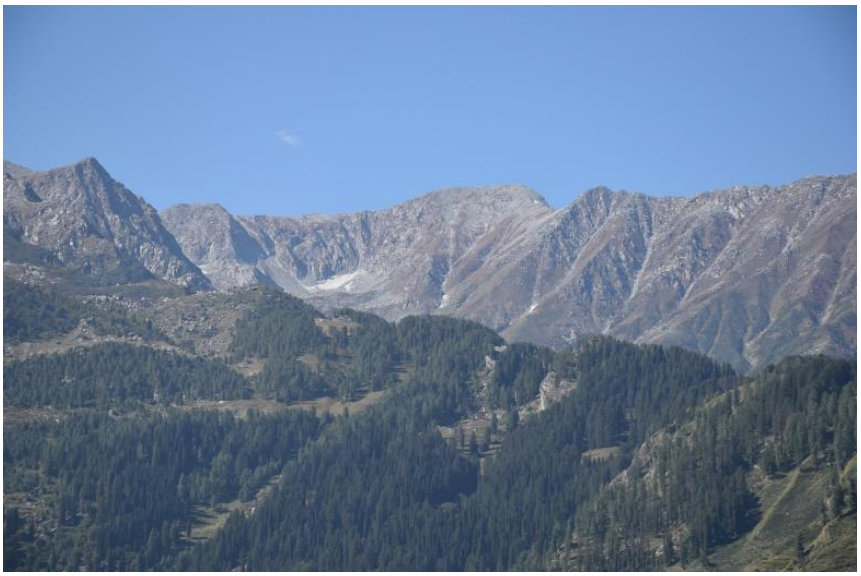


Plate 2.16 – Different Types of Forests in Ravi River Basin

(B) Forests in Union Territory of Jammu & Kashmir

The Forests of J&K UT have been categorized and described in the light of Revised Forest Types of India (1968) by Champion and Seth. Forest Types represented in the Himalayan part of Jammu and Kashmir UT of Ravi Riverscape are given in Table 2.12.

Table 2.12 – Forest Types in the Jammu and Kashmir UT of Ravi Riverscape

Major Group	Type Group	Sub Group	Forests Type
Montane Sub- Tropical Forests	9-Sub-Tropical Pine Forests	-	9/C1b: Upper or Himalayan Chir Pine Forests
Sub-Tropical Dry Evergreen Forests	10-Sub-Tropical Dry Evergreen Forests	-	10/C1a *Olea ferruginea* Forests
Montane Temperate Forests	12-Himalayan Moist Temperate Forests	12-C1: Lower Western Himalayan Temperate Forests	12/C1a: Ban Oak Forests (*Quercus oblongata*)
			12/C1b: Moru Oak Forests (*Quercus floribunda*)
			12/C1b: (a, b) DS1/Oak Scrubs
			12/C1c: Moist Deodar Forests
			12/C1d: Western Mix Coniferous Forests

(Source: Modified after Champion and Seth, 1968)

9/C 1b- Himalayan or Montane Chir Pine Forests

Pinus roxburghii is the characteristic species of this type of forests, and is found localized in extent. These forests are mostly young to middle aged and is of low quality. *Pinus wallichiana* and *Quercus floribunda* occur at upper and lower limits respectively. Sporadically *Dalbergia sissoo* occurs in the lower drier parts. This type is also subjected to heavy grazing and fires are usually common. This type of forest is in climatic sub-climax.

10/C 1a Sub-Tropical Dry Evergreen *Olea ferruginea* Forests

Olea ferruginea is the major species of this forest. This sub-type occurs along the lower limits in the narrow valleys and extends in the higher reaches until it is replaced by *Ilex dipyrena.* It occurs in pure patches and is under heavy human pressure. The common associates are *Punica granatum, Pistacia integerrima, Pinus roxburghii, Dalbergia sissoo, Myrsine africana, Daphne oleoides* and *Plectranthus* spp.This sub type's forms only negligible percentage of forest land and is mostly spread over revenue lands.

12/C 1a- Ban Oak (*Quercus oblongata*) Forests

These are feebly represented in the area and is only found along the transitional belt between Deodar, Kail and *Ilex dipyrena.* This type occupies shallow and hotter stretches, mostly on southern and south-western aspects receiving good amount of monsoon rains. This type represents climatic sub-climax. Being close to the habitation, Ban Oak is heavily lopped for fodder and also cut for firewood.

12/C 1b- Mohru Oak (*Quercus floribunda*) Forests

Quercus floribunda is the prominent species although it does not occur gregariously, it is found as widely distributed species, usually as an understorey with kail and deodar. The species is not regenerating due to heavy biotic pressure. Its common associates are *Cedrus deodara, Pinus wallichiana, Quercus oblongata, Ulmus wallichiana, Fraxinus micrantha, Toona ciliata,* and *Alnus nitida.*

12/C 1c- Moist Deodar (*Cedrus deodara*) Forests

Cedrus deodara is the dominant species of this forest. It often occurs as pure, but at times mixed with blue pine, fir and spruce. It occurs on all geological formations on well drained soils and avoids ill drained and damp soils. The common associates are *Pinus wallichiana, Abies pindrow, Picea smithiana, Ilex dipyrena, Quercus floribunda, Quercus oblongata, Rhus succedanea, Prunus cerasoides, Fraxinus micrantha, Aesculus indica, Rhododendron arboreum, Celtis australis, Populus ciliata* and *Alnus nitida.*

12/C 1d- Western Mixed Coniferous Forests

This type refers to the main community of *Abies pindrow* and *Picea smithiana* (Spruce) mixed at places with deodar and kail. The occurrence is mostly governed by edaphic and microclimatic variations in this type. Fir occurs on cooler portions, kail on hotter spurs and Deodar on steep grounds as well as on shallow and rapidly drained soils in this type. Walnut, and Poplar, *Acer* spp., *Corylus jacquemonti* and *Prunus cerasoides* are the outstanding broadleaved species. *Viburnum* spp., *Spiraea* spp. and *Skimmia laureola* are the characteristic shrubby growth.

The Forests of J&K UT have been categorized and described with slight modifications in the light of Revised Forest Types of India (1968) by Champion and Seth. Major species of different forest types are given in Table 2.13.

Table 2.13- Forest Types and Major Species of Forests in J&K UT

Forest Type	Major Species
9/C 1b- Himalayan or Montane Chir pine forests	*Pinus roxburghii*, *Pinus wallichiana, Ilex dipyrena*
10/C 1a Sub-Tropical Dry Evergreen *Olea ferruginea* Forests	*Olea ferruginea, Punica granatum, Pistacia integerrima, Pinus roxburghii, Dalbergia sissoo, Myrsine africana, Daphne oleoides* and *Plectranthus rugosus*
12/C 1a- Ban Oak forests (*Quercus oblongata*)	*Cedrus deodara, Pinus wallichiana, Neolitsea pallens, Cornus macrophylla, Fraxinus micrantha* and *Lyonia ovalifolia*
12/C 1b- Mohru Oak Forests	*Cedrus deodara, Pinus wallichiana, Quercus oblongata, Ulnus wallichiana, Fraxinus micrantha, Toona sinensis* and *Alnus nitida*
12/C 1c- Moist Deodar Forests (*Cedrus deodara*)	*Pinus wallichiana, Abies pindrow, Picea smithiana, Ilex dipyrena, Quercus floribunda, Quercus oblongata, Rhus succedanea, Prunus cerasoides, Fraxinus micrantha, Aesculus indica, Rhododendron arboreum, Celtis australis, Populus ciliata* and *Alnus nitida*
12/C 1d- Western Mixed Coniferous Forests	*Abies pindrow, Picea smithiana Acer* spp., *Corylus jacquemontii, Prunus cerasoides* and *Prunus cornuta*

(Source: Modified after Champion & Seth, 1968)

Forest Resources and Botany

The rich and diverse forests of Himachal Pradesh have attracted a large number of ethno-botanists, taxonomists, professional foresters, botanical explorers, ecologists and conservationists from various reputed organizations of the State and Country. Works of these organizations were focused on ecological studies, phytogeography, floristic studies, sacred natural sites a sacred groves, etc. The Flora of Himachal Pradesh by Chowdhery and Wadhwa (1984) highlights botanical explorations and studies during the; (a) early historical period: 1821–1900; (b) middle period: 1900-1950; and (c) recent period: 1951 onwards. The available information is fragmentary in nature with respect to the river stretches/catchment areas/zones.Various researchers pursuing doctoral studies has thus attempted to provide a brief review of literature. A

large number of papers describe plant diversity and related aspects specific to a particular zone/ district/ forest division/ protected areas.

Temperate Grasslands and Meadows

All the gentle and accessible meadows in the temperate, sub-alpine and alpine regions have undergone extensive habitat degradation with over 70% of the natural vegetation reported has been lost (Singh, 1991). Temperate grasslands and alpine pastures are important grazing resources for wild fauna as well as livestock, particularly sheep and goat as they practice trans-humance migration. The village pastures (*Ghasnis*) are grass dominated areas in village surround, mostly on the warmer southern slopes. The migratory sheep and goat moves upward and downward through different forests along the altitudinal gradient every year during migration to and from alpine areas. Pastoralists along with their migratory sheep and goat use pastures (*Thatches*) or grass openings in the mid temperate (2,000 -<2,800 m amsl), upper temperate (2,800 -<3,300 m amsl), and sub-alpine (3,300 - 3,600 m amsl) forests. Generally, alpine pastures occur above the natural tree line (Mathur and Mehra, 1999). Rawat (1998) has described five types of grasslands across the Himalaya. These are: (a) warm temperate grasslands, (b) cool temperate grassy slopes, (c) sub-alpine meadows, (d) alpine meadows, and (e) steppe formations of the Trans-Himalaya. In the present case, the first four types of grasslands are relevant. Livestock rearing, particularly sheep and goat is an aged old occupation of local people and shepherd communities in Himachal Pradesh. They have been using specific grazing routes and grazing resources year after year as grazing rights and other concessions have been well documented in the old settlement reports (Misri, 1998; Mehra and Mathur, 2001; Singh *et al.*, 2006). Nevertheless, grazing resources have been severely impacted and drastically reduced owing to their large scale conversion for the expansion of agriculture and other developmental activities. In several instances, alpine pastures are either overburdened or neglected. Efforts are required to maintain and restore grassy slopes on southern aspects and to conserve alpine pastures as they offer habitat for wild ungulates, grazing resources for migratory livestock, and source for a wide range of medicinal plants besides they help in checking runoff and allow infiltration of water.

Medicinal and Aromatic Plants

The diverse culture of our country is a rich source of traditional medicines. Traditional folklore knowledge is a treasure of India. Medicinal and aromatic plants play an important role in local health care systems and upliftment of rural livelihoods in the western Himalayan regions. Medicinal plants are used in the Ayurvedic, Unani and other traditional systems of medicine and in plant-based pharmaceutical industries (Samant *et al.*, 1998). A large number of species are being traded and several of its species are extracted in excessive quantities. In the country, > 70% people rely on medicinal plants for curing various ailments/diseases (Holley and Williams,

1996). An estimated 50% of the plants of an ecosystem in India are used by various communities as medicine. India is second largest volume exporter of raw herbal drugs to the global market after China (Lange, 1997). Of the total medicinal plants traded in India, about 90% collected from wild, in which 70% collection involves destructive harvesting (Ved *et al*., 1998; Natesh, 2000). Himachal Pradesh supports 643 medicinal plants (Samant *et al*., 2007). Himachal Pradesh is the largest supplier of Atish, Salampanja, Dhoop, Kutki, Bankakri, Daruhaldi, Talispatra, Revandchini, Vach and Somlata in the country. The entire pressure is on the wild populations and only a few crops like Kuth, Manu, Kalazeera and Hops are cultivated in Lahaul-Spiti and Kinnaur. The State has 179 species of commercial importance for drugs and phyto-pharmaceuticals, 32 species yielding essential oils, 16 species utilized for manufacturing of dhoop and incense, 30 species as source of phyto-chemicals, 40 species useful for tans and dyes and 42 species which can be used as potent substitute for exotic species, thereby discouraging their import and saving foreign exchange reserve (Chauhan, 2003). The Chamba district of Himachal Pradesh which comes under Ravi River Basin is considered as one of the richest areas of traditional and potential medicinal wealth (Negi, 1963). There is no proper record available regarding the traditional medicinal knowledge of the tribal area except few studies carried out by Rani *et al*. (2013) and Thakur *et al*. (2014 & 2016) from Chamba district of Himachal Pradesh.



Plate 2.17 – *Phyllanthus emblica* (Amla) medicinal Plant



Plate 2.18 – *Sinopodophyllum hexandrum* (Bankakdi) medicinal plant

Gaddis and Gujjars are the two main tribal communities of the area. The Gaddis, a semi-nomadic tribe, are the sheep and goat rearers and Gujjar tribes inhabit Siunta, Banikhet and areas adjoining to the plains of Himachal Pradesh. These nomads climb up the hills during summers and return to the plain in winter. During 2013-2016, Kumar *et al*., 2019 recorded 239 medicinal plants (19 trees, 38 shrubs, 173 herbs, and 09 ferns) belonging to 185 genera and 85 families. Of the recorded medicinal plants, 101 species were native, 23 near endemic and 01 endemic (i.e., *Scrophularia himalensis* Roye ex Benth). Different parts of the medicinal plants were used by the inhabitants for curing cough, cold, fever, cuts, wound, blood purification, tonic liver and kidney complaints, antidote to snake, insect bite, etc. But, due to over exploitation, habitat degradation, changing environmental conditions and high anthropogenic pressures, the population of most of the species are decreasing rapidly as well as increasing the vulnerability of these species. The local people (Shepherds in particular) believe in the healing power of these herbs, along with the power of Tantra and Mantra, but knowledge thereof is restricted to a very few elderly folks. Moreover, the younger generation does not seem much interested in keeping this traditional knowledge alive. This valuable information needs to be systematically collected and documented, so that it can serve mankind for generations to come and may also conserve the precious plant resources of high economic utility.

Herbaceous flora of the district Chamba (Himachal Pradesh) which contributes significantly (76%) to the number of species is an integral part of the seasonal vegetation. This includes all the annual herbs and perennials. Common Rainy season herbs are *Polygala arvensis, Sida cordata, Urena lobata, Triumfetta pentandra, Oxalis corniculata, Cassia occidentalis, C. tora, Crotalaria bialata, C. prostrata, Indigofera linifolia, Mollugo pentaphylla, Oldenlandia corymbosa, Ageratum conyzoides, A. houstonianum, Artemisia parviflora, A. capillaris, Conyza stricta, Erigeron bonariensis, Lactuca dissecta, Sonchus oleraceus, Xanthium indicum, C. zeylancium, Lychnis fimbriata, Geranium nepalense, G. wallichianum, Oxalis corniculata, Impatiens racemosa, Crotalaria albida, Trifolium repens, A. busua, Myriactis nepalensis, Cyathula capitata, Mentha longifolia,* etc. Common spring season herbs are *Fumaria indica, Capsella bursa-pastoris, Arenaria serpyllifolia, Stellaria media, Crotalaria medicaginea, Medicago polymorpha, Melilotus indica, Blumea mollis, Cirsium arvense, Avena fatua, Cynodon dactylon, Boerhavia diffusa, Ranunculus laetus, Viola canescens, Stellaria media, C. vulgare , Lamium album, Poa alpina, Tripogon purpurascens,* etc. (Singh and Sharma, 2006). From Chamba district, 135 families and 359 genera were recorded (Singh and Sharma, 2006).

In concerned district of Ravi River Basin *Nasturtium officinale, Portulaca oleracea, Trianthema portulacastrum, Solanum nigrum, Amaranthus blitum, A. viridis, Digera muricata, Chenopodium album, Fagopyrum dibotrys, Rumex hastatus* and *Urtica dioica,* are used as pot herbs. Unripe fruits of *Abelmoschus manihot, tetraphyllu var. pungens, Cucumis hardwickii, C. melo, var. agrestis;* Ripe fruits of *Berberis lycium, Flacourtia indica, Ziziphus jujuba, Fragaria vesca, Prunus cerasoides, Rubus biflorus,* and flower buds *of Capparis spinosa* Linn., are eaten raw and those of *Bombax ceiba* are used as vegetables (Singh and Sharma, 2006). Whereas *Agrostis munroana, Avena fatua, Brachiaria ramosa, Briza minor, Chrysopogon fulgus, Cynodon dactylon, Dactylis glomerata, Dactyloctenium aegyptium, Dicanthium annulatum, Digitaria ciliaris, Echinochloa colona, Eragrostis minor, E. tenella, E. unioloides, Ischaemum rugosum, Panicum psilopodium, Paspalum dilatatum, Sporobolus diander, Themeda anathera,* etc. are used as fodder plants (Singh and Sharma, 2006).

Grazing by domestic animals like cows, bufalloes, goats, sheep, donkeys and horses of Gaddis and Gujjars tribe is also a major cause for the destruction of vegetation. These animals are allowed to graze freely. Excessive grazing by these sizeable population of cattle has resulted in the loss of pasture vegetation, including a large number of herbaceous species which appear during summer and spring season. Due to the constant and intensive grazing by herbivores, several areas become depleted of much of their plant wealth. *Berberis lycium, Ziziphus nummularia, Dodonaea viscosa, Mimosa himalayana, Prinsepia utilis, Rubus ellipticus. Rhododendron arboreum, Carissa opaca, Justicia adhatoda, Lantana camara, Achyranthes aspera, A. bidentata, Girardinia diversifolia* and *Urtica dioica* are the conspicuous species which are free from the browsing and consequently plentiful in their respective climatic zones. Among the grasses, which are unpalatable to the livestock and consequently free from their

browsing influence are *Arundinella nepalensis, Arundo donax, Cymbopogon martini, Eulaliopsis binata, Imperata cylindrica, Neyraudia arundinacea,* and *Pennisetum flaccidum*. Growth of seeding is also adversely affected by these animals who trample the soil (Singh and Sharma, 2006).



Plate 2.19 –Medicinal Plants in Ravi River Basin

A study conducted by Thakur *et al.* (2016) in Holi and Bharmour area of Chamba district stated that *Jurinea dolomiaea, Gentiana kukrrooa, Valeriana jatamansi, Morchella esculenta, Viola serpens, Carum carvi* and *Picrorhiza kurroa* are found in Holi and Bharmour area and among them *Viola serpens* is collected maximum by the local people. Three plant species i.e., *Gentiana kurroo, Carum carvi* and *Picrorhiza kurroa* are reported endangered whereas one species *Jurinea dolomiaea* is vulnerable. Moreover, *Jurinea dolomiaea* is the highest extracted plant, followed by *Gentiana kurroo* with harvested yield of 1600 kg/yr and 900 kg/yr. Whereas, *Viola serpens* (10 kg/yr) is the least extracted medicinal plant species in the study area. Most of the

species are disapprrearing at faster rate because of its excessive extraction due to forest fire and over grazing (Thakur *et al*., 2016). Medicinal plants of different altitudinal zones in Himachal Pradesh is given below in Table 2.14.

Table 2.14- The Representative Medicinal Plants of the Different Altitudinal Zones in Himachal Pradesh

Sr. No.	Altitudinal zones	Representative species
1	Tropical and Sub-tropical< 1800m	*Justicia adhatoda, Achyranthes aspera, Mangifera indica, Apium graveolens, Rauwolfia serpentina, Acorus calamus, Calotropis gigantea, Asparagus adscendens, A. racemosus, Azardirachta indica, Artemisia absinthium, A. japonica, Tagetes minuta, Berberis asiatica, Rorippa indica, Bauhinia variegata, B. vahlii, Caesalpinia decapetala, Cassia fistula, Terminalia alata, T. arjuna, T. chebula, Cyperus rotundus, Dioscorea bulbifera, Emblica officinalis, Swertia angustifolia, Hypericum perforatum, Curculigo orchioides, Ajuga parviflora, Mentha arvensis, M. piperata, Ocimum canum, O. sanctum, Salvia plebeia, S. lanata, Cinnamomum tamala, Aloe barbadensis, Woodfordia fruticosa, Tinospora cordifolia, Syzygium cuminii, Malaxis acuminata, Ziziphus mauritiana, Prinsepia utilis, Rubia manjith, Zanthoxylum armatum, Sapindus mukorossi, Bergenia ligulata, Bacopa monnieri, Withania somnifera, Atropa belladonna, Urtica parviflora, Hedychium spicatum* and *Elaeagnus conferta*
2	Temperate 1801–2800 m	*Ferula jaeschkeana, Heracleum candicans, Asparagus filicinus, Ainsliaea aptera, Berberis aristata, Betula alnoides, Sagina saginoides, Corylus jacquemontii, Rosularia rosulata, Gentiana kurroo, Skimmia laureola, Geranium nepalense, Elsholtzia fruticosa, Rhododendron arboreum, Malva verticillata, Oxalis corniculata, Phytolacca acinosa, Polygala sibirica* and *Taxus wallichiana*
3	Sub-alpine 2801–3800 m	*Allium humile, Bunium persicum, Malaxis muscifera, Carum carvii, Geranium wallichianum, Angelica glauca, Archangelica himalaica, Bupleurum falcatum, Heracleum lanatum, Arisaema flavum, Saussurea auriculata, S. costus, Tanacetum gracile, T. tenuifolium, T. tomentosum, Impatiens gladulifera, Arnebia benthamii, Eritrichium canum, Rhododendron campanulatum, Ribes orientale, Polygonatum multiflorum, P. verticillatum, Plantago depressa, Aconitum ferox, A. leave, A. heterophyllum, A. falconeri, Pedicularis pectinata, Polygonatum verticillatum, Dactylorhiza hatagirea* and *Picrorhiza kurroa*

4	Alpine>3800 m	*Cortia depressa, Selinum tenuifolium, Heracleum wallichii, Inula royleana, Saussurea graminifolia, S. obvallata, S. simsoniana S. gossypiphora, Arnebia euchroma, Corydalis meifolia, C. govaniana, Iris kumaonensis, Fritillaria roylei, Polygonum affine, Rhododendron anthopogon, Rheum australe, R. moorcroftianum, R. webbianum, Dactylorhiza hatagirea, Picrorhiza kurroa, Aconitum heterophyllum, A. rotundifolium, A. violaceum, A. spicatum, Delphinium cashmerianum, D. vestitum* and *Nardostachys grandiflora*

(Source: Samant *et al*., 2007)

Medicinal plants have been used by mankind since the beginning of human civilization. The ayurvedic importance of herbs and shrubs are increasing. Nature has been a source of medicinal agents for thousands of years. Medicinal plants have been used by mankind for its therapeutic value and an impressive number of modern drugs have been isolated from natural sources. Medicinal plants produce bio-active compounds such as polyphenols, terpenes, glycosides; used mainly for medicinal purposes. About 115 species of Angiosperms and Gymnosperm plants of medicinal importance from Kathua district of Jammu (J&K UT) and some of them are *Abrus precatorius, Acacia nilotica, Achillea millefolium, Achyranthes aspera, Acorus calamus, Justicia adhatoda, Adiantum capillus-veneris, Aegle marmelos, Aesculus indica, Ajuga bracteosa, Bauhinia variegata, Boerhavia diffusa, Colebrookea oppositifolia, Centella asiatica,* etc. (Sharma *et al*., 2017).

The district of Kathua is subdivided into five tehsils, three of them Billawar, Basohli and Bani lie in the Shiwalik Himalaya whereas Kathua and Hiranagar lie in the plains besides foothills. The number of villages in the district is approx. 512 and the population of the district is 6.15711 Lacs (as per 2011 Census). The mainstay of the population is agriculture and rearing livestock. The area has a rich floral diversity particularly in the Shiwalik hills. Innumerable plants have been used by the people for different benefits even today. The over-exploitation of the valuable resource coupled with habitat destruction has its impact on the rarity and even the extinction of plants (Gupta, 2014). Common fodder of these area are *Grewia optiva, Grewia serrulata, Celtis tetrandra, Albizia lebbeck, Albizia chinensis, Bauhinia variegata, Acacia nilotica, Senegalia catechu, Quercus oblongata, Quercus semecarpifolia, Quercus floribunda, Dendrocalamus strictus, Ficus hispida, Ficus racemosa, Ficus benghalensis, Ficus virens, Ficus auriculata, Erythrina suberosa,* etc. (Gupta, 2014).

Sacred Natural Sites (SNS)

Sacred Natural Sites (SNS) are considered to be the junction of biodiversity that make up a global, natural and social network and is not well understood or well-known, often under-funded and increasingly under threat. As humanity continues to advance development by polluting the natural world human destroys these special areas, unknowingly, overuse of resources and the

social pressures that result from poverty and social ills. They are natural gene pool and serve as a repository for rare and endemic species. They include the most important ethno-botanical plants. High plant density also helps to conserve soil and water. Traditionally, local communities in the Himalayan hills have been setting aside forests, forests, forests groves, pastures and select water bodies as sacred places. Sacred Groves protected over the centuries have often been rich in biodiversity. They are very important to the environment and have the potential to provide a variety of environmental services (Anthwal *et al*., 2006; Bhagwat and Rutte, 2006; Gokhale and Pala, 2011; Negi, 2012). In Himachal Pradesh, the local myths and legends associated with sacred groves go a long way in preserving the forests from destruction. There are several groves named Dev Van or Devta Ka Jungle where one is not allowed to cut trees or even carry dry leaves outside the area. 329 Sacred Groves have been documented in the state. Deodar, Kail and Oak, with occasional Spruce and Silver fir are among the most commonly found plant species in the Sacred Groves. Manimahesh Lake is the sacred site for Hindu pilgrimes. The site around the temples is also considered sacred. In Dalhousie and Bharmour, there are many temples with shrines. It helps to protect many species of plants including trees. Sacred groves are present throughout Jammu and Kashmir UT, administered by religious organizations or administrative committees. The local names of these grooves are known as Banis. A total of 76 sacred groves have been registered so far. Some of the species commonly found in the sacred trees are the mango, banyan, Indian plum, mountain ebony, pipal, three-leaf caper, white fig, Bengal quince, and neem. People living around the groves voluntarily protect them (Sharma and Devi, 2014).

(C) Forests and Grasslands in Ravi River Plains of Punjab

Most of the tract is flat, being part of the Indo-Gangetic alluvial plain, and has a general slope from north-east to south-west. Various roads, railway lines, canals and bundhs act as barriers to the natural flow of water. There are burrow pits in various strips where rain water gets collected during the rainy season. The soil is alluvial varying from loamy to clay loam in the strip forests. In the case of areas along the Ravi River, the soil is fresh alluvium and varies in texture and composition i.e., sandy to silty loam. Amritsar Forest Division normally experiences a dry climate all through the year, the monsoon showers constituting about 70 % of the annual rainfall. The average annual rainfall in Amritsar during the last 15 years is about 700 mm. (Randhawa, 2014). The existing stand on all strips and Rakhs comprises mainly of *Dalbergia sissoo* (Shisham), *Acacia nilotica* (Kikar/Babul), *Prosopis juliflora* (Mesquite), *Eucalyptus hybrida, Mangifera indica* (Mango), *Morus alba* (Toot), *Syzygium cumini* (Jamun), *Albizzia procera, Albizia lebbeck* (Siris), *Acacia leucophloea* (Reru) and *Azadirachta indica* (Neem). These remnant forests and protected areas are located mainly in district of Amritsar, Pathankot and Gurdaspur. The part of Alluvial Plains is represented by the following two forest types and major species in Ravi River Plains (Punjab) are described in Table 2.15.

(i) 5B/C1 – Northern Dry Deciduous Forests

In this type of forest, the vegetation tends to be xerophytic in nature and species like *Acacia nilotica*, *Senegalia catechu*, *A. leucocephala*, *Tamarindus indica* and *Anogeissus latifolia* are preponderous. The associated shrubs are *Carrisa opaca*, *Murraya koenigii*, *Trema orientalis*, *Ziziphus* spp. and *Justicia adhatoda*. In the north-eastern parts of the State, *Dendrocalamus srictus* is found mixed with *Anogeissus latifolia*, *Lannea coromandelica*, *Terminalia arjun*, etc. Seral stages of Khair-sissoo, *Senegalia catechu* and *Dalbergia sissoo* forests are found along the streams or riparian areas.

(ii) 5B/C2 - Dry Deciduous Forests

The majority of areas in the *Kandi* tract fall under this type. The main species are *Senegalia catechu* and *Dalbergia sissoo* along with *Bombax ceiba*, *Phyllanthus emblica*, *Lannea grandis*, *Toona ciliata*, *Azadirachita indica*, *Diospyros tomentosa*, *Cassia fistula*, *Acacia nilotica*, *Hymenodictyon suaveolens*, *Ehretia laevis*, *Ficus racemosa*, etc.

Table 2.15 - Forest Types and Major Species in Ravi Plains in Punjab State

Forest Types	**Major Species**
Northern dry deciduous forests 5B/C1	*Senegalia catechu, Acacia nilotica, A. leucocephala and Anogeissus latifolia. Carissa opaca, Grewia optiva, Justicia adhatoda, Dendrocalamus strictus, Anogeissus latifolia, Lannea grandis* and *Terminalia alata*
Dry deciduous Forests 5B/C2	*Bombax ceiba, Emblica officinalis, Lannea grandis, Toona ciliata, Azadirachita indica, Diospyros tomentosa, Cassia fistula,* and *Acacia nilotica*
Shiwalik Chir-pine Forest 9/C/a	*Pinus roxburghii, Terminalia alata, T. bellirica, T. chebula, Phyllanthus emblica* and *Anogeissus latifolia*
Dry deciduous bamboo Forests 5/Ea	*Lannea coromandelica, Diospyros montana, D. tomentosa, Butea monosperma, Holoptelea integrifolia* and *Cassia fistula.*

(Source: Modified after Champion & Seth, 1968)

Major crops and fodder of Punjab plains: Wheat is a major cereal crop of Punjab. It was grown on an area of 35.12 lakh hectares during 2017-18 with production of 178.30 lakh tonnes and average yield of 50.77 quintals per hectare (20.54 quintals per acre). Wheat is a cool season crop can be grown on all kind of soils, except the highly deteriorated alkaline and water-logged

soils. *Durum* wheat should preferably be sown on medium to fine textured soils. Improved varieties of wheat are Unnat *PBW* 343, Unnat *PBW* 550, *PBW* 1 Zn, and *PBW* 725. Rapeseed and Mustard crops grow well in areas having 25 to 40 cm of rainfall. Taramira is preferred in low-rainfall areas, whereas raya, gobhi, sarson, African sarson and toria are grown in medium to high rainfall areas. It grows best on well-drained, light-tomedium textured soils. Berseem is a highly nutritious and palatable fodder. It grows well on medium to heavy soils and with stands alkalinity. Improved varieties are *BL 43, BL 42,* and *BL 1.* Fodder crops are Ryegrass, Shaftal, Lucerne, Senji, Hay making, Silage making, etc.

Medicinal, Spice and Aromatic Crops: Celery, commonly known as Karnauli, is grown mostly in districts of Amritsar, Gurdaspur and Tarntaran. The seed and its products are exported. It requires mild cool climate for luxuriant growth in the early stages and warm dry weather at maturity, its variety is *Punjab Celery.* Some other prominent plants are, Coriander, Fennel, Dill seed, Honey plant, Fenugreek, etc. (Bhatti *et al.,* 2019).Sacred groves in Punjab have species of native trees and medicinal plants, herbs and grasses.

2.4.3 Forest Cover and Change

Forest Survey of India (FSI) conducts survey and assessment of forest resources in the country, and provide the India State of Forest Report (ISFR) biennially since 1987, using Remote Sensing and Geographical Information System (GIS) technologies and field validation. The sixteen such reports were provided in the year 2019. The forest cover assessment is wall to wall mapping exercise based on remote sensing supported by intensive ground verification and field data from National Forest Inventory. The term 'Forest Cover' refers to all land more than 1 ha in area with a tree canopy more than 10% irrespective of land use, ownership and legal status. On the other hand, the term Recorded Forest Area (RFA)' refers to all the geographic areas recorded as 'Forests' in the government records. RFAs are largely consists of Reserved Forests (RFs), Protected Forests (PFs), and Un-demarcated Forests (UDFs) or Unclassified Forests constituted as per the provision of Indian Forest Act, 1927. The FSI categorizes forests in five categories based on canopy classes. These are: (a) VDF - Very Dense Forest (i.e., lands with tree canopy density of >70%); (b) MDF - Moderately Dense Forest (i.e., lands with tree canopy density of 40% - <70%); (c) OF – Open Forest (i.e., lands with tree canopy density of 10% - <40%); (d) SF – Scrub Forest (i.e., degraded forest lands with canopy density <10%); (e) Non-Forests i.e., lands not included in any of the previous four categories, includes water (FSI, 2019). Changes in forest cover between the two consecutive assessment periods allow appreciation of the actual change on the ground during the intervening period. The real changes on the ground can be on account of diversion of forest lands for non-forestry uses, plantation activities, harvesting of short rotation plantations, silviculture based fellings, shifting cultivation, clearances in encroached areas and conservation measures (FRI, 2016). In addition to the vital information on forest cover that provides an insight on the aerial extent of country's forests, the FSI also provides crucial

information on growing stock which is the measure of substance of its tree wealth. In recent years, FSI has also started providing valuable information on the Tree Outside Forests (TOFs). TOFs are the tree resources outside RFAs. The inventory of TOFs is carried out in both rural and urban areas of the randomly selected Districts. Further, FSI has started estimating the carbon stock in the Indian Forests based on the methodology of 'Good Practices Guidance (GPG)' provided by the Inter-governmental Panel on Climate Change (IPCC). More recently, FSI has also started collecting information on Bamboo Resource of India. An insight on forest cover, TOFs, growing stock, carbon stock, spatial pattern of forest cover and fragmentation and forest changes in two states representative within the Ravi riverscape is provided below based on the information published by FSI in its biennial ISFRs (FSI, 2019).

(a) Forest Cover

According to the ISFR–2019 (FSI, 2019), India had a Recorded Forest Area (RFA) of 7, 67,419 km^2 representing 23.34 % of the country's geographical area. This RFA included 57%, 29%, and 15% proportion under the legally defined Reserved Forests (RFs), Protected Forests (PFs), and Unclassed Forests (UFs), respectively. The values dsffg of RFAs in Himachal Pradesh, Punjab and Jammu & Kashmir Union Territory along the course of the Ravi River ARE 37,033 km^2 and 3,084 km^2, 20,230 km^2, respectively. The Himachal Pradesh and J&K UT, have nearly 67% and latter 9.1% area as the recorded forest area while the agriculture dominated State of Punjab had a meager recorded forest area of just 6.12% of its geographical area. The proportion of reserved forest in both the states was substantially low as bulk RFA was in the legal category of protected forest. The Himachal Pradesh with it's nearly 67% RFA contributes 4.82% of the country's RFA while the Punjab contributes a minuscule proportion of country's RFA. Union Territory of Jammu & Kashmir contributes 2.63% proportion of country's RFA. The factual information provided in Table 2.16 amply revealed that Himachal Pradesh wherein the Ravi River not only originates, but also have catchment of some of its major tributaries still has considerable RFA. However, the bulk RFA is under the relatively lower category of PFs. The situation of forests in terms of overall RFA as well as their lower legal categories i.e., PFs and UFs in the Punjab alluvial plains is dismaying in proportion to the larger size of this State. The factual insight about the current forest cover in two States and one Union Territory, the historical information on the considerable loss of forests in these two States in the past century or so warrants intensive forestry interventions in the riverscape by way of plantations as well as strict protection to the existing limited extent of forests.

Table 2.16- Recorded Forest Areas (RFAs) in India, Himachal Pradesh, Punjab and Jammu & Kashmir Union Territory including Ladakh Represented in the Ravi Riverscape

Sr. No.	India/ State/UT	Geogra-phical Area km^2	Reserved Forests	Protected Forests	Unclass-ed Forests	Forest Recorded Area	Country/ States' Geograp-hical Area	% of India's Forests Area
			km^2	km^2	km^2	km^2	(%)	(%)
1	**All India**	**32,87,269**	**4,34,853**	**2,18,924**	**1,13,642**	**7,67,419**	**23.34**	**100.00**
2	Himachal Pradesh	55,673	1,898	33,130	2,005	37,033	66.52	4.82
3	Jammu & Kashmir (including Ladakh)	222,236	17,643	2,551	36	20,230	9.10	2.64
4	Punjab	50,362	44	1137	1903	3084	6.12	0.40
	Total (1-4)	**328,271**	**19,585**	**36,818**	**3,944**	**60,347**	**18.38**	**7.86**

Further, the close scrutiny of information on forest cover on canopy density provided by the FSI in its ISFR – 2019 in two concerned States and one UT provided almost similar impression (Table 2.19). Notably, out of total forest areal extent of 40895 km^2 in two States and One Union Territory, a small area (7,402 km^2) or 7.45% was under the category of Very Dense Forests i.e., with >70% canopy density while as much as much 5.56% forests were under the category Open Forests. The Moderately Dense Forests (MDFs) with >40% and <70% canopy density constituted 5.36% of total forests in two States and one UT. The lowest proportion of VDFs in both the States and a meager extent of just 8 km^2 of VDFs in Punjab justify improvement of forests by way of protection, massive plantation and interventions like assisted natural regeneration and gap planting (Table 2.17).

Table 2.17 - Forest Cover in India, Himachal Pradesh, Punjab and Jammu & Kashmir Union Territory including Ladakh Represented in the Ravi Riverscape

Sr. No.	India/ State	Geograph-hical Area km^2	VDF	MDF	OF	Total Forests	Percent Geographical area (%)	Tree Cover	Total Forest and Tree Cover	Scrub
			km^2	km^2	km^2	km^2		km^2	km^2	km^2
1	All India	3,287,469	99,278	3,08,472	3,04,499	7,12,249	21.67	95,027	8,07,276	46,297
2	Himachal Pradesh	55,673	3,113	7,126	5,195	15,434	27.72	829	16,263	315
3.	Jammu &Kashmir	2,22,236 (53,258*)	4,281 (4,203*)	8,612 (7,952*)	10,719 (8,967)*	23,612 (21,122*)	39.66	7,944	31,556	548 (250)*

	UT including Ladakh									
4.	Punjab	50,362	8	801	1,040	1,849	3.67	1,592	3,441	33
	Total (1-4)	**328,271**	**7,402**	**16,539**	**16,954**	**40,895**	**12.45**	**10,365**	**51,260**	**896**

(Source: FSI, 2019)

* UT of Jammu & Kashmir

(b) Tree Cover

Tree cover in small tree patches (i.e., <1 ha in extent) outside the recorded forest area and usually those lie in village woodlots, orchids, homesteads, urban areas, industrial plantations, and compact blocks along roads, canals, railway lines, etc. and as well as scattered trees is of immense value as it provides multiple benefits. Owing to mapping limitations, isolated small tree patches (<1 ha) are excluded from 'Forest cover', however, their contribution is captured in the form of tree cover. The entire country as per the ISFR-2019 had tree cover outside RFAs to the extent of 95,027 km^2while two States and one Union Territory along the Ravi River course together had 10,365 km^2 tree cover outside RFAs (Table 2.19). The Punjab State which was deficient in the actual forest cover had greater areal extent of 1592 km^2 than the mountainous State of Himachal Pradesh having 829 km^2 of tree cover.Union Territory of Jammu and Kashmir having 7944 km^2 of tree cover (Table 2.17).

(c) Growing Stock

The ISFR-2019 by FSI (2019) provided the insight on the growing stock in the RFA. The growing stock for the whole country was computed to the extent of 4,273.47million m^3 while the growing stock in TOFs was 1,642.29 million m^3 (Table 2.18). Collectively, diverse forests in Himachal Pradesh, Punjab and J&K Union Territory had the growing stock in RFAs to the tune of 649.82 million m^3 and this constituted 15.20% growing stock of the country in RFA. Himachal Pradesh, Punjab and J&K Union Territory contributed just 10.28% growing stock of the country in TOFs. Incidentally, both States i.e., Himachal Pradesh, and Punjab included in the riverscape were poor contributors to the growing stock in RFA as well as TOFs as compared to Jammu & Kashmir UT and the whole country.

Table 2.18 - Growing Stock in India, Himachal Pradesh, Punjab and Jammu & Kashmir Union Territory Represented in the Ravi Riverscape

Sr. No.	Country/ state/ UT	Geographical Area km^2	Forest Recorded Area in TOF km^2	% of India's Forest Area (%)	Country/ State/ UT' Geographical Area (%)	Growing Stock in RFAM m^3	Growing Stock in TOF M m^3
1	All India	32,87,469	**7,**67,419	23.34	23.34	4,273.47	1,642.29
2	Himachal Pradesh	55,673	37033	4.82	66.51	347.07	25.19
3	Jammu & Kashmir UTincluding Ladakh	222,236	20,230	2.63	9.10	291.63	125.14
4	Punjab	50,362	3084	0.40	6.12	11.12	18.56
	Total (1-4)	**328271**	**60347**	**7.86**	**18.38**	**649.82**	**168.89**

(Source: FSI, 2019)

Above revelations with regard to the extent of RFA, legal categories of forests, forest cover, representation of canopy density classes, contribution to the growing stock of RFA and TOFs of the country by two concerned States noticeably explained that the overall situation of forests in two catchment States is notably not very sound. These observations provide ample clues that there is enormous scope not only to enhance the forest extent in two States along the river course, but also to improve the quality of forests and the resultant contribution to the growing stock.

(d) Spatial Pattern of Forest Cover and Fragmentation in Different Patch Size

Anthropological distributions depend on forests for their survival, from the air they breathe to the wood use. Besides providing habitats for animals and livelihoods for humans, forest also offer watershed protection, prevent soil erosion and mitigate climate change. Most of the world's forests have been exploited and used by human for multiple benefits since time immemorial. In country like India, a substantial rural population, particularly forest dwellers and people living in forest fringe villages have been traditionally dependent on forest resources for their subsistence and livelihoods. In addition, the country's forests have long history of management. Further, substantial chunk of forests was cleared for expansion of agriculture and in a larger part of the north-east India shifting cultivation is being practiced. Forest lands are being diverted for non-forest uses and various developmental projects. These multiples uses, long history of management, and changes in land use owing to developmental works have resulted into fragmentation of natural as well as man-made forests. Laurance (2000) has defined fragmentation as simultaneous reduction of forest area, increase in forest edge and sub-division

of large forest area into smaller no-contiguous fragments or forest patches. The process of forest fragmentation has produced a mosaic of natural and managed ecosystems in the human dominated landscapes (Roy *et al.*, 2013; Midha and Mathur, 2010).

The fast-growing discipline of Landscape Ecology aims to study and assess the spatial patterns or landscape structure, composition, and dynamics as a result of developmental activities, change in land use and implications of fragmentation. The Fragmentation may be defined as the breaking of large contiguous, forested areas into smaller pieces of forest; typically these pieces are separated by roads, agriculture, utility corridors, sub-division, or other human development. The landscape ecology examines spatial variation in fragmentation by way of assessing the spatial patterns or landscape structure, composition and dynamics by way of patch characteristics i.e., patch number, size, shape, abundance and forest matrix that characterize forest fragmentation and impact of human activities on forests and other natural ecosystems. Forest fragmentation not only disrupts the contiguity but also results into the loss of biodiversity and associated ecosystem processes and services. The emerging tools and procedures as a part of the advancement in the discipline of landscape ecology examines spatial patterns by way of patch characterization and also evaluate the condition of the matrix. Non-forest patches tend to multiply and expand until eventually the forest is reduced to scattered, disconnected forest islands. The surrounding non-forestland sand land uses seriously threaten the health, function, and value of the remaining forest. When a forest becomes isolated, the movement of plants and animals is inhibited. This restricts breeding and gene flow and results in long-term population decline. Fragmentation is a threat to natural resilience, and connectivity of forest habitats may be a key component of forest adaptation and response to climate change. Recognizing the need to appreciate the changes in and around forests and impact of forest fragmentation, the FSI from the year 2015 started the assessment of number and size of patches with regard to the forest cover of the whole country as well as for each of the State/ UT and different forest types. Thus, valuable information on spatial patterns, patch characteristics and fragmentation are available for the entire country as well as all States/ UTs for two biennial assessments on forest cover and patch characteristics. Availing this information from ISFR-2015and ISFR-2017, the following section attempts to compare the situation with regard to patch characterization in the entire country and two concerned States and one UT located along the course of Ravi River (Table 2.21) (FSI, 2015 and 2017).

According to ISFR–2017, it was revealed that > 40% of the forest cover for the entire country was contained in nine larger patches, each having area greater than 10,000 km^2. 65 patches, each having an area above 1,000 km^2 covered more than 65% of the forest cover of the country. The largest patch was located in the northeastern State and covered an area of 1, 58,439 km^2. As many as 7,27,380 forest patches or 97.4% of total patches recorded in the country were < 1 km^2 in size and these patches constituted just 7.64% of the forest cover of the country (FSI, 2017). While comparing the most recent situation on forest cover and patch characterization as of 2017

at the national level with the previous biennial assessment (FSI-2015) provided startling revelations. These revelations based on comparison were: (a) the forest cover in the country showed slight increase from 7,01,673 km^2 to 7,08,273 km^2 in two year intervening period, (b) total number of patches decreased from 9,53,244 to 7,46,386 showing loss of 2,06,858 forest patches in just two years or 21.7% loss in number of forest patches, (c) the maximum loss of patches, being 2,08,484 was in the smallest patch size range (0.01 - <1.0 km^2), and (d) the second lower patch size range (1.0 - <10 km^2) category showed increase of 1,487 patches in the year 2017 (Table 2.19). These revelations evidently reflected that on one hand the country showed increase in the overall forest cover while in a short span of just two years lost a large number (2,08,484 or 21.7%) of smaller patches (<1 km^2) indicating significant loss of forest and a very high rate of forest fragmentation. Indeed, it is a worrisome situation and calls for widespread forestry interventions to safeguard from the deteriorating situation.

Table 2.19- Patch Size Classes in India, Himachal Pradesh, Punjab and J&K Union Territory Represented in the Ravi Riverscape

Forest Cover Informatics in Different Patch Size Class							
All India							
Sr.No.	**Patch Size Range (km^2)**	**ISFR – 2015**			**ISFR - 2017**		
		No. of Patches	**Area (km^2)**	**(%)**	**No. of Patches**	**Area (km^2)**	**(%)**
1	0.01 - <1.0	9,35,864	50,494	7.20	7,27,380	54,082	7.64
2	1.0 - <10	14,957	40,583	5.78	16,444	43,639	6.16
3	10 - <100	2,056	57,675	8.22	2,183	58,052	8.20
4	100 - <500	240	48,476	6.91	257	51,298	7.24
5	500 - <1000	58	40,109	5.72	57	39,628	5.59
6	1000 - <5000	45	92,041	13.12	42	85,407	12.06
7	5000 - <10000	15	62,718	13.21	14	90,028	12.71
8	≥10000	9	2,79,577	39.84	9	2,86,139	40.40
	Total	**9,53,244**	**7,01,673**	**100**	**7,46,386**	**7,08,273**	**100**
Himachal Pradesh							
1	0.01 - <1.0	18,041	1390	9.46	22,082	1,578	10.45
2	1.0 - <10	551	1459	9.93	554	1,482	9.82
3	10 - <100	84	2843	19.35	76	2,276	15.07
4	100 - <500	9	2133	14.51	9	1,635	10.83
5	500 - <1000	4	3013	20.50	4	3,020	20.0
6	1000 - <5000	3	3858	26.25	4	5,109	33.83
Total		**18,692**	**14696**	**100**	**22,729**	**15,100**	**100**
Jammu & Kashmir UT							
1	0.01 - <1.0	40,097	2,432	10.58	41,872	2,900	12.48
2	1.0 - <10	774	1,949	08.48	798	2,067	8.89
3	10 - <100	83	2,663	11.58	97	2,754	11.85
4	100 - <500	14	2,790	12.14	15	3,120	13.42

5	500 - <1000	5	3,414	14.85	4	2,874	12.37
6	1000 - <5000	3	4,023	17.50	5	9,526	40.99
7	5000 - <10000	1	5,717	24.87	0	0	0.00
8	≥10000	0	0	0.00	0	0	0.00
Total		**40,977**	**22,988**	**100**	**42,791**	**23,241**	**100**
Punjab							
1	0.01 - <1.0	5065	385	21.74	6,086	451	24.55
2	1.0 - <10	89	212	11.97	92	222	12.08
3	10 - <100	3	65	3.67	3	65	3.54
4	100 - <500	3	553	31.23	3	548	29.83
5	500 - ≤1000	1	556	31.29	1	551	30.00
Total		**5,161**	**1,771**	**100**	**6,185**	**1,837**	**100**

(Source: FSI, 2015 and 2017)

On the above lines of national level assessment of forest cover and patch characterization, information for Himachal Pradesh which makes the primary catchment of the Beas River is also available for two consecutive biennial assessments by FSI. As per the ISFR-2017, the State had 15,100 km^2 area under the forest cover, and it was represented by 22,729 patches under various patch size classes. More than 97% patches were in the lowest patch size range (0.01 - <1.0 km^2) category indicating that bulk forest patches were of very small size (<1 km^2) prone to gradual disappearance, fragmentation, and degradation owing to the severe human pressure and disturbances. These small size patches constituted just 10.45% of forest cover of the State. There were just four large patches (1000 - <5000 km^2 extent) covering 5,109 km^2 area and constituting 33.83% of the total forest cover of the State. Ninety three patches (10 km^2 in size) constituted nearly 60% forest cover of the State (Table 2.21). On a comparison with the data of ISFR-2015, important observations made were: (a) the State registered a slight increase in the forest cover from 14,696 km^2 to 15,100 km^2 i.e., a gain of 434 km^2 area under the forest cover, (b) the number of forest patches in the State increased from 18,692 to 22,729 indicating gain of 4,037 patches or 21.5% increase in overall number of patches reflecting rapid fragmentation, and (c) the bulk gain by 4,444 patches was in two lowest patch size range categories i.e., up to <10 km^2 in 2-year period was quite significant showing the high pace of fragmentation (FSI, 2015 and 2017). This type of further division of smaller patches indicates their vulnerability and reduced ecosystem services they can offer.

Likewise, two consecutive biennial assessments on forest cover and patch characterization in the case of Punjab State also offered startling observations based on FSI-2015 and FSI-2017. In 2017, the State had a forest cover of 1,837 km^2 represented by 6,185 patches. There was just one large patch in the patch size range of 500 - ≤1000 km^2 constituting 30% of the total forest cover of the state (Table 2.21). As many as 98.39% patches were less than 1 km^2 and they constituted nearly 25% of the total forest cover in the State. There were just seven patches >10 km^2 those constituted 63.37% of the total forest cover. While comparing the situation of forest cover and patch characterization based on ISFR-2015, notable observations were: (a) an increase in number of forest patches from 5,161 to 6,185 with majority increase in the lowest patch size category (<1

km^2), (b) the contribution by singular largest patch to overall forest cover of the State decreased from 556 km^2 to 551 km^2 in two years of intervening period. The contribution of this patch to State forest cover decreased from 31.29% to 30% (FSI, 2015 and 2017). In one way, the situation of Punjab resembled to great extent with the overall country and the State of Himachal Pradesh as they all showed the bulk proportion of patches in the smallest forest patch range class and greater pace of fragmentation of smaller patches.

(e) Forest Changes in Himachal Pradesh, Punjab and Jammu & Kashmir UT

The spatio-temporal changes in forest cover between two consecutive assessment periods reflect the change on the ground during the intervening period and provide an insight on the forest dynamics in human dominated landscapes. A comparison of total forest cover and forest canopy density classes in two consecutive assessment periods (2017 and 2019) in the case of entire country, two concerned States and One Union Territory relevant to the Ravi Riverscape provided noteworthy observations (Table 2.20). Accordingly, the country and concerned States and Union Territory registered slight increase in respective forest cover in 2017 than the previous biennial assessment. The extent of Very Dense Forests (VDFs) increased in two-year period from 98,158 km^2 to 99,278 km^2 in the case of entire country. Likewise, Himachal Pradesh and Jammu & Kashmir UT showed an increase in the extent of VDFs from 3,110 km^2 to 3,113 km^2 latter 4075 km^2 to 4281 km^2. However, Punjab hasn't showed any change in VDFs i.e., 8 km^2. Similarly, in case of MDFs, the country again showed gain i.e., from 3,08,318 km^2 to 3,08,472 km^{2}while Himachal Pradesh states relevant to the Ravi Riverscape recorded slight gain in MDFs over two-years intervening period. While, Punjab State showed very little decline in MDF. The extent of Open Forests was enhanced in the case of whole country, Punjab and Union Territory of Jammu & Kashmir, while in contrast; Himachal Pradesh registered a slight decline in the extent of open forest in 2017 in comparison to the previous biennial assessment (Table 2.20).

Table 2.20– Comparison in Forest Cover and Canopy Density Classes in India, Himachal Pradesh and J&K Union Territory Between two Consecutive Assessments of 2017 and 2019

Sr. No.	India/ State	Geo-graphical Area (km^2)	2017 Assessment				2019 Assessment			
			Total Forest Cover (km^2)	VDF (km^2)	MDF km^2	OF (km^2)	Total Forest Cover (km^2)	VDF (km^2)	MDF (km^2)	OF (km^2)
1	All India	32,87,469	7,08,273	98,158	3,08,318	3,01,797	7,12,249	99,278	3,08,472	3,04,499
2	Himachal Pradesh	55,673	15,100	3,110	6,705	5,285	15,434	3,113	7,126	5,195
3	Jammu and Kashmir UT including Ladakh UT	222236	23241	4075	8579	10587	23,612 (21122*)	4281 (4203)*	8612 (7952)*	10,719 (8967)*

4	Punjab	50,362	1,837	8	806	1,023	1849	8	801	1040
	Total (1-4)	**328,271**	**40,178**	**7,193**	**16,090**	**16,895**	**40,895**	**7,402**	**16,539**	**16,954**

(Source: FSI, 2017 and 2019) *UT of Jammu & Kashmir

(a) Changes in Forest Cover

As stated earlier, FSI has been carrying out biennial assessment on forest cover for the entire country and each of the State and UT since 1987. Thus, in past 16 consecutive assessments until 2019, valuable insight on changes in forest cover has been obtained. The same has been summarized in Table 2.21 for the entire country, concerned States and UT relevant to the Ravi Riverscape. Accordingly, in general, the country has shown the continuous gain in the extent of forest cover from 1987 to 2019, except in 1991 assessment. The forest cover increased from 6, 40,819 km^2 in 1987 to 7, 12,249 km^2 in the intervening period of 32 years. The current assessment i.e., 2019 shows an increase of 3,976 km^2 (0.56%) of forest cover, 1,212 km^2 (1.29%) of tree cover and 5,188 km^2 (0.65%) of forest and tree cover put together, at the national level as compared to the previous assessment i.e., FSI, 2017. Like India, the concerned States and Union Territory also showed gradual increase in forest cover since 1987 except an aberration between 2001 and 2005 in the case of Punjab when the forest cover decreased from 2,432 km^2 to 1,558 km^2 (Table 2.21).

Table 2.21– Comparison of Forest Cover in India, Himachal Pradesh, Punjab and J&K Union Territory including Ladakh UT between 1987 and 2017

Sr. No.	India/ State	Geo-graphical Area km^2	Change in Total Forest Cover Since 1987 km^2							
			Assessment Years							
			1987	1991	1995	2001	2005	2011	2017	2019
1	All India	3,287,263	6,40,819	6,39,879	6,38,879	6,75,538	6,77,088	6,92,027	7,08,273	7,12,249
2	Himachal Pradesh	55,673	12,480	12,480	12,502	14,360	14,369	14,669	15,100	15,434
3	Jammu & Kashmir UT including Ladakh UT	222,236	20905	20,449	20,433	21,237	21,273	22,539	23241	23,612
4	Punjab	50,362	943	1,343	1,342	2,432	1,558	1,764	1,837	1849
	Total (1-4)	**328,271**	**34,328**	**34,272**	**34,287**	**37,191**	**37,200**	**38,972**	**40,178**	**40,895**

(Source: FSI, 2017 and 2019)

Undoubtedly, the country as well as concerned States and UT showed gradual increase in forest cover in past 32 years. However, such increase in forest cover has to be seen with caution in connotation with the valuable insight on various forest canopy density classes, growing stock,

spatial patterns of forest cover, patch characterization, and the pace of fragmentation, particularly loss of smaller forest patches at a very fast pace. The forgoing description on changes in forest cover, the condition of the growing stock and the alarming rate of forest fragmentation warrants extensive as well as intensive forestry interventions so as to ensure healthy forests, efficient catchments, and sustainability of river ecosystems.

2.4.4 Carbon Stock in Forests

Forests play an important role in mitigation and adaptation of climate change. Climate Change has emerged as leading environmental issues in recent past. Forest and Climate Change are intimately interwined. A growing forest captures carbon from atmosphere and a mature forest is a store house of carbon. Climate Change and its resulting variability impacts a serious threat to the environment and to the quality to human life in all over the world. In carbon sequestration forests plays an important role. Diverse forests in the concerned states and UT along the Ravi River course make significant contribution in this direction. Proposed forestry interventions will further improvise the current carbon stock in diverse forests and help in mitigation of adverse impacts of climate change.

Climate Change has emerged as the leading environmental issue of the present century and has become a global concern. Climate change and its implications not only pose enormous challenges for natural ecosystems, but also likely to severely influence the quality of human life. Among natural ecosystems, forests have important role to play in climate change mitigation as forests and Climate change are intricately connected. On the one hand, forests regulates the climate, rain, ground water, and soil while on the other hand climate influences the spatio-temporal patterns of forests, their diversity, associated floral and faunal life, productivity, and even the ecosystem services they offer to humankind. Forests are both, the source as well as sink of carbon. Forests sequester the carbon as well as store more carbon than any other terrestrial ecosystem. Carbon sequestration by forests has been recognized as a major contributor towards the climate change mitigation. The ‘Good Practices Guidance (GPG)’ developed by the Inter-governmental Panel on Climate Change (IPCC) is the universally accepted source book for concepts, definitions, various pools, methods, default values, various required equations, etc. for preparing account of Forest Carbon Stock (FCS). The total carbon which is stocked in the forests has been divided into five pools by GPG (FSI, 2019). The living portion of carbon in biomass is in two pools *viz.*, the Above Ground Biomass (AGB) and the Below Ground Biomass (BGG) and they are major stores of significant amount of carbon. The Dead Organic Matter (DOM) is also categorized into two pools *viz*., the ‘Dead Wood’ and ‘Litter’. The fifth pool is Soil Organic Matter (SOM) which also contains substantial amount of Organic Carbon. Since, FSI has a huge repository of past data on forest growing stock as well as continue to carry out biennial assessment of forest cover in the country, States and UT, and forest types; FSI is in a position to provide an insight on carbon stock in India’s forests and changes. The ISFR – 2019 has provided

updated valuable information on State-wise carbon stock in different carbon pools. This valued information provided by FSI (2019) is used below to summarize the current situation of carbon stock in different pools into concerned States and Union Territory relevant to the Ravi Riverscape.

The forest carbon stock for the country has been estimated to be 7,124.6 MT (FSI, 2019). An increase of 42.6 MT of carbon stock has been recorded in comparison to the estimates of previous assessment. The annual increase of carbon stock is estimated 21.3 million tonnes which is 78.1 million tonnes of CO_2 equivalent. Soil organic carbon is the largest pool of forest carbon accounting for (56.19 %), followed by AGB (31.67 %), BGB (9.84 %), Litter (1.80 %) and dead wood (0.50 %). On comparing the changes between the present and previous assessment, the largest increase has been observed in soil organic carbon, followed by AGB and dead wood (Table 2.22). The forest carbon stock in Himachal Pradesh as per the ISFR-2019 was 252.36 MT of the country's total forest carbon stock. Like in the case of entire country SOM was the largest pool in the mountainous State, followed by AGB, BGB, Litter and Dead Wood. The values of per hectare stock in different pools ranged from 44.89 t ha^{-1} (SOM) to 0.14 t ha^{-1} (Dead Wood). The forest carbon stock in the Punjab State recorded in 2019 was 133.44 MT. The AGB contributed 110.04 MT while the SOM contributed 106.3 MT of carbon. The value of per hectare stock was higher in Himachal Pradesh, being 163.51 than Punjab which registered the value of 72.18 per hectare stock and Jammu and Kashmir UT is registered the value of 165.25 (Table 2.22) (FSI, 2019).

Table 2.22 – Forest Carbon Stock in Different Carbon Pools (values in '000 t) in India, Himachal Pradesh and Jammu & Kashmir Union Territory along the Course of Ravi River (values in parentheses are of per ha of a stock in tonnes)

State	Forest Cover (km^2)	AGB (MT)	BGB (MT)	Dead Wood (MT)	Litter (MT)	SOM (MT)	Total (MT)
All India	7,12,249	22,56,533 (31.68)	7,00,824 (9.84)	35,842 (0.50)	1,27,902 (1.80)	40,03,575 (56.21)	71,24,676 (100.03)
Himachal Pradesh	15,434	1,10,045 (71.30)	30,745 (19.92)	2,559 (1.66)	2,711 (1.76)	1,06,300 (68.87)	2,52,360 (163.51)
Jammu & Kashmir	23,612	1,70,222 (72.09)	47,806 (20.25)	3,813 (1.62)	3,706 (1.57)	1,64,648 (69.73)	3,90,195 (165.25)
Punjab	1849	3,529 (19.09)	1,367 (7.40)	25 (0.14)	125 (0.67)	8,298 (44.89)	13,344 (72.18)

(Source: FSI, 2019)

2.4.5 Wetlands

Wetlands are amongst the most productive ecosystems on the Earth (Ghermandi *et al*., 2008). However, they are also ecologically sensitive and adaptive systems (Turner, 2000). As per the Ramsar Convention definition most of the natural water bodies (i.e., rivers, lakes, coastal lagoons, mangroves, peat land, coral reefs) and man-made wetlands (i.e., ponds, farm ponds, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals) constitute the wetland ecosystem (Sharma and Dua, 2017). Wetlands are defined as land transitional between terrestrial and aquatic ecosystem where the water table is usually at or near the surface or the land is covered by shallow water. wetland are referred as areas with water covered periodically, seasonally, or permanently, such as, tidal flats, and flooded areas near rivers, rice paddies, swamps or lakes. Wetland performs numerous valuable function such as recycle nutrients, purify water, attenuate floods, recharge ground water and also serves in providing drinking water, fish, fodder, fuels, wildlife habitat, control rate of runoff in urban areas, buffer shorelines against erosion and recreation to society (Kanaujia and Kumar, 2014). With the advancement in technology, holistic planning for the conservation and preservation of natural resources is gaining momentum. Wetlands are one of the most important resources that have played a major role in human history. It is only wetlands, whether perennial rivers or large water-bodies, have been the sources of water and consequently the development of civilisations. These are transitional areas between aquatic and terrestrial ecosystems where the water table is at or near the surface, or the land is covered by shallow water. They are among the most productive ecosystems of the world, although they account only about 4% of the earth's ice-free land surface (Prigent *et al*., 2001). But ironically, preservation of wetland ecosystem has received very little attention till recently. The ever increasing demand for economic growth during the last half century with utter disregard for the long term ecological consequences has led to over exploitation of wetlands. Realising their importance, steps have been initiated world over during the past few decades, for preservation and conservation of this vital resource.

India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad *et al*., 2002). The available estimates about the areal extent of wetlands in India vary widely from a lower of 1% to a highest of 5% of geographical area, but do support nearly fifth of the known biodiversity (SAC, 2011; Bassi *et al*., 2014). In India, various attempts have been made to prepare the inventory of wetlands and assess the areal extent (Woistencroft *et al*., 1989; WWF and AWB, 1993; Garg *et al*., 1998). However, these earlier assessments were marred by problem of inadequate understanding of the definition and characteristics of wetlands (Gopal and Sah, 1995). The National Wetland Atlas prepared by the Space Application Centre (SAC), ISRO is the latest scientific inventory on wetlands of the entire country, identified and mapped on 1:50,000 scale (SAC, 2011). A total of 2, 01,503 wetlands were mapped in the country. In addition, 5, 55,557 wetlands with area <2.25 ha which is smaller than minimum

measurable unit were identified as point features (Bassi *et al*., 2014). Thus, India has about 7, 57,060 wetlands covering total area of 15.3 million ha, accounting for nearly 4.7% of the country's geographical area.

The Ravi Riverscape of Himachal Pradesh, Punjab and Jammu &Kashmir UT encompasses a wide variety of wetlands, spread in various ecological zones which are the source of livelihood besides having enormous values of biodiversity, aesthetic, recreational and tourism. Altogether, 30 inland wetlands (natural-10; man-made-17; wetlands <2.25 ha-13) covering an area of 46.67 km^2. Jammu & Kashmir has 221 inland wetland (natural- 19; man- made- 21; wetlands >2,25 ha-200) covering an area of 217.40 km^2 and Punjab has 426 inland wetland (natural- 42; man-made-146; wetland 2.25 ha- 280), respectively.

Table 2.23- List of Wetlands in Himachal Pradesh, Jammu & Kashmir UT and Punjab

Sr. No.	Wetland Category	Himachal Pradesh			Jammu & Kashmir UT			Punjab		
		Number of Wetlands	Wetland Area (ha)	% of Wetland Area	Number of Wetlands	Wetland Area (ha)	% of Wetland Area	Number of Wetlands	Wetland Area (ha)	% of Wetland Area
A	**Inland Wetland- Natural**									
1	Lakes/Ponds	1	2	0.04	-	-	-	8	401	2.57
2	Oxbow Lakes/Cut-off Meanders	-	-	-	-	-	-	6	171	1.03
3	High Altitude Wetlands	4	30	0.64	-	-	-	-	-	-
4	Riverine wetland	-	-	-	-	-	-	6	145	2.01
5	Waterlogged	-	-	-	-	-	-	30	1213	8.54
6	River/Stream	10	3631	77.80	19	16130	74.20	42	17209	78.44
B	**Inland Wetland- Man-made**									
7	Reservoir/Barrages	2	991	21.23	2	5410	24.89	1	2333	14.09
8	Tanks/Ponds	-	-	-	-	-	-	43	144	1.60
9	Waterlogged	-	-	-	-	-	-	10	322	1.94
C	Total Inland Wetlands	17	4654	99.72	21	21540	99.08	146	21938	98.17
D	Wetlands (<2.25ha)	13	13	0.28	200	200	0.92	280	280	3.34
	Grand Total	**30**	**4667**	**100.00**	**221**	**21740**	**100**	**426**	**22218**	**100.00**

(Source: SAC, ISRO 2011)

In the context of Ravi Riverscape, the Khajjiar Wetland, Manimahesh Wetland, Lama Dal Lake, Ranjeet Sagar and Jastarwal Wetland are the prominent wetlands in Ravi riverscape of greater ecological, cultural and recreational importance. Brief description in case of these prominent wetlands is provided below.

Khajjiar Wetland

The Khajjiar Lake "The Mini Switzerland of Himachal Pradesh" located in the western part of Chamba district of Himachal Pradesh. It lies 32° 26´ N Latitude and 76° 32´ E Longitude about 1920 m amsl between Chamba and Dalhousie. The average depth of this lake is stated to be thirteen feet as per district gazetteer. Khajjiar Lake has a clump of reeds and grasses exaggeratedly called an island in it. Fed by slim streams this small lake rests in the centre of large glade of Khajjiar. This glade is greenish in its turf and contains in its centre a small lake having approximate area of 5000 square yards. Khajjiar Lake has thick forest of Kala Top, Khajjiar Wildlife Sanctuary surrounding its soft green grass. There is a 'Golden' domed temple at the edge of this meadow, dedicated to the deity 'Khajjinag', from whom the area derives its name. Khajjiar Lake is situated in Khajjiar-Kalatop Wild Life Sanctuary. This small sanctuary lies in the catchments of the Ravi River, located in western part of Chamba district. The vegetation consists of mature mixed Blue Pine and Deodar forests, with some Green Oak and Rhododendron (Singh and Banyal, 2013).

Manimahesh Wetland

The Manimahesh Lake (also known as Dal Lake, Manimahesh) is located at 4,080 m amsl near the Manimahesh Kailash Peak on the Himalayan Pir Panjal Range, in the Bharmour area of Chamba district in Himachal Pradesh. The religious significance of the lake lies alongside Lake Manasarovar in Tibet. The lake is the site of a highly esteemed pilgrimage made during the month of August/September which coincides with the month of Bhadon according to the Hindu calendar, on the eighth day of the new moon. It is known as the 'Manimahesh Yatra'. The Government of Himachal Pradesh has honored this as State-Level Pilgrimage.

Lama Dal: The Lama Dal is a high altitude lake located in district Chamba (45 km from Chamba main town) about 3,960 m amsl. It is also held sacred to Lord Shiva. It is part of holy pilgrimage that is held in July/August based on Hindu calendar. Kareri Lake is situated just 3 km (air distance) south west.



Plate 2.20 - Khaiiiar Wetland



Plate 2.21 - Manimahesh Wetland

Jastarwal Wetland: The Jastarwal wetland is situated in the Block Harcha Chhina near Ajnala Township in the District Amritsar. It is located at 31º48'19.3" N Latitude and 74º42'40.5" E Longitude at an altitude of 208 m amsl, and is spread over an area of 103 acres. This is a low-lying site near village Jastarwal. This wetland lies along the flood plain of Ravi River and area is locally called Bet Ravi. It stretches between the Ravi River to the west and its tributary *Sakki Nallah* to the east.



Plate 2.22 - Ranjeet Sagar on Ravi River

2.4.6 Terrestrial and Aquatic Weeds

Lantana camara, Ageratum, conyzoides, Parthenium hysterophorus and *Chromolaena adenophorum* is perhaps one of the most important invasive alien plant species (exotic weed) in forest ecosystems of Himachal Pradesh (HPFD). Weeds are unwanted plants in a particular situation or a plant in the wrong place. Weeds have been considered enemies of the farmers since the dawn of agriculture. The struggle of the farmers against them to save their precious crop has been continuing. The weeds cause drastic losses in the productivity and resultant loss of economy. Over the past 4-5 decades, the concept of invasive alien species and threats by them has received special attention all over the world. An alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential. However, some

of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and out-compete native species (Raghubanshi *et al*., 2005). Invasive Alien Species (IAS) have devastating impacts on native biota, causing decline or even extinction of native species, and negatively affecting ecosystems as they reproduce rapidly, out-compete native species for food, water and space, and has been recognized as one of the main causes for global biodiversity loss. Invasive species are the second largest threat to biodiversity after habitat loss. Invasive species impact native ecosystems by way of habitat modification, out-compete native species, predation of native species, herbivory on native plants, bring pathogens, and hybridize with natives, leading to loss of genetic diversity. About 40% of the species in the Indian flora are alien, of which 25% are invasive. Proliferation of invasive alien species is caused due to higher level of disturbances (i.e., livestock grazing, forest/ grassland fires, lopping, excessive openings, etc.).

Himachal Pradesh has been gifted with plenty of land that cannot be put under frequent cultivation. Such lands are under orchards, pastures, grasslands, forests and wasteland ecosystem. Since, most of these lands do not receive frequent cultivation and intensive care of the owners, the obnoxious invasive alien species or weeds like *Lantana camara, Ageratum houstonianum, Parthenium hysterophorus, Chromolaena adenophorum,* and *Urtica dioica* have invaded most of these areas (Angiras, 2014). *Lantana camara* and *Cannabis sativa* is perhaps one of the most important invasive alien plant species (exotic weed) in forest ecosystems of India as also in Himachal Pradesh. Commonly called as 'Phulnu' or 'Panchphulli', *Lantana camara* is probably a native of South America which was introduced in India for ornamental purposes. At present, *Lantana* has infested open lands in tropical and sub-tropical regions of the world and is spreading like a wild fire. In Himachal Pradesh, around 2600 km^2 of area under forest cover lies in the lower elevation (up to 1000 m amsl). Out of this nearly 60% is infested with *Lantana* in varying extent. Infestation is rapidly spreading and has been noticed in elevations up to 1500 m amsl. The districts of Kangra, Bilaspur, Hamirpur, Solan, Sirmour, Chamba and Mandi have been heavily infested, while Shimla has been marginally affected (HPFD website, https://hpforest.nic.in/pages/display/invasive-alien-species.)

Aquatic weeds are those unwanted plants growing in water and complete atleast a part of their life cycle in water. Some of the Aquatic weed are species of *Eichhornia, Azolla, Nymphaea, Hydrilla, Vallisneria, Potamogeton, Najas, Ceratophyllum, Typha, Utricularia*, etc are problematic weeds in fishery lakes and tanks of many areas. The distribution, growth and productivity of native vegetation are thus drastically reduced in most of the areas all along the Ravi Riverscape. Much needs to be done to address the problem of prominent weeds and restoration of degraded areas.

Aquatic and Marshy Vegetation: Ravi River and some tributaries of Beas River flow through the Chamba district. Besides, there are several perennial streamlets or *nallahs* which are good source of perpetual water. Fairly good amount of precipitation which flows down the slopes

collects at several places forming pools and puddles. The famous Khajjiar Lake also provides excellent habitat for the development of the aquatic plants. Based upon contact with soil, water, and air; aquatic and marshy plants have been grouped into seven categories i.e., (i) Free floating hydrophytes, (ii) Suspended hydrophytes, (iii) Submerged anchored hydrophytes, (iv) Floating-leaved anchored hydrophytes, (v) Floating-shoot anchored hydrophytes, (vi) Emergent-anchored hydrophytes and (vii) Wetland hydrophytes. Hydrophytes of this class in the area are *Ranunculus sceleratus, Cardamine flexuosa, Aeschynomene indica, Hydrocotyle javanica, Limnophila indica, Veronica anagallis-aquatica, Polygonum hydropiper, Monochoria vaginalis, Juncus articulatus, Acorus calamus, Alisma plantago-aquatica, Cyperus alulatus, C. brevifolius, C. difformis, C. cyperus esculentus, C. iria, C. sanguinolentus vahl, Scirpus juncoides, Ranunculus muricatus, R. sceleratus, Tillaea pharnaceoides, Ammannia baccifera, Rotala indica, Caesulia axillaris, Cotula anthemoides, Eclipta prostrata, Sonchus wightianus, Limnophila indica, Lindernia anagallis, L. antipoda, Polygonum chinensis, P. nepalense, P. plebeium, Phyllanthus urinaria, etc.*



Plate 2.23 – Aquatic Vegetation in Punjab Plains

2.4.7 Wildlife

The Ravi River, its tributaries and surrounding lands from the river origin to mouth depict different landforms, vast altitudinal variation and climatic extremes, besides enormous diversity of forests, grasslands and wetlands. These physical and biological systems thus provide an array

of faunal species belonging to terrestrial, aquatic and coastal ecosystems. Diversity of wild fauna in these ecosystems is described below.

(A) Terrestrial Ecosystem

The Himalaya are home to unique biodiversity including at least 350 species of mammals, 1200 species of birds, 635 species of amphibians and reptiles, and numerous plants including those with medicinal properties. Over 335 species of wild relatives of cultivated crops are found in the region. There are numerous biologically important wetlands that form breeding grounds for waterfowl.

The Himalayan Mountains in Himachal Pradesh, Jammu & Kashmir UT are home to an array of rich and unique wild fauna including mammals, birds, reptiles, amphibians and enormous invertebrate fauna. Prominent mammalian species of the Ravi Riverscape are Snow Leopard (*Uncia uncia)*, Himalayan Brown Bear (*Ursus arctos*), Himalayan Black Bear (*Ursus thibetanus*), Sloth bear *(Melursus ursinus),* Common Leopard (*Panthera pardus*), Indian wolf (*Canis lupus*), Himalayan Tahr (*Hemitragus jemlahicus*), Blue Sheep (Bharal) (*Pseudois nayur*), Serow (*Naemorhedus sumantraensis*), Himalayan Musk deer (*Moschus chrysogaster*), Goral (*Naemorhedus goral*), Chital (*Axis axis),* Sambar *(Rusa unicolor*), Barking Deer (*Muntiacus muntjac*), Hog Deer (*Axis porcinus*), Wild Pig (*Sus scrofa*), etc. High diversity of reptiles, amphibians and invertebrates (e.g., insects and spiders) is also reported. Voluminous literature of published and unpublished documents including research papers, surveys and research reports is available, focusing different regions, taxonomic groups and taxa. Considering the importance, relevance to the DPR, diversity of terrestrial fauna is described below for each of State/UT under consideration, i.e., Himachal Pradesh, Jammu & Kashmir, and Punjab.

(a) Himachal Pradesh

The higher reaches of Himachal Himalaya form the habitat of elusive and the flagship species of the Himalayan Mountains i.e., snow leopard. Snow leopard is a globally endangered species. Effective protection and management of this priority conservation species requires timely implementation of activities as envisaged by the Project Snow Leopard including status surveys of Snow Leopard and its prey, assessment and mitigation of Snow leopard-human conflict besides need to carry out awareness campaigns and efforts for improved livelihoods of impacted pastoral communities.

Snow Leopard a Flagship species: In India, states encompassing the Himalayan region constitute the range and habitat of the Snow Leopard. The snow leopard is reported to occur throughout most of the high altitude regions of Central Asia and the Himalaya (Jackson *et al*., 2008). In India, Jammu and Kashmir and Ladakh UTs, the states of Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh represent the range of the Snow Leopard (Prater,

1972), which is listed as Endangered in the IUCN Red List (Jackson et al., 2008) and comes under Schedule I of the Indian Wildlife (Protection) Act of 1972 (WPA). Several studies have been carried out regarding the status, habitat, conservation and livestock depredation by the Snow Leopard in the Himalaya, mostly covering the Trans-Himalayan region (Chundawat, 1990; Fox *et al*., 1991; Bagchi and Mishra, 2006; Maheshwari and Sharma, 2010). To safeguard the habitat of Snow Leopard in Himachal Pradesh, several areas (those above 3,000 m amsl) were also covered under the Project Snow Leopard by the Ministry of Environment and Forests (MoEF). These areas are Lahaul, Spiti, Pangi, Kinnaur, Upper Chamba (especially Bharmour), Upper Kangra (Bara Bhangal), Upper Kullu i.e., Mantalai, Pin Parvati, upper Great Himalayan National Park, upper Manali and Upper Shimla i.e., Rupi Bhaba, Dodra Kwar. Out of which Chamba and Bara Bhangal areas comes under Ravi River Basin.

Important mammalian and avifauna are Tahr (*Hemitragus jemlahicus*), Ibex (*Capra sibirica*), Goral (*Nemorhaedus goral*), Musk Deer (*Moschus chrysogaster*), Brown Bear (*Ursus arctos*), Black Bear (*Ursus thibetanus*), Monal (*Lophophorus impejanus*), Koklass (*Pucrasia macrolopha*), Cheer (*Catreus wallichii)* and Snow Cock (*Tetraogallus himalayensis*) (Mahar *et al*., 2011).

Other Prominent Carnivores: Carnivores generally represent the apex of the food chains in most of the biological communities, and play a vital role in maintaining the essential balance of the ecosystems (Terbourgh *et al.,* 1999). The Himalaya, in spite of being a land of steep cliffs and dead ridges, provides habitats for a variety of mammalian carnivores including charismatic species such as the Snow Leopard, Common Leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), Brown Bear, Asiatic Black Bear (*Ursus thibetanus*), Tibetan Wolf (*Canis lupus chanko*), Wild Dog, Red Panda, Red Fox, Leopard Cat *(Felis benghalensis*), Jungle Cat (*Felis chaus*), Himalayan Yellow-throated Marten (*Martes flavigula*), Weasels *(Mustela* spp.),Himalayan Palm Civet (*Paguma larvata*) and many more (Schaller, 1977, 1998; PSL, 2006; Sathyakumar, 2006).

Himachal Pradesh has two species of bears *viz*., Asiatic Black Bear (*Ursus thibetanus*) and Himalayan Brown Bear (*Ursus arctos isabellinus*). Black Bear and Himalayan Brown Bear are reported to be present in and around several Protected Areas (PAs). Black Bear is seriously threatened due to poaching for its gall bladder and skin. Brown Bear is threatened due to retaliatory killings by shepherds to avoid livestock loss due to predation by Brown Bear.Populations of Black and Brown Bears are under severe threat.

Wild Ungulates: Ungulates are a major constituent of the Himalayan fauna and they are also the major prey base for the large carnivores. They are known to modify their activity pattern in response to habitat differences, seasons and disturbance factors, and their behaviour could be a sensitive indicator of habitat quality, protection and management. In total, 19 ungulate species belonging to four families, viz. Moschidae, Cervidae, Bovidae and Equidae, inhabit the Himalaya (Schaller, 1977; Bhatnagar, 1993). Species such as the Wild Yak (*Bos grunniens*),

Tibetan Antelope (*Pantholops hodgsonii*), Tibetan Gazelle (*Procapra Picticaudata*), Kashmir Markhor and Hangul are restricted to few areas in the Indian Himalaya and their populations are less than a few hundred animals in the wild (Schaller, 1998; Sathyakumar and Bhatnagar, 2002; Ranjitsinh *et al.*, 2005; Qureshi and Sathyakumar, 2008). Seven species of Caprids are reported to occur in Himachal Pradesh. They are Tibetan Argali (*Ovis ammon*), Bharal or Blue Sheep (*Pseudois nayaur*), Asiatic Ibex (*Capra ibex*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Naemorhedus sumatraensis*) and Goral (*Nemorhaedus goral*). Bharal or Blue Sheep is a commonly encountered species in the Trans-Himalaya and some alpine regions of the Greater Himalaya between 3,500 - 5,500 m amsl. Some of the Protected Areas known for holding populations of Blue Sheep include Kibber WLS, GHNP, Tundah WLS, Sechu Tuan WLS, Lippa Asrang WLS, and Sangla WLS. Major threats are competition with livestock, habitat degradation /loss and poaching. Some of the Protected Areas holding populations of ibex include Pin Valley NP, Kugti WLS, Tundah WLS and Sechu Tuan WLS. Protected Areas that are reported to have Serow are GHNP, Kalatop-Khajjiar WLS, Tundah WLS, Sangla WLS, Dharangati WLS, Rupi Bhabha WLS and Talra WLS. Out of these Tundah WLS and Sechu Tuan WLS, Kugti WLS and Kalatop-Khajjiar WLS comes under Ravi River Basin in Himachal Pradesh.

Avifauna and Galliformes: Himachal Pradesh is bestowed with rich avifaunal diversity due to the representation of four major biotic provinces in the State. The Himachal Pradesh Bird Checklist includes 657 bird species from 18 Orders and 88 Families. This is 52% of the bird species reported from India and includes 53 Threatened and Near Threatened species as per the IUCN. Among them, Critically Endangered are 4 species, Endangered-5, Vulnerable-19, Near Threatened-24 and Data Deficient-1 (HPSFD, 2017 https://thenewshimachal.com/). Himachal Pradesh is rich in Pheasants (7 species) and over 12 other species of Galliformes. Of these Pheasants, the Western Tragopan (*Tragopan melanocephalus*) and Cheer Pheasant (*Catreus wallichii*) are among the most vulnerable bird species (according to IUCN Red Data List). They are among the most popular wildlife in the State and *Tragopan melanocephalus* (Western Tragopan) has been 'The State Bird' and is found in folklore, described as 'the King of all Birds'. They are also known to play a significant role as a prey base for mammalian and avian predators. Other pheasants are Kalij (*Lophura leucomelanos*), Red Junglefowl (*Gallus gallus murghi*), and the Indian Peafowl (*Pavo cristatus*). Given the 'Flagship' stature of this group, it would be logical to assume that conservation initiatives for these species would also help survival of other forest wildlife. However, scientific support for several of these species is grossly inadequate to be able to effect efficient conservation/ management actions for the wildlife in the State.

Herpetofauna: Herpetofauna include amphibians and reptiles. Amphibians are poikilothermic (cold blooded) vertebrates with smooth skin leading a bimodal life i.e., life in water as well as land (Amphi-meaning "on both sides" and bios meaning "life"). Amphibians are ecological indicators and in recent decades there has been a dramatic decrease in their populations. Many

species are now threatened or extinct. Reptiles are cold-blooded vertebrates which breathe by lungs throughout their life and their body is covered by scales. Of the 19 orders of reptiles, only 4 survive today and they are typically recognized as Crocodilia, Sphenodontia, Squamata and Testudines. Amphibians are the least amongst the vertebrates and comprise nearly 6.6% of the total vertebrate life on the earth (Lagler *et al.,* 1962). Total number of species in the world has been estimated around 3,140 and in India 214 species are known, while in Himachal Pradesh only 17 species belonging to 4 families has been recorded. This is 7.8% of the total Indian species (Mehta, 2005). Reptiles are diverse in south Asia with approximate 632 species belonging to 185 genera and 25 families. India harbours 456 species of reptiles belonging to 25 families and 4 orders including 3 species of Crocodilia, 31 of Testudines, 178 of lizards and 244 species of serpents. There have been some herpetological studies in different parts of the country and the state. The information on the amphibian fauna of different parts of the state is available in the works of Annandale, Boulenger, Kriplani, Dubois, Tilak and Mehta and Mehta (Annandale, 1907, Boulenger, 1920, Kriplani, 1952, Dubois, 1975, Tilak and Mehta, 1983, Mehta, 2000). Some of the important contribution to amphibian research in India is made by some other workers (Gruber, 1981, Dutta, 1997, Chanda, 2002, Dinesh *et al*., 2009). Recently, Venugopal (Venugopal, 2010) has revealed the presence of 199 species of lizards within the boundaries of India. A list of 55 species of reptiles belonging to 40 genera and 14 families has been prepared from Himachal Pradesh by Saikia (Saikia, *et al*., 2007).

Invertebrates: Invertebrates are animals that neither possess nor develop a vertebral column (commonly known as a backbone or spine), derived from the notochord. This includes all animals apart from the subphylum Vertebrata which includes insects, mollusces, cruteceans etc. It is commonly believed that 75-80 % of the total animal species on this planet are insects (Ehrlich and Wilson, 1991). The insect fauna of India is vast. In an old estimate, Lefroy and Howlett (1909) in the monumental book 'Indian Insect Life' reported 25,700 Indian species. Roonwal (1989) estimated that insects constitute two-thirds of the total fauna in India and comprise nearly 1, 00,000 species, of which about half remain yet to be studied. Varshney (1997) has reported 589 families and 51450 species of insects from India. In a recent estimate, Alfred *et al*. (1998) estimated 59353 species of insects from India belonging to 619 families. Indian insects belong to 27 orders of which Coleoptera is most dominant with about 15,500 species. Butterflies and Moths with about 15,000 species is another important group. These are followed by Hymenoptera (10,000 spp.), Diptera (6093 spp.) and Hemiptera (6500 spp.) (Varshney, 1998). In Himachal Pradesh, Butterflies and Moths (1250 spp.) form the most dominant group. They are followed by Coleoptera (1100 spp.), Diptera (720 spp.), Hymenoptera (470 spp.) and Hemiptera (368 spp.). These five orders together constitute 89.6 % of Himachal entomofauna. Little knowledge is there about the butterflies and grasshoppers of Chamba (Thakur *et al*., 2002; Mehta *et al*., 2002) and few studies on birds and mammals are also there (Singh and Banyal, 2012a, b). A vast study has been conduted on fauna of Khajjiar Lake which is one of the oldest

conservation areas for wildlife. This area is under immense anthropological pressure because of the most favoured tourist destination.

A total of 121 species of insects belonging to 108 genera spread over 28 families and 8 orders have been recorded from Khajjiar area. Of these, Lepidoptera (49 species) was the most dominant insect order in the present study area, followed by Orthoptera (29 species), Coleoptera (15 species), Odonata (10), Hymenoptera (7), Hemiptera and Diptera (5 each), and Homoptera (1 species). Himachal Pradesh is known to harbour 88 species of Odonata (dragonflies and damselflies) (Kumar, 2005) and a study revealed the presence of 10 species belonging to 8 genera spread over 5 families of odonates from Khajjiar lake area. It has been analysed that family Libellulidae supported the highest number of species (6 species, under 4 genera) and all other families have been represented by a single species each. In addition, some species like *Anotogaster basalis, Anax immaculifrons, Orthetrum sabina sabina, Orthetrum triangular triangular, Orthetrum pruinosum neglectum, Palpopleura sexmaculata sexmaculata, Trithemis festiva, Neurobasis chinensis,* etc. were also recorded from Khajjiar area (Kumar, 2005).. Orthoptera (Grasshoppers) is one of the largest insect orders with over 20,000 species known to the science throughout the world (Gillot, 2005). Khajjiar area supported a total of 29 species of Orthoptera belonging to 28 genera, spread over 5 families. Recently, Shishodia and Gupta (2010) have reported 165 species of grasshoppers belonging to 105 genera and 16 families from Himachal Pradesh, therefore, orthopterans of Khajjiar area represent more than 17% of the State fauna (Singh and Banyal, 2013).

(b) Jammu & Kashmir UT

The Outer Himalaya consists of a series of low hills gradually rising from the plains and is composed of rocks. These series of hills are called Shivaliks. The Kathua and Samba districts fall under the Ravi Riverscape is the region of convergence of the Shivaliks and the Outer Plains, which are the northernmost extensions of the Great Indian Plains. The conspicuous features of this terrain are deep valleys and steep escarpments.

The Jammu & Kashmir UT is home to an array of rich and unique wild fauna including mammals, birds, reptiles, amphibians and enormous invertebrate fauna. Prominent mammalian species of the Ravi River Basin are: Leopard (*Panthera pardus*), Snow Leopard (*Panthera uncia*), Mangoose (*Herpsters aurpunctatus*), Red Fox (*Vulpes alopex montanu*), Himalayan Black Bear (*Selenaractors thibetanus*), Common Otter (*Lutra lutra*), Jackal *(Canis aureus*), Jungle Cat (*Felis chaus*), Indian Fox (*Vulpes benghalensis*), Five Striped Palm Squirrel (*Funambulus pennanti),* Indian Crested Porcupine (*Hystrix indica*), Grey Himalayan Goral (*Nemorhaedus goral*), Barking Deer (*Muntiacus muntjak*), Nilgai or Blue Bull (*Boselaphus tragocamelus*), Chital or Spotted Deer *(Axis axis*), Indian Wild Boar (*Sus scrofa*), Grey Langur (*Semnopithecus entellus*), etc. Rodents species are Red Flying Squirrel (*Pectaurista philippens*

altervente), Fire Striped Palm Squirrel (*Funambulus penanti*), Indian Field Mouse (*Mus boodnga*), Indian Porcupine (*Hystrix indica*) and The Indian Hare (*Lepus negricolis*).

High diversity of reptiles and birds is also reported. Former includes various species of lizards, Common house gecko (*HemidactyIus frenatus*), Common garden lizard (*Calotes versicolor*), Common Indian monitor lizard (*Varanus benghalensis*), Common Water monitor lizard (*Varanus salvator*), The Keeled Indian Mabuya or Many-keeled Grass Skink (*Eutropis carinata*), The Indian Chameleon (*Chamaeleo zeylanicus*) etc. Cobra (*Naja naja*), Vipers (*Glodious himalayanus*), Kraits (*Bungrus caeruleus*), Python (*Python molurus*) and a variety of non-poisonous snakes. Tortoises are reported to occur in local water bodies. The two most common species occuring are The Indian Star Tortoise (*Testude elegans*) and The Common Three Keeled Land Tortoise (*Melanochelys tricarinata*). The birds include Monal Pheasant (*Lophophorus impejanus*), Koklas Pheasant (*Ceriornis macrolophus*), Cheer Pheasant (*Catreus wallichii*), Ring Dove (*Streptopelia decocto*), Rufous Turtle Dove (*Streptopelia orientalis*), White Backed Bengal Vultures (*Psuedogyps bengalensis*), Red jungle fowl (*Gallus gallus*), Common peafowl (*Pavo cristatus*), and Grey francolin (*Francolinus. pondicerianus*). Chakor or Rock partridge (*Alectoris graeca*), Blue rock pigeon (*Columba livia*), spotted dove (*Streptopelia chinensis*), Ring-necked dove (*Streptopelia capicola*), Indian white-rumped vulture (*Gyps bengalensis*), etc.

The water body of Ujh barrage near Jasrota village attracts a number of water fowls. Birds which are reported to occur in this region are *Anas platyrhynchos* (Mallard), *Anas crecca* (Common or EurasianTeal), *Anas acuta* (Northern Pintail), *Anas penelope* (Eurasian Wigeon), *Anas strepera* (Gadwal) and *Anas ferina* (Common Pochard). In the water bodies of Kathua Forest Division, 17 species of fishes belonging to eight different families have been reported (J&K FD, 2018).

(c) Alluvial Plains in Punjab

Punjab has made an unparalleled progress in the agriculture since the advent of Green Revolution in the mid-sixties as a result the State is densely populated and intensively cultivated. Nearly 84% of the State's geographical area is under agriculture with a cropping intensity of 183%. Only a meager area i.e., 5.7% of the geographical area is under forest that too mainly confined to northeastern part of Shivalik hills. Owing to the expansion of agriculture and conversion/ reclamation of natural areas (i.e., forests, grasslands and wetlands), and creation of several large dams and barrages have resulted into the great loss of natural diversity. Punjab Plains use to have abundant populations of antelopes (i.e., Blackbuck and Nilgai). Populations of antelopes have also suffered. The threatened fauna of Punjab includes the White-backed vulture (*Gyps benghalensis*), Sarus crane (*Grus antigone*), Indian rock python (*Python molurus*) and Indian Roofed turtle (*Pangshura tecta*).

(B) Aquatic Ecosystem

Aquatic ecosystem provides many vital environmental functions both to human being and other organisms. For example, they are important in nutrient recycling, flood attenuation and habitats provision to wildlife (biodiversity). The largest proportion of rainfall comes from evaporation of water bodies. They are also used for human recreation, and are very important to the tourism industry, especially in coastal regions. Aquatic ecosystems are composed of biotic communities (also called biota) and abiotic environmental factors, which form a self-regulating and self-sustaining unit. The Ravi River, its numerous tributaries and diverse wetlands in Himachal Pradesh, Union Territory of Jammu and Kashmir and the alluvial plains of Punjab constitute rich and unique aquatic ecosystems and they are home to a wide variety of aquatic plants, fishes, reptiles (crocodilians), amphibians, and aquatic mammals.

Fish Fauna: Fish fauna represent nearly half of all known vertebrate species and are an important resource worldwide especially as food. Nearly, 22,000 species of fishes have been recorded in the world of which about 11% are found in Indian waters (Jagtap, 2013). Out of the 2,200 species so far listed, 73 (3.32%) belong to the cold fresh water regime, 544 (24.73%) to the warm fresh waters domain, 143 (6.50%) to the brackish waters, and 1,440 (65.45%) to the marine ecosystem. Roughly, 40 families of fresh water (warm fresh water species) fishes out of 450 families recorded globally are represented in India.

Different researchers have either provided insight on the diversity and status of fish fauna state-wise or specific to different stretches/ river zones based on biotic status *viz*., (a) Crenon zone - area near the source of river with lower oxygen level and colder temperatures, (b) Rhithron zone – the upstream area of the river characterized by faster and turbulent flowing speeds, cooler temperatures and higher oxygen level, and (c) Potamon zone – the downstream area of the river having slower water flowing speeds, warmer temperatures with lower oxygen level. Sehgal (1974) has provided an account on fisheries survey of Himachal Pradesh and some adjacent areas with reference to trout, mahseer and allied species while Tilak and Hussain have provided a checklist of fishes of Himachal Pradesh. Later, Sharma and Tandon (1990) have provided an account of fish and fisheries of Himachal Pradesh. Johal *et al*. (2002) described the fish diversity in the streams of lower Middle Western Himalayas. Dhanze and Dhanze (2004) provided an updated insight on fish diversity of Himachal Pradesh. However, in the case of Ravi River, Moza (2014) have presented the findings based on the investigations carried out in the potamon zone (downstream area in plains of Punjab) of Ravi River and gave complete picture of the environment i.e., water abstraction, pollution source and load, ecology i.e., soil texture, riverbed quality, water quality and organization various biotic forms, fish diversity, fisheries resources and its economics.

The Ravi River contains subsistence fishery all along its course, maximum fishery resources are confined to Ranjit sagar reservoir, where approximate catch was 2 q/day. The River Basin

comprises mainly of *Tor putitora* (60%), *Cyprinus carpio* (30%) and minor carps (10%) in winter and 60% of *Cyprinus carpio* and 40% of *Tor putitora* in summer (Moza, 2014).

The major fishes available in various rivers/streams were Trout, Mahseer, *Nemacheilus* spp., *Barilius* spp., *Schizothorax* spp., *Crossocheilus* spp., *Glyptothorax* spp., etc (Jagtap, 2013).

2.4.8 Conservation Initiatives and Challenges

Conservation of wild flora and fauna has been an integral part of Indian history, and conservation planning of the country is based on the philosophy of identifying and protecting representative wild habitats across all the ecosystems. India has a network of 868 Protected Areas (PAs), extending over 1, 65,088.57 km^2 (5.02% of total geographic area), 104 National Parks, 550 Wildlife Sanctuaries, 87 Conservation Reserves and 127 Community Reserves. National Parks in India (104 no.'s) covers an area of 40501.13 km^2, which is 1.23% of the geographical area of the country (J&K, ENVIS, 2018).

The foundation of scientific forestry was laid after appointment of Sir Dietrich Brandis, a German Forester as the first Inspector General of Forests in 1864 and passing of the First Indian Forest Act, 1865. It was revised in 1878 & 1927 and provided formation of Reserved and Protected Forests. The first Forest Policy was adopted by Govt. of India resolution of 19th October 1894. The main focus was to ensure maintenance of adequate forest cover for general well-being of the country and meeting needs of local people. After meeting the local requirements, focus was also on the collection of maximum revenue. In view of dwindling forest resources, the awakening towards protection and conservation of forests, wildlife and environment started in 1960. Since then, Government of India (GoI) had started formulating various National level policies, enacted laws and launched priority National level conservation projects besides a large number of other initiatives so as to safeguard the environment and the country's rich biodiversity.

The life support systems i.e., forests, grasslands, and wetlands in Himachal Pradesh, Union Territory of Jammu and Kashmir and the alluvial plains of Punjab are now under great stress due to the impact of modern civilization, economic development and growth in human and livestock population. These States and UT have longer historical perspective of management of their natural resources prior to the independence of the country as well as their subsequent reorganization(s). Further, both States and one UT on the account of physical, biological, and socio-cultural sub-environments exhibit uniqueness and varied peculiarities and challenges for conservation of natural resources.

In Himachal Pradesh, nearly 90% of the population lives in rural areas. Most of the villages are situated on steep slopes and are either adjacent to or enclosed by forests. Thus, forests are deeply integrated with the livelihood of the local people. They depend on the forest for timber, for the

construction of the houses, firewood, agriculture implements, fodders and a variety of other products and services, including certain medicinal herbs. A larger proportion of the rural population is still use fuel wood for cooking and heating. Almost 90% of the forests of the State apart from protected areas and forest areas taken up for regenerations and plantations are open to grazing. Cultivation of green fodder in the agriculture fields is virtually non-exist. Much of the human population in higher reaches keeps substantial population of sheep and goat and they still practice transhumance seasonal migration to sub-alpine forests and alpine pastures every year in summer. Local people have recorded rights for constructional timber. Almost half of the yield from the forest annually goes in Timber Distribution (TD) Rights. The menace of encroachment of the forest areas particularly in the undemarcated protected forests is alarming. The fate of village common lands vested in the government is similar. The forests fires are of a recurring nature and cause lot of damage to forests and wildlife. The increasing demand of land for agriculture, lead to the clearance of the forest tracts, especially in the years after independence under Grow 'More Food' campaign and later, when the big landed estates were abolished and the scheme for 'Allotment of Land to the Landless' was launched in the mid-1970s also resulted in substantial loss of forests. Expansion of horticulture and large requirement of wood based packing crates for fruits during 1970s-1990s brought extra burden on forests. Further, the mountainous stretches were maneuvered mainly for power generation by creation of sequential hydro-electric projects (HEPs).

The forests of Himachal Pradesh and J&K UT continues to lose its biodiversity at alarming rates due to habitat destruction, overgrazing, deforestation, land pollution, unsustainable harvesting of natural resources, and the introduction of plant species, among others. Invasive and extinct species are a major threat to the environment. They threaten traditional species with the effects of land grabbing, habitat change or disruption of ecosystems. The challenge of dealing with the loss of biodiversity becomes even more acute when one is working with shared resources where the laws and policies of different countries are incompatible.

Unfortunately, our unique wetlands are under great pressure from nature especially because they are seen as the only source of water, ignoring their vitality as a complete biotic system. Apart from the fact that the most productive wetlands are closed mainly in the Kashmir region of J&K UT. The remaining vacancies are also facing increasing threats, especially from new industrial development and infrastructure projects including tourism and housing. The impact of this on the fishery is well documented, but it is undervalued and serves as an example of the need to integrate the sectoral planning process.

The rivers and river ecosystems of J&K UT are damaged, due to sand mines, intrusion and excessive exploitation. The river rejuvenation program which includes local livelihoods, self-help groups, schools and colleges must be prioritized. Proper actions and regulations may also be required to protect river systems and to maintain their good health (J&K State Environment Policy, 2018).

Likewise, the pressure on forests and other natural ecosystems in Punjab after the independence of the country was not different than Himachal Pradesh as it increased several folds because of policies favoring the expansion of agriculture, increased food production, construction of large dams and vast network of canals besides rapid development of agro-based industrial and food processing units. In 1966, at the time of trifurcation of the erstwhile Punjab State into three parts, the State had only 3.72% (1,875 km^2) area under forest cover which has now increased to 6.12% (3,084 km^2) of its geographical area in 2017 (FSI, 2017). However, the bulk of the forests are still under the lower categories of protected – 36.8% and unclassed forests–61.7%. In contrast, the extent of reserved forests is grossly meager of just 1.43%.

As such, both the above States and Union Territory have initiated much earlier a wide range of conservation programmes and initiated measures to protect the forests along other natural ecosystems so as to safeguard the interests of varied terrestrial and aquatic wildlife. However, like most world countries and other parts within the country, the awakening towards the protection of environment and conservation of natural ecosystems and wildlife in particular started late in 1960s. Since 1960s, the Government of India has enacted different laws pertaining to the environment, forests, wildlife, and forest dwellers; formulated numerous national level policies and launched countrywide programmes, projects, and schemes besides several other initiatives so as to protect the environment and conserve the country's natural heritage. Likewise, the State Governments also initiated several priority actions for conservation of scarce natural resources of their respective State.

The Wildlife (Protection) Act, 1972 enacted by the GoI was the first unified piece of legislation of the country for the protection of wildlife and their habitats by setting aside protected areas for conservation of diverse flora and fauna in their natural environment. The establishment of Protected Areas (PAs) was recognized as the foremost step towards protection and conservation of natural ecosystems, (Fig 2.8) and their associated flora and fauna alongside genetic resources so they can continue to provide varied ecosystem services to humanity.

Forest (Conservation) Act another important step in the above direction was enacted in 1980 and amended later in 1988. Under the Act, it was made mandatory for the states to take approval of the Government of India before diversion of any forest land for non-forestry purposes with a specific provision for compensatory afforestation preferably on non-forest areas. This Act also banned felling of green trees above 1,000 m amsl. Government of India, in 1985, shifted subject of Forestry and Wildlife from Ministry of Agriculture to a new Ministry of Environment and Forests (MoEF&CC) to ensure a more focused attention to the emerging forestry issues. With all this background in view, the country became a signatory to several important conventions of the world, *viz.,* the Ramsar Convention (1971) on Wetlands, the Convention on International Trade in Endangered Species of Wild Flora and Fauna - CITES (1975), the Convention on the Conservation of Migratory Species of Wild Animals - CMS (1983), Convention on Biological Diversity - CBD (1992), the UN Framework Convention on Climate Change - UNFCCC (1994),

United Nation Convention to Combat Desertification - UNCCD (1996), etc. and it is now obligatory to effectively follow and implement all of them as a party. The country is also associated with the UNESCO's programme on Biosphere Reserves and World Heritage Sites.

Prior to the abrogation of article 370, J&K had its own policies, laws and acts for conservation, management of forests and wildlife of the region. At that point of time, the State Government had notified more than 17000 km^2 as Protected Area Network comprising of 5 National Parks, 14 Wildlife Sanctuaries, 33 Conservation Reserves and 14 Wetland Reserves in Jammu and Kashmir including Ladakh, however, on 31 October, 2019, Jammu and Kashmir was reorganized into two Union Territories *viz.*, J&K and Ladakh. Henceforth, all the laws and acts of Government of India will be applicable in the Union Territory of Jammu and Kashmir. Details of the protected areas in Ravi River Basin are as under.

Protected Areas: The list and brief description of important protected areas of Ravi River Basin is given below in Table 2.24 and Fig. 2.8.

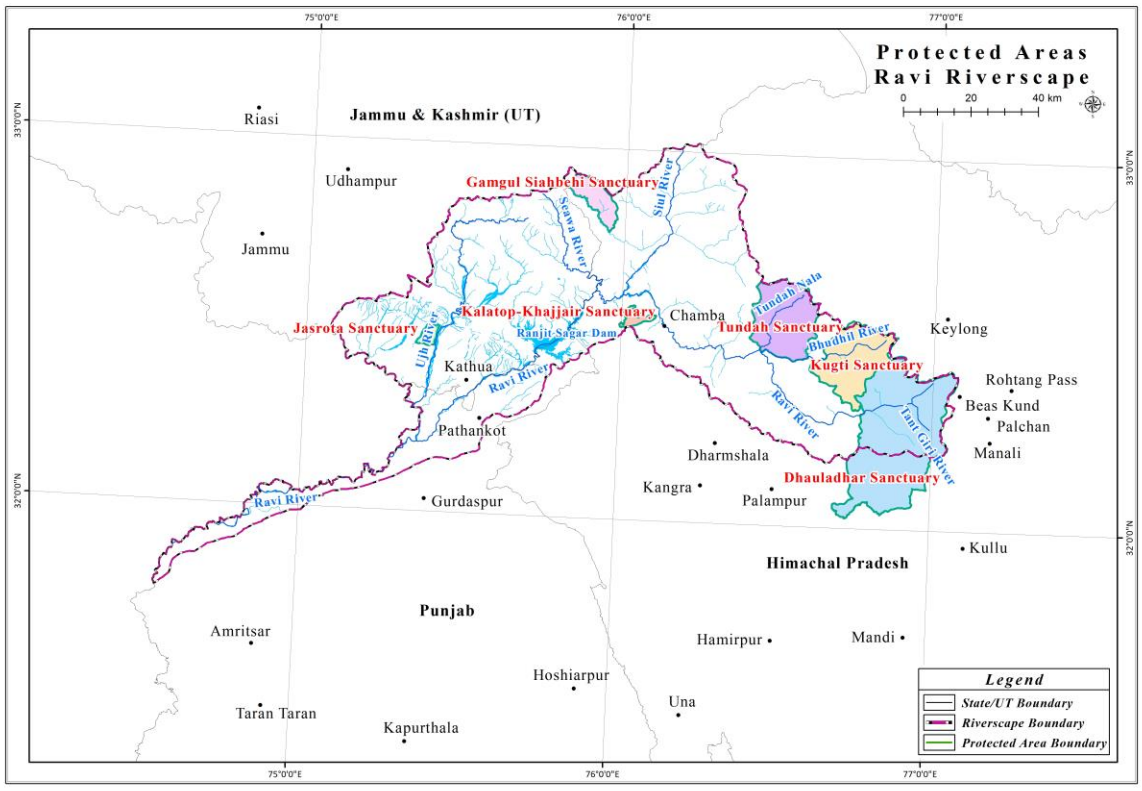


Fig 2.8 - Protected Areas in Ravi Riverscape

Table 2.24- Representation of Biogeographic Provinces in the existing Protected Areas Network in Ravi Riverscape

Biozone Number	Province Name	State /UT Name	Protected Areas	Area (km^2)
Ravi Riverscape				
02A	North West Himalaya	Himachal Pradesh	Tundah Wildlife Sanctuary	64.00
			Kugti Wildlife Sanctuary	405.49
			Kalatop-Khajjiar Wildlife Sanctuary	17.17
			Dhauladhar Wildlife Sanctuary *	982.86
			Gamgul Siahbehi Sanctuary	108.40
		Jammu and Kashmir UT	Jasrota Wildlife Sanctuary	25.75

* -The area of Dhauladhar WildlifeSanctuary falls under Ravi and Beas Riverscapes.

Overall in the Ravi Riverscape, there are altogether 6 PAs. Himachal Pradesh has 5 Wildlife Sanctuary covering an area of 1,577.92 km^2, Jammu and Kashmir UT has 1 Wildlife Sanctuary with an area of 25.75 km^2 in Ravi Riverscape. A brief description of key features of PAs of the Ravi Riverscape is provided below.

(i) Kugti Wildlife Sanctuary (KWS)

KWS is situated in the Chamba District of Himachal Pradesh and represents the bio-geographical zone 2A of the North-West Himalayas (Rodgers and Panwar, 1988). The broad vegetation type represents the Himalayan moist temperate zone with 1400 mm annual rainfall (Maheshwari and Sharma, 2010). The habitat was typically covered with Juniper species. The sanctuary also supports typical high-altitude Himalayan fauna such as Brown Bear (*Ursus arctos*), Asian Black Bear (*Ursus thibetanus*), Goral (*Naemorhedus goral*), Himalayan Tahr (*Hemitragus jemlahicus*) and Ibex Capra ibex, as well as several avifaunal species Monal (*Lophophorus impejanus*), Cheer Pheasant *(Catreus wallichii*), Lammergeier (*Gypaetus barbatus*), Golden Eagle (*Aquila chrysaetos*), Snow Pigeon (*Columba leuconota*), Snow Cock (*Tetraogallus himalayensis)*, Redbilled Chough (*Pyrrhocorax pyrrhocorax*) and Yellow-Billed Chough (*Pyrrhocorax graculus*).

(ii) Tundah Wildlife Sanctuary

Tundah Wildlife Sanctuary covers an area of 83 Km^2, and lies in the Chamba district. The vegetation mainly comprises of oak forests, moist deodar and mixed coniferous, temperate moist mixed deciduous, sub-alpine Rhododendron and moist alpine scrub forests. Important mammalian and avifauna seen in the Sanctuary are Tahr (*Hemitragus jemlahicus*), Ibex (*Capra sibirica*), Goral (*Nemorhaedus goral*), Musk Deer (*Moschus chrysogaster*), Brown Bear (*Ursus arctos*), Black Bear (*Ursus thibetanus*), Monal (*Lophophorus impejanus*), Koklass (*Pucrasia macrolopha*), Cheer (*Catreus wallichii*) and Snow Cock (*Tetraogallus himalayensis*).

(iii) Kalatop-Khajjiar Wildlife Sanctuary

It includes moist temperate mixed coniferous forest and sub-alpine/alpine moist pasture. The Sanctuary is drained by a number of perennial tributaries of Ravi River (Islam and Rahmani, 2004). The Kalatop and surrounding areas contain thick patches of Cedar (*Cedrus deodara*) followed by Ban Oak (*Quercus oblongata*) and Blue Pine (*Pinus wallichiana*). Khajjiar is a small meadow surrounded by Cedar. The area supports a fairly good number of faunal elements such as birds namely, Kaleej Pheasant (*Lophura leucomelanos*), Koklass Pheasant (*Pucrasia macrolopha*), Cheer Pheasant (*Catreus wallichii*) and Himalayan Monal (*Lophophorus impejanus*) (Thakur *et al.,* 2002), and mammals namely Goral (*Nemorhaedus goral*), Serow (*Capricornis sumatraensis*), Asiatic Black Bear (*Ursus thibetanus*) and Indian Muntjac (*Muntiacus muntjak*) (Singh and Banyal 2012).

(iv) Dhauladhar Wildlife Sanctuary (DWS)

Dhauladhar Wildlife Sanctuary (DWS) has significance in their conservation including conservation of wildlife species. This Wildlife Sanctuary is located in in Kangra district in the Himachal Pradesh with its different habitat types adjoining to area was Bir, Biling, Rajkunda and Swad (Saklani *et al*., 2018).

(v) Jasrota Wildlife Sanctuary

Jasrota Wildlife Sanctuary (JWS) is situated on the right bank of the Ujh River (District Kathua, J&K). The vegetation is comprised of broad-leaved associates, namely *Lannea coromandelica, Dendrocalamus strictus, Senegalia catechu, A. arabica, Dalbergia sissoo, Bombax ceiba, Ficus religiosa* and *Ziziphus jujuba.*The area comprises a small population of ungulates such as Indian muntjac (*Muntiacus muntjak*), Spotted Deer or Chital *(Cervus axis),* Sambar (*Rusa unicolor*) and Wild Pig (*Sus scrofa*). The JWS is believed to be the northern most limit of some species (e.g. Chital and Sambar) distribution range in the wild in the J&K Union Territory. The Sanctuary is a home to more than 50 species of birds including genetically threatened Red Jungle Fowl (*Gallus gallus*) (Noor *et al*., 2016).

Natural Resource dependency

The natural resources of the Himalaya have been of great utility to the local communities in particular and the mankind in general. The Himalaya is the major supplier of timber, fuel wood, fodder, medicines, organic manure, fibre, oils, spices and condiments. Resource dependency of the local people ranges from sustainable in a few areas to unsustainable levels in most parts of the Himalaya. The Himalaya is gradually depleting making it unable to maintain the demands of the changing life style of its growing inhabitants as well as other dependent populace down below in the plains. In the higher altitudes, the major Himalayan glaciers, which are the main source of water in northern and eastern India, are receding fast (Rawat and Sathyakumar, 2002).

There should be some strategies to determine appropriate measures to conserve threaten medicinal species, due to their rising demand along with degradation and fragmentation of natural habitats. Indigenous knowledge and use have to be analyzed to develop appropriate management measures that build on both scientific and local knowledge (Thakur *et al.*, 2016). Due to changing perception of the local people and the ever increasing influence of global commercialization and socio-economic transformation, indigenous knowledge on plant resource use is constantly diminishing. Due to the lack of organized sustainable and scientifically monitored cultivation and harvesting proper management techniques, and lack of awareness of social factors, the number of useful plant resources is decreasing at an alarming rate. Furthermore, the indigenous knowledge on the use of lesser known plants is also rapidly declining. Hence illegal and unscientific extraction at hilly areas needs to be stopped. Licenses holders shall be allowed to extract limited amount of material for harvesting or even if possible; they may be stopped until the population of these species will increase.

Way forward

A few recent initiatives such as “Project Snow Leopard” launched in 2006 by the Government of India in the lines of Project Tiger could provide the much needed support to the wildlife managers of the Himalayan PAs, particularly the management at the landscape level (PSL, 2006). Species specific conservation programmes such as the Project Hangul that was initiated in 2008 will help in the recovery of critically endangered populations of the Hangul in its last strong hold in Kashmir. The general strategies for conservation and management of wildlife resources in the Himalaya have been listed by Rawat and Sathyakumar (2002). In addition to that, we propose a few more strategies to ensure long-term conservation and management of wildlife in the Himalaya.

1. Most of the PAs in the Himalayan region lack adequate man power and funds for proper management. In addition, several PAs have ill-defined boundaries and improper zonation leading to conflicts between the local communities and PA management. There is an urgent need to

strengthen the management of most of the PAs allocating more well trained, well equipped and motivated staff, budget and infra-structure.

2. In the Trans-Himalaya, where much of the wildlife is outside PA network and coexists with local communities or nomadic herders, there is a need for developing and implementing landscape level management plans where the participation of local people will be crucial in ensuring conservation goals. Coordination between different line departments is essential in ensuring long-term conservation goals in a region.

3. The management of Biosphere Reserves in the Himalaya need to be strengthened in order to fully realise the potential of participatory role of local communities in maintaining the use of natural resources in the buffer zones below sustainable levels and ensuring the integrity of the core zones for biodiversity conservation.

4. Several Reserved Forests and other critical wildlife habitats that are outside the PA Network in the Himalayan region could be protected and managed through declaration of Conservation Reserves or Community Reserves, the two new categories of PAs in India. The latter is based on the initiatives taken by the local people where they are the partners in conservation and management. States and UT such as Himachal Pradesh and Jammu & Kashmir and have already made a beginning by declaring conservation reserves.

5. Management of wildlife-human conflicts will not only ensure local community support for conservation but also help in protecting endangered large carnivores that suffer due to retaliatory killings. Site specific measures with the support of local communities such as livestock insurance scheme practiced in Kibber Wildlife Sanctuary in Himachal Pradesh could be attempted in other regions of the Himalaya.

6. Currently, there is no organised system of harvesting wild medicinal and aromatic plants and uncontrolled harvest often results in the degradation of habitat. There is a need to evolve policies related to rotational harvest of medicinal plants for the benefit of communities and there is a need to control excessive pressure on the land. As part of eco-development measure cultivation of medicinal plants needs to be promoted in the buffer zones of various PAs where human pressure for these commodities is excessive.

In addition, from time to time during the past four decades or so, the Central Government has formulated various strategies and action plans relevant to wildlife, biodiversity and environment. The country's first National Wildlife Action Plan was launched in 1983 which was later revised in 2002 and effective upto the year 2016. In spite of all above stated best intentions, timely actions and wide ranging conservation initiatives, the current challenges for natural resource conservation in a fast developing and human dominated country like India are enormous. The current challenges of natural resource conservation seek to strike a balance among space required by the country’s wide ranging terrestrial, aquatic, coastal and marine biodiversity on one hand

while increasing levels of resources consumption by a single species, the human and competition for habitat and resources on other hand.

2.5 The Socio-Economic Environment

Rivers have been the backbone for nearly all human settlements for generations (Adoloye, 2009). It has been of fundamental importance throughout the human history. Water from the river is a basic natural resource, essential for various human activities. It is seen that the daily life of the river-bank dwellers begins centring on river and ends in rivers (Buzarboruah, 2014). River Basin is the most advantageous location for economic prosperity due to its manifold prospects and potentialities in the field of agriculture, industry, hydel power generation, navigation, irrigation etc. despite the usual prevalence of the threat from flood, siltation, sand deposition, bank erosion of the river (Das, 2014). Rivers have always been and remain a central feature of the economic environment. Human settlement has almost always been close to water, because of the essential role water plays in human life and economic endeavour (Sadoff *et al*., 2002). Thus rivers play a vital role in the socio economic welfare of a region. But overdependence on river water also has negative impact on river characteristics. Water of the river is used for irrigation, supply of drinking water, hydroelectricity generation, tourism development and to fulfil various household needs. Besides, huge amount sand has been extracted from the bed of the river for constructional purpose. But overdependence on the river to fulfil human needs result in modification of channel character (Ahmed, *et al.,* 2015). The ecology of the river refers to the relationships that living organisms have with each other and with their environment – the ecosystem. According to ancient history traced to Vedas, the Ravi River was known as Iravati (also spelt Eeraveti). The part of the legendary battle of the ten kings was fought on the banks of the Parushani River, later inferred by MacDonell and Keith as the Ravi River. When the Indian National Congress changed it goals to Purna Swaraj or Total Independence, President Jawaharlal Nehru unfurled the tricolor on the banks of Ravi River in the midnight hours of 31st December 1929 amidst the slogans of ‘Inquilab Zindabad’ and ‘Bande Mataram’. Mukteshwar Temple is a popular shrine of Lord Shiva in and around Pathankot. Lord Shiva is main deity in this Temple. The temple area consists of caves. The Manimahesh Peak and the lake, which feeds the Budhil River - a tributary of the Ravi River, in Chamba, has several myths associated with it. It is believed that Lord Shiva resides with Maa Parvati in Manimahesh Kailash. A rock formation in the form of a shivling on this mountain is considered as the manifestation of Lord Shiva and the field at the base of the mountain is called by the local people as Shiva’s Chaugan. The local Gaddi community considers this region as Shiva Bhoomi. Legend says that before Shiva married Maa Parvati at the Mansarovar Lake and they became universal parents, Shiva created Mount Kailash and made it his abode. The Manimahesh Ganga River originates in a cascade from the lake and joins the Budhil River on its left bank (Kotwal, 2016). Another popular festival held in Chamba is the "Minjar Mela" which marks the triumph of the Raja of Chamba over the ruler of Kangra, in 935

AD. The festival also celebrates the paddy and maize crops grown at this time of the year. On 28 the last day of the festival Minjar Mela, a parade is held from the Akhand Chandi Palace to Ravi River, where offerings are made to the river. This commemorates an event in which Raja Sahil Verman changed the course of the river, to make the Hari Rai temple accessible to all devotees.

Water flow can alter the shape of riverbeds through erosion and sedimentation, creating a variety of changing habitats. The human processes of farming, industrial production and consumption of commodities are carried out by similar rules as those of the matter and energy flows of the natural ecosystems. Also in the production and consumption of commodities, matter and energy are derived from nature, pass through the productive processes and get to the consumption stage. Waste and scrap are generated and disposed of in the environment during the production and consumption of commodities. The intricate relationship between man and nature has given rise to the realm of human ecology which is expressed as the study of man's position within the natural environment (Quinn, 1950).

2.5.1. Historical Perspective - Creation of Forest Reserves, Timber Extraction Commercialization of Forests and Deforestation

Villagers keep larger flocks of sheep and goat since long and followed the migratory transhumance system. Most villages in hills had temples to ancient local gods and goddesses (*devtas* and *devis*). Temple groves of the sacred deodar tree were under the care of the *devtas*, protected against cutting. Community involvement emerged as a new paradigm in forest management in the nineteen eighties. Participation of local people began to be seen as the solution to rising deforestation rates, as the impact of spontaneous local joint-management initiatives became evident (Poffenberger, 1994; Lynch and Talbot, 1995). Policies and projects in India and internationally began incorporating a social component, and people's participation became an essential aspect of forestry projects. National Policy also reflected these changes. "The National Forest Policy, 1988, envisages people's involvement in the development and protection of forests. These developments are well recorded in numerous books and articles on the theory and practice of participatory forestry (Jeffery and Sundar, 1999; Kalam, 1998; Freeman, 1998; Kothari *et al.*, 1996; Campbell, 1992; Poffenberger, 1990, 1993; Poffenberger and McGean, 1996; Sanchez, 1995). Of course, this process has not been complete or all-encompassing. In many regions of India local people continue to have restricted access to forests they have used for several generations (Sundar, 2001). However, most experts in the field today argue that cooperation of forest-dependent local communities is essential for the sustainable management of India's forests. Over fifteen percent of India's forest-lands are under Joint Forest Management (JFM), managed by nearly 45,000 Forest Protection Committees m twenty three states of India (RUPFOR 2001). These changes have been crucial for a small forest dependent state like Himachal Pradesh. The forests of Himachal Pradesh play a vital role in the unique

Western Himalayan ecosystem by conserving the integrity of the upper watersheds of five major Indian Rivers i.e., Chenab, Ravi, Beas, Sutlej, and Yamuna, sustaining the agro-pastoral livelihoods of hill peoples, and balancing the economy of this hill State. The wide range of altitudes and climatic conditions in the state sustain a variety of forest types including moist tropical, dry tropical, montane subtropical, montane temperate, sub-alpine, and alpine scrub (Vasan, 2001).

The ownership of all forests of the Union Territory is vested in the J&K UT Government and fall under the administrative control of J&K Forest Department. The concept of eco-tourism and nature tourism in the State forest policy is welcome step and has immense potential on our State. Encroachment of forest land is a serious issue; land records of revenue department should be reconciled. Demarcation of forests should be completely modernised. Remote sensing technology will play important role in monitoring the encroachments and record will be maintained in digital format. Jammu Kashmir UT also has rare species of aromatic and medicinal plants. This newly emerging sector has vast scope in the State for providing required raw material for manufacturing plant-based drugs and high-grade perfumes and cosmetics having ever increasing demand world over. In order to conserve and protect wildlife in Jammu and Kashmir UT, a lot of new laws have been enacted by the State Legislature in the past few years. New policies and programs have been launched to involve people in conservation and protection of Wildlife and reforestation and afforestation activities. The State has amended the J&K Wildlife (Protection) Act, 1978 on the lines of the National Wildlife Protection Act, 1972. Under the amended Act, different schedules have been revised. Hunting of almost all species under the schedules has been prohibited. Number of endangered species of wild animals and plants have been upgraded and brought under Schedule-I and Schedule-VI of the Act respectively to accord them more protection. A recent amendment pertains to amendment in Schedule VI of the Act respectively to accord them more Protection. A recent amendment pertains to amendment in schedule VI related to medicinal plants in the Wildlife Act. The State has also the responsibility to manage Captive and injured animals in Zoos and Rescue Centres respectively.

Forests are very important for soil, water security, and meeting the needs of local population for timber, firewood, food and other forest produce. Being the largest land based useful thing/valuable supply in the State, forests have huge possibility of supporting jobs and helping (to reduce) poorness. Commercial extraction of timber from the forests in the past is connected with too much/too many grazing, invasions, cutting down of trees, and diversion of forest land for non-forestry purposes has resulted in insulting/worsening of forests and loss of forest land. Not having enough basic equipment needed for forestry operation and less trained manpower for managing forest useful things/valuable supplies have further worsen the problem.

The situation of forests in Punjab, in the past and in the present time was quite different in comparison to upper Ravi River Basin. The State had a small extent of forests as it experiences

the arid to semi-arid climatic conditions and natural forests were sparsely distributed. All through, the forests in human dominated landscapes experienced traditional resource dependence and they were heavily exploited. The post-independence of the country, the thrust of the Central and State Governments was on expansion of agriculture, construction of reservoirs/ barrages/ canals for irrigation and establishment of HEPs for power generation, and grow more food programme under the ambitious programme of the Green Revolution. These activities not only neglected the scant and remnant forests in the State but also the forestry sector including wildlife. Further, grasslands and wetlands were reclaimed for expansion of agriculture. Moreover, pollutants from agriculture and associated industries severely impacted the quality of water in all major rivers of the State and their tributaries. In the process, there was heavy toll of forests and wildlife including aquatic fauna. In 1960s and on other occasions, the GoI launched different schemes of plantation/ afforestation including the social forestry programme to meet the growing demands of fuel wood, fodder, etc. and also to expand the forest cover in the hills/plains. However, most of these efforts were project/ scheme based or ad-hoc in nature that too with mixed success and definitely not adequate to compensate what was lost by way of clear fellings and other allied activities of forestry. Cumulatively, large-scale deforestation and other human disturbances (collection of fuel wood and fodder, livestock grazing, forest fires, and harvest of NTFPs, etc.) impacted the river environment downstream.

2.5.2. Land and people

Himachal Pradesh and Punjab and Union Territory of Jammu and Kashmir along the Ravi River have natural resources and opportunities like agriculture, fisheries, industries, and tourism which have always attracted people.

(A) Land and Land Use

Himachal Pradesh, Punjab and Union territory of Jammu & Kashmir together covers 128,257 km^2 or 3.90% of the country geographical area. Himachal Pradesh represents 1.69% area of the country. Punjab represents 1.53% area of the country and Jammu and Kashmir UT represents 0.67% geographical area of the country (Table 2. 40). By and large, both States are near equal in their respective geographical area. However, H.P and J&K Union Territory are totally mountainous with high hills while Punjab is in plains. Hence, both States are contrast in terms of topography and altitudinal gradient. In terms of land use categories *viz*., forests, net area sown, permanent pastures and other grazing lands, and area not available for cultivation, both States exhibit contrasting situation. The extent of forest as land use category in Himachal Pradesh represented 24.21% area, Jammu & Kashmir represented 56.65% while in Punjab, and it was just 5.86%. Punjab is largely agriculture dominated State having the higher value of net area sown of 82.83% of the geographical extent and Jammu & Kashmir UT having 18.69% of total net area sown, while net area sown in Himachal Pradesh accounted 11.9%. The extent of permanent pastures and other grazing lands was much higher (32.89%) than Jammu & Kashmir UT (2.77)

and Punjab (0.14%). A larger proportion of geographical extent (24.82%) in Himachal Pradesh, 14.08% in Jammu & Kashmir UT and 10.25% in Punjab was not available for cultivation. Thus, it is clearly evident that the upper Ravi River Basin is rich in forests and permanent pastures and other grazing lands while the lower Ravi River Basin in alluvial plains distinctly had relatively meager area of these two land use categories. Land use pattern in Himachal Pradesh, Jammu and Kashmir UT and Punjab is depicted in Table 2.25.

Table 2.25 – Land Use Pattern in Himachal Pradesh, Jammu and Kashmir UT and Punjab

Land Use							
Sr. No.	**Land Use**	**Himachal Pradesh**		**Jammu & Kashmir UT**		**Punjab**	
		Area (km^2)	**Per cent Geographical Area of Country/ State**	**Area (km^2)**	**Per cent Geographical Area of Country/UT**	**Area (km^2)**	**Per cent Geographical Area of Country/ State**
1	Total Geographical Area	55,673	1.7	22,224	0.67	50,360	1.53
2	Reporting Area for Land Utilization	45,490	100.00	4,058	100	50,330	100.00
3	Forests	11,010	24.21	2,299	56.65	2,950	5.86
4	Not Available for Cultivation	11,290	24.82	571	14.08	5,160	10.25
5	Permanent Pastures and other Grazing Lands	14,960	32.89	113	2.77	70	0.14
6	Land Under Misc. Tree Crops and Groves	650	1.43	57	1.39	50	0.10
7	Culturable Wasteland	1,380	3.03	139	3.44	30	0.06
8	Fallow Lands other than Current Fallows	150	0.33	15	0.37	0	0.00
9	Current Fallows	640	1.41	106	2.61	370	0.74
10	Net Area Sown	5,410	11.90	758	18.69	41,690	82.83

(B) Human Settlement and Demography

The total population of Himachal Pradesh, Punjab and Jammu & Kashmir UT including Ladakh UT as per census 2011 was 47.11 million representing –3.89% of the country population. Out of this, rural population constitute 89% (HP), 62.46% (PB), 72.62% (J&K erstwhile) while 10.03% (HP), 37.53% (PB), 27.37% (J&K erstwhile) population live in urban areas against the country's 68.8% rural and 31.2% urban population, indicating that the proportion of rural population in above and UT along the Ravi River much lower than the average country's population. The average population density in the concerned States and UT ranged from 56 persons/ km^2 in Jammu & Kashmir UT including Ladakh to 551 persons/km^2 in Punjab, against the country's

average human density of just 382 persons/ km^2. Punjab ranked last in these concerned States and UT in terms of human density. The Ravi River in the northern- western Himalaya makes the Indo-Pak international border. Earlier, much of the Terai region was inhospitable owing to water-logged conditions. The erstwhile 'Mahalwari' (Landlord) System used to own large land holdings of arable and forest lands. Once Mahalwari System was abolished, the acquired excess cultivable land was distributed to landless agricultural laborers. A large number of displaced persons at the time of country's independence were also brought in and settled in the Punjab region i.e., Pathankot and Gurdaspur. Thus, inhabitants in most of northern part of Himachal are ‘Gaddis’ ‘Gujjar’ Tribes and ‘Bakarwals’ in Jammu and Kashmir UT. These Tribes depend on the forests for food, fodder, medicines, agriculture implements, handicrafts and social and religious ceremonies. A large proportion of the population in the Ravi River terain inhabiting villages in proximity to forests depends upon forest resources for their subsistence, livestock or labour-oriented works mainly in fast expanding agriculture or neighbouring towns/cities. Census data of Himachal Pradesh, Punjab and Jammu and Kashmir UT including Ladakh of Ravi River Basin is given in Table 2.26.



Plate 2.24 – Urban Landscape in the Himalayan Tract within Ravi Riverscape

Table 2.26- Census 2011 data of Himachal Pradesh, Punjab and Jammu & Kashmir UT including Ladakh

Sr.No.	Variable	Himachal Pradesh	Punjab	Jammu & Kashmir including Ladakh
1	Geographical area (km^2)	55,673	50,362	222236
2	Population as per census 2011	6864602	27704236	12541302
3	Urban	688552	10399146	3433242
4	Rural	6176050	17305090	9108060
5	Average population density	123	551	56
6	Livestock population	48,44,431	81,17,101	92,00,842
7	No. of district as per census	12	22	22
8	No. of hill district	12	0	22
9	No. of tribal district	4	0	-
10	Sex ratio	972	895	889
11	Literacy (%)	83.8%	75.84%	67.16%
12	Poverty line (per capita/month as of 2011-2012)rural	708	830	891
13	Poverty line(per capita/month of 2011-2012) urban	888.3	960.8	988

(a) Sex Ratio, Literacy and Poverty Line

The values of sex ratio (male:female) in Himachal Pradesh, Punjab and Jammu & Kashmir Union Territory ranged from 889 to 972 females/1,000 males against the country's average of 940 females/1,000 males. Himachal Pradesh and Punjab having lower rural populations as compared to Union Territory of Jammu & Kashmir (erstwhile J&K). Male population of these States and UT was 52.84%, 52.95% and 50.72% respectively. The population of the two State and one UT (47110140) lived in 56 of the country's total 640 districts, respectively. Of these, 34 are hill districts and 32 are tribal. The UT of Jammu and Kashmir has as many as 22 hill districts while the Himachal Pradesh have 3 and Punjab have nil tribal districts.

The values of literacy among the States and UT ranged from 67.16% to 83.18% against the country's average of 74.04%. The lowest literacy rate among the States and UT was in Jammu and Kashmir (67.16%) while the highest literacy was in the state of Himachal Pradesh (83.18%). The values of poverty line (per capita income/ month) in rural population in the the States and UT ranged from per capita income of Rs. 708 per month to Rs. 891 per capita per month against the country's average rural poverty line of Rs. 972 per capita income per month; the poverty line in urban population of the States and UT ranged from per capita income of Rs. 888.3 per month

to Rs. 988 per capita income per month against the country's average urban poverty level of Rs. 1,457 per capita income per month. Among the State and UT, the Union Territory of Jammu & Kashmir had the lowest poverty line in the rural as well as urban populations.

(b) Culture and Religion

Culture refers to the cumulative deposit of knowledge, traditions, beliefs, values, experience, attitudes, meanings, hierarchies, religion, notion of time, spatial relations, concepts of the universe, and material objects and possessions acquired by the group of people in the course of generations through individual and group striving (Kumar, 2017). Culture of a place is exhibited by different aspects *viz*., people and lifestyle, language, religion, art and craft, music and dance, fairs and festivals, and cuisines. Himachal Pradesh known as *Dev Bhumi* one of the few Indian States that had remained largely untouched by external customs and exposures, mainly owing to its difficult terrain. However, with the technological advancements, efficient road transport and communication systems, and linkages with markets in far flung areas, the State has changed rapidly. The State has three well defined eco-cultural zones *viz*., (a) the tribal belt dominated by Buddhism and Tibeto-Burmes language of the Himalayan group, (b) the middle belt adjoining the tribal areas, inhabitated by communities following terrace cultivation, horticulture, and some elements of pastoralism, and (c) the lower and sub-montane areas inhabitated by communities practicing settled cultivation and animal husbandry. The inhabitants of the latter two belts are mainly *Pahari* language speakers whereas in the first belt, only the Gaddis, Pangwalas, Gujjars, Sipis and some minor communities like Swangla speak *Pahari* language while rest speak a language akin to the Himalayan group of Tibeto-Burmes. Although the population is predominantly Hindu, the State also has small populations of Christians, Muslims, Sikhs and Buddhists. The State is a multi-religional, multi-lingual, and multi-cultural due to migrations and settlements.



Plate 2.25 – Chourasi Temple Bharmour within Ravi Riverscape

Being a Himalayan mountainous State and in general characterized by inaccessibility, fragility, marginality and diversity in a vast geographical extent and highly variable geo-climatic situation coupled with wide array of environmental risks, people of the State have adopted unique ways of living in harmony with nature's gift of natural resources. The culture of Himachal Pradesh has remained traditional and its ethnicity and originality have been retained to a great extent. The beauty of the culture of the State lies in its simplicity. Culture is not only exuberant in the physical attires of the *Himachalis*, but also in their festival celebrations, musical melodies, rhythmic dance and simple life style (Kumari and Punam, 2016).

Large proportion of the population does not belong to the aboriginal stock. Occasional waves of migration of considerable magnitude have taken place at different times. New settlers matrimonial alignments with the natives in the beginning of 9th century and continued for centuries (Nangia *et al*., 1999). Institution of *Devta* (God) is the major religious establishment and generally each village has a *Devta* while some *Devtas* have jurisdiction over several villages. People go to neighboring *devta* at every occasion, at the beginning or closer of sowing, the harvesting time or any other auspicious occasion such as festival, marriage, birth and construction, etc. Numerous fairs and festivals exhibit their collective expression of the traditional and cultural values. Society is very closely knitted and on such occasions, all strata of society be it old and young, man and woman, and boys and girls in large number. They wear

colourful dresses, caps and costumes. The portraits of *Devtas* are made of wood and metal and are kept in village temple. However, they are frequently brought out from temple at the time of festivals and other public ceremonies. People seek guidance and blessing of *Devta* on all occasions of important events in their life. Himachal Pradesh has been recognized a land of dance and music. The dance and music of the State is mainly religion-oriented where gods are invoked by singing and dancing during festivals. According to the belief, dancing when done with body and soul gets a person connected with the almighty. The local fairs and festivals have their unique attraction (Kumari and Punam, 2016, Nangia *et al*., 1999). The State is well known for its various handicrafts *viz*., carpets, shawls, caps, paintings, wood work, metal wear, leather works, etc. and worth appreciating. Pashmina shawl is one of the products in high demand. The rich culture and tradition of the State are reflected in its cuisine that encompasses a wide range of delicacies with a plethora of aroma and taste. However, traditional feast known as *Dham* is being prepared in *Himachali* style and served on special occasions such as marriages, local festivals and other important events. Dham forms an integral part of *Himachali* traditions (Tanwar *et al*. 2018). The State harbours numerous historical and old temples. Such as Bharmour (HP) is one of the many pristine destinations of Chamba district which remains mostly unexplored by tourists. It lies between the Pir-Panjal and Dhauladhar Ranges, between Ravi and Chenab valley.

Punjab is fertile alluvial lowland situated in the west of Yamuna River, and bounded by the stony and highly broken slopes of the Himalayan Mountains in the north, the desert tract in the south, and rich Ganga plains in the east. Punjab has a cultural and ethnic background going back to the Indus Valley Civilization, which existed from 2,800-1,800 B.C., and was remarkable for its ordered cities and advance sanitation, excellent roads and uniquely structured society. Thus, Punjab has one of the oldest and richest cultures of the world. Its diversity and uniqueness is evident in the Punjabi poetry, philosophy, spirituality, education, artistry, music, cuisine, science, technology, military warfare, architecture, traditions, values and history. The culture of Punjab has its own unique fragrance and it is a land of dynamic people, portrays vitality and liveliness, which is amply reflected in the traditional culture. The culture of Punjab is unmatched. People of Punjab exhibit compassion and high spiritedness in their lifestyle. Punjabis are known for their strong determination. There is artistry in every aspect of life in Punjab and an aura of embellishment dominate the place. The century-old culture in Punjab is renowned for its tolerance, progressiveness and logical approach to life as well. The culture of Punjab has undergone significant phases of evolution. Different phases can be broadly classified into three categories. The ‘Ancient Punjab’ had a rich baked-brick urban architecture. During the ‘Middle Age’, the State experienced several foreign invasions. Greek, Persian, Mongol and Afghan invasions had significant influence on the cultural landscape of the State. During this phase, the birth and growth of Sikhism occurred, giving a new dimension to the Punjabi culture. The rich and fertile land of the Punjab was meeting ground of different people and races. Its people descended from various stocks and consist of heterogeneous racial elements. Today, people from Punjab (prominently Sikhs) are distributed all over the world and as a result the traditional

Punjabi culture has been expanded and strengthened in the western world as well. Punjab is inhabited by people of diverse socio-cultural dominations. They are basically of Indo-Aryan ethnic origin and belong to South Asia. Numerous invaders including British have invaded, settled and ruled the region, giving the State a unique culture. Punjab, being a multi- religional State has prominence of Sikhism and Hinduism religions while other religions like Islam, Christianity, Jainism and Buddhism also flourish, though relatively low in proportion. Punjabis celebrate several religious and seasonal festivals *viz*., Dussehra, Diwali, Lohri, Holi, Baisakhi, and several others. In addition, there are numerous anniversary celebrations as well in honor of 10 religious Gurus or Leaders of Sikhism and various saints. Punjab is a land of legends, myths, folklore, and the Sufi philosophical and material culture which are carried forth by its continuing relevance to the present communities. Sikh identity arouses an image of potentially powerful, economic, political and cultural force. The Punjabi culture is renowned for variety of reasons as it reflects exclusiveness and liveliness of the people. The scope, history, sophistication and complexity of the culture are vast. Undoubtedly, the culture of Punjab is one of the distinctive culture found anywhere around the globe. The people of the State are friendly, hospitable, hard-working and relish living.

The folk heritage of the Punjab reflects its thousands years of history. The State has a very rich tradition of romantic dances, particularly the folk once. The vitality of people is vigorously displayed in their folk dances. Dances are typically performed at the time of celebrations such as crop harvest (Baisakhi), weddings, festivals, fairs, etc. The State had a rich tradition of arts and crafts and the richness of the land is reflected in its handicraft. The fascinating art works include mud work (mud plaster on house walls in rural areas), metal work, phulkari, an intricate needle and embroidery work, basketry, cotton flat woven rugs (*Duries*), wood work, weaving, etc. and they provide enormous opportunities for varied markets (Kaur, 2013). Punjab is one of the prime destinations for pilgrimage in India as the State has a large number of holy shrines of equal religious significance. Apart from the world's largest Gurdwara – The Golden Temple and predominance of Sikh religious places, one can also visit a host of mosque dating back to the mughal times, temples and churches.

Kathua (J&K UT) district is considered as one of the most beautiful districts of the UT and is popular for various tourist attractions and religious centres which attract the attention of visitors especially in Billawar, Basholi and Bani tehsils. Diversity of style and architecture of these ancient monuments portrays the era when these were built. The district is also bestowed with religious wealth in the form of numerous shrines and places of worship enjoying reverence and allegiance of people professing different faiths and religions. Mahabilvakeshwar Temple, dedicated to Hindu God of destruction - Lord Shiva, is one of the most popular temples in Kathua District which is situated in Billawar tehsil. *Sukrala Mata, Jasrota Wali Mata, Judian-wali Mata, Shiva Temple Airwan* etc. are some of the religious centre. The Various shrines

associated with Muslim saints are ziarats of Pir Fozal Shah near Kathua and Pir Chhatar Shah near Parole (District Census Kathua, 2011).

(c) People, Occupations and Resource Dependence

People in the hill districts of Himachal Pradesh and parts of Jammu chiefly depend on forest resources and pastorals practice transhumance livestock rearing. Increasing population pressure, declining forest and alpine pasture resources and other options of earning in urban areas make livestock rearing lesser lucrative. Traditional resource dependent occupations are not able to cover current livelihood needs for the whole year. Villagers have to search for alternative sources of livelihood thus migrating to urban areas to earn wages or engaging in illicit extraction of forest resources. Migration in the case of population in hilly region of Himachal Pradesh is a major concern. Increasing restrictions on the use of forest resources, depleting forest resources and enhanced human- wildlife conflict are some important concerns. Forest Policy in Himachal Pradesh has recently undergone dramatic changes as the state attempts to involve communities in sustainable forest management after decades of ineffectual top-down management. The Pradesh faces a litany of environmental problems which are exacerbated by poverty. New management thinking and policies are needed to transition the state from its earlier extractive system to a more balanced sustainable approach that considers social, economic and environmental concerns. It is important to understand this transition within the backdrop of recent changes in national and state forestry policy. The first State Forest Policy for Himachal Pradesh was adopted on September 3, 1980, in furtherance of the National Forest Policy Resolution of 1952. The policy's focus was on industrial development where the primary purpose of public forests was to produce timber. The rural peoples' dependence on forests was viewed more as a destructive nuisance and the common perception was that rural people were impediments to good forest health. The National Commission on Agriculture captured this sentiment in 1976: "Free supply of forest produce to the rural population and their rights and privileges has brought destruction to the forest and so it is necessary to reverse the process".

(d) Livestock

As per 19th livestock census statistics (2011-12) Jammu and Kashmir Erstwhile State experienced 92,00,842 Livestock population. Punjab having 81,17,101 and 48,44,431 is experienced by Himachal Pradesh as total Livestock Population (Table 2.27). Union Territory of Jammu & Kashmir (Erstwhile J&K) has maximum number of Rural livestock (89,11,441) followed by Punjab (76,97,973) and then Himachal Pradesh (48,15,505). In terms of urban livestock number, Punjab (4,19,128) is ahead of Union Territory of Jammu & Kashmir (2,89,401) and Himachal Pradesh (28,926). Total Livestock covers cattle, buffalo, sheep, goat, pig, horses, ponies, mules, donkeys, camels, mithun and yak and total poultry include total birds in the poultry farms and hatcheries. Total Number of Livestock and Poultry in Himachal Pradesh, Punjab and Jammu & Kashmir UT is given in Table 2.27.

Table 2.27 - Total Number of Livestock and Poultry in Himachal Pradesh, Punjab and Jammu & Kashmir UT including Ladkah.

State/UT	Rural		Urban		Total (Rural +Urban)	
	Livestock	Poultry	Livestock	Poultry	Livestock	Poultry
Himachal Pradesh	48,15,505	10,88,792	28,926	15,684	48,44,431	11,04,476
Punjab	76,97,973	1,59,01,002	4,19,128	8,93,074	81,17,101	1,67,94,076
Jammu and Kashmir including Ladakh	89,11,441	74,90,476	2,89,401	7,83,233	92,00,842	82,73,709

(e) Agriculture and Allied Activities

Agriculture is the largest occupation and source of livelihood to most people in Himachal Pradesh and Punjab. In Himachal Pradesh, the agriculture is the source of livelihood for nearly 67% of the total population. Cultivation is mainly done on terraces as topography of the State is largely hills. The cultivation in hills is subjected to soil erosion since crop cultivation is usually on 5% to over 30% slopes. Nearly, 81% agriculture is rainfed. The size of land holdings up to 1 ha covers 61.5% farming community (GoHP, 2012). The small and marginal farmers put together account for 82.1% and cover an area of 43%. The medium farmers with holdings ranging from 2 ha to 10 ha cover an area of 47.2%. The agriculture workforce is nearly 35% of total population of which 63.25% are cultivators. The ratio of agriculture labourers to total workers forms only 2.66%. Agriculture in the State though made significant progress yet faces enormous challenges. Major challenges include: (a) Land fragmentation and small size of land holdings leading to unremunerative agriculture; (b) Hill agriculture is seriously constrained unless it is backed up by a scientifically designed strategic policy framework; (c) The society is undergoing changes in economic transitional phase as the joint family systems are becoming nuclear families and consequently working hands in agriculture are severely reduced; and (d) Vagaries of weather. With the provision of irrigation in some of the districts, there is a clear cut shift in the cropping pattern. Major shift is from cereal crops to vegetable crops. Multiple cropping has also been introduced in irrigated area. The replacing crops are generally cash crops and have become a predominant factor in small farm management to earn cash in order to meet their input requirements and needs of the family money. However, this trend in certain situation is detrimental to meet the enhanced demands for cereal crops. Increasingly, there has been a heavy reliance on higher energy inputs in the form of tractors, diesel and electric pump sets and threshers. The State recorded the substantial increase nearly by four times in the number of tractors from 1987 to 1997. There has been a wide spread use of various chemicals in agriculture including fertilizers (NPK), pesticides, fungicides, herbicides and weedicides. The use of

fertilizers has substantially increased from 34,852 MT in 1997-98 to 46,808 MT in 2003-04. In comparison to fertilizers, the use of farm yard manure has been progressively decreasing as nuclear families are hardly engaged in rearing cattle or domestic animals. There has been a sharp rise in the use of pesticides, particularly in vegetable crops. In recent times, various agriculture and horticulture crops face a serious threat from proliferation of invasive alien species and also by crop depredation due to increasing populations of wild pig and monkeys. In addition, the agriculture faces problems of market access, and inadequacy of soil and water conservation programmes. The hill agriculture has undergone a big transformation in past five decades or so and conspicuous changes have occurred in cropping patterns, fruit orchards have replaced traditional cereal farming and cultivation of cash crops gained lot of significance (GoHP, 2012). The bullock cultivation is replaced by the use of tractors for cultivation. Use of fertilizers and other chemicals has gone very high. Several old crops and traditional/ local varieties have been replaced. New crops are being adopted to diversify crop cultivation. Mixed cropping is fading away. Farmers have become conscious about using the available water resources of which earlier they were ignorant. Definitely, there has been evident erosion in agro-biodiversity. The State has been bestowed with conducive environment for cultivation of large variety of horticulture crops *viz*., fruits, vegetables, ornamental plants and herbs in prevailing wide range of agro-climatic conditions within the State. Presently, more than 30 fruit species are being grown. Prominent once are: apple, apricot, peach, pear, plum, almond, walnut, pecan-nut, mandarin, sweet orange, mango, guava, papaya, litchi, kiwi, olive, and strawberry. Various fruit crops grown during 2017-18 in the State covered 2,30,852 ha, out of this apple with maximum extent of 1,12,634 ha was distinctly prominent and provided total production of 4,46,574 t (elets.gov., 2019).



Plate 2.26 – Agriculture crops in Ravi Riverscape

Like Himachal Pradesh, Punjab has also made unparalleled progress in the agriculture since the advent of green revolution in the mid-60s with traditional agriculture progressively giving way to modern and commercial agriculture. Presently, 82% of the geographical area of the State is under cultivation and cropping intensity is around 191% with over 99% of the cultivatable area with under assured irrigation. The State has 41,370 km^2 area as net sown in 2015-16. The production food grain in the State increased from 3.16 MT in 1960-61 to 28.39 MT in 2015-16 as a result of introduction of High Yielding Varieties and new technologies to the hardworking and receptive farmers with the support of the government policies. The State known as 'Granary of India' has played key role in transforming India from grain importing nation to self-reliant and export surplus nation. The State has highest yield of rice, being 4.41t/ha while the yield in case of wheat has been 5.04 t/ha. The State contributed 46.4% of wheat and 29% of rice to central pool during the year 2016-17. The stunning rise of food grain production from 11.92 MT in 1980-81 to 29.44 MT in 2013-14 was attributed to intensive use of farm chemicals. The consumption of chemical fertilizers (NPK) was increased from 0.76 MT to 1.71 MT in 2013-14. Enhanced use of nitrogenous fertilizers and relative under use of other fertilizers and micro nutrients has led to imbalance in micronutrients in soils of the State. It is also worth mentioning here that 85% of water consumption in the State is accounted by the agriculture sector. Canals provide about 27% irrigation while tube wells contribute 73% irrigation. The number of tube wells has increased considerably in past decades. The groundwater is being over exploited to meet the increasing demand of water for irrigation. The present groundwater development in the State is 170% with groundwater in 80% geographical area of the State is over exploited. Farm mechanization has played a key role to bring a significant improvement in agriculture productivity in the State. Against the national average of one tractor per 62 ha net cultivated area in the country, Punjab has one tractor for every 8.17 ha of net cultivated land in the State. Farm mechanization in the State has reached at a saturation point. Punjab produced nearly 20 MT of rice straw and 17 MT of wheat straw annually and farmers practice open field burning of straw after combine harvesting. This straw burning has been recognized as a major pollutant of air impacting the neighboring regions. Undoubtedly, the State has immensely helped the country in bringing the self-reliance in food grain production and made significant contribution to the country's/State economy. However, from the perspective of rivers, excessive groundwater abstraction and decline of water quality due to chemical pollutants are important concerns.

(f) Growing Tourism and Pressure on Forests

Eco-tourism-ecologically balanced tourism in wilderness areas with a motive of enjoying natural beauty is latest useful tool in nature conservation. It is helpful in bringing proximity between citizens and nature. There is a lot potential of eco-tourism in this hilly tract so that people may be encouraged to increase and conserve forests. Therefore facilities for eco-tourism which blend with the environment can be constructed. Walking trails, temporary camping sites with requisite

facilities for eco-tourists can be developed in suitable areas. There are many potential sites in the Forest Division, which could be developed as camping sites for nature loving tourists. Sites which have great potential in terms of natural attraction would be taken up. It is being planned to implement, community based Eco-tourism plan, on a pilot basis. After the successful implementation, the model of these activities would be expanded/replicated to other sites in the Forest Division. All these activities shall be aimed at raising interest and awareness level in biodiversity conservation. Some important sites have been identified for his purpose. Forest Department in collaboration with Forest Corporation, other Government Departments, corporation and local community/will facilitate creation of appropriate infrastructure for Eco-tourism which blends with natural surroundings. The Manimahesh Lake is situated Twenty-six kilometers from Bharmour in the Budhil valley, one of the chief pilgrimage spots in Himachal Pradesh. The lake is situated at an altitude of 3962.4 m at the foot of the Kailash peak. Every year, on the eighth day of the light half of the moon in the month of Bhadon, a fair is held at this lake, which attracts thousands of pilgrims who assemble here to take a dip in the holy water. Lord Shiva is the presiding deity of this fair/jatra. He is believed to reside in Kailash. A rock formation in the shape of a Shivling on Kailash is considered to be the manifestation of Lord Shiva. The snowfield at the base of the mountain is called Shiva's Chaugan by the local people. Bharmour is beautiful town surrounded by high lush green mountains located at a distance of 62 km from Chamba. Bharmour is often referred as the land of Shiva because of belief that lord Shiva resides at mountain Kailash which is located in this area. Bharmour is popular for its natural beauty and for Chaurasi temples. Amritsar not only is home to hundreds of thousands of Sikhs but also is the chief pilgrimage destination for Sikhs living elsewhere in India and abroad. The principal focus for those pilgrims is the Golden Temple and its complex of several adjacent buildings located around the tank.



Plate 2.27 - Ecologically Sensitive Khajjiar Wetland Experiences Ever Increasing Tourism Pressure

(g) Other Activities

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential globally. It is endowed with hydro-power potential to the tune of 2,50,000 MW. The Hydro-power potential of Ravi River System has been assessed at 2294 MW. The earliest project built was the Madhopur Headworks, in 1902. The rhitherone zone of Ravi River within the Himalaya has been maneuvered extensively for generation of power by formulation of many dams, Chamera I, II, III and Ranjitsagar/Thein.

As far as the potential capacity of the hydro-electric power generation in Himachal Pradesh is concerned it has five perennial river basins having total installation capacity of 25,000 MW. NHPC has played a very vital role in the development of this sector since 1980s with the installation of Baira Siul Hydel-electric Project of 198 MW, then after it was Chamera-I of 540 MW which has been successfully commissioned day back in 1994 then Chamera-II of 300 MW in the upstream of Chamera-I in 2004 in Chamba district of Himachal Pradesh, studied minutely by the researcher (Salariya, 2011). The watersheds of the Ravi River have given much more than agriculture, horticulture and fish produce, and water for harnessing of hydroelectric potential. Large-scale mining of stone and sand takes place along river beds of Ravi especially along Modhupur- Kathlour region where river bed is stony, gravel and scarce of water resources with the result even growth and breeding of minor fishery is constrained The Ravi River on the whole especially in Indian Punjab is not subjected to much industrial and municipal effluents as the catchment as well as adjoining area of river do not have many heavy or small-scale industries. Moreover, river flows some 20 to 30 km away from big cities and towns, with the result is not subjected to much municipal effluents (Moza, 2014).

The Himachal Pradesh Forest Development Corporation undertakes collection and marketing of minor minerals from the river beds of reserved forest areas in order to protect the forest lands, agricultural crops and inhabitations from the havoc of floods. Likewise, the other States and UT downstream also extract huge quantities of such minor minerals from river beds. Owing to the presence of various raw materials and water, major industrial towns are located on the banks of the river.

2.6 Development Programmes, Conservation Issues and Implications

In ancient times as well as during the past two centuries or so, two States and one Union Territory along Ravi River remained in the forefront of all round development, starting with the early process of Indus civilization, forestry and forest management, agriculture expansion and fisheries, hydro-electric projects i.e., dams, canals, barrages, industrialization, river mining (sand, boulder, etc.), inland navigation, urbanization and finally pilgrimage (Bharmour Manimahesh Chamba, Golden temple, etc.) and tourism activities. These developments undisputedly impacted and influenced the natural ecosystems i.e., forests, grasslands and

wetlands in three states due to increasing commercial activities as well as growing demands of increasing populations of human and livestock. Despite efforts from time to time and various initiatives by the Central and State Governments and even local communities for protection and conservation of forests and wildlife, the pressures continue to mount and the decline continues. The foregoing narrative on the physical, biological and socio-economic environment in the context of the Ravi River Basin and riverscape has attempted to appropriately detail and highlight the decline of forests, wildlife and other natural resources. The process of decline in quantity/extent and quality of natural variables in context of forests, grasslands, wildlife, and river and water resources is on and the situation in many instances is being aggravated to the point of no return.

In a nutshell, this Chapter on the environment i.e., physical, biological and socio-economic in the context of the Ravi River has tried to summarize the intricate interrelationships of the mighty river with its larger environment, chronology of events and their implications, conservation significance and issues and the urgent need to rejuvenate the precious Ravi and its dynamic river ecosystem by way of appropriate forestry interventions.

2.7 Research and Monitoring

Research and monitoring activities are vital to develop the information base, setting goals and objectives and evolving strategies besides facilitating policy and decision making. It is evident from the foregoing description on the physical, biological and socio-economic environment in the context of Ravi River and the riverscape that for Aviral and Nirmal Dhara, a large number of interrelated variables and factors from the origin to mouth of the river come into play. The subject of river ecology and management is therefore multi-faceted, intricate and elaborate. A large number of organizations responsible for different aspects of river ecology (i.e., glaciology, hydrology, forestry, wildlife, demography, sociology, development, economics, etc.) are working in isolation and as per the entrusted mandate of each sector. Thus, most of the available research and monitoring information is either isolated, scattered or, in some instances, obsolete/archival in nature, piecemeal, or relevant to specific segments/ stretches of the river or its tributaries only (Table 2.30). Under such circumstances, it is difficult to develop a holistic understanding of intricate interrelationships those are vital for addressing the requirements of a complex and dynamic river ecosystem. The foregoing review has revealed that on the one hand enormous varied information through researches undertaken by geologists, meteorologists, climatologists, hydrologists, biologists, ecologists, foresters, social scientists, economists, conservationists, etc. has been made available on essential aspects on the ecology of Ravi River, on the other hand it is also evident that there are considerable gaps in the information and developed understanding. Likewise, many agencies are involved in various types of monitoring activities relevant to different dimensions of river ecology. Monitoring of glacial retreat, water flow and quality, sedimentation, distribution and abundance of terrestrial and aquatic vegetation and fauna, forest

resources and utilization, and demography by different international, national and state level government and non-government organizations and individuals have contributed much valuable information in the context of Ravi River (Table 2.28). However, there is a felt need to improve, strengthen, augment and institutionalize these efforts in a more meaningful and effective manner.

Table 2.28- Type of Researches and Monitoring Efforts in the context of Ravi Riverscape

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
1.	The Sate and Fate of Himalayan Glaciers	Geological Survey of India ICIMOD SAC, ISRO	Broad based baseline information on glaciers exists and study/ monitoring protocols standardized. No specific periodicity or consistency in procedures evident. Mostly, one time project based outputs. Longer gaps in monitoring. Appears as no single authority designated for monitoring and keeping long term database. Several piecemeal, sporadic monitoring efforts by individual scientist or group of scientists for specific glacier or a basin level monitoring.	Himalayan Glaciers and Glacial Lakes – Bhambri and Bolch, 2009; Bolch, 2012; SAC, 2016; Campbell, 2004; Kasturirangan *et al.*, 2013; Ravindra and Laluraj, 2012; Sharma *et al.*, 2015, Bahuguna *et al.*, 2007 and 2014; Kulkarani *et al.*, 2005, Chand and Sharma, 2016	Broad based insight on the state and fate of Himalayan Glaciers and Glacial Lakes region/basin-wise exists. Monitoring of glaciers in different basins during 2000-2011 undertaken. Glacier fluctuation in Ravi River Basin Inventory of glaciers and glacial lakes by ICIMOD during 2002-2015 provided.
2.	Cryosphere, Snow Cover, Glacial Lakes and Permafrost	National Institute of Hydrology (NIH) SAC, ISRO Wadia Institute of Himalayan Geology	Probably no specific designated agency. Sporadic and *ad.hoc* initiatives by different agencies/ group	Permafrost – Allen *et al.*, 2016; Owen and England, 1998; Schmid *et al.*, 2015; Vaughen *et al.*, 2013. Inventory of	Mostly piecemeal efforts. SAC, ISRO carried out probably one time study on snow cover in different basins during 2000-2011. It was difficult to

		(WIHG) H.P. State Centre on Climate Change (HPSCC), HIMCOSTE	of scientists. Lack of consistency in procedures/ protocols, monitoring sites and even periodicity.	GLOFs – Randhawa and Sharma, 2014	comprehend a precise information on snow cover, GLOF, etc. specific to the Basin.
3.	Surface and groundwater Resources and E-Flows	Central Water Commission (CWC) Central Ground Water Board (CGWB) – State Units State Council for Science and Technology Department of Irrigation National Institute of Hydrology (NIH) Wadia Institute of Himalayan Geology (WIHG) Indian Institute of Technology (IIT), Roorkee International Water Management Institute (IWMI)	Valuable information on the State-wise and District-wise ground water resources on annual basis is being provided by CGWB. Information on surface water, estimation of snow/ glacier melt contribution on *ad.hoc* basis-fragmentary studies. Evaluation of water budget – river specific studies/ monitoring. Monitoring in specific stretches of river. Information on E-flows for Indian River basins based on longer stretches of time periods by IWMI.	CGWB, 2019; Ahluwalia *et al.*, 2015, Vajja and Roy, 2005; Lakhera *et al.*, 2016; Kumar *et al.*, 2007; Jain and Kumar, 2014; Jain, 2015; Kumar *et al.*, 2017; WMO, 2019; Sharma, 2018; Gupta, 2009; Jha and Sharma, 2009; Dyson et al., 2003; Maasri, 2013; Ramchandra, 2007; Daniel *et al.*, 2016; Magilligan *et al.*, 2016; Boehler *et al.*, 2017; Pavel *et al.*, 2016; Tharne, 2003; Acreman and Dunbar, 2004; Acreman *et al.*, 2014; Karchnak *et al.*, 2009	Desired information on ground water and surface water being provided on regular basis for each of the State/ District and prominent rivers. Likewise, valuable information on environmental flow in case of prominent rivers and hydroelectric projects being generated. However, there is a need to organize large datasets for optimal use by various user agencies. Insight on E-flows for smaller streams/ tributaries of major rivers is desirable.
4.	Sediment Transport and Sediment Budget and Flooding	Various international and national agencies carry out the studies on sediments load in major rivers. National Institute of Hydrology (NIH) Indian Institute	Methods to assess sediment fluxes in reservoirs have been improved using RS and GIS technologies. Piecemeal and fragmentary studies. No specific periodicity.	Sherman and Davis, 2013; Bloesch 2004; Clift abd Giosan, 2013; Milliman and Meade, 1983; Gupta *et al.*, 2012; Clift *et al.*, 2002; CWC, 2019; Dayal *et al.*, 2016; Isaac *et al.*, 2014	Review revealed that probably no specific national level agency responsible for comprehensive and adequate monitoring of sediment transport through various rivers, tributaries, and confluences.

		of Technology (IIT), Roorkee and Bombay Scientific studies on assessment of sedimentation in different reservoirs ad role of mega dams in reducing sediment fluxes.			
5.	Water quality	Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) are the agencies for monitoring water quality in rivers and other water bodies. In addition to CPCB/SPCBs, a large number of institutions, universities, and scientists.	Regular monitoring of water quality on select permanent monitoring stations in different seasons relevant to prominent rivers and water bodies. Individual efforts are predominantly piecemeal or specific to a river/ tributary stretch or a wetland.	CPCB, 2007; Bhardwaj, 2005; Suratman *et al*., 2015; MoEF, 1993; BIS, 2012; Sanchez *et al.*, 2007; Jindal and Sharma, 2011; Dasmohapatra, 2011; Kumar *et al.*, 2005; Moza, 2014; Carpenter *et al.*, 1998; Jervie *et al*., 1998; Kumar and Dua, 2009; Saffran *et al*., 2001	Standard guidelines for monitoring of water quality (parameters, tolerable range and periodicity) by MoEF&CC, CPCB and BIS are available. However, water monitoring in various rivers, tributaries and confluence points needs intensification.
6.	Forest Cover, Forest Types, TOFs, Growing Stock and Carbon Sequestration, Biodiversity, (floristics)	Forest Survey of India (FSI), HFRI, GBPNIHE.	FSI undertakes biennial assessment on overall forest cover – entire country, State and District-wise since 1987. Situation of forests including temporal changes in TOFs being provided on regular basis. Valuable insight on growing stock, carbon sequestration, forest fires, bamboos, etc. is also made available.	Biennial ISFRs by FSI-Dehradun, Site specific and general inventory prepared, (Samant, 2015)	Much reliable, authentic and institutionalized process. Considering the significance of prominent rivers and their tributaries, it would be desirable that basin-wise information is also generated atleast on a periodical interval of five years to start with the available data. Considering the threat of weeds/ IAS (Invasive Alien species).
7.	Carnivores (Snow leopard,	State Forest	The Wildlife	NCF, 2019;	Efforts so far have

	bears) and Herbivores	Department (SFD), Wildlife Wing WII ZSI NCF Snow Leopard Trust Local Universities/ State level Institutions Individual Experts/ Scientists	wing of the State Forest Department organizes periodic/ annual assessments on population estimation of select species (carnivores, ungulates and primates) in select PAs. In recent years, NCF and HPFD have collaborated to monitor the population of snow leopard and its prey. WII and ZSI have also intensified activities on field surveys/ assessments of faunal species in project mode.	Jackson *et al*., 2008; Rodger and Panwar, 1988; Maheshwari and Sharma, 2010; Chundawat *et al.*, 1988; Mahar *et al.*, 2011; HPFD, 2005	been made mainly to standardized methods/ protocols for field surveys/ assessments/ monitoring of elusive snow leopard and its prey in vast rugged terrain and harsh climatic conditions. Concerted efforts, collaborations are required to develop comprehensive scientific protocols to assess high altitude fauna and their habitat on periodic basis on the lines of All India Monitoring of Tiger, its Prey and Habitat as implemented by NTCA in all tiger range States/ UTs. Replication of similar efforts in the Himalayan States or the Project Snow Leopard States is desired.
8.	Fish Fauna	State Fishery Department National Bureau of Fish and Genetic Resources (NBFGR) ZSI WII SANDRP WWF - India	Several institutions/ experts have carried out fragmentary/ isolated studies on the diversity, abundance and distribution of fish fauna in different rivers/ stretches or other water bodies. By and large, most efforts are in the form of surveys/ research studies or one time initiative.	Hooper, 2005; Moza, 2014; Sharma and Tandon, 1990; Johal *et al.*, 2002; Dhanze and Dhanze, 2004; Sugunan, 1995.	Considering the significance of fish fauna in river ecology, there is an urgent requirement to develop and adopt standard protocol for long term monitoring of fish fauna in the Ravi River Basin/ Riverscape or relevant, prominent rivers and tributaries in a State on the lines of Sarkar *et al*., 2012 as adopted in the case of Ganga River.
9.	Herpetofauna	State Forest Department (SFD)	So far, ZSI has made efforts to provide	WII ENVIS Bulletin, 1999; Lagler *et al*.,	In general, the review of available information on

		ZSI WII WWF - India	comprehensive insight on the diversity of herpetofauna in the concerned States/UT. Sporadic studies have been carried out by experts from WII and WWF – India	1962; Mehta, 2005; Mehta, 2000a; Tilak and Mehta, 1983; Saikia and Sharma, 2009; Kriplani, 1952; Saikia *et al.*, 2007	herpetofauna in the context of Ravi River in two concerned States and one Union territory revealed that there is highly inadequate information, particularly on their status, distribution and efforts to monitor them were conspicuously absent.
10.	Avifauna in general and waterfowls	State Forest Department (SFD), Wildlife Wing BNHS, Bird International WII WWF, India	The focus of avifaunal surveys, research studies and *ad.hoc* fragmentary monitoring efforts have been restricted to preparation of checklists, galliforms and pheasants, waterbirds, particularly migratory in prominent wetlands.	HPFD, 2017 2013; Kumar, 2014; Singh, 2015; WII ENVIS Bulletin, 2017; HPFD, 2018a, b and c	As such planned long term monitoring of avifauna in the Ravi River Basin in concerned two States and one Union Territory is missing, except comprehensive and institutionalized monitoring of avifauna particularly migratory waterfowls in select wetlands or even some PAs.
11.	Aquatic Mammals	State Forest Department (SFD), Wildlife Wing WWF-India WII	Diversity of different mammalian species in Ravi River Basin in concerned states and UT should be evaluated. Preliminary insight on otter in Beas River in Punjab was provided by Singh, (1999). Subsequently Khan (2015) has provided updated information on the occurrence of smooth-coated otter in	Sharma and Sidhu, 2016; Singh, 1999, Khan, 2015 Behra *et al*., 2008; Khan, 2013, 2014 and 2016; Khan and Pant, 2014; Jagtap, 2013; Sugunan, 1995; Johal *et al.*, 2002	Mechanism for occurrence of otters in Ravi Basin in two concerned States and one Union Territory is yet to be evolved and institutionalized. Considering the significance of aquatic mammalian biota, it is necessary that if otters are present in Ravi River then they should be monitored on a regular basis on much shorter interval so as to keep track of these sensitive and specialized species.

			Punjab. At the same pattern occurrence of Otter in Ravi River should also be evaluated		
12.	Socio-economic: Demography; resource dependence on forests, grasslands, wetlands and river; collection of NTFPs including medicinal and aromatic plants; alternate income generation options.	Census of India Various universities and scientific organizations (GBPIHED, HFRI, WII, WWF-India, FRI, etc).	Insight on socio-economic situation in concerned two States and one UT and District-wise is primarily available from decadal census. In addition, various agencies, departments and scientific institutions are contributing on the socio-economic theme and its different related aspects.	Census India, 2011 Tucker, 1999; Nangia *et al*., 1999; Baviskar, 1998; Kumar, 2019; Ahmed *et al.*, 2015; Sadoff *et al*., 2002; Das, 2014; Quinn, 1950; Samant, 2015; 2007; 1998	There is an urgency to design and develop a comprehensive and well institutionalized monitoring covering various aspects of socio-economics, particularly resource dependence, collection of NTFPs, , community participation, access and benefit sharing, conflict, etc.
13.	Social and Village Level Institutions; Community Participation; Sustainable Livelihoods; and Vulnerability.	Disaster management Cell, State Government	Only a handful studies provide insight on village level institutions, sustainable livelihoods and vulnerability. However, the approach is largely fragmentary and widespread. In recent years, a large number of studies have come up with regard to hazards, vulnerability and risk analysis relevant to mountain hazard susceptibility, livelihood security and climate change implications.	GoI, 2003; Kahlong *et al*., 2014; TARU, 2015; SEEDS, 2009; Prasad *et al*., 2016, Singh and Singh, 2018; GoHP, 2012; Chandel and Brar, 2010	Concerned States/UT are having several types of village level institutions created for various purposes. While some old, traditional village institutions are dying, several new institutions at village/ panchayat level are being created. There is an urgent need to have detailed study on such institution, their roles and contributions in natural resource management, particularly rivers and their tributaries.

14.	Impact of developmental projects (e.g., HEPs and road network), mass pilgrimage/ congregation and tourism.	Organizations under the MoEF&CC (e.g. FRI, WII, GBPIHED, HFRI, etc) Universities. Non-governmental organizations and individual experts.	Most EIA studies are project specific and often focusing either on limited components/ themes or specific aspects.	RSET, 2019; Himdhara, 2019;Nag, 2013; Kuniyal *et al*., 2007	Information on various developmental projects and their monitoring is widely distributed among several organizations/ agencies. No institutional mechanism and appropriate databases.

Notably, the above review also revealed that current researches and monitoring activities have ignored in developing an understanding of the linkages between forested vegetation and forestry with river hydrology in a vast country like India wherein the Himlayan as well as other major rivers play crucial role in the maintenance of vital freshwater resources, ecology and prosperity of the region. Considering the looming water crisis and to ensure water secutiry, it is of utmost importance to develop the discipline of Forest Hydrology in accordance with the socio-cultural milieu of the country. Further, there is a distinct deficiency of a reliable knowledge management centre in the context of rivers in India. Likewise, developed nations have gained considerable experience in restoration of rivers and appropriate applications of tools and techniqus related to biofilters and bio-remediation. Prority attention and support for these activities at all levels is need of the hour. The significance of reseracah and monitoring in interrelated disciplines of river ecosystem cannot be undermined, if the country has to restore the river ecology neglected for a long. Thus, the present DPR proposes support for the long term, inter-disciplinary researches and monitoring activities as a precursor to the sustainable mangemnet of river ecosystems.

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Chapter 3

Approach and Methodologies

3.1 River Management - Emerging Concepts of Planning Area

Fresh water resources play a significant role for the human well-being. There are no substitutes of water and while it is renewable there is only a finite amount of it (Cosgrove and Loucks, 2015). Rivers provide a multitude of services such as water supply for farms and cities, waste disposal of factories and households, fisheries to provide food for communities, energy to drive economies, flood attenuation for downstream developments, cultural and recreational enjoyment for people, spiritual upliftment for believers and a habitat for many animals (Pegram *et al.*, 2013).

The law of gravity can be interpreted by the observer that water flows from top to downwards in the hills, joins streams and finally goes in to the sea. The concept of management of watershed appears to be late in history, but management and planning can be increased or add ground water rentention capacity in the watershed or river basin. In the initial stages, navigation from the river to the land (or vice versa) provided a observable journey through the network of river systems. (Pereira, 1973; Pereira, 1989). The rational management of watershed is good for agriculture or forestry to reduce degradation of soil (Cooper *et al*., 1995) and helpful in stabilizing the flow decrease the sedimentation flow, in the stream and enhance the recharge of ground water. The proper planning and management can increase subsurface water. The dams and barrages can modify the stream flow or water flow in river basin. The transfer of water intra basin and inter basin transfer of water must be taken in to consideration for the management of water in the watershed. River Basin Development and Planning Management (RBDPM) take in to consideration integration of watershed, groundwater, land-use, river regulation, welfare improvement, healthcare, and most aspects of development (Barrow, 1998).

The RBDPM offers a framework for integrating water planning and management with environmental, social and economic development. Potentially it should support integration between planning, construction and operational management; between policies, programmes and projects; between national, regional and local; and between sectors and departments (Wiener, 1972; Marquand, 1989; Mitchell, 1989; Rowntree, 1990). Barrow (1998) described it as ‘the orderly marshaling of water resources of basins for multiple uses to promote human welfare’. According to Ward (1998), a riverine landscape indicates a holistic approach linking the rivers and its banks, or its riparian area, within a fluvial system. The foregoing introductory chapter has emphasised the importance of a holistic perspective required for river management, wherein four

types of river connectivity, various interactions and exchanges all along the river course from origin to mouth occur and they contribute towards ecological processes and in maintenance of ecological integrity and river health. The rapidly evolving concept of riverscape now finds an important place in the growing literature on the river management.

3.1.1 Global Insight on Riparian Corridors or Riparian Buffers

Riparian zones occur as transitional areas between aquatic and upland terrestrial habitats. Although not always well defined (Fischer *et al.*, 2000), they generally can be described as long strips of vegetation adjacent to streams, rivers, lakes, reservoirs, and other inland aquatic systems that affect or are affected by the presence of water. Riparian zones typically comprise a small percentage of the landscape, often less than one percent, yet they frequently harbour a disproportionately high number of wildlife species and perform a disparate number of ecological functions when compared to most upland habitats. Riparian zones have been widely recognized as functionally unique and dynamic ecosystems within the past 25 years. Even more recently, these areas have become a major focus in the restoration and management of landscapes (Knopf *et al*., 1988). Riparian areas function in maintaining ecological processes such as: regulating stream temperature, stream flow, cycling nutrients, providing organic matter, filtering chemicals and other pollutants, trapping and redistributing sediments, stabilizing stream channels and banks, absorbing and detaining floodwaters, maintaining fish habitats, and supporting the food web for a variety of biota, and regulating stream temperature (Wenger, 1999; Fischer *et al.*, 2000; Obedzinski *et al.*, 2001; CRA 2002; Chambers and Miller, 2004).



Plate 3.1 – Riparian Vegetation along Ravi River

Riparian health assessments consider various associated buffer widths. Proper widths for various objectives may vary significantly by region and depend on a variety of ecological and physical factors. Scientific studies have shown that efficient buffer widths range from 10 feet for bank stabilization and stream shading to over 300 feet for wildlife habitat. Necessary widths will also vary depending on site conditions, such as soil type, slope and adjacent land use and other factors (Hawes and Smith, 2005). Richard *et al.* (2000) suggested that the buffers wider than 10 m should be promoted for optimizing a range of multiple objectives for water quality, stability, and habitat functions (Fig. 3.1). However, widths of 100 m or more are usually needed to ensure values related to wildlife habitat and use as migration corridors.

Welsch (1991) has defined three-zone systems in the riparian forest buffers performing different functions for protection and enhancement of water resources. These are: (a) the Zone I – Undisturbed Forest in the immediate vicinity of stream/river or flowing water; (b) the Zone II – Managed Forests; and (C) the Zone III – Runoff Control (Grasslands/ Pastures/ Farm lands). This three zone system was originally developed as a part of an initiative to protect the Chesapeake Bay in USA. The combination of vegetation types i.e., trees, grasses, herbs and shrubs helps maximize the efficiency and diversity of benefits that the riparian buffer provides (Hawes and Smith, 2005) (Fig. 3.2)

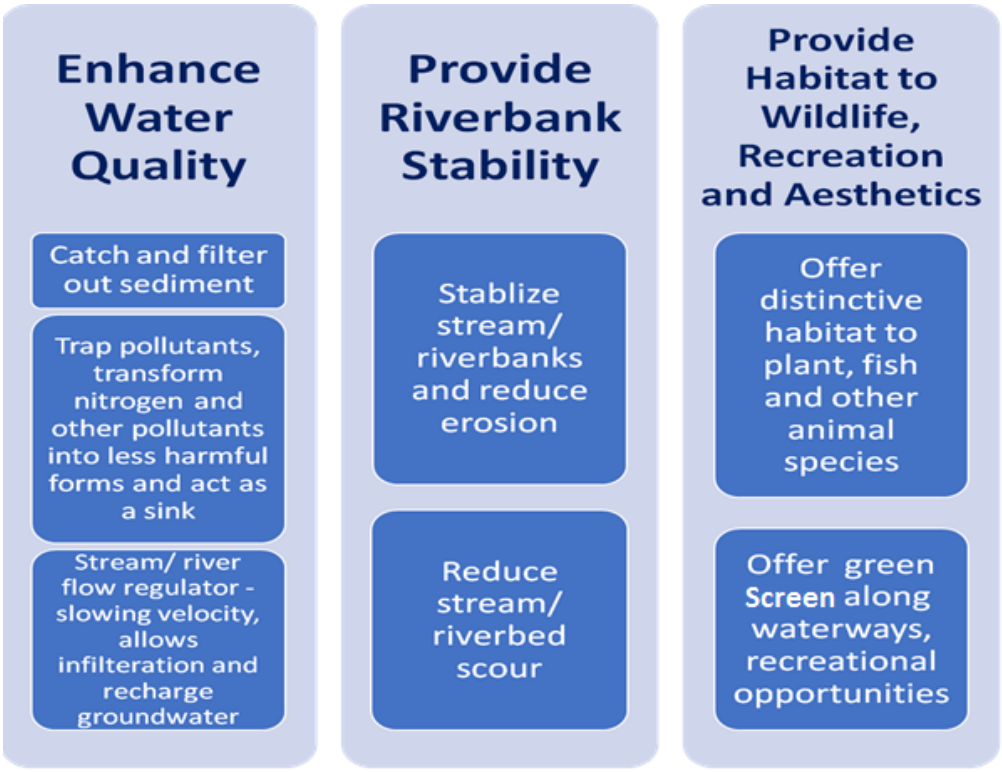


Fig. 3.1 - Functions of Riparian Buffer

According to Pinay *et al*. (2018), riparian corridors are not inert physical boundaries between aquatic and terrestrial environment, they also process the matter and energy during their transfer. The riparian zone is a source of nutrients and organic matter for streams and rivers (Vannote *et al*., 1980) as well as also store these elements. These mineral can be transport immobilised along and within the corridors of riparian zone.

The riparian ecosystem has potential to control the exchange the material between aquatic and terrestrial ecosystems (Lowrance *et al*., 1984; Peterjohn and Correll, 1984; Jacobs and Gilliam, 1985; Burt *et al*., 2010). The bidirectional nature of riparian zone in terms of exchanging material between stream and catchment or vice versa is quite essential for ecological and function Characteristics in the landscape nearby river (Naiman and Décamps, 1990). According to Vidon *et al*. (2017), the zone is helpful in decreasing the contaminants or pollutants in subsurface flow and in subsurface flow and only function as hot spots of methyl mercury production in the landscape when dominated by mercury (Hg) rich wet organic soils. However, it does not give regular benefits with respect to Sulphate Removal Package (SRP) or Green House Gas (GHG) emissions.

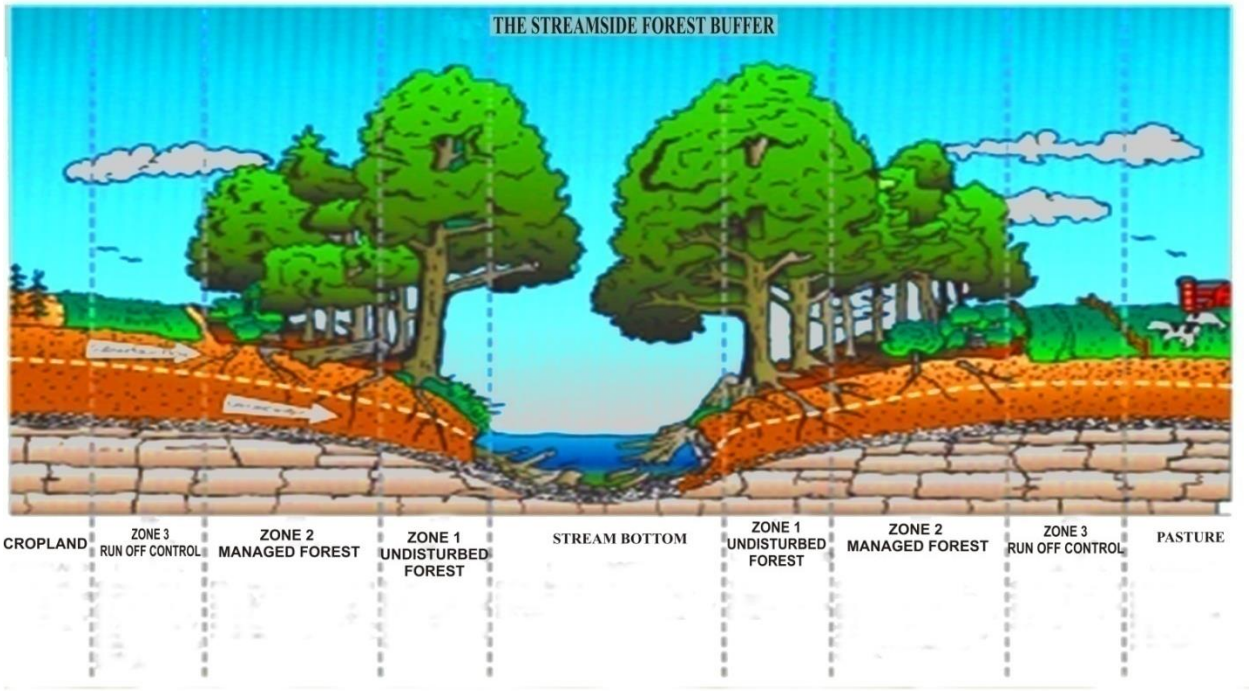


Fig. 3.2 -Three-Zone Systems in the Riparian Forest Buffers
(Source: Welsch, 1991)

(A) Issues with Maintaining a Riparian Corridor and Buffer Zone

There is no 'one-size-fits-all' description of an ideal riparian corridor or riparian buffer as several factors influence the effectiveness of buffers. Proper widths for various objectives may vary significantly by a region as it depends on variety of environmental and physical factors. The width of buffer is also a function of the stream order (Strahler system). NSW (2012) has prescribed 20 m, 40 m, and 60 m width of riparian corridor in case of 1st order, 2nd order, and 3rd order streams/water course types. Larger width of river corridors was recommended in the case of 4th order or greater streams/river courses.

Riparian buffer zones controls water quantity and quality, moderates temperature, stabilizes channel geometry, and provides tree roots and woody debris for habitat. For urban (and/or suburban) circumstances, water quality can be protected by designation of riparian buffer zones. Riparian buffer zones alone are not adequate to ensure that water quality will be improved.

The conservation and management of riparian corridors can benefit from proactive community planning, sensible regulatory measures and appropriate developmental design standards. In Michigan, local Govt. plays a major role in riparian corridor management. Community home rule means that the major responsibilities and choices for implementation of riparian protection and restoration initiatives rest at the local level. Tools such as local masters, plans, zoning ordinances and subdivision regulations can be used to address conservation and management needs of riparian corridors, as well as guide sustainable and profitable development within communities. Non-regulatory tools such as public education and innovative land preservation approaches may also be used by communities to protect and restore local riparian areas.

A study conducted by Santa Cruz Country, California on criteria for determining buffer from Arroyos which states that the buffer shall always extend 50 feet from the edge of riparian woodland and 20 feet beyond the edge of the woody vegetation as determined by the drip-line. Once the buffer is determined, a 10-foot setback from the edge of the buffer is required for all structures, to allow for construction equipment and use of yard area.

The riparian buffers having higher diversity have more capacity to absorb wide range of pollutants than the zone have less diversity. Effective removal ranges from 61% nitrate, 72% of total phosphorus and 44% of orthophosphates from grass buffers to 92% nitrate, 93% of total phosphorus and 85% orthophosphates from combined grasses and woody buffers (Jontos, 2004).

Buffers are short term sinks for phosphorous, but over the long term, their effectiveness is limited. In many cases phosphorous is attached to sediment or organic matter, so buffers sufficiently wide to control sediment should also provide adequate short-term phosphorous control. However, long-term management of phosphorous requires effective on-site management of its sources. Buffers can, however, provide very good control of nitrogen including nitrate. The widths necessary for reducing nitrate concentrations based on local hydrology, soil factors, and

slope and to the variables. In most cases, 30 m (100 ft) buffers should provide good control and 15 m (50 ft) (Wengar, 1999) buffers should be sufficient under many conditions. It is especially important to preserve wetlands which are sites of high denitrification activity. To maintain aquatic habitat, literature indicates that 10 m to 30 m (30 ft-100 ft) native forested riparian buffers should be preserved or restored along all streams. This will provide stream temperature control and inputs of large woody debris and other organic matter necessary for aquatic organisms. While narrow buffers offer considerable habitat benefits to many species, protecting diverse terrestrial riparian wildlife communities requires some buffers of at least 100 m (300 feet). To provide optimal habitat, native forest vegetation should be maintained or restored in all buffers (Wengar, 1999).

(B) River Ecology Concepts and the Riparian Buffers

The idea of a riparian corridor seems to be very simple enough, but it is important to understand the deeper logic and science behind the planning for such vegetative growth and plantations. In many cases, developing a riparian corridor may actually not be a natural aspect of the ecological system at all, and it must be clearly seen as a management initiative which is planned for the protection and restoration of river quality, particularly in regard to North Indian Rivers. However, the basic concepts of river ecology if not understood, could create a gap in the design of the project.

3.1.2 Rationale for Selection of Reasonable 'River–Forest' Buffer or Riparian Corridor

Riparian vegetated corridor is a strip of vegetation that connects two or more larger patches of vegetation (i.e.,habitat) and through which an organism will likely move over time. These landscape features are often referred to as 'conservation corridors,' 'wildlife corridors,' and 'dispersal corridors'. Some scientists have suggested that corridors are a critical tool for reconnecting fragmented habitat 'islands' (Richard *et al.*, 2000). It performs multiple functions for health and river flow and there is wide variation with regard to forest buffer/riparian corridor. Himalayan Rivers are different in their magnitude of flow due to its proneness to natural disaster (avalanches, cloudburst, landslide), upstream area requires different dimension of riparian corridor/forest buffer.

Riparian forest buffers can be used in green infrastructure projects to perform a variety of tasks, especially in rural and urban areas. Green infrastructure is an approach that involves creating a network of green spaces for the benefit of people and wildlife. It is also helpful in conservation of biodiversity. The riparian forest buffer is an area close to wetlands, lakes or streams that contain a combination of woody vegetation and/or other perennials and is managed in different way from the surrounding areas, especially to provide conservation benefits (USDA, 2017). Riparian forest buffers are designed combinations of trees, shrubs, grasses, forbs and

bioengineered structures adjacent to, or within, a stream channel designed to mitigate the impact of land use on the stream. At the landscape level, riparian forest buffers link land and aquatic ecosystems, and perform vital ecosystem services. By establishing, or managing, trees, shrubs and grasses in the zone adjacent to streams, water quality and aquatic ecosystem health can be sustained or enhanced. However, to be effective, buffer design and management strategies must include plants that are adapted to specific riparian environments (channel condition, flood regime, soils, water table depths, and upland topography), as well as provide management guidelines.

Thus, considering the global insight on the width of riparian corridors and the nature of channel morphology and dynamics in the case of Ravi River and its tributaries, considerable discussion and brainstorming took place during the initial consultative workshops on issues regarding riparian corridor/forest buffer in context to the Ravi Riverscape and finalization of a strategy for the present DPR. The Ravi Riverscape area is fragile and mostly bounded by forests in hilly State of Himachal Pradesh and Jammu & Kashmir U.T. and agriculture lands in Punjab. As a river, the Ravi varies in its nature all through its length, having some stretches where vast flood plains exist and are annually flooded, while other, deeper sections see the river flowing relatively peacefully for most of the year. Continuous urbanization has created a wide spread of concrete which destroys natural scenic beauty as well as hydrological flow resulting into flooding problems.



Plate 3.2 – Catchment of Ravi River

High siltation problem and construction of numerous hydro-electric projects on river changes the course of river. The substantial consultative process showed that the river should have riparian corridors on both sides; a width of 5 km on either sides in the case of Ravi stem and 2 km in case of tributaries of the Ravi would be appropriate once the river descends into plains. For the present DPR, which is to be implemented by the concerned Forest Department(s) of the States/UT, the concept was adapted to cover as much of forest lands as would be available, and if possible to include agriculture and revenue lands in rural and urban environment respectively, by incorporating community and village lands through the involvement of the communities themselves. The consultative process also identified the requirement to treat the natural landscapes, agriculture landscapes, and the urban landscapes within the defined width of forest buffer (5 km - Ravi stem and 2 km - tributaries) on either side of the river banks while taking into account the high flood levels of recent times. The rationale of 5 km and 2 km width/buffer was applied on the main river once it has entered into the plains. However, in the case of high altitude areas of Himalayan Mountain State, the whole catchment formed the part of the Riverscape for planning, assessment, and proposed forestry interventions (FRI, 2016).

3.2 Planning and Assessment Area – Preparation of DPR on Forestry Interventions

For the proposed interventions on Ravi River Basin there is an urgent need of adopting a holistic and comprehensive approach for its management. The preceding chapter has emphasized the importance of holistic perspective required for the river management. This holistic approach involves collection and compiling of literature on river conservation programs related to basin area in addition to GIS based geospatial analysis.



Plate 3.3 - Ravi River Flowing through Plains in Jammu and Kashmir UT

The Ravi River originates in the Lesser Himalayas in India. The river is 880 km long with a catchment area of 24, 960 km^2. It runs almost along the India-Pakistan border. The Ravi River has five major tributaries (Ujh, Bein, Basantar, Deg and Hudiara *Nallahs*), the upper catchments of which lie in India. The largest tributary is *Deg Nallah* river, which is 256 km long with a catchment area of 730 km^2 (FAO-AQUASTAT, 2011; NDMA-UNDP, 2010). But according to Moza (2014) and Iqbal *et al.* (2018), total length of the Ravi River, both in India and Pakistan, is about 720 km, out of which 320 km is in India, of which 158 km lies within Himachal Pradesh and 162 km within Punjab. In India, flowing westward, it is hemmed by the Pir Panjal and Dhauladhar Ranges, forming a triangular zone (Moza, 2014). According to GIS data, length of Ravi River is 340.69 km is in India, of which 167.67 km lies within Himachal Pradesh, 63.38 km in Jammu & Kashmir and 109.64 km within Punjab. Ravi River known as Irawati to ancient India originates from northern face of Rohtang pass in the Himachal Pradesh and flows through the junction formed by the Bara Bhangal Dhauladhar range of the Himalayas as two channels namely Budhil and Tantgari at an elevation of 4,423 msl and 4,418 msl (Moza, 2014). After joining, it flows through Himachal Pradesh mainly Chamba district, where it receives many tributaries. The river enters Punjab near Pathankot, forms International boundary while passing through Gurdaspur and Amritsar districts of Punjab and finally leaves Indian Territory at Goina/Kakarmani village some 80 km away from Lahore city. It flows a distance of nearly 100 km, some of it in Pakistani Punjab, before joining Ravi near Chak Ram Sahai in Indian Punjab. The average width of the river in the plains is about 1.2 km. It flows through Kathua district of Jammu division. Basantar is another tributary of Ravi River which flows through Samba district. The largest tributary is Deg *Nallah* river, which is 256 km long with a catchment area of 730 km^2 (NDMA-UNDP, 2010).



Plate 3.4 - Hydro Electric Power Project on Ravi River

It is one of the rivers which still have good drinking water. The rhithron zone of Ravi within the Himalayas has been maneuvered extensively for generation of power by formulation of many dams, Chamera I, II, III and Ranjit sagar/Thein. The potamon zone within plains has been exploited for irrigation by carving of canals so much so that river becomes isolated entity after Madhopur, but it regains its riverine habitat due to induction of number of perennial and flashy torrents between Madhopur to Derababa-Nanak. These large-scale changes in river must have effected ecology and thereby fishery of this basin, but how much and in what way, is not known. The river has been analyzed only for its water characteristic between Chamba (Himachal Pradesh) to Madhopur (Punjab) by Central Pollution Control Board (1995-96) and at Chamera dam by Central Inland Fisheries Research Institute (2000) (Moza, 2014).



Plate 3.5 - Ravi River flowing through Himalayan Mountains in Himachal Pradesh

Ravi River Basin in India spreads over two States (Himachal Pradesh, Punjab) and one Union Territory (Jammu & Kashmir). The largest part of the riverscape lies within Himachal Pradesh (5,041 km^2) constituting 54.95% of Ravi Riverscape. For the present assignment, on the basis of directions from the MoEF&CC and consensus emerged in the extensive consultative process with various stakeholders out of 11,706.41 km^2 basin area, 9,173.61 km^2 area has been included

in the riverscape delineated for the purpose of planning, assessment and proposed management by way of forestry interventions in the context of Ravi River whereas 2,532.8 km^2 area of basin has been excluded. All tributaries have been included as a part of the riverscape. In short, the entire catchment in the mountainous states forms part of the riverscape while once the river descends in the alluvial plains of Punjab State, only effective areas of micro-watersheds influenced. Details of the riverscape under consideration from the point of view of present DPR are shown in Table 3.1, Location map is shown in Fig 3.3 and state-wise spatial extent is presented in Table 3.2.

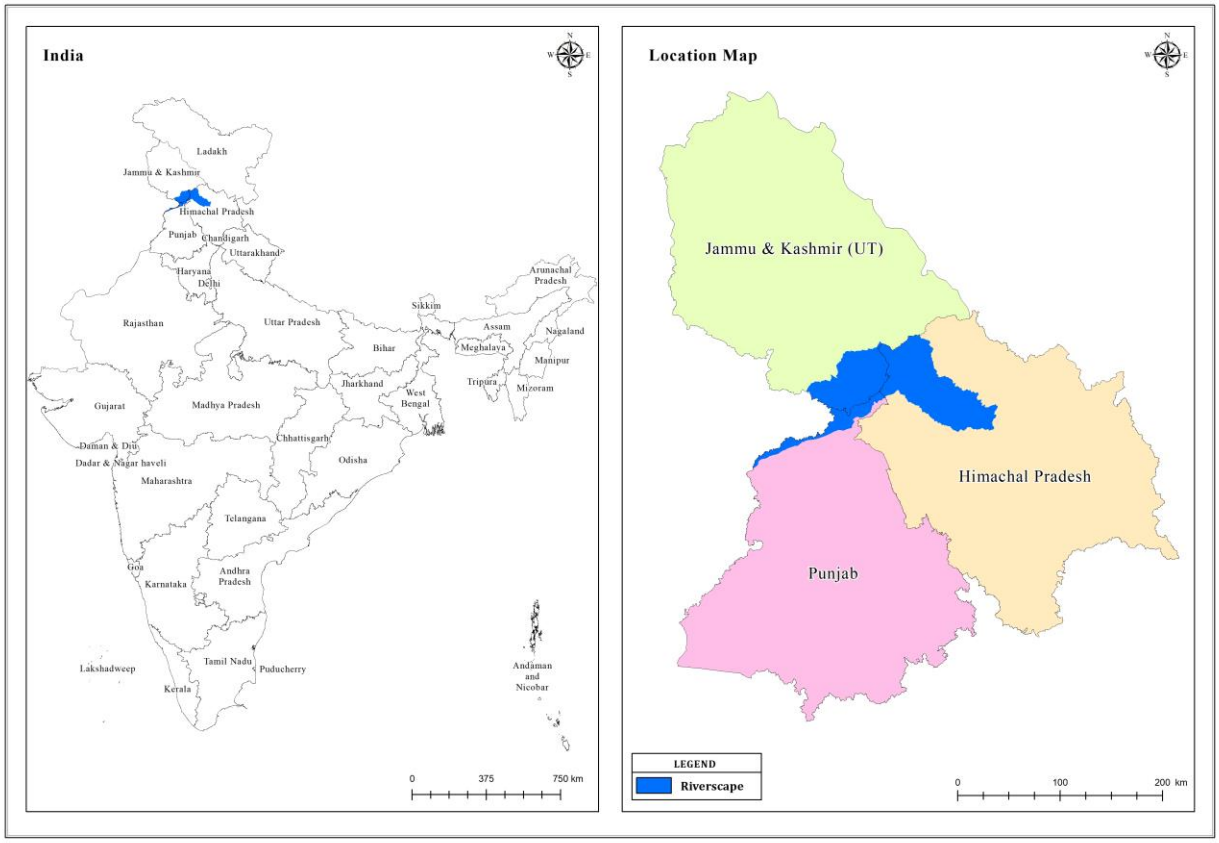


Fig 3.3 Location Map of Ravi Riverscape

Table 3.1- Details of the Ravi Riverscapes and Catchment beyond Ravi Riverscapes

Sr. No.	Ravi River	Area (km^2)	Percentage
1	Ravi Riverscapes	9,173.61	78.36
2	Catchment Area beyond Ravi Riverscape	2,532.80	21.64
Total =		**11,706.41**	**100**

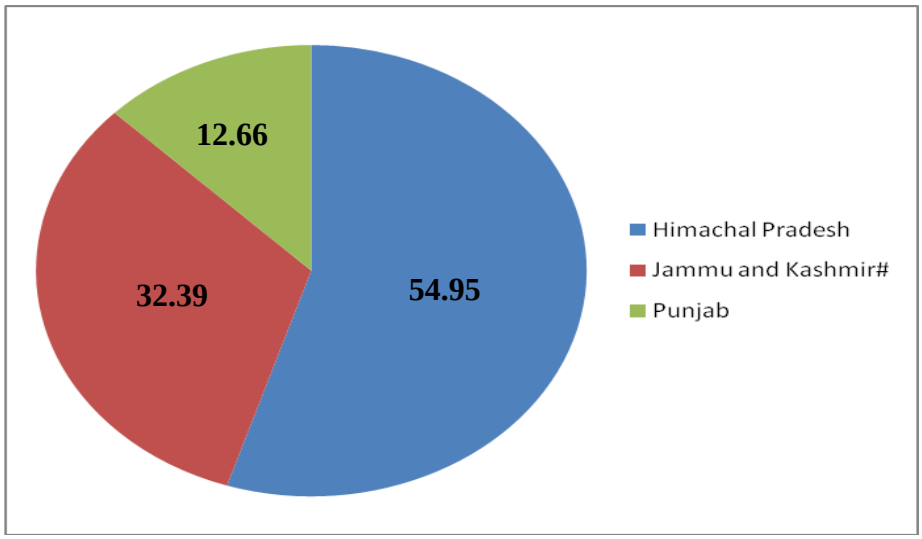


Fig 3.4- State-wise Spatial Extent of the Ravi Riverscape

Table 3.2- Details of the Geographical Area of States and UT concerning Ravi River Basin

Sr. No.	State/UT	Geographical Area of State/UT (km^2)	Catch-ment Area (km^2)	Represent ative Area included in Riverscape (km^2)	Geographical Coordinates		Represent ative Area of Riverscape (%)
					Latitude N	Longitude E	
1	**Himachal Pradesh**	55,673**	5,041.00	5,041.00	32°10'31"N to 33°01'25"N	75° 47'51"E to 77° 4'44"E	54.95
2	**Jammu and Kashmir UT**	53,258*	2,970.91	2,970.91	32°16'34"N to 32°56'44"N	75° 4'11"E to 75° 56'6"E	32.39
3	**Punjab**	50,362*	3,694.5	1,161.70	31°46'10"N to 32°30'42"N	74° 33'8"E to 75° 54'1"E	12.66
	Total	**1,59,293**	**11706.41**	**9,173.61**			**100.00**

(Source: FSI, 2019)

Himachal Pradesh: Himachal Pradesh has geographical area of 55,673 km^2 representing 1.69% geographical area of the country. Out of this, the spatial extent included in the Ravi Riverscape is 9,173.61 km^2 and it represents 78.36% area of the total basin area in two states and one UT. The selected area of the riverscape falls in two administrative districts of Himachal Pradesh. These districts are: Kangra and Chamba. Very small area of Kangra district forms the upper reaches of Ravi River basin where Ravi originates while Chamba district forms the lower part of the basin in Himachal Pradesh. The river has a total length of about 167.67 km in Himachal Pradesh and its major tributaries are Budhil, Siul, Baira, Tantgari, Saho, Chirchind *Nallah* and Bhadal River which represents 1,183 micro-watersheds and included in the riverscape for the purpose of planning, assessment and proposed interventions. Ravi River rises from the Bara Bhangal (a branch of Dhauladhar) as a joint stream formed by the glacier-fed Bhadal and Tantgari. Town Chamba is situated on the right bank of the Ravi River. The Ravi River first flows westwards through a trough separating the Pir Panjal Range from Dhauladhar Range and then turns southward, cutting the deep gorge through the Dhauladhar range. It flows nearly 130 km in Chamba region, before leaving it finally at Kheri. The Ravi River forms the biggest sub-micro region of Chamba district. From Bara Bhangal of Kangra district, river flows through Bara Bansu, Tretha, Chanota and Ulhansa. The well-known human settlements along the river are Bharmaur, Madhopur and Chamba town.



Plate 3.6 - Ravi River Flowing through the Rugged Terrain in Himachal Pradesh

Jammu & Kashmir: Jammu & Kashmir Union Territory has a geographical area of 53,258 km^2 and constitutes 1.62% of geographical area of country. Jammu has an average elevation of 300 m. Riverscape area in Jammu & Kashmir Union Territory is 2,970.91 km^2 which constitute 25.38% of total catchment area of Ravi River and 32.39% of total Riverscape area. Basantar, Ujh, sewa, Chiril, Biani and Tarnala are its main tributaries in Jammu region. The selected area of the Ravi Riverscape in J&K includes the main stem and its tributaries i.e. Basantar, Ujh, sewa, Chiril, Biani and Tarnala which fall in 1C1B sub-catchment having 3799.55 km^2 area. Ravi's main tributary is Ujh River which originates in Kailash Mountains (near Bhaderwah Hills, part of the Pir Panjal Range) at an altitude of 4,300 m. It flows a distance of nearly 100 km, some of it in Pakistani Punjab, before joining Ravi near Chak Ram Sahai in Indian Punjab. The average width of the river in the plains is about 1.2 km. It flows through Kathua district of Jammu division. Basantar is another tributary of Ravi River which flows through Samba district. Major cities and towns situated on the banks of Ravi River and tributaries are Kathua, Samba and Basohli.



Plate 3.7 - Ravi River Flowing through Jammu Plains

Punjab: Punjab is the heart of India's Sikh community. Punjab has a geographical area of 50,362 km^2 constitutes 1.53% area of the country's geographical area. The area of 3,694.5 km^2 of the state falls under Ravi catchment in Punjab which constitutes 7.34 % of geographical area of the state. Out of the total catchment area of Ravi River, only 1161.7 km^2 area has been included in the Ravi Riverscape and 2532.8 km^2 area has been excluded from the perspective of the Ravi Riverscape in Punjab. Ravi River flows into the south-west, near Dalhousie, and then cuts a gorge in the Dhauladhar Range, before entering the alluvial plains in Punjab near Madhopur and Pathankot. Out of 20 districts of Punjab State, areas of only three administrative districts fall within the riverscape. These are Pathankot, Gurdaspur and Amritsar. The select area of the Ravi Riverscape in Punjab includes the main stem and only one tributary i.e. Ujh which

has catchment area of 566.52 km^2. Major cities, towns and villages situated on the banks of Ravi River and tributaries are Gurdaspur, Narot Jaimal Singh, Rakwal, Kamalpur, Sundergarh and Kassowala. The river forms international boundary between India and Pakistan while passing through Gurdaspur and Amritsar districts of Punjab and finally leaves Indian Territory at Goina/Kakarmani village some 80 km away from Lahore city. It then flows along the Indo–Pak border for 80 km before entering Pakistan and joining the Chenab River.



Plate 3.8 - Ravi River Flowing through Punjab Plains

3.3 The Approach – Preparation of DPR on Forestry Interventions

The proposed DPR adopted a holistic approach of river basin management for restoration through multi-stakeholders consultative process. The existing scientific knowledge, past experiences, land-use changes and their effects, and varied expertise available were fully utilized for developing the framework, strategies and activities of the DPR. As stated earlier, the MoEF&CC and ICFRE had entrusted a major task to the HFRI, Shimla on the preparation of five separate DPRs of five tributaries i.e., Beas, Chenab, Jhelum, Ravi and Sutlej of the Indus River concurrently during the financial year 2019-20 and allowed one year time for the completion of assigned task. Hence, the HFRI undertook the entrusted task concurrently on DPRs of five rivers. The task was initiated in April, 2019. The Institute has constituted five independent teams, one for each of the river and each team included a Senior Scientist, Technical Officers, Project

Fellows and Data Entry Operators. The work of these five teams was supervised and steered by a team of Senior Officials designated as the Team Leader, River Co-ordinator, Nodal Officer, Project Co-ordinator and Chief Project Co-ordinator for the purpose of DPRs. The HFRI also engaged consultants for providing desired resource inputs for the preparation of DPRs. In addition, the Institute had availed technical inputs from concerned experts/ agencies, particularly for the themes *viz*., soil and water conservation, policy and law, Remote Sensing and GIS, and design and development of project web portal. The broad approach and the framework developed and adopted for the first time in the country in case of DPR specific to the Ganga River was employed for the preparation of five DPRs by HFRI (FRI, 2016). Accordingly, the approach in the preparatory phase for the present DPR on the Ravi River included seven key steps *viz*., (a) Project Initiation - Background Analysis/Contextual Analysis, (b) Identification of Stakeholders and the Consultative Process, (c) Development of web portal, (d) Launched workshop & brainstorming session for five rivers of Indus basin, (e) Extensive consultation process, (f) Preparation and Finalization of DPR, (g) Preparation & discussion of final DPR, (h) Finalization & submission of final DPR for its implementation, (i) Implementation phase - year 1-5, (j) Preparation of DPR-II for scaling up & replication in additional site, (k) Phase-II implementation. These key steps and allied activities carried out as a part of the multi-pronged and multi-stakeholder consultative planning process for the preparation of DPR are diagrammatically presented in Fig. 3.4 and each of the key steps is briefly summarized below one by one:

3.3.1 Project Initiation - Background Analysis/ Contextual Analysis

Ecology of Ravi River is constantly influenced by economic, social and political processes that take place in society. The project planners and implementers thus seek information about the overall picture on the environment, including technical national and sectoral informations. Project activities started off by performing an overall preliminary study (*pre-study*), feasibility study or the inception phase. The pre-study involved the collection and compilation of information related to external environment of Ravi Riverscape by consulting various related sectors, agencies, states and organizations involved as well as any data that existed about the target disciplines, sectors, themes, etc.

River is a complex and dynamic ecosystem and it is strongly linked with varied forests and its surroundings. To understand linkages of river with its surroundings, an adequate knowledge of relevant multi-disciplinary subjects and application of various technologies are essentially required. There is a growing literature on the wider subject of river ecology and management besides a long historical perspective on the management of the each of the major river including the Ravi River. Thus, the foremost key step in the present planning exercise on the preparation of DPR was a systematic review of vast available literature on the subject through internet surfing and library consultation. The websites of prominent international, national and state level

agencies and organizations dealing with any of the aspects related to river resources and conservation were extensively searched and required information was downloaded for developing the desired insight. The relevant secondary information from related organizations was also collected. The combined effort on the review of literature and collection of background information immensely helped in the contextual analysis. The contextual analysis also provided desired insight on the Ravi Riverscape and its three sub-environments (i.e., physical, biological and socio-economics).

3.3.2 Identification of Knowledge Gaps

The activities related to forestry in Ravi Riverscape have been carried out in isolation in the past. Different government agencies such as forestry, agriculture, horticulture, urban bodies undertake plantation activities separately. In this DPR, integrated and holistic approach involving varied government agencies has been envisioned to undertake forestry intervention activities in Ravi Riverscape. There is inadequate research, monitoring, database, baseline information, lack of technological innovation, etc. w.r.t. to river basin. The information available is in scattered form. Multiplicities of laws and policies make it difficult to manage the issues concerning riverscape. The forest plays important role in hydrological cycles; however, link between forests and their role in hydrological function is not understood adequately. Hence, the studies on role of forests in hydrological cycle need more attention. There is need to review the minimum E-flow to be maintained. In the plantation activities, the provision for maintenance of plantation areas is inadequate, which is considered one of the main reasons behind failures of the plantation. This DPR envisages two phases i.e., implementation phase of first five years and maintenance phase of next five years. Besides, adequate provisions of supporting activities like research and monitoring, capacity building and awareness have also been envisioned; however, such provisions are normally not incorporated in forestry projects.

There are few of knowledge gaps that are providing target for future efforts and need further research/inspection for developing qualitative and quantitative results for Ravi River Rejuvenation project i.e., (a) Major knowledge gap is lack of holistic approach; (b) Partial approach on appropriate forestry interventions; (c) Some of the regulatory gaps include the planning and construction of projects without adequate assessment of their individual as well as cumulative environmental impacts; (d) The interrelationship between forests and their hydrological function is not adequately understood; (e) The provisions of the Forest (Conservation) Act, 1980, the Environment (Protection) Act, 1986 and the Biological Diversity Act, 2002 must be creatively applied in order to achieve the task of long term protection of the forests adjoining the rivers; (f) Previous projects were focused on division level approach as compared to micro-watershed level. Less studies were available on pollution and E-flow on Ravi River; (g) There is a need to review the minimum flow requirement prescribed by various states; and (h) No common platform to work and share their experiences together.

3.3.3 Participation of Stakeholders and the Consultative Process

The second vital step for successful planning and implementation required broader participation of stakeholders at all stages of planning of the project activities. The assignment envisaged stakeholder consultations at the national and state levels at the time of launch of entrusted task and also after the preparation of draft DPR. Hence, it was essential to first identify which individuals and stakeholders affect and are affected by the project and which ones should be involved in the planning process. Likewise, it was critical to identify which stakeholders should be informed and involved during and after the project implementation. Accordingly, prominent consultations for the preparation of DPR were held at the national and state levels. In the context of present assignment, broad five groups of stakeholders were identified as a part of the Step 1 on the contextual analysis. These five stakeholder groups included: (a) the Target group (primary and secondary target groups and beneficiaries); (b) Project owners and project groups; (c) Decision makers (at different levels, in organizations, at authorities and agencies, local politicians); (d) Experts and subject matter specialists; and (e) Financing agencies (those who sponsored/ finance the project as well as state/ national or international financiers who shall support and fund the project implementation (FRI, 2016).

The one year duration of Project's preparatory phase included the extensive consultative process with identified groups of stakeholders right from the beginning. Table 3.3 provides a broad-based list of stakeholders in five identified groups, highlighting the prominent Central/State Governments Ministries, Departments, Agencies, Organizations besides Civil Agencies and NGOs that were consulted or their representatives participated in Project Launch and Brainstorming Workshop and Subsequent sequential Consultative Meetings organized for the purpose at the Forest Circle/Division and state levels in two States (Himachal Pradesh and Punjab) and one Union Territory (Jammu & Kashmir) lying along the main river course. Details of the consultative process and sequential meetings are presented in Table 3.4.

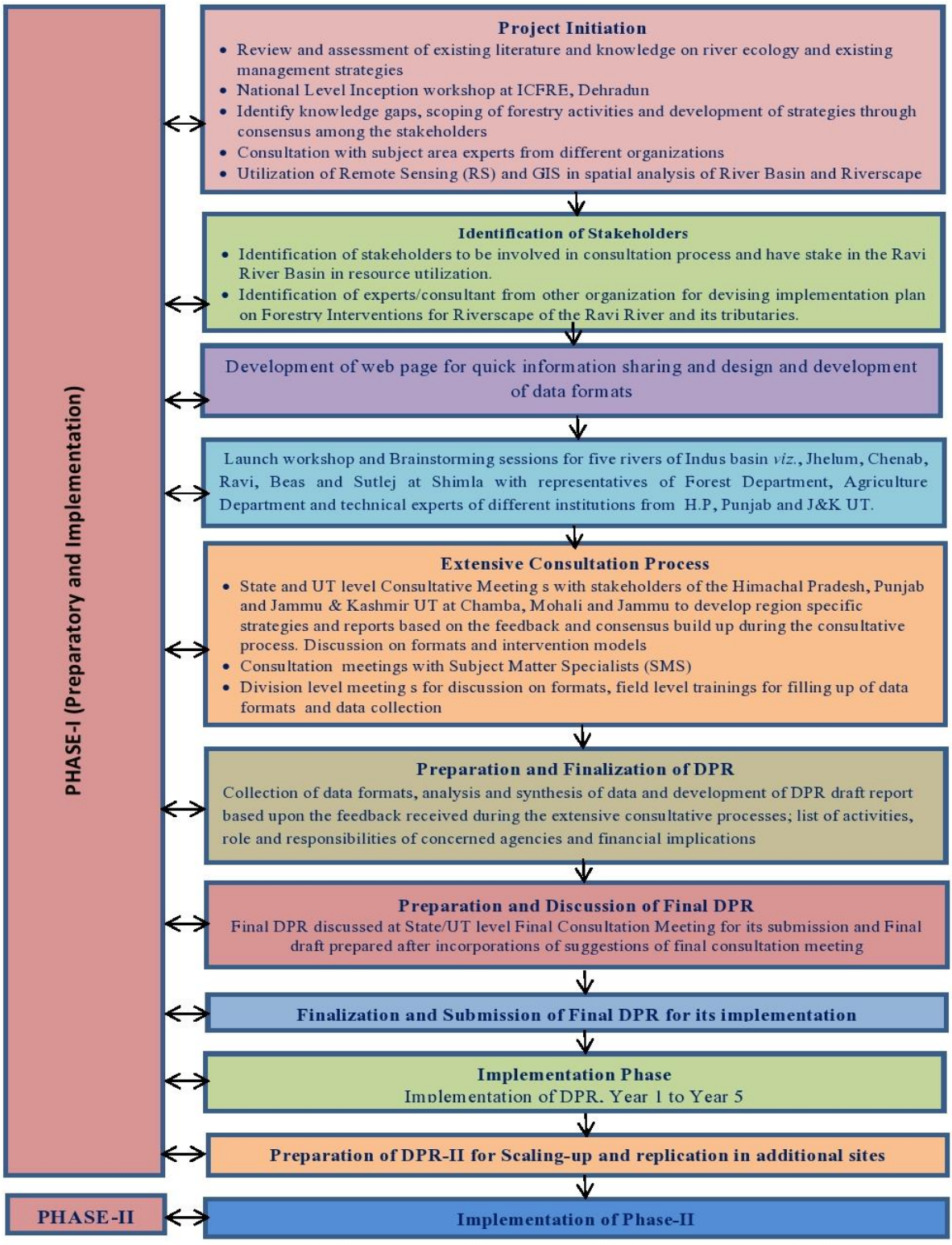


Fig. 3.5- The Approach of Preparation of DPR for Forestry Interventions on Ravi River

Table 3.3- Prominent Stakeholders or their Representatives Involved in the Consultation Process in Himachal Pradesh, Punjab and Jammu & Kashmir

A. Target Groups (Primary and Secondary Target Groups and Beneficiaries)
Civil Society – Villagers, Farmers, Fishermen and Urban Population
State/UT Forest Departments (SFD)
Department of Agriculture, concerned States/UT
Department of Animal Husbandry, concerned States/UT
Department of Horticulture, concerned States/UT
Department of Soil and Water Conservation, concerned States/UT
Department of Fisheries, concerned States/UT
Department of Highways and PWDs, concerned States/UT
Department of Irrigation, concerned States/UT
Hydroelectric Projects, concerned States/UT
Department of Tourism, concerned States/UT
Para Military Forces (Eco Task Force and ITBP), concerned States/UT
Panchayats
Municipal Corporations/Municipal Boards
State and Central Universities
State and Central Governments
Research and Development Organizations
State Biodiversity Boards
State Medicinal Plants Boards
Pollution Control Board
State Electricity Board
B. Project Owners and Partner Organisations
Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi
Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, Uttarakhand
State Forest Departments (SFDs) – Himachal Pradesh, Jammu & Kashmir and Punjab

Himalayan Forest Research Institute, Shimla, Himachal Pradesh
C. Decision Makers
The Central Government Ministries/Departments/Agencies/Organisations
NITI Aayog, New Delhi
Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi
Ministry of Jal Shakti, New Delhi
Ministry of Youth Affairs and Sports (MoYA&S), New Delhi
Ministry of Rural Development (MoRD), New Delhi
Ministry of Panchayati Raj (MoPR), New Delhi
Ministry of Defense (MoD), New Delhi- Eco Task Force
Ministry of Home Affairs (MHA), New Delhi- ITBP
Central Water Commission (CWC), New Delhi
National River Conservation Directorate (NRCD), New Delhi
Central Pollution Control Board (CPCB), New Delhi
National Medicinal Plant Board (NMPB), New Delhi
National Biodiversity Authority (NBA), Chennai
Nehru Yuva Kendra Sangathan (NYKS), New Delhi
D. Experts and Specialized Scientific Organizations
Indian Council of Forestry Research and Education (ICFRE), Dehra Dun
Forest Research Institute (FRI), Dehra Dun
Forest Survey of India (FSI), Dehra Dun
Himalayan Forest Research Institute (HFRI), Shimla
Indian Institute of Soil and Water Conservation (IISWC), Dehra Dun
National Institute of Hydrology (NIH) and Its Regional Centers
Central Water Commission (CWC), New Delhi
Central Groundwater Board (CGWB)
Wildlife Institute of India (WII), Dehra Dun

Indian Institute of Remote Sensing (IIRS), Dehra Dun
Zoological Survey of India (ZSI), Regional Station, Solan
Botanical Survey of India (BSI), Kolkata
Survey of India (SOI), Dehradun, Uttarakhand
National Horticulture Board (NHB), Gurugram
National Bureau of Plant Genetic Resources (NBPGR)
National Bureau of Fish Genetic Resources (NBFGR), Lucknow (UP)
Indian Agriculture Research Institute (IARI) and Its Regional Centers
Centre of Inland Waters in South Asia (CIWSA), Madhya Pradesh
Central Inland Fisheries Research Institute (CIFRI). Kolkata, West Bengal
National Medicinal Plant Board (NMPB), New Delhi
Bombay Natural History Society, Mumbai
WWF – India, New Delhi
Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh
Himachal Pradesh University, Shimla, Himachal Pradesh
CSK Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh
Himachal Pradesh Central University, Shahpur
Punjab Central University, Bhatinda
Punjab Agriculture University (PAU), Ludhiana, Punjab
Punjab University, Chandigarh
Guru Nanak Dev University, Amritsar, Punjab
E. Sponsoring and Financing Agencies
Central Government – Ministry of Finance, MoEF&CC, MoJS, MoA, MoRD, Ministry of AYUSH, MoPR andIndian Council of Forestry Research and Education (ICFRE)
State Government - Ministry of Finance/ Environment and Forests/ Rural Development/ Agriculture/ Tribal Affairs/ Panchayati Raj, etc.

Table 3.4-Consultative Meetings at the National and State Levels for the Preparation of DPR

Sr. No.	Consultation Event	Date and Venue	No. of Participant
1	National Level Inception Workshop on Preparation of DPRs of Indian Major Rivers	24-25 April, 2019 ICFRE, Dehradun	61
2	State Level Project Launch and Brainstorming Workshop	28-29 June, 2019 Hotel Holiday Home, Shimla	178
3	First Consultation Meeting for Chamba Forest Circle, Himachal Pradesh	2 August, 2019; DRDA Hall, Hardaspura, Chamba	77
4	First State Level Consultative Meeting – Punjab	21 August, 2019 Forest Complex, Mohali, Punjab	65
5	First State Level Consultation Meeting - Jammu & Kashmir	12 October, 2019 Forest Information Centre, Vikram Chowk, Jammu (J&K)	50
6	Field training in HP (Chamba, Churah, Dalhousie etc)	Oct.2019 to Dec., 2019	Concerned field staff
7	Field training in Punjab (Amritsar, Gurdaspur, Pathankot)	Oct. 2019 to Dec., 2019	Concerned field staff
8	Field training in J&K(Kathua, Samba, Billawar, Basohli, Ramnagar and Bhaderwah)	Dec. 2019	Concerned field staff
9	Second State Level Consultation Meeting - Jammu & Kashmir	25 February, 2020 Convention Center, Jammu	116
10	Second State Level Consultation Meeting – Punjab	12 March, 2020 Forest Complex, Mohali	75
11	Second Consultative Meeting-Himachal Pradesh	26 June, 2020 HFRI (Through Video Conference)	55

Following is the chronological summary of consultative meetings organized at the state and national levels and summarizes the major recommendations, decisions and outcomes:

(A) National Level Inception Workshop on Preparation of DPRs of Indian Major Rivers (ICFRE, Dehra Dun; 24-25 April, 2019)

The ICFRE, Dehra Dun, being the Nodal and Coordinating Agency entrusted with the task to get DPRs for major Indian Rivers on forestry interventions, had organized the Inception Workshop at its headquarters based at Dehra Dun on 24-25 April, 2019 under the Chairmanship of DG, ICFRE. The representatives (the Directors and Members of the Core Team) from all Regional Institutes of ICFRE those were involved in the preparation of DPRs and Resource

Persons/representatives from the Forest Research Institute, (FRI), Dehra Dun Indian Institute of Soil and Water Conservation (IISWC), Dehra Dun; Forest Survey of India (FSI), Dehra Dun; State Forest Department, Uttarakhand; Namami Gange - State Project Management Group), Dehra Dun besides professional agencies connected with RS and GIS; IT and Development of Web Portal; and select Resource Persons were the participants in the workshop. Altogether, there were 61 participants in 2-day workshop. The workshop also had four participants from HFRI. The objectives of the workshop included: (a) the familiarisation with the goals of the entrusted task, expected outputs and timelines; (b) development of an acquaintance with the approach and framework on the preparation of DPR adopted in the case of Ganga River during 2015-16; (c) creating awareness about the emerging and evolving concepts and strategies related to river ecology, linkages between forests and river, complex and dynamic nature of rivers, human disturbances in the context of river fragmentation, availability of water (e-flow), and water quality; (d) sharing of experiences and lessons learnt in the preparation of DPR on Ganga; (e) emphasizing on the need for adopting holistic and participatory approach based on the extensive consultations and the use of 'Riverscape approach'; and (f) highlighting the need of knowledge management and sharing, science and results-based planning and monitoring, development of appropriate strategies for planning, assessment and implementation.

The select resource persons those were associated with the preparation of DPR on Ganga River made presentations and acquainted the workshop participants with the emerging concepts in the context of river conservation and broad framework and approach adopted for the preparation of DPR. The resource persons elaborated on the key steps and components involved, formats used for field data collection and the incorporated strategies on forestry interventions. The concepts of Riverscape, its RS and GIS based geo-spatial analysis and the requirement of assessing and describing the Riverscape environment were shared with the participants.

The workshop allowed intensive deliberations and working out the modalities and mechanisms for implementation of time bound major project involving nine major Indian River Basin Systems.

(B) State Level Project Launch and Brainstorming Workshop (Hotel Holiday Home, Shimla; 28-29 June, 2019)

The first National Level 'Kick-off' Meeting of the Stakeholders was organized for five tributaries of the Indus River Basin i.e, Beas, Chenab, Jhelum, Ravi and Sutlej rivers and was attended by wide representatives from Himachal Pradesh, Jammu & Kashmir and Punjab. A large number of Experts, Resource Persons and representatives from the State Forest Department and specialised national/ state level scientific organisations *viz*., the Forest Research Institute (FRI), Indian Institute of Soil and Water Conservation (IISWC), Indian Institute of Remote Sensing (IIRS), Forest Survey of India (FSI), Zoological Survey of India (ZSI), Botanical Survey of India (BSI), Central Water Commission (CWC), National Institute of Hydrology (NIH), and State Pollution Control Board (SPCB) attended the workshop. Representatives of wide range of line agencies (i.e., Agriculture, Animal Husbandry, Horticulture, Medicinal Plants Board, Irrigation, Mining, Power, Rural Development, Hydroelectric Projects, Tourism, Himachal Pradesh Council of Science Technology and

Environment (HIMCOSTE), State Biodiversity Board, etc.) also attended the workshop and actively participated in the Workshop.



Plate 3.9 - State Level Project Launch and Brainstorming Workshop

The Hon'ble Forest Minister, Himachal Pradesh highlighted the need of water security, livelihoods, sustainable development and the priority agenda on rejuvenation of five rivers in Himachal Pradesh, J&K and Punjab those are important tributaries of the Indus River Basin. He suggested adopting the approach/ framework on the lines of DPR on Ganga River and the efforts made under the National Mission for Clean Ganga (NMCG) and the *Namami Gange* program initiated by the Government of India (GoI). The Hon'ble Minister emphasized that the proposed plantation models should take into consideration the topography, geology, and forest types of the concerned areas keeping in view the varied landforms, climatic and edaphic conditions in the mountainous states of H.P. and J&K. The PCCF and HoFFs of two States - H.P. and Punjab emphasized on reduction of soil erosion in the hilly tract by appropriate soil and moisture conservation and forestry interventions. The PCCF (Wildlife) and CWLW, H.P. told about the concepts of river conservation and the approach adopted for the preparation of DPR on Ganga River. She also emphasized on global challenges, particularly the water crisis, the vital aspect of connectivity in the context of complex and dynamic river ecosystems besides the important aspects of ecological integrity and river health.



Plate 3.10 – Participants during State Level Project Launch and Brainstorming Workshop

The PCCF and HoFF**,** HP remarked that the DPR of Indus River Basin should focus on the reduction of silt in the river using forestry interventions and assured full cooperation and support of HPFD to HFRI for preparation of DPR of the tributaries of Indus River.

PCCF and HoFF Punjab while highlighted on likely water crisis and the need for water security and water politics in future due to depletion of river resources. The PCCF (Wildlife), HP told that the concerned State Forest Department being the major stakeholders has important role to play in the preparation of DPR and its implementation. Highlighting the problems, issues and road map for the implementation of DPR. She suggested to follow the DPR of Ganga River as the format for preparation of DPR of the Indus River Basin.

The workshop and brainstorming sessions of the launch workshop was attended by participants, experts and stakeholders of 43 different departments. Group discussions on different issues related to the Indus River were held as an important step in the preparation of DPR and for identification of priority areas. The meeting greatly helped in deciding the way forward for preparation of each of the DPR. The necessity to understand the ecology of the Indus River and its tributaries on a priority was emphasized. A need for harmony between the environment of Indus River and the associated urbanization and industrial development by way of forestry interventions, particularly bioremediation, was spelt out. Selection of treatment sites and areas on the basis of physical and geomorphological attributes, *viz*., slope, aspect, soil, etc. was recommended for the proposed forestry interventions. A comparison of past and present data was recommended so that the proposed conservation activities could be focused in areas with substantial change on a priority. Mapping of flood zone for the entire Indus Basin was recommended so as to delineate the maximum bank lines of the river during peak floods.

Formulation and enactment of policies and legal provisions for the protection of entire river basin were recommended.

Altogether, in the inaugural and five technical sessions, there were 20 presentations by various resource persons and experts. The Technical Session I included presentations by senior forest officials representing two States (H.P. and J&K) and they shared information on current efforts towards implementation of catchment area treatments plans, particularly soil and moisture conservation activities, development of appropriate technologies for afforestation including suitable nursery and plantation techniques. They emphasized on the micro-watershed treatment plans, snow water harvesting techniques, avalanche prone treatment area plans, selection of water efficient plant species, need for replenishment of medicinal plants, and a review of existing nursery techniques especially for plants relevant to cold arid zone.

The Technical Session II included multiple presentations from the representative of the universities, scientific organisations and NGOs. These presentations highlighted that in Himachal Pradesh, nearly 30% area is under heavy erosion and about 50% area has medium soil erosion, causing displacement of around 280 MT of soil through water erosion every year losing 5.4 MT to 8.4 MT NPK per year, and hence enormous loss in productivity. This heavy loss of soil by erosion calls for urgent mechanical and vegetative measures for effective control of erosion and improving soil moisture condition. The representative from IISWC, Chandigarh informed that maps on soil erosion for H.P. and Punjab by his institute will help HFRI in the assigned task on the preparation of DPR. A Senior Expert in the field of soil and water conservation/ watershed management shared his experiences on the earlier efforts of watershed management programs carried out in the catchment of Swan River, Una, H.P. wherein the approach of treating entire watershed from top to bottom by adopting appropriate forestry interventions, pollution control measures, sewage treatment activities and allied actions for river rejuvenation was adopted. Based on experience gained, recommendations for treating the entire catchment with brushwood, bamboo plantations, stone check dams, and silt retention structures were made. Illustrating on the lessons learnt from the implementation of the World Bank supported ‘Mid-Himalayan Watershed Project’, the Resource Person informed the participants that the project was covered in 10 Districts, 710 Panchayats, and 45 Development Blocks has constructed check dams and water harvesting structures and as a result there was reduction in water speed and discharge from 40% to 20%, promotion of crop diversification, and increase in crop productivity and horticulture produce. The Resource Person from Naik Environment Research Institute Limited (NERIL) while highlighting the issues and concerns in preparation of DPR for rejuvenation of river emphasized for a need to collect primary as well secondary data with regard to topography, soil conditions and climatic patterns, and advocated for identification of critical areas, development of site specific plantation models, and selection of suitable native species in proposed plantation programmes.

During the Technical Session III, the Resource Person from the Central Water Commission, Shimla in his presentation recommended for effective management of factors responsible for degradation and deterioration of environmental flow and water quality. A priority need for treating solid waste and sewage disposal; and checking soil erosion, land mining, sedimentation flux, unsustainable land use, and industrial effluents was emphasized so as to seek uninterrupted flow and clean water in rivers under consideration. The Technical Session IV covered multiple

presentations from specialized Institutes and the State Pollution Control Board. The Experts from NIH, Western Himalayan Regional Centre, Jammu, J&K UT broadly discussed the role of springs in the Himalayan Mountains and voiced concerns about their drying up, resulting in migration of as high as 200 million people living around those springs and traditionally dependent upon them. The house was informed about the structural, vegetative, and social measures for rejuvenation of springs. The Experts from IIRS, Dehra Dun emphasized on the geospatial support needed for the preparation of DPR and informed that a wide range of data on snow cover dynamics, land use change, socio-economic and climatic changes, hydrological and geospatial modeling, discharge data, forest fragmentation, vegetation and disturbance mapping, and biodiversity characterization are available with IIRS besides similar information/data can be availed from NRSC, Hyderabad, WRIS and Bhuvan portal of ISRO. Likewise, the resource Person from FSI, Dehra Dun informed about the availability of varied information *viz*., forest cover and forest type mapping, and extent and intensity of forest fires. He suggested to optimally using the information from the Web Map Service (WMS), and Digital Elevation Model (DEM) available with FSI while information on soil types can be obtained from BHUMI Portal of the NBSS, Nagpur.

On second day of workshop, different participants of the workshop gave power point presentation on restoration of Indus River Basin through forestry interventions. The participants felt that there is an opportunity to recognize and identify the riparian realms which have been, otherwise, neglected in the context of the Indus River system and other major rivers. The main purpose of the project is to improve the terrestrial environment around the Indus River and its tributaries. A need to initiate long term research programs availing project funds for better understanding the relationship between forestry and river water quality was also emphasized. Considering the ecological significance of water budget and forest hydrology, careful selection of tree species for proposed plantations was recommended. Species like *Eucalyptus*, *Robinia*, must be avoided for plantations. Protection and conservation of riverine wetlands along the Indus and its tributaries was recommended on a priority. Review of past interventions so as to learn appropriately from failed and successful efforts was also recommended. The up-scaling of all such successful efforts and initiatives for visible results in a short span of time is the need of the hour for the restoration of principal rivers of the Indus River.

Area of Consideration

The issue of delineation of riverscape was discussed in above said consultative meetings and apprised participants that FRI, Dehra Dun has earlier incorporated the entire catchment of Ganga River in hilly state of Uttarakhand while a buffer of 5 km on either side from the High Flood Level (HFL) in the case of main stem and 2 km buffer on either side from the HFL in the case of selected tributaries once they have descended in the plains was included. Initially, some of the participants were of the opinion to either consider the whole catchment or focus on the watershed approach. However, after considerable deliberations, the unanimous consensus was built to consider the entire catchment of a river in the mountainous Himalayan State as a major part of the riverscape while in the case of plains, a buffer of 5 km and 2 km for main stem and tributaries, respectively from the respective HFL was considered adequate for inclusion in the riverscape. It was also decided that private lands should also be treated well along with Government lands along the river and availability of land may be ascertained on the ground

before taking up forestry interventions. Priority areas should be identified for forestry interventions for each landscape which includes 'Natural landscape', 'Agriculture landscape' and 'Urban landscape'.

Selection of Planting Material

Some participants were of the opinion that careful selection of suitable species for plantation/treatment models is prerequisite for effective recharge and rejuvenation of groundwater as in several instances *Nallah* and streams were dried up due to plantations of *Populus* spp. and *Eucalyptus* spp. Finally, the consensus was built around selecting native and fast growing species those can provide multiple benefits and to avoid exotics and species those have high water requirement.

Significance of Cryosphere

Concerns about declining glaciated area in each river basin, changing climatic and glacio-hydrological regimes of the Himalayas and effect of glacier recession on runoff were emphatically stressed upon. Implications of depleting cryosphere under changing climate on water, energy and food security particularly in Indus River Basin were highlighted. A need for estimating the snow and glacier melts, rainfall runoff, permafrost contribution and base flow at each of the sub-basin scale in the Indus River Basin was highlighted. The significance of protecting high altitude wetlands in the fore fields of glaciers in the upper Indus River Basin that play a vital role in maintaining the hydrological regimes of rivers was also emphasized.

The Planning Process

The Chairperson of the session in her concluding remarks strongly advocated for the adoption of riverscape concept on the lines of DPR on Ganga River and emphasized on the extensive and exhaustive consultative process involving various stakeholders. In view of the short time of one year for the preparation of DPR, she stressed upon the need to review the progress after 2 months so as to identify gaps and constraints in accomplishment of the targets and objectives. Contributions by stakeholders, especially the specialized organizations towards varied information required in the process of preparation of DPR were considered of paramount importance.

The 2 Days Workshop was successfully concluded and it could achieve its various objectives. Participants applauded the efforts made by HFRI in bringing together various stakeholders so as to discuss the priority agenda of river rejuvenation by forestry interventions and providing an opportunity to them for sharing their experiences and interactions. The workshop concluded with a vote of thanks to the Chair, Resource Persons and Participants, and acknowledged significant contributions made by the participants.

(C) First Consultation Meeting for Chamba Forest Circle, Himachal Pradesh (DRDA Hall, Hardaspura, Chamba; 2 August, 2019)

HFRI, Shimla organized sequential meetings for consultation with the stakeholders at the level of each Forest Circle/Division level in the State of H.P. after the Launch Workshop. The field level meeting provided an opportunity to acquaint the forest officials, particularly the frontline

staff with the process and templates for collecting primary field data that will be required for preparation of the report. First Consultation Meeting in the context of Chamba Forest Circle, Himachal Pradesh was organized at DRDA Hall, Hardaspura, Chamba. The meeting was attended by CCF Chamba, Himachal Pradesh State Forest Department and total of 77 representatives from different departments including Divisional Forest Offices (DFOs), Assistant Conservator of Forests (ACFs), Range Offices (ROs), Forest Guards of State Forest Department and representatives from District Rural Development Agency (DRDA), Krishi Vigyan Kendra (KVK), Chamba of UHF Nauni, Hydro-Electric Power Projects (HEPs), Town & Country Planning Office, District Revenue Office, Irrigation and Public Health Department (IPH), Fisheries Department, Agriculture Department, Tourism Department, Animal Husbandry Department, Govt. College Chamba and NGO (Himalayan Niti Abhiyan, Chamba).



Plate 3.11 – Consultation Meeting for Chamba Forest Circle



Plate 3.12 – Consultation Meeting for Chamba Forest Circle

During the consultation meetings, it emerged that holistic approach of river restoration should be adopted and entire catchment area of river should be considered for forestry interventions in Himachal Pradesh. Topographical factors of the area should be kept in mind while proposing forestry interventions. Generally, lack of local participation of the local people is the major failure of all programmes/schemes; therefore, involvement of local people/stakeholders should be emphasized. Needs of the local people must be kept in mind so as to address the issue of livelihood can be addressed. Training needs on value addition of products produced in this region for giving brand name so that local people can earn good price in the market was also realized. Micro-watershed level treatment plan for Ravi Riverscape was recommended by some of the participants. Importance of rehabilitation of dumping sites was also discussed which should be done immediately by planting grass species. There were suggestions regarding plantations along Ravi River bank which should be area specific and Geo-jute technique can be used as vegetative barrier to stop soil erosion in fragile areas. In Ravi Riverscape, silt is the major problem so site specific bio-engineering models should be proposed in DPR. Instead of exotic species, indigenous and native plant species should be used in plantation models and plantation species should be selected on the basis of agro-climatic zones. Secondary data from various departments should be reviewed and suitably incorporated in DPR. In DPR, instead of

5-year management, plant height above the likely damaged height should be chosen as criteria to leave out the plantation (>5years). Rejuvenation of natural water resources should be included in DPR. Need of capacity building of the staff and local people were also realized. Making a provision for some prizes/incentives to good workers involved in the preparation of DPR was also one of the suggestions during the deliberation.

(D) First State Level Consultative Meeting – Punjab State (Forest Complex, Mohali, Punjab; 21 August, 2019)

Himalayan Forest Research Institute (HFRI), Shimla organized the Consultative Meeting for preparation of Detailed Project Report (DPR) for restoration of Indus River Basin (i.e., Sutlej, Beas and Ravi) through forestry interventions on 21st August, 2019 at Forest Complex, Mohali, Punjab as all these three rivers flow through the plains of Punjab. On this occasion, about 60 numbers of officers and experts from various line departments *viz*. Forest Department of Punjab; Chandigarh Forest Department; Agriculture Department; Rural Development Department; Water Resource Department; Animal Husbandry and Sewage Board; Punjab Agriculture University, Ludhiana; World Wide Fund for Nature India; Central Water Commission, Chandigarh, etc. participated in the Consultative Meeting. The main objective of this consultative meeting was to seek valuable suggestions from various stakeholders from the State of Punjab and Union Territory of Chandigarh for preparation of DPR for restoration of the tributaries of Indus River Basin, so that their valuable and relevant suggestions can be incorporated in the preparation of DPR.

The Hon'ble Forest Minister, Punjab emphasized that clean water and clean air are essential for survival of all living beings, and the role of forests in improving the quality and quantity of water cannot be under estimated. He further stated that development activities as well as agricultural development has caused serious loss of forest in the State of Punjab and suggested that the time has come to increase the forest wealth of the State through plantations and protection of forests. He shared various new initiatives launched by Punjab Forest Department to green the state. In particular he briefed that on the occasion of 550th Birth Anniversary of Sh. Guru Nanak Devji, the State has launched planting of 550 plants in each village. Under this scheme, 13,000 villages are being covered and more than 70 lakh plants will be planted.



Plate 3.13 – First State Level Consultative Meeting for Punjab



Plate 3.14 – Participants during First State Level Consultative Meeting for Punjab

The one day meeting concluded that the industrial and sewage pollution are the two main causes for the pollution of the Indus River and its tributaries, particularly in Punjab. Hence, there is a need for proper planning with the inclusion of new technologies and appropriate conservation methods. The need to involve different departments for proper implementation of the project was also felt. The participants felt that there is no need of dovetailing this DPR with other projects. Since riparian vegetation is of great ecological significance, multi-tier planting system on either side of the river bank should be planned along with legal regulations for PAs, riparian zones and eco-sensitive zones. Bioremediation and microbial treatment for implementation were also recommended. Selection of plantation species on the basis of agro-climatic zones was emphasized. The need for conducting a mass awareness campaign for people living along the Indus/Ravi River, particularly pilgrims was felt. Availability of land for plantations in Punjab was seen as a major constraint. Conservation of wildlife was also emphasized.

(E) First State Level Consultative Meeting – Jammu & Kashmir ((Forest Information Centre, Jammu; 12 October, 2019)

Himalayan Forest Research Institute (HFRI), Shimla organized Consultative Meetings with the stakeholders for preparation of Detailed Project Report (DPR) for restoration of rivers *viz.*, Chenab, Ravi and Jhelum through forestry interventions on 12 October, 2019 at Forest Information Centre, Jammu, J&K UT. About 50 participants from various line departments including Forest, Agriculture, Horticulture, Soil & Water Conservation, Animal Husbandry, Photo-Interpretation Department, Urban bodies, Jammu Municipal Corporation and representatives of various research institutes of repute and universities like Sher-e Kashmir University of Agriculture Science and Technology (SKUAST), National Institute of Hydrology (NIH), Indian Institute of Integrative Medicine (IIIM) and National Institute of Technology (NIT) attended this significant meeting organized for the restoration of the principal rivers of the Indus Basin.



Plate 3.15 – First State Level Consultative Meeting for J&K UT

PCCF & HoFF J&K Forest Department highlighted the importance of river rejuvenation through forestry intervention and underscored the fact that canopy cover of the forests plays a key role in increasing the infiltration, reducing the soil erosion, habit management and finally leads to improving the quality and quantity of water in the river ecosystem. He further said that this assignment of DPR preparation for the main tributaries of the Indus River Basin is complex and requires the multi-sectoral approach and inclusive & integrated role by various agencies. During the meeting, it was concluded that the sites should be prioritized and proposed for forestry interventions on basis of the various parameters in context with the respective river basins e.g. soil characteristics, pH, slope, gradient, forest canopy and forest density, land use and land covers patterns, hydrological data (i.e., snow melt, COD and BOD of water quality, ground water, lakes and wetlands) and hydro-metrological data(i.e., rainfall, snowfall, temperature, evaporation, wind speed, relative humidity). The data collected with substantial application of the GIS should be tailored to locate the pin point locations for interventions. Role of various land management agencies like Soil & Water Conservation Department, Agriculture Department, and Horticulture Department must be clearly identified and an integrated and multi-sectoral approach should be adopted in the DPR. The DPR should be well documented and free of any ambiguities so that it can be implementable straightway. For suggesting the soil and moisture conservation works on different landscapes, spur to bottom and against the slope approach should be adopted and provisions of drain line treatment, *Nallah* treatment and minor engineering works and treatment of micro-watershed areas should be included in the DPR proposals.



Plate 3.16 – Participants during Consultative Meeting for J&K

For suggesting the plantations models on the agriculture landscapes across the Riverscape, agro- forestry and integrated models should be proposed and there should be ,some provisions for drought management, more water for cropping, recharging of aquifers and emphasis on the micro- irrigation. There should be ample provisions for the skill development, capacity building

of the local inhabitants in the DPR. There should be provisions of the livelihood enhancement to check the migration of people from the rural areas. Suitable workable strategies should be suggested for tackling the monkey menace. Because wood is a versatile material and it also helps in mitigation of climate, so suitable clones of the fast growing wood species should be suggested in the proposed plantations models for natural landscapes. More and more emphasis should be laid on the treatment of the catchments of tributaries of the rivers.

Urban bodies like Municipal Corporations and Municipal Committees should be actively involved in the formulation of the DPR. Plantations models should include the species like apricot and seabuckthorn (SBT) and there should be more stress on the production of the quality planting material (QPM). Ways and means should be suggested for improvement of the traditional ponds in the *Kandi* areas. There should be provisions for development of the wood-based industries and of livestock improvement in the DPR. SKUAST (Sher-e-Kashmir University of Agriculture Science and Technology) should be involved as a partner in the DPR. High altitude wetlands should also be treated as a part of the DPR. Sharing of the existing information between the various agencies and stakeholders e.g. National Institute of Hydrology (NIH), Pollution Control Boards (PCBs), Photo Interpretation Department (PI), SKUAST, Agriculture Department, Horticulture Department, Forest Department, Urban Bodies and Municipal Corporation was necessitated.

For suggesting the plantations models on the natural landscapes, particularly in the Doda area, cultivation of wild shrub *Plectranthus rugosus* should be encouraged as it establishes a strong and proportional relation with the production of honey. There should be provisions for solid waste management, constructions of the compositing zones and shifting of the slaughter houses from the stretch. Because springs of the Himalayan regions play a vital role in hydrology of the rivers and maintains the water perennial. Status and extent of the springs should be exhaustively studied and provisions should be made for the revival of the springs. In case of the inter-state Ravi River, the catchment is virgin and there are more than 500 springs. The available data about the main water quality parameters should be consulted, collated and made to use in the DPR. Recommendations of the River Rejuvenations Committee (RRC) must be considered and incorporated in the DPR of the Chenab, Ravi and Jhelum.

(F) Second State Level Consultative Meeting – Jammu & Kashmir (Convention Centre, Jammu; 25 February, 2020)

Himalayan Forest Research Institute (HFRI), Shimla, Himachal Pradesh in collaboration with Jammu & Kashmir Forest Department organized 'Final Consultative Meeting for the Finalization of Detailed Project Reports for Rejuvenation of Chenab, Jhelum & Ravi River Basins through Forestry Interventions' on 25th February 2020 at Convention Centre, Jammu, Jammu & Kashmir. About 116 participants from Central and State Govt., R&D Organizations, J&K State Forest Department and various other Departments like SPCB; SKUAST, Srinagar; SKUAST, Jammu; University of Jammu, Jammu; Central University, Jammu; CGWB, NIH; Jammu Municipal Corporation, Agriculture Department and various other stakeholders actively participated in the Consultative Meeting**.**



Plate 3.17 – Second Consultative Meeting for J&K UT



Plate 3.18 – Participants during Second Consultative Meeting for J&K UT

Vice Chancellor, SKUAST, Jammu pointed out towards interruption caused due to climate change and expressed his concern over shrinking of natural water resources at an alarming rate. He appreciated the efforts of HFRI, Shimla for considering views of all stakeholders while preparing these DPRs, for overall improvement of water quality and flow of Jhelum, Chenab, and Ravi rivers.

The PCCF and HoFF (J&K) appreciated the efforts of HFRI in preparation of DPRs and hoped that HFRI has incorporated the suggestions of stakeholders given during the first consultative meetings in the Draft DPR. Deliberations were held on the forestry interventions models prepared by HFRI, Shimla. There was general agreement in the proposed activities, however, few suggestions were provided by some of the participants that more emphasis should be given to those forestry species which will provide more livelihood options to the local populace, besides conservation of the soil and moisture. In this context, high quality improved grass species and high value medicinal plants should be preferred in the plantation models. Indigenous species should be preferred while carrying out plantations in the sites suggested for forestry interventions.









Plate 3.19 – Discussion during Second Consultative Meeting for J&K UT

(G) Second State Level Consultative Meeting – Punjab (Forest Complex Mohali, Punjab; 12.03.2020)

Himalayan Forest Research Institute (HFRI), Shimla, Himachal Pradesh in collaboration with Punjab Forest Department organized 'Second Consultative Meeting for the Finalization of Detailed Project Reports for Rejuvenation of Beas, Ravi and Sutlej River Basins through Forestry Interventions' on 12thMarch, 2020 at Forest Complex, Mohali, Punjab. About 75 participants from Central and State Govt., R&D Organizations, Punjab Forest Department and various other departments like SPCB, Indus Basin Organization (IBO), Bhakhra Beas Management Board, Central University, Bhatinda, Punjab. Punjab University Chandigarh, Punjab Agriculture University, Ludhiana, Department of Water Resources Mohali, Agriculture Department, Soil and Water Conservation Department, Punjab State Council for Science & Technology and various other stakeholders including representatives from NGOs participated in the Meeting.



Plate 3.20 – Second Consultative Meeting for Punjab State

Sh. A. S. Dogra, IFS, Ex-PCCF & HoFF, Punjab Forest Department, pointed out towards interruption caused due to climate change and expressed concerns over shrinking of natural water resources at alarming rate which in turn adversely affected the productivity of agriculture. Raising concern over increasing rate of soil erosion and fast depletion of natural water resources, forestry interventions was advocated for restoration and recharging of these resources. Emphasis was also laid on the quality and uniformity of planting stock along with adaptability of indigenous species, while implementing various forestry interventions. Need of community participation was also emphasized besides community involvement in DPR implementation works.

The participants recommended preferring Indigenous species for the plantations in the priority areas. It was also suggested to include separate plantation models for industrial and urban areas in the DPRs. It was advocated to give more emphasis to those forestry species which provide more livelihood options to the local populace besides conservation of the soil and moisture. Thus, high value broad leaved fodder species, milk yielding grasses and high value medicinal plants were suggested to be preferred in the plantation models. Bund plantations proposed to be included in the models along with very dense plantations. Interventions related to pollution removal proposed to be highlighted as high priority area. Provisions of monitoring of soil erosion and conservation of water bodies and biodiversity was also proposed to be included in the DPRs. Besides this activities related to groundwater recharging proposed to be included on priority basis. Last but not the least, involvement of local communities/community participation during the implementation process was highly recommended.

(H) Second Consultative Meeting for Finalization of Detailed Project Reports (DPRs) for Rejuvenation of Sutlej, Beas, Ravi, and Chenab River Basins through Forestry Interventions' for the State of Himachal Pradesh held through Video Conferencing on 26.06.2020

The HFRI organized One Day Final Consultative Meeting on 26 June, 2020 primarily involving Officers/Officials and other staff persons from Himachal Pradesh Forest Department. The meeting was initially Chaired by PCCF, H.P. PCCF cum Chief Wildlife Warden, PCCF (CAT Plan), CCFs, CFs, DFOs and other Officers and Officials of different Forest Circles and Divisions from HPSFD (Himachal Pradesh State Forest Department) and from HFRI, Shimla Chief Project Coordinator, Indus, Project Coordinator, Indus, Nodal Officer, Indus and River Coordinators, Team Leaders were also present in the Meeting held through Video Conferencing. Initially, PCCF Finance chaired the Meeting. She briefed the Forest Officers about the aim of the Final Consultative Meeting. Later on, PCCF & HOFF chaired the Meeting. In his Inaugural Address PCCF & HOFF highlighted the work done on preparation of Detailed Project Reports (DPRs) so far by HFRI, Shimla and asked CCFs, CFs, DFOs and other Officers/Officials of different Forest Circles/Divisions to actively participate in the Meeting, as the implementation of DPRs will be primarily to be done by HPSFD.

Director, HFRI gave detailed presentation about Draft DPRs of four Rivers *viz*., Sutlej, Beas, Ravi and Chenab, including riverscape analysis of these rivers of Himachal Pradesh, methodology followed for delineation of riverscape, sub basin wise data of rivers, consultation process followed, soil erosion, soil type, soil depth, aspects and role of RS & GIS, development

of Web Portal, collection and analysis of data received, models developed for different landscapes, prioritization of sites, etc.

The Participant recommended and initiated the discussion, with key issues such as. To boost EcoTourism for improvement of livelihood of local people. Reducing the biotic pressure on forest dependency. It was also suggested to cultivate mix forests along with pure forest and the maintenance provision of plantations should have been made up to 5 years. Three types of fence posts *viz*., Wooden/Iron and RCC fence posts should be proposed in the models. In continuation of the suggestions, CCF Chamba, added that there would be provision of Data Entry Operator in State Project Management Unit activities. And the final recommendation was, need for rationalization of costing and revaluation of models.

PCCF cum HOFF, in his closing remarks said that Director, HFRI should consider all the points suggested by concerned CCFs, CFs, DFOs and other Senior Officers and Officials of HPSFD for making DPRs a concrete and implementable document. In the end of the Meeting, Director, HFRI assured PCCF & HOFF that HFRI would incorporate all the necessary and suitable suggestions in the document before further submission.

3.3.4 The Ravi Riverscape – Situation and Problem Analysis

Preparation of DPR involves delineation the Ravi Riverscape for the purpose of planning, situation and problem analysis, developing an insight on the Riverscape environment, and prioritization of areas for proposed forestry interventions.

The background analysis/ contextual analysis and the consultative process adopted at the National, State and Forest Circle levels provided the much desired insight on the Ravi River, its basin and tributaries, terrestrial and aquatic biodiversity, past management, associated States, Union Territory and developmental activities.

Riverscape within the larger river basin was delineated. Detailed geospatial analysis of the Riverscape using remote sensing and GIS technologies was carried out. The approach adopted for application of remote sensing and GIS

Set - I

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS
PROFORMA OF DATA COLLECTION FOR PROPOSED SITE
HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH
(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS	**NATURAL LANDSCAPE**
B. MODEL NO.	*To be proposed*

C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	
2.	AREA (IN HECTARE)	
D. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj ☐ Chenab ☐ Ravi ☐ Beas ☐ Jhelum ☐
2.	State	Himachal Pradesh ☐ Punjab ☐ Jammu & Kashmir ☐
3.	District	
4.	Forest Circle	
5.	Forest Division	
6.	Forest Range	
7.	Forest Block	
8.	Forest Beat	
9.	Development Block Name	
10.	Tehsil	
11.	Panchayat	
E. BASELINE DATA		
1.	Current Status of Flora and Fauna	
2.	Current land use	
3.	Legal Status of land	
4.	Geology and Soil type	
5.	Slope	
6.	Aspect	

for geospatial analysis for the Ravi Riverscape is described in the section 3.4. It provided an understanding on the situation of physical attributes i.e., land use and land cover, altitudinal variation, slope, aspect, soil, erosion, forest types and forest cover, fragmentation, etc. Proforma of Data collection for proposed site is another vital mode of gathering information of river basin that contains few information collective points such as: type of landscapes, model no., treatment site, geographical details, baseline data, etc. The review of secondary information from a variety of sources (National/State level agencies/departments, scientific organizations and Universities) allowed developing an understanding on the riverscape environment (i.e., physical, biological, socio-economics) and identification of challenges, constraints, problems, and threats in river conservation. The situation analysis facilitated developing an insight on the state specific challenges and threats as two States namely, HP, Punjab and J&K, UT wherein the river flows depicts contrasting situation owing to large variations in the physical, biological and socio-economic sub-environments. The consultative process and the sequential meetings with varied stakeholders definitely helped in the identification of focal problems in both the States and J&K, UT, understanding their reasons/causes, and effects or implications on the river itself and surrounding lands. Every effort must be made to make the project successful. Hence, careful planning for DPR based on extensive consultations and scientific facts and principles is required. Regular flow of funds at all stages of the implementation phase should be ensured to carry out the project activities effectively.

3.3.5 Development of Web Portal - Collection and Analysis of Primary Field Data

The present project has envisaged collection of primary field data for the entire riverscape with the support of concerned State Forest Department (SFD), Agriculture Department and other line agencies. Prior to the collection of primary field data, the essential requirement was on the development of plantation and treatment models, design of field data formats and software for analysis of field data. The team preparing this DPR visited sites from where the river flows and so as to develop successful wetland models to critically evaluate them for use in this project.

(A) Suggested Plantation and Treatment Models

In the case of Ravi River, HFRI developed models for three types of landscapes. These were: (i) Natural, (ii) Agriculture and (iii) Urban landscapes. The purpose of various models planned in the natural landscape was primarily protection, eco-restoration and conservation. Each treatment/ plantation model had incorporated details of various proposed activities planned, criteria for selection of sites, planting species, spacing, and cost norms during the establishment and maintenance phases.

Topography of Ravi River is similar to Ganga River as it also originates in the Himalayan Mountains and traverses a long distance in the mountainous state of Himachal Pradesh and J&K UT before it descends into the plains of Punjab. Thus, taking a clue from the past experience on the development of various treatment models, the multi-disciplinary expertise at HFRI developed various treatment/plantation models specific to natural, agriculture, and urban landscapes and shared them with the SFDs of H.P., J&K and Punjab so as to seek their valuable feedback and modify, if the need arises. Finally, based on the feedback from two States, and one

Union Territory, HFRI finalized 87 treatment models in total to be implemented in the case of Ravi Riverscape in two States and one UT. Out of which, 28 models are of Natural Landscape, 6 are of Agriculture landscape, 10 are of Urban landscape, 15 are of soil moisture conservation work, 7 are of other intervention and 21 are of other supporting activities. Once, treatment/plantation models were finalized, the next step was to design for field data formats.

As suggested in consultation meetings, multi-level plantations of trees, herbs, shrubs, grasses and important medicinal plants may be included. More and more medicinal plants should be grown in the nurseries of concerned department and it should be on the priority list to cultivate more medicinal plants in the hills of Himachal Pradesh and J&K. While selecting species for planting, ability of plants to tolerate the temperature and other factors of that area should also be considered. In the upper areas of Himalayas, the species which are planted should be useful in conserving soil and also provide the shade for aquatic animals in the river in hot days. Grasses and other ground cover must be kept intact during plantations and other activities. It is important to ensure the planting stock needs and the quality with the help of research nurseries and other quantity planting stock production units of the State Forest Research Institutes or the research wings of the SFDs. Grass plantation activities for monsoon should be planned carefully, so that, these activities are in harmony with the overall project for which DPR is being prepared. In the three-tier models of plantations, emphasis should be given to indigenous species of fodder, fruits, medicinal and other values which would include bamboo, grass, shrub, medicinal plant, tree and horticulture species.

(B) Design of Field Data Formats

HFRI has developed five formats in the context of Ravi River (Annexure 2). Five elaborate formats were meant for the collection of primary field data. Various efforts should be taken for the collection of correct information and data in a uniform template for all the States/UT which comes under the DPR project. The data formats are very useful for preparing the DPR. Details of these five data formats, types of information required, and the procedure to collect desired information were shared with stakeholders, particularly the forest officials and frontline staff during the consultative process and field specific training sessions organized. Adequate soft and hard copies of formats were made and widely distributed to forest officials and other stakeholders during the consultative process and Training Programmes.

(C) Development of Software and Web Portal

The State Forest Department of Himachal Pradesh, Jammu & Kashmir and Punjab returned a large number of duly filled in field data forms to HFRI. In total HFRI received 380 filled data formats for Natural Landscape, 72 formats for Agriculture Landscape, 84 formats for Urban Landscape, 606 formats for soil and moisture conservation work, 12 formats for Other Intervention and 58 formats for other activities. Thus altogether, these datasheets contributed voluminous information and it was difficult to handle such large data sets manually in a short time available for the preparation of DPR. Hence, it necessitated to take help of software so as to effectively collate, analyse, synthesize, and interpret the voluminous data sets and retrieval of desired information relevant to each of the involved States/ Forest Divisions/ Forest Ranges and

the three pre-defined landscapes within the riverscape. For this purpose, HFRI engaged a commercial vendor to develop a web based software.

The firm developed software in PHP/Mysql, server Linux based and that works on Code igniter Framework basis. It is a web based and easily accessed via internet. The software can compute cost calculations according to selected specified models for unlimited created models and is password protected. In the software, field data was entered as per the five specified formats, *viz*., natural, agriculture and urban landscapes, conservation interventions and supporting activities and can be saved in digital format. The software is capable of generating reports in the desired formats e.g, State-wise, District-wise, Division-wise, Model-wise and Activity-wise, and Annual Consolidated Reports can be generated to obtain insight on year-wise areas under different landscapes to be treated and corresponding costs.

3.3.6 Objective Analysis and Strategic Planning

The foregoing Chapter 1 has elaborated the significance of the Logical Framework Analysis (LFA), Results-Based Management (RBM) and broad objectives of river restoration efforts. These concepts emphasize on the structure and clarity of a results-oriented participatory planning process, the principles of 'change' and 'impact' of a development project, continuous monitoring and organizational learning. The consultative process with stakeholders allowed an understanding to develop the long-term vision and goals that indicate the desired direction or pathways for actions and activities. In the process, it was also understood which changes the project can contribute to in the longer term and why is the project important for the society, biodiversity and the river ecosystem. The multi-disciplinary team of HFRI with resource inputs form wide-range of stakeholders was able to decide the goals, objectives, outputs and outcomes that can be attained. The consultative process gave desired insight on the problems in achieving various objectives and identification of priority actions for rejuvenation of the river. Ultimately, the process also immensely helped in firming up the strategies for implementation of the project.

Accordingly, it was decided that the strategies are required to be formulated for: (1) sustainable land and ecosystem management, (2) conservation of biodiversity, and (3) improvement of livelihood and programme implementation has to be concurrent in natural, agriculture and urban landscapes within the riverscape. Further, a variety of 'conservation interventions and supporting activities' would also be required for effective implementation, knowledge management and sharing, capacity development, monitoring, and adaptive management.

3.3.7 Preparation of Draft DPR – Activities, Resource Planning and Schedule

The aforesaid key steps and the process adopted ultimately helped HFRI in the preparation of draft DPR presenting the background information, situation analysis and environment of the delineated Ravi Riverscape, formulation of strategies, planning of specific activities, resource planning (i.e., manpower, equipment and the finances), and year-wise schedule of operations. Draft DPR (Vol. I and II) was shared with two concerned States and one Union Territory, SFDs and other stakeholders in the State/UT as well as the National Level Consultation Meetings

seeking their feedback and valuable inputs. Copies of the DPR were also submitted to the ICFRE, Dehra Dun and the MoEF&CC, New Delhi and comments were invited. Necessary presentations were also made at ICFRE and MoEF&CC for the inputs and validation and finalization of DPR.

3.3.8 Finalization of DPR, Implementation and Monitoring

The draft DPR is finalized incorporating the feedback and specific comments received from the respective States/UT, SFDs, ICFRE and the MoEF&CC. Initially, the project implementation during Phase 1 has been planned for duration of five years by respective States/UT and concerned SFDs as the implementing agencies. A provision for inbuilt, Results-Based Monitoring has been made for continuous monitoring, organizational learning and adaptive management. The Phase II after five year implementation would deal with maintenance phase of plantations raised during the phase I, scaling up of the activities and covering of the left over tributaries.

3.4 Ravi Riverscape – Application of Remote Sensing and GIS for Geospatial Analysis

Ravi River is a major river of the Trans-Himalayan Indus River system. It is also among one of the perennial rivers of the Indus River system. The surrounding forests, agriculture and human activities collectively exert enormous influence on the river, its flow and numerous associated ecological characteristics and processes. Vegetation cover in general and forest cover in particular, are vital and serve as indicators for the quality and functioning of the riverine environment or riverscape. Different land uses, particularly forests or other types of vegetation cover are vital and serves as indicators for the quality and functioning of the riverine environment or the riverscape. Thus, the present task on the preparation of DPR for forestry interventions on Ravi River required a better insight and understanding not only of Ravi and its tributaries but also of the surrounding lands and expanding human footprints.

The Geospatial Technology, an emerging field of study that includes Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS) has enabled to acquire data that is referenced to the earth and its use for analysis, modeling, simulations, and visualization (Van Laake, 2000; Chaudhary, 2014). Thus, Geospatial technology offers unparalleled help to study a wide-range of disciplines and have immense utility in natural resource management. Geospatial technology can be used to create intelligent maps and models and to reveal spatial patterns that are embedded in large volumes of data that may not be accessed collectively or mapped otherwise. Geospatial technology has become an essential part of everyday life. The Geospatial technology provides enormous opportunities for planning, assessment, management and monitoring of vast extent of river basin and the complex and dynamic river ecosystem. Geospatial technology also facilitates informed decisions based on the importance and priority of resources most of which are wide spread and sparse in nature.

3.4.1 Remote Sensing Technology

Remote Sensing (RS) techniques offer unparalleled help to monitor green and non-green land changes in the surroundings of the river at the regional and local scales, while it also facilitates in understanding the channel dynamics, particularly channel morphology, changes in the river course, and trends in sedimentation over a long period of time. Recent advancements in the fields of remote sensing due to satellites with improved temporal frequency of data acquisition and better spatial and spectral resolution have offered unparalleled opportunities for resource inventory and surveys, planning, management and monitoring of varied natural and man-made resources and objects. New sensors with moderate and high resolution data have enabled evaluation of impacts on biodiversity of specific management policies (Prasad *et al*., 2015).The accelerated rate of deforestation, forest fragmentation, and forest degradation is not only a threat to continuous supply of forest products for the livelihood of local people but also has several adverse consequences on multiple levels, particularly the downstream. Further, planning for Ravi River management, particularly the proposed forestry interventions for Ravi restoration, need a pre-requisite information on the farthest bank lines during the maximum flood period for the main river and its tributaries so as to avoid such areas from the perspective of proposed forestry interventions. Furthermore, an insight is needed on the distribution and extent of diverse forests, land use, and identification of likely available sites for proposed plantations and forestry interventions. Remote sensing (RS) technology combined with Geographic Information System (GIS) which excels in storage, manipulation and analysis for geographic information and socio-economic data provides a wider application. Integrated assessment can be defined as an interdisciplinary and participatory process of combining, interpreting, and communicating knowledge from diverse scientific disciplines to allow a better understanding of complex phenomena (Rao, 2000). Integration of information on natural resources, socio-economics and climatic conditions and other related ancillary information in a holistic manner for prescribing for a given area is very crucial (Rao, 2000). Land resource managers and environmental decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes (Hughton, 1994).

Advances in RS techniques definitely have advantage over traditional/conventional cumbersome techniques in terms of spatial, spectral, radiometric and temporal data availability. It offers acquisition of real-time data from inaccessible or remote areas within a short span of time. Over the years, RS technology has become an efficient and powerful tool in assessment, exploration, evaluation, analysis, monitoring and management of water resources, particularly surface water in river ecosystems and groundwater for the long term societal benefits. RS technology is a rapidly changing domain with the advent of new improved sensors, platforms and application techniques which support new form of data and newer views of the landscapes/riverscapes through which foresters, hydrologists and river scientists could better evaluate the Earth's surface and other specific features in the context of forests, rivers and other land uses.

Assessment of the availability and condition of the natural resources is the first step for the planning and development of a plan for the sustainable resource development. Field managers,

conservationists and decision makers often require quantitative information on the spatial distribution of land use types, their conditions, as well as temporal changes in them (Al-Bilbisi and Tateishi, 2002; FRI, 2016). The RS technology was needed as a pre-requisite for delineation of boundaries of the Ravi riverscape keeping in view the farthest bank lines during the maximum flood period for the main river and its tributaries so as to avoid flood prone areas from the perspective of proposed forestry interventions. Further, the RS technology was of the immense utility in understanding the spatial patterns and processes in the context of diverse forests, other land uses, and identification of priority areas for proposed plantation sites and other forestry interventions.

3.4.2 Geographic Information System (GIS)

Geographic Information System (GIS) is basically an information system working with geographically referenced spatial and non-spatial data, for planning, monitoring and effective implementation of the management plans. GIS can handle large volumes of spatial data derived from a variety of sources such as field surveys, Aerial surveys and space remote sensing, in addition to the already existing maps and reports. This involves bringing together diverse information from a variety of sources on a common platform. In the management of natural resources, there is a greater emphasis on integrate relationships over time and space, between resources/ species and the human impact overall. Hence, manager of such resources needs to incorporate even more data in the decision-making process and applies GIS for the management and analysis of large data sets (Van Laake, 2000). The role of GIS is invaluable for optimal land use planning and making integrated development plans. A GIS database is a structured collection of digital spatial and non-spatial data that describes map features, spatial relationship and character of features. They may be linked to GIS through common identifier or other mechanisms. GIS has two distinct utilization capabilities, the first pertaining to querying and obtaining information and the second pertaining to integrated analytical modeling (Burroughs, 1986). However, both of these capabilities depend upon the GIS database for queried results through a GIS package having the capability of handling both spatial and non-spatial databases.

3.4.3 Global Positioning System (GPS)

The Global Positioning System (GPS) technology has greatly enhances the ease and versatility of spatial data acquisition and diversifies the approaches with which it is integrated with remote sensing and GIS (Gao, 2002). GPS technology has rendered an excellent opportunity for location measurements, and has become an essential tool for management of agricultural and natural resources.

3.4.4 Geospatial Modeling

Spatial modeling is a process of analysis performed with the help of a Geographic Information System (GIS) to define the basic processes and structures of a given set of geographical features. The spatial modeling is very helpful the ability to study and

simulate spatial objects or events that is found in the real world and make it easier to solve problems and planning.

The integration of Remote Sensing (RS), Geographic Information System (GIS) and Global Positioning System (GPS) (3S) has opened up several new avenues. These are: (a) mapping - collection of thematic layers in geographic format, (b) measuring - rigorous mapping process and quantification, (c) modeling - a process to describe and simulate the present, past or future behavior, and (d) monitoring - periodic assessment of conditions to record the shifts or changes in natural phenomena and human activities. The integration of three technologies has received considerable attention in the field of geospatial modeling, particularly the hydrological modeling as the occurrence and movement of surface and ground water are controlled/ influenced by a wide range of variables *viz*., macro and micro topography, geology, lithology, stratigraphy, structural control, geomorphology, soil types, land use/cover, geological lineaments, etc. (Das, 1994). Three geographic-based technologies not only offer an ideal environment for integrating spatial and attribute data on natural resources and environment but facilitate spatial modeling, and analytical processes to describe basic processes and properties for a given set of spatial features.

One of the most important utilities of Geospatial data is its capability of being integrated for decision making through synthesis of spatial and non-spatial attributes information within the framework of application. Geospatial modeling techniques moves from relatively passive form so inquiry to more active form of decision making and involves conjunctive analysis of multi-parameter data (say maps and non-spatial data). Towards this, there are two aspects that are of importance: a model/criterion that defines the logic for analysis of the composite information set and the relative importance or weightage of each parameter for the end objective.

3.4.5 Application of RS, GIS and GPS in the Present Assignment

Remote Sensing and Geospatial modeling has much role to play in identification of suitable sites for forest plantations in the Ravi River catchment and its tributaries. Land evaluation analysis involve the execution and interpretation of basic surveys of climate, soils, vegetation and other technical aspects of lands in terms of requirement of alternative forms of land use, land use requirement of land utilization types and the availability of existing land quality and land characteristics. It has been well documented that remote sensing techniques have been highly effective and useful in this regard. The significant inputs which we can derive from remote sensing technology in the field of land evaluation are based on all cover type information which are ultimately stratified into different land units containing different land qualities and land characteristics. The ground truth information substantiates the land use requirement of land utilization types viz., forest types/individual tree species and management/silvicultural practices in a particular site condition. It has been now well established that remote sensing techniques have been highly effective and useful in developing a better understanding of land evaluation and land use patterns. The main objective of the use of RS and GIS technologies in the present assignment was for the identification, selection and delineation of suitable sites for proposed forest plantations and other forestry interventions and to relate these with the selection of appropriate plantation species on the basis of their requirements and matching with the existing qualities and

characteristics of the available lands/potential sites. This essentially involves several aspects relevant to the technical, social and economic suitability of land along the delineated buffer or influence areas within the Ravi riverscape, as it is not feasible to manually integrate, analyze and manipulate such vast amount of spatial and non-spatial data and retrieve the desired information for site suitability analysis. Hence, the use of geospatial modeling has been made in selecting suitable sites.

(A) RS and GIS Methodology

Image processing and GIS tools used in the present assessment were ERDAS Imagine, Geo-media Professional, ArcGIS, and other application software. The GIS software provides the tools needed to store, analyze and display geographic information.

(B) Satellite Data Used

Landsat 8 satellite data for the month of November& December 2018 has been used for preparation of Land use/ Land cover map of the riverscape. The Row, Path along with Date of Pass of the satellite data used in the current study for the parts of two States (Himachal Pradesh and Punjab) and one UT (Jammu & Kashmir) covering the riverscape is given in Table 3.5 & Fig.3.6.

Table 3.5-List of Data Downloaded and Used in the Geospatial Analysis of the Ravi Riverscape

State/UT	Path	Row	Date of Pass	Satellite
Jammu & Kashmir	148	037	03-Dec-2018	Landsat-08
Jammu & Kashmir	148	038	17-Nov-2018	Landsat-08
Himachal Pradesh	147	037	10-Nov-2018	Landsat-08
Himachal Pradesh	147	038	10-Nov-2018	Landsat-08
Himachal Pradesh	148	037	03-Dec-2018	Landsat-08
Himachal Pradesh	148	038	17-Nov-2018	Landsat-08
Punjab	148	038	17-Nov-2018	Landsat-08
Punjab	149	038	08-Nov-2018	Landsat-08

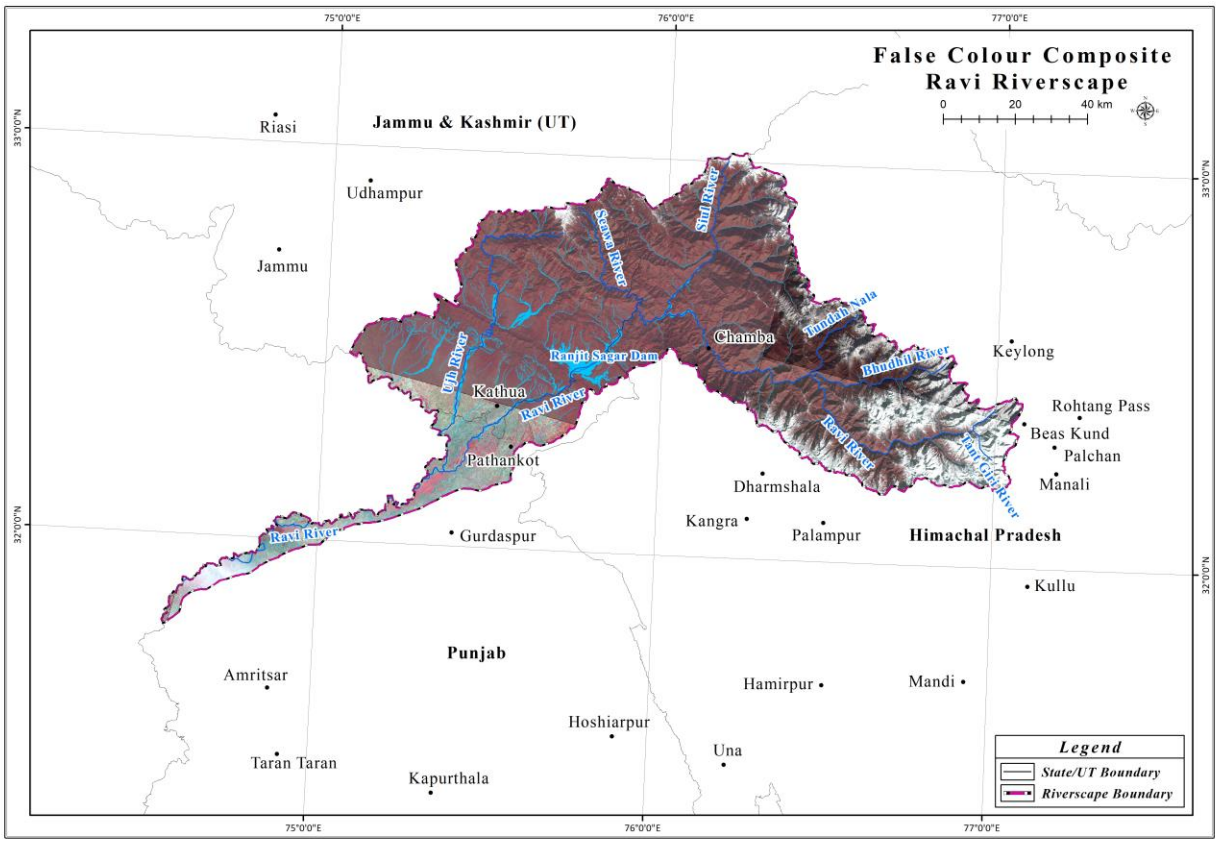


Fig. 3.6 - Satellite map (False Colour Composite) of Ravi Riverscape

(C) Ancillary Data

Almost all of the ancillary information has been taken from various Government of India sources. Information about the State and District boundaries for the riverscape taken up for analysis were obtained from the Survey of India. Basin boundary, Catchment boundary, Sub-Catchment boundary, Watershed boundary and Micro-watershed boundaries were obtained from Soil and Land Use Survey of India, New Delhi. Village and Tehsil boundaries were obtained from the published document 'Administrative Atlas of Himachal Pradesh/ Jammu & Kashmir /Punjab' by Census of India (2011). Forest Type and Forest Density data were obtained in digital format from Forest Survey of India. Soil map and soil depth information was obtained from published maps of National Bureau of Soil Survey & Land Use Planning, Nagpur. Soil erosion data which is the backbone of multi-criteria analysis was obtained in GIS format from the Indian Institute of Soil & Water Conservation, Dehradun. Topographical sheets on 1:50,000 scale obtained from Survey of India have been used for Geo-reference only. Bhuvan data was also referred, wherever required for the preparation of land use map.

(D) Data Downloading

Relevant Landsat-8 satellite datasets specific to the riverscape were downloaded from *www.earthexplorer.usgs.gov*. The time frame has been selected by keeping in mind the post-monsoon season and maximum differentiation in various land cover features.

(E) Map to Image Registration as per Accepted Projection System

Image registration is one of the important components for area analysis and display of output on definite projection system as well as integration and modeling the land cover parameters. The projection parameters used in the current assessment are defined below:

Projection:	Lambert Conformal Conic
Spheroid:	WGS84
Datum:	WGS84
First Standard parallel	12^0 28’ 22.6”
Second Standard Parallel	35^0 10’ 22.10”
Longitude of Central meridian	82^0 00’ 00.00”
Latitude of origin of projection	20^0 00’ 00.00’
False Northing	2000000 m
False Easting	2000000 m

(F) Spatial Data Creation and Analysis

Spatial database creation is considered as the most important step in Geospatial Modeling. Spatial integration of basic layers is of utmost importance from the perspective of study/ assessment.

(G) Delineation of Riverscape Boundaries

Initially, Landsat-8 satellite images of 2018 were used for the digitization of main stem and major tributaries taken into consideration in the current DPR. The SOI topographical sheets of 1:50,000 scale were used as a reference for the identification of the streams. Furthermore, a tentative riverscape boundary was created covering a 5 km buffer on southern side of the bank line for the main channel of Ravi flowing through Punjab, because the northern side is falling in Pakistan Territory. The entire catchment area in Himachal Pradesh state and Jammu & Kashmir UT, as per the demarcation of the same by Soil and Land Use Survey of India in the maps from Micro-watershed atlas of India was used. In the later stage of the preparation of this DPR, stakeholder consultation resulted in the idea to merge micro-watershed boundaries in the alluvial plains of Punjab so as to arrive at the final riverscape used in the current DPR. In other words, the 9,173.61 km^2 riverscape area which comprises of 78% of the total catchment area of Ravi River has been demarcated by considering the whole sub-catchment area falling within Himachal Pradesh and Jammu & Kashmir and concerned micro-watershed boundaries merged together for the state of Punjab.

(H) Selection and Demarcation of Watershed Boundaries up to Micro-watersheds

The watershed boundaries up to micro-watershed level were delineated using source maps from Soil and Land Use Survey of India, New Delhi. Each micro watershed has been depicted with a code as per the codifications standards in five stages. All the seven stages are described below to offer an understanding of the codes.

(a) Stage One – In the stage one, major 'Water Resources Regions (WRR)' in the country have been denoted using the Arabic Numerals *viz*., 1,2,3…

1. Indus drainage
2. Ganges drainage
3. Brahmaputra drainage
4. All drainage flowing in Bay of Bengal except Sr. No. 2 & 3.
5. All drainage flowing into Arabian Sea except at Sr. No. 1
6. Western Rajasthan mostly ephemeral drainage.

(b) Stage Two – Basin: Each WRR would been divided into basins which constitutes big individual river. They were denoted by Capital English alphabets suffixed to WRR code for example A, B, C. Thus, the basin will be denoted as 1C Ravi River

(c) Stage Three – Catchments: Each basin was further divided into a number of catchments which mainly pertains to main tributaries or a group of contiguous small tributaries or individual stream. They were denoted by Arabic number suffixed to Basin Code for example 1, 2, 3….. Thus catchments were expressed as 1C1.

(d) Stage Four – Sub catchments: The Sub-catchments were further subdivided into a number of sub-catchments which are mainly smaller tributaries or streams. They were denoted by capital English alphabets suffixed to catchment code as A, B, C …… expressing the sub-catchment was 1C1A.

(e) Stage Five – Watersheds: Each sub catchment was divided into a number of watersheds which are the smallest hydrological unit delineated in 1: 1 m Watershed Atlas of India in the macro level category. They were denoted by Arabic numbers suffixed to sub-catchment code for example 1, 2, 3, and watershed was symbolized as 1C1A3.

(f) Stage Six – Sub watersheds: This delineation and codification was transferred in 1: 50,000 Survey of India topo-maps for further delineation at micro level. The watersheds were subdivided in sub watersheds which are either the banks of small tributaries or discreet streamlet. They are denoted by small English alphabets suffixed to code of watershed. However, the use of e, i,o, and l alphabets are avoided. Thus the sub watershed was expressed as, 1C1A3a.

(g) Stage Seven – Micro watersheds: The sub-watersheds were further divided to the smallest micro-level hydrological unit i.e., micro-watersheds which were part of small streams or streamlets. They are denoted by Arabic numbers but restricted to 9 only and suffixed to sub-watersheds code. This completes the delineation and codification at micro-level. Thus the micro-watershed was coded as 1C1A3a3, 1C1A3a4, etc. The micro-watershed code 1C1A3a3 will represent water resource region 1, basin 1C, catchment 1C1, sub-catchment 1C1A, watershed 1C1A3, and sub-watershed 1C1A3a. (Source: Micro-watershed Atlas of India)

Using the dataset from Micro Watershed Atlas of India, layers of Catchment of Ravi River followed by sub-catchment, watershed and sub-watershed were derived. The entire riverscape of Ravi can be divided into 3 Sub Catchments, 12 Watersheds, 168 Sub-Watersheds and 1,180 Micro-Watersheds. The list under each category falling within riverscape along with the maps is given below in Fig.3.7-Fig.3.10, Table 3.6 and Table 3.7. Distribution of riverscape Area under Various Watershed Categories is given in Table 3.8 and Distribution of riverscape area under various Sub-Watershed categories is given in Table 3.9.

Table 3.6– Details on Various Catchment Categories within the Ravi Riverscape

Sr. No.	Catchment Category	State-wise Representation of Catchment Units in the Riverscape			No. of Common Catchment Units in Two States and one UT	Actual Number of Catchment Units in the Riverscape
		Himachal Pradesh	Jammu & Kashmir	Punjab		
1.	Sub-Catchments	1	2	2	2	3
2.	Watersheds	8	6	4	6	12
3.	Sub-watersheds	85	57	32	6	168
4.	Micro-watersheds	619	383	181	3	1180

Table 3.7- Distribution of Riverscape Area under Various Sub-Catchment Categories

Sub-Catchment	Area Covered (km^2)	Area Percentage
1C1A	566.52	6.18
1C1B	3799.55	41.42
1C1C	4807.54	52.41
Total	**9173.61**	**100**

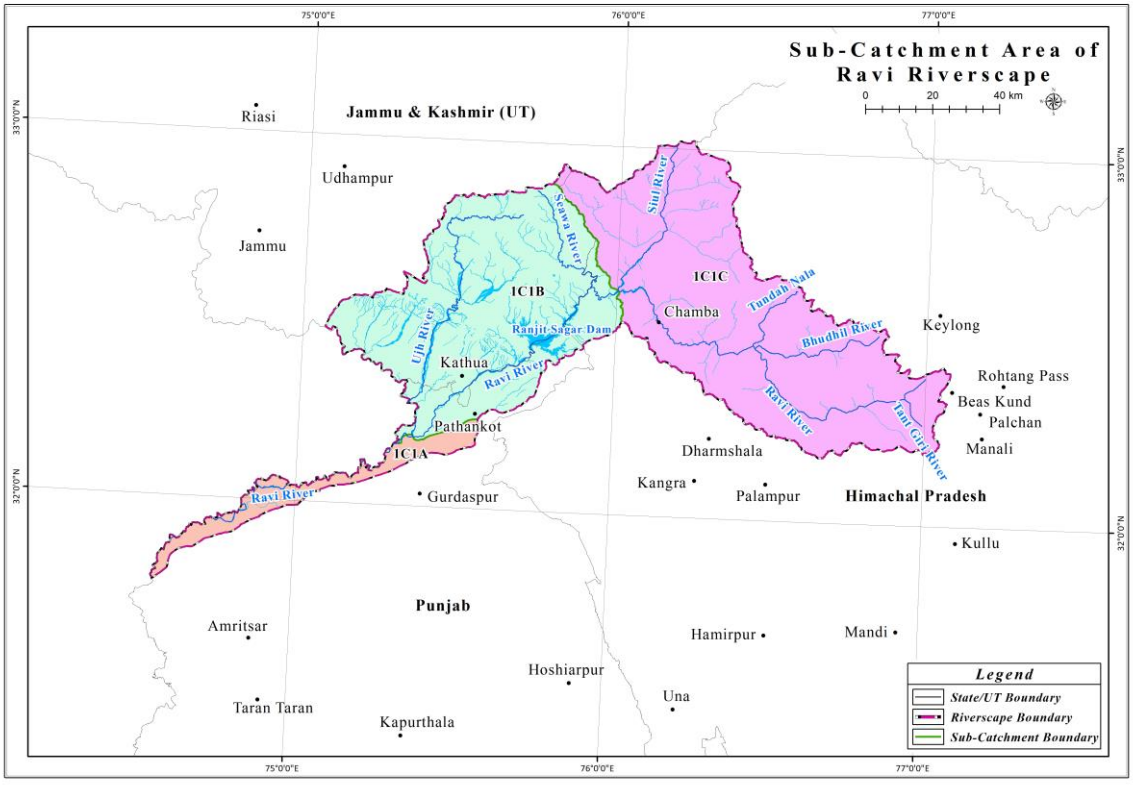


Fig. 3.7 - Ravi Riverscape with Tributaries and Sub-Catchment

Table 3.8 - Distribution of Riverscape Area under Various Watershed Categories

Watershed Code	Area Covered (km^2)	Area Percentage
1C1A3	566.52	6.18
1C1B1	1086.03	11.84
1C1B2	859.63	9.37
1C1B3	712.87	7.77
1C1B4	629.76	6.86
1C1B5	511.26	5.57
1C1C1	988.66	10.78
1C1C2	651.89	7.11
1C1C3	1010.14	11.01
1C1C4	832.62	9.08
1C1C5	716.24	7.81
1C1C6	607.99	6.63
Total	**9173.61**	**100**

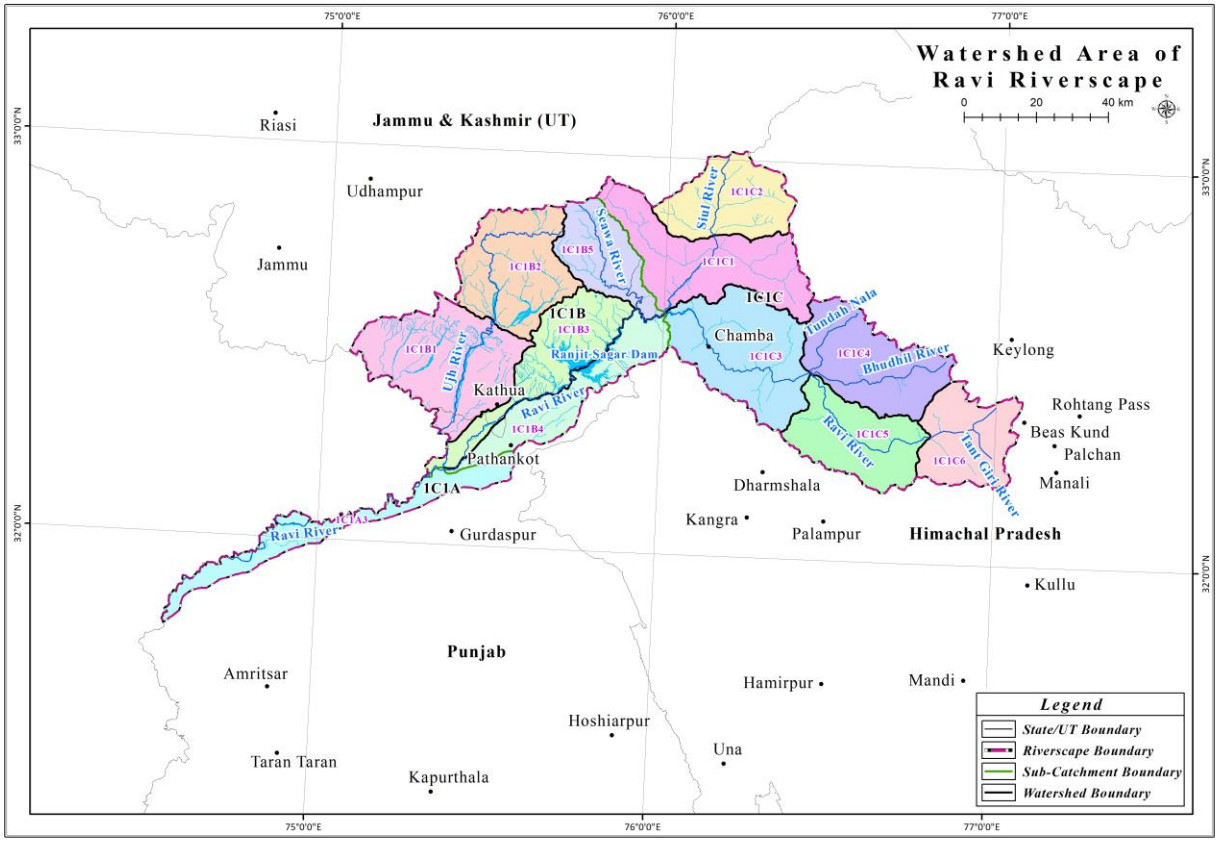


Fig. 3.8 – Ravi Riverscape with Tributaries and Watershed

Table 3.9 - Distribution of Riverscape Area under Various Sub-Watershed Categories

Sub-Watershed	Area (km^2)	Percentage of Total Area (%)	No. Micro-watersheds
1C1A3a	24.86	0.27	4
1C1A3b	32.95	0.36	4
1C1A3c	47.15	0.51	7
1C1A3d	44.19	0.48	7
1C1A3f	14.53	0.16	2
1C1A3g	36.35	0.4	5
1C1A3h	25.72	0.28	5
1C1A3j	22.77	0.25	4
1C1A3k	49.52	0.54	7
1C1A3m	25.53	0.28	4
1C1A3n	26.82	0.29	5
1C1A3p	22.66	0.25	5
1C1A3q	33.02	0.36	6
1C1A3r	51.41	0.56	8
1C1A3s	41.7	0.45	8
1C1A3t	42.38	0.46	8
1C1A3u	24.96	0.27	4
1C1B1a	42.24	0.46	6
1C1B1b	60.57	0.66	7
1C1B1c	40.6	0.44	6
1C1B1d	44.96	0.49	6
1C1B1f	54.85	0.6	7
1C1B1g	57.86	0.63	7
1C1B1h	70.33	0.77	9
1C1B1j	75.69	0.83	9
1C1B1k	65.74	0.72	9
1C1B1m	43.98	0.48	5
1C1B1n	67.56	0.74	9
1C1B1p	66.41	0.72	8
1C1B1q	41.96	0.46	6
1C1B1r	56.42	0.62	8
1C1B1s	67.98	0.74	9
1C1B1t	70.97	0.77	9
1C1B1u	56.67	0.62	7
1C1B1v	56.13	0.61	7
1C1B1w	45.11	0.49	6
1C1B2a	49.11	0.54	6
1C1B2b	38.9	0.42	6
1C1B2c	59.43	0.65	7
1C1B2d	67.32	0.73	9

Sub-Watershed	Area (km^2)	Percentage of Total Area (%)	No. Micro-watersheds
1C1B2f	50.75	0.55	7
1C1B2g	47.01	0.51	6
1C1B2h	76.52	0.83	9
1C1B2j	48.76	0.53	6
1C1B2k	36.11	0.39	6
1C1B2m	44.68	0.49	6
1C1B2n	70.46	0.77	9
1C1B2p	28.07	0.31	4
1C1B2q	72.11	0.79	9
1C1B2r	65.34	0.71	7
1C1B2s	55.36	0.6	7
1C1B2t	49.7	0.54	6
1C1B3a	132.85	1.45	10
1C1B3b	41.94	0.46	6
1C1B3c	42.88	0.47	6
1C1B3d	80.28	0.88	9
1C1B3f	28.78	0.31	4
1C1B3g	60.69	0.66	8
1C1B3h	71.17	0.78	9
1C1B3j	46.93	0.51	7
1C1B3k	74.76	0.81	9
1C1B3m	76.36	0.83	9
1C1B3n	56.23	0.61	8
1C1B4a	22.83	0.25	4
1C1B4b	57.41	0.63	9
1C1B4c	51.85	0.57	7
1C1B4d	51.69	0.56	8
1C1B4f	32.51	0.35	4
1C1B4g	55.73	0.61	10
1C1B4h	52.38	0.57	7
1C1B4j	38.01	0.41	9
1C1B4k	34.94	0.38	7
1C1B4m	29.47	0.32	6
1C1B4n	16.67	0.18	4
1C1B4p	24.09	0.26	6
1C1B4q	19.31	0.21	5
1C1B4r	31.51	0.34	7
1C1B4s	20.66	0.23	5
1C1B4t	35.43	0.39	7
1C1B4u	55.27	0.6	9
1C1B5a	62.43	0.68	9

Sub-Watershed	Area (km^2)	Percentage of Total Area (%)	No. Micro-watersheds
1C1B5b	43.89	0.48	6
1C1B5c	40.1	0.44	6
1C1B5d	46.91	0.51	5
1C1B5f	62.77	0.68	8
1C1B5g	39.97	0.44	6
1C1B5h	39.02	0.43	5
1C1B5j	65.5	0.71	8
1C1B5k	59.94	0.65	8
1C1B5m	50.73	0.55	6
1C1C1a	75.84	0.83	9
1C1C1b	79.54	0.87	9
1C1C1c	47.92	0.52	7
1C1C1d	66.39	0.72	9
1C1C1f	62.81	0.68	8
1C1C1g	34.01	0.37	5
1C1C1h	50.27	0.55	7
1C1C1j	42.28	0.46	7
1C1C1k	43.22	0.47	6
1C1C1m	58.13	0.63	10
1C1C1n	37.73	0.41	8
1C1C1p	56.17	0.61	6
1C1C1q	43.7	0.48	6
1C1C1r	41.78	0.46	6
1C1C1s	66.34	0.72	9
1C1C1t	76.21	0.83	9
1C1C1u	59.43	0.65	9
1C1C1v	46.89	0.51	7
1C1C2a	53.07	0.58	8
1C1C2b	57.8	0.63	9
1C1C2c	67.98	0.74	9
1C1C2d	59.21	0.65	9
1C1C2f	76.35	0.83	9
1C1C2g	65.18	0.71	9
1C1C2h	59.53	0.65	9
1C1C2j	52.63	0.57	8
1C1C2k	65.91	0.72	9
1C1C2m	63.68	0.69	6
1C1C2n	30.55	0.33	5
1C1C3a	48.6	0.53	6
1C1C3b	80.42	0.88	7
1C1C3c	80.64	0.88	9

Sub-Watershed	Area (km^2)	Percentage of Total Area (%)	No. Micro-watersheds
1C1C3d	81.61	0.89	8
1C1C3f	100.33	1.09	9
1C1C3g	60.25	0.66	6
1C1C3h	97.08	1.06	9
1C1C3j	77	0.84	8
1C1C3k	52.25	0.57	6
1C1C3m	67.6	0.74	7
1C1C3n	42.87	0.47	5
1C1C3p	63.82	0.7	8
1C1C3q	31.23	0.34	4
1C1C3r	62.06	0.68	6
1C1C3s	64.38	0.7	7
1C1C4a	69.87	0.76	8
1C1C4b	51.42	0.56	6
1C1C4c	62.14	0.68	8
1C1C4d	92.08	1	9
1C1C4f	47.57	0.52	5
1C1C4g	44.55	0.49	5
1C1C4h	46.54	0.51	4
1C1C4j	51.86	0.57	6
1C1C4k	62.19	0.68	9
1C1C4m	70.71	0.77	7
1C1C4n	71.16	0.78	7
1C1C4p	50.9	0.55	7
1C1C4q	48.24	0.53	4
1C1C4r	63.39	0.69	8
1C1C5a	60.37	0.66	7
1C1C5b	49.06	0.53	6
1C1C5c	53.92	0.59	6
1C1C5d	67.09	0.73	9
1C1C5f	89.67	0.98	9
1C1C5g	83.05	0.91	9
1C1C5h	57.3	0.62	6
1C1C5j	45.24	0.49	5
1C1C5k	69.81	0.76	7
1C1C5m	85.46	0.93	9
1C1C5n	55.27	0.6	5
1C1C6a	74.74	0.81	9
1C1C6b	80.67	0.88	9
1C1C6c	82.54	0.9	8
1C1C6d	80.71	0.88	9

Sub-Watershed	Area (km^2)	Percentage of Total Area (%)	No. Micro-watersheds
1C1C6f	65.95	0.72	9
1C1C6g	61.02	0.67	7
1C1C6h	28.34	0.31	5
1C1C6j	83.29	0.91	8
1C1C6k	50.73	0.55	7
Total	**9173.61**	**100**	**1183**

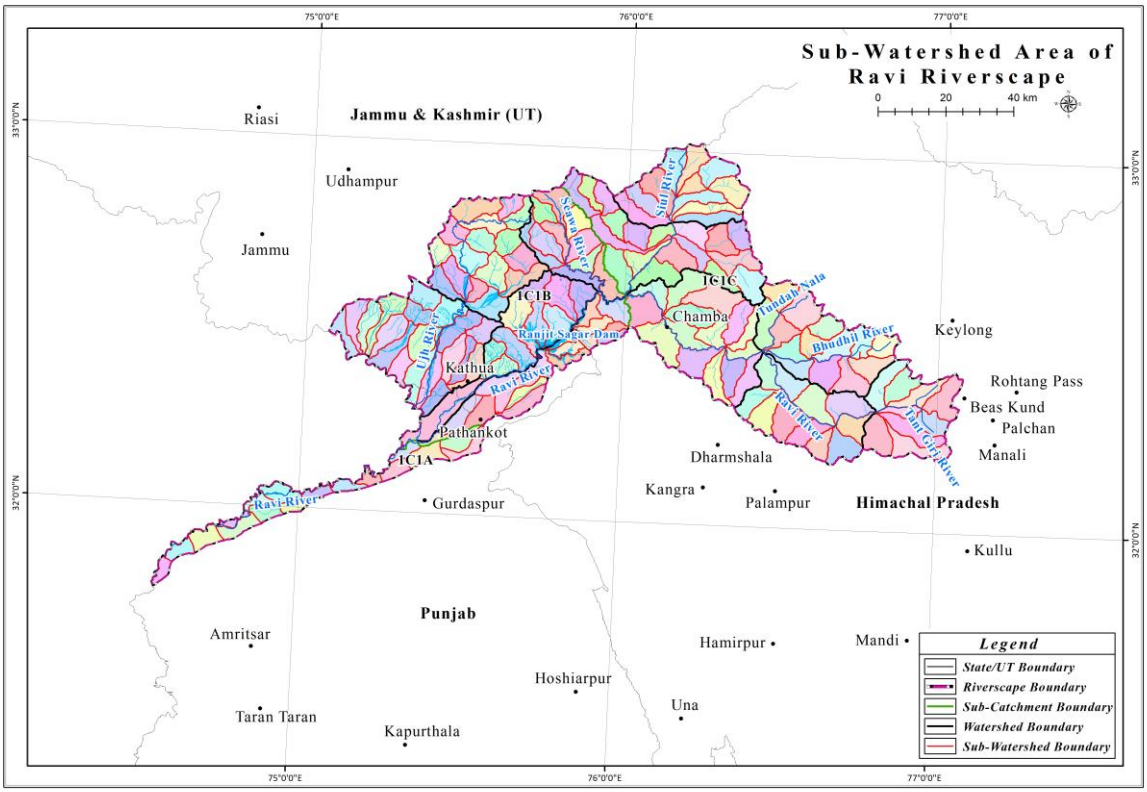


Fig. 3.9 – Ravi Riverscape with Tributaries and Sub-Watershed

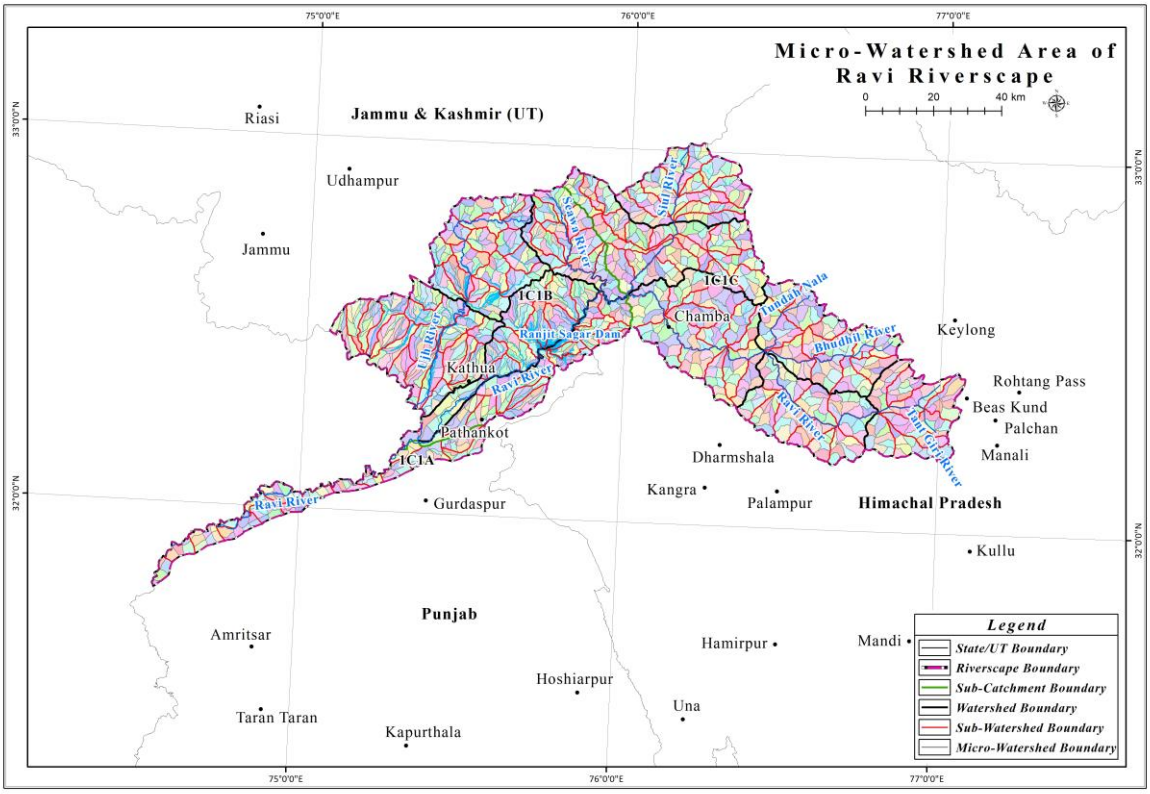


Fig. 3.10 – Ravi Riverscape with Tributaries and Micro-Watershed

(I) Land Use/ Land Cover (LULC) Analysis

Land information is important to a wide variety of human activities such as agriculture, forestry, water resources, and as other types of land resource management. The preprocessed geometrically and radio-metrically corrected PAN merged satellite datasets were displayed on screen for attempting visual interpretation of various land use classes. Standard image interpretation keys, viz., shape, size, color, tone, texture, pattern, shadow, site, association, and phenology have been used to generate Image Interpretation scheme (Fig. 3.11a &b).

Agricultural Land

This landscape is primarily used for farming and production of food, fiber, horticulture, etc. They are mainly the lands with standing crops (i.e., cropland; bright red to red color on satellite image), fallow land (i.e., uncropped for one or more season; yellow to greenish blue tone), agriculture plantations (tea, coffee, etc.), plantations (herbs, nurseries, orchards, etc.; dark red to red and regular sharp edged shapes).

Natural/Semi-natural Grassland

These are the areas of grassland, dominated by the grasses and forb. They appear in light red to light brown of varying sizes and irregular shapes.

Alpine/Sub-alpine are the places between the sub-alpine forests and permanent snow covered areas. An alpine zone commences is variable and line between 3000-5600 m asl (Above sea level).

Barren

This is delineated on the basis of bright white to light blue to yellow to brown color tone depending upon the rock type. These are located on isolated hill slopes, plateau, etc.

Water bodies

This category comprises areas with surface water (i.e., ponds, lakes, rivers, canals, etc.) these can clearly be seen on a satellite image in blue to dark blue or cyan color depending on the depth of water.

Rivers (perennial/dry) are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards another water body in most cases, sea, another river, lake, marsh, etc. They appear in light to dark blue and irregular shape (non-linear). There are two major categories of rivers, perennial (flow continuously throughout the year) and dry (flow only during monsoon period).

Canals

These are artificial water courses constructed for irrigation purposes has a regular linear shape on image.

Forests

These are the areas bearing an association predominantly of trees and other vegetation types (within the notified forest boundaries).
Dense areas with Dark red to red color tone include canopy cover/density of more than 70%.

Moderately Dense forest areas with Red to light red in color tone include the canopy cover/ density of 40-70%.

Open forest areas with Light red color tone include the canopy cover/density of 10-40%.

Scrubs

This land is prone to deterioration due to erosion. These land generally occupy higher locations. They appear light yellow to brown to greenish blue depending upon the surface moisture and vegetation cover. It varies in sizes from small to large and generally found agricultural field borders, river banks and alpine slopes.

Built-up/Settlements

These are the areas of human habitation developed due to non-agricultural use and that has a cover of buildings, transport, and communication utilities associated with water, vegetation and vacant lands. They appear in dark bluish green in the core and bluish in the periphery. The size varies from small to big; can be centered, clustered, or in scattered form.

Snow covered/Glacial area

These are the areas under perpetual snow cover confined to the Himalayan region. It appear bright white to white in color depending on the moisture and thickness of snow. It poses irregular shape and located in mountain peaks in the higher altitude areas.

The pre-processed geometrically, radio-metrically corrected, and resolution merged Landsat -8 satellite datasets were displayed on screen for attempting visual interpretation of various land use classes. Standard image interpretation keys, *viz*., shape, size, color, tone, texture, pattern, shadow, site, association, and phenology have been used to generate Image Interpretation scheme. Onscreen visual interpretation technique has been used for delineating major land use& land cover types i.e., Dense Forest, Moderately Dense Forest, Open Forest, Scrub, Agriculture, Alpine Pastures, Barren, Settlement, Canal, Water body, Wetland, River (Dry)/River Sand, River (Perennial), Snow/Glaciers etc. Thus, the distribution of area under corresponding land cover and land use classes for the entire riverscape State/UT-wise was computed.

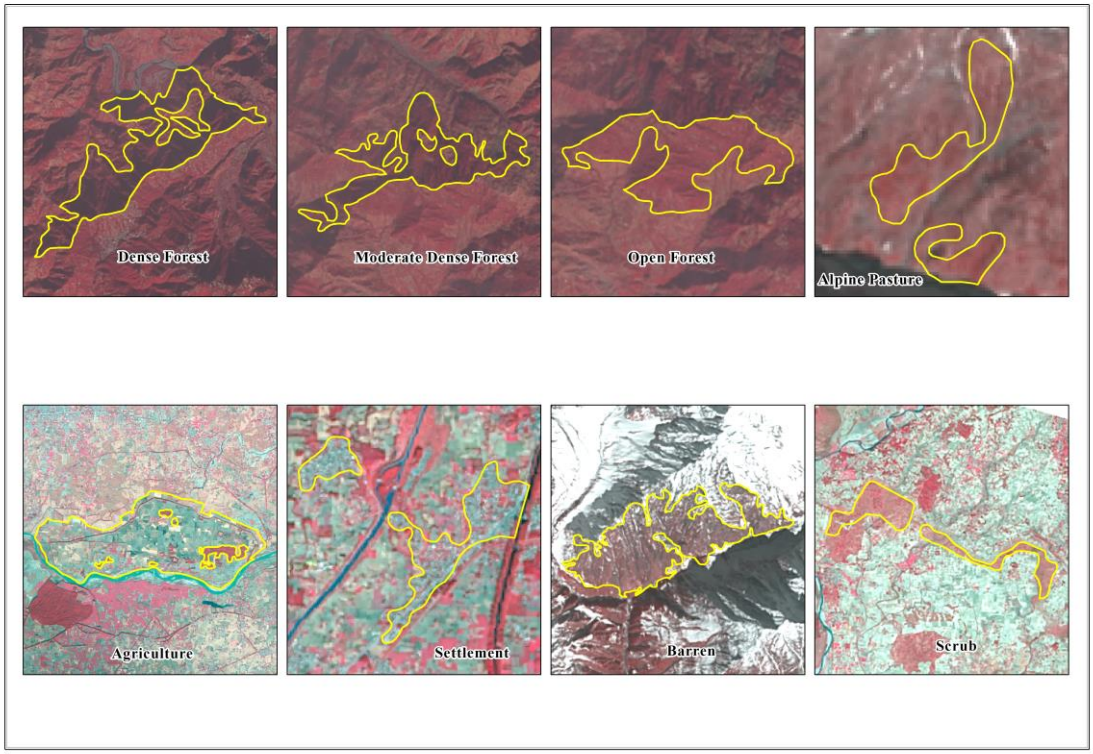


Fig. 3.11a - Land Use and Land cover classification key

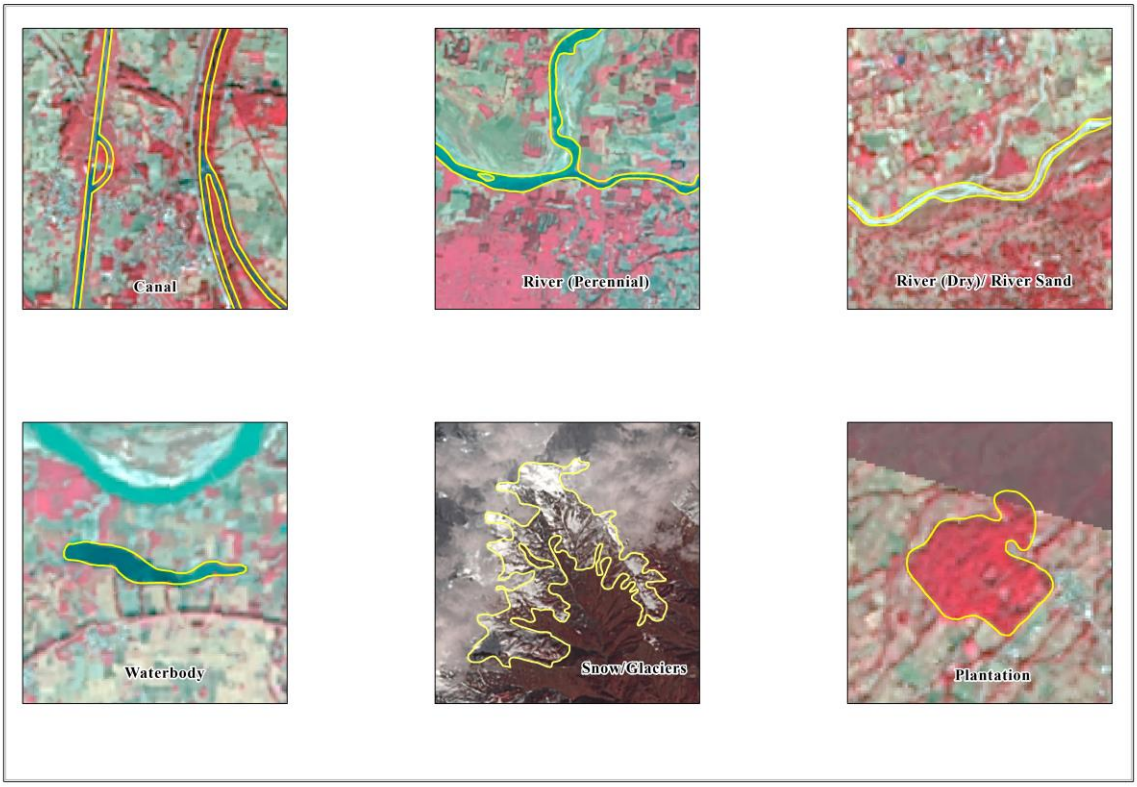


Fig. 3.11b - Land Use and Land cover classification key

3.4.6 Prioritization of Suitable Areas for Proposed Forestry Interventions

For the purpose of preparation of DPR and for identification of priority areas for the proposed treatment/forestry interventions in the Ravi Riverscape, GIS-assisted decision making process by way of geospatial analysis and modeling was used. GIS was used to generate different layers within the riverscape like land use, soil erosion rates, and slope of the topography. The above shape files were superimposed to obtain a combination-matrix of various layers that revealed the prevalent features of any area within the Riverscape with regard to vegetation, land use, erosion, and degree of slope. The land use & land cover classes were merged in to 7 classes *viz.*, Dense forest, Alpine Pastures, Open forest, Agriculture, Barren, Settlement, and Others. A weightage from 1 to 6 scale was given to the above land use & land cover classes. Further, the slope layer was categorized into three categories and each category was assigned a weightage of 1 to 3 based on the degree of slope. The erosion layer received from Institute of Water and Soil Conservation (IWSC) had 5 major categories of erosion *Viz.*, <5, 5 to 10, 10-20, 20-40, and >40 (erosion in t/ha/year). Each category of erosion was given a weightage in multiples of 1.5. GIS overlay operations were carried out on the above three layers and the weightages for various combinations were combined together by means of addition to arrive at summed weightage for each combination. These values were then categorized in to low medium and high based on statistical quartile. For example, an open forest area is classified as 'high priority' if it has an erosion 20 to greater than 40 t/ha/year devoid of any slope class. Likewise, the agriculture area having slope 0-30 and erosion rate <5 t/ha/year has been classified as 'low priority'. It is this

data which was then depicted on map as low medium and high priority zones (Fig.3.13). The priority information for Ravi Riverscape is given in Table 3.10a. & 3.10b.

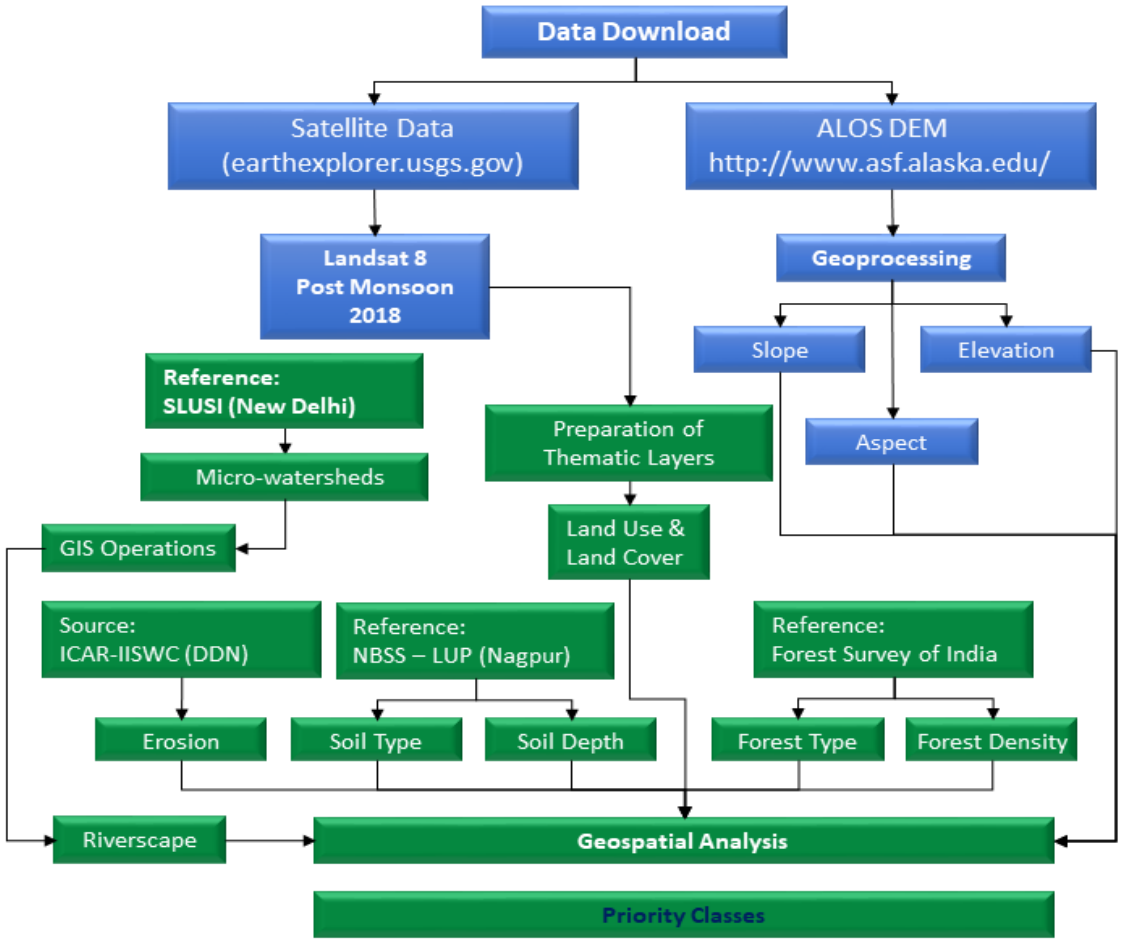


Fig. 3.12 – The Adopted Approach for Geospatial Analysis and Prioritization of Areas

Table.3.10a - Weightage to Different LULC, Slope, and Erosion Categories for MCA

Sr. No.	LULC	Weightage	Slope (Degrees)	Weightage	Erosion (t/ha/year)	Weightage
1.	Dense Forest	6	0 to 30	1	<5	1.5
2.	Open Forest	5	30 to 40	2	5-10	3
3.	Alpine Pasture/ Scrub	6	Greater than 40	3	10-20	4.5
4.	Agriculture	4			20-40	6
5.	Barren	3			Greater than 40	7.5
6.	Others	1				
7.	Settlement	2				

Table 3.10b - Priority zones for forestry intervention in the Ravi Riverscape

Sr. No.	LULC	Slope	Erosion	Weightage (Slope)	Weightage (Erosion)	Weightage (LULC)	Total	Priority
1.	**Dense Forest**	0° to < 30°	<5	1	1.5	6.0	8.5	Moderate
2.	**Dense Forest**	>30° to 40°	<5	2	1.5	6.0	9.5	Moderate
3.	**Dense Forest**	> 40°	<5	3	1.5	6.0	10.5	High
4.	**Dense Forest**	0° to < 30°	>40	1	7.5	6.0	14.5	High
5.	**Dense Forest**	>30° to 40°	>40	2	7.5	6.0	15.5	High
6.	**Dense Forest**	> 40°	>40	3	7.5	6.0	16.5	High
7.	**Dense Forest**	0° to < 30°	10 - 20	1	4.5	6.0	11.5	High
8.	**Dense Forest**	>30° to 40°	10 - 20	2	4.5	6.0	12.5	High
9.	**Dense Forest**	> 40°	10 - 20	3	4.5	6.0	13.5	High
10.	**Dense Forest**	0° to < 30°	20 - 40	1	6.0	6.0	13	High
11.	**Dense Forest**	>30° to 40°	20 - 40	2	6.0	6.0	14	High
12.	**Dense Forest**	> 40°	20 - 40	3	6.0	6.0	15	High
13.	**Dense Forest**	0° to < 30°	5 - 10	1	3.0	6.0	10	Moderate
14.	**Dense Forest**	>30° to 40°	5 - 10	2	3.0	6.0	11	High
15.	**Dense Forest**	0° to < 30°	Non Soil	1	1.5	6.0	8.5	Moderate
16.	**Dense Forest**	>30° to 40°	Non Soil	2	1.5	6.0	9.5	Moderate
17.	**Dense Forest**	> 40°	Non Soil	3	1.5	6.0	10.5	High
18.	**Open Forest**	0° to < 30°	<5	1	1.5	5.0	7.5	Moderate
19.	**Open Forest**	>30° to 40°	<5	2	1.5	5.0	8.5	Moderate
20.	**Open Forest**	> 40°	<5	3	1.5	5.0	9.5	Moderate
21.	**Open Forest**	0° to < 30°	>40	1	7.5	5.0	13.5	High
22.	**Open Forest**	>30° to 40°	>40	2	7.5	5.0	14.5	High
23.	**Open Forest**	> 40°	>40	3	7.5	5.0	15.5	High
24.	**Open Forest**	0° to < 30°	10 - 20	1	4.5	5.0	10.5	High
25.	**Open Forest**	>30° to 40°	10 - 20	2	4.5	5.0	11.5	High
26.	**Open Forest**	> 40°	10 - 20	3	4.5	5.0	12.5	High
27.	**Open Forest**	0° to < 30°	20 - 40	1	6.0	5.0	12	High

Sr. No.	LULC	Slope	Erosion	Weightage (Slope)	Weightage (Erosion)	Weightage (LULC)	Total	Priority
28.	**Open Forest**	>30° to 40°	20 - 40	2	6.0	5.0	13	High
29.	**Open Forest**	> 40°	20 - 40	3	6.0	5.0	14	High
30.	**Open Forest**	0° to < 30°	5 - 10	1	3.0	5.0	9	Moderate
31.	**Open Forest**	0° to < 30°	Non Soil	1	1.5	5.0	7.5	Moderate
32.	**Open Forest**	>30° to 40°	Non Soil	2	1.5	5.0	8.5	Moderate
33.	**Open Forest**	> 40°	Non Soil	3	1.5	5.0	9.5	Moderate
34.	**Alpine Pasture/Scrub**	0° to < 30°	<5	1	1.5	6.0	8.5	Moderate
35.	**Alpine Pasture/Scrub**	>30° to 40°	<5	2	1.5	6.0	9.5	Moderate
36.	**Alpine Pasture/Scrub**	> 40°	<5	3	1.5	6.0	10.5	High
37.	**Alpine Pasture/Scrub**	0° to < 30°	>40	1	7.5	6.0	14.5	High
38.	**Alpine Pasture/Scrub**	>30° to 40°	>40	2	7.5	6.0	15.5	High
39.	**Alpine Pasture/Scrub**	> 40°	>40	3	7.5	6.0	16.5	High
40.	**Alpine Pasture/Scrub**	0° to < 30°	10 - 20	1	4.5	6.0	11.5	High
41.	**Alpine Pasture/Scrub**	0° to < 30°	20 - 40	1	6.0	6.0	13	High
42.	**Alpine Pasture/Scrub**	>30° to 40°	20 - 40	2	6.0	6.0	14	High
43.	**Alpine Pasture/Scrub**	> 40°	20 - 40	3	6.0	6.0	15	High
44.	**Alpine Pasture/Scrub**	0° to < 30°	5 - 10	1	3.0	6.0	10	Moderate
45.	**Alpine Pasture/Scrub**	0° to < 30°	Non Soil	1	1.5	6.0	8.5	Moderate
46.	**Alpine Pasture/Scrub**	>30° to 40°	Non Soil	2	1.5	6.0	9.5	Moderate
47.	**Alpine Pasture/Scrub**	> 40°	5 - 10	3	3.0	6.0	12	High
48.	**Agriculture**	0° to < 30°	<5	1	1.5	4.0	6.5	Low
49.	**Agriculture**	>30° to 40°	<5	2	1.5	4.0	7.5	Moderate
50.	**Agriculture**	> 40°	<5	3	1.5	4.0	8.5	Moderate
51.	**Agriculture**	0° to < 30°	>40	1	7.5	4.0	12.5	High
52.	**Agriculture**	>30° to 40°	>40	2	7.5	4.0	13.5	High
53.	**Agriculture**	> 40°	>40	3	7.5	4.0	14.5	High
54.	**Agriculture**	0° to < 30°	10 - 20	1	4.5	4.0	9.5	Moderate

Sr. No.	LULC	Slope	Erosion	Weightage (Slope)	Weightage (Erosion)	Weightage (LULC)	Total	Priority
55.	**Agriculture**	>30° to 40°	10 - 20	2	4.5	4.0	10.5	High
56.	**Agriculture**	0° to < 30°	20 - 40	1	6.0	4.0	11	High
57.	**Agriculture**	>30° to 40°	20 - 40	2	6.0	4.0	12	High
58.	**Agriculture**	> 40°	20 - 40	3	6.0	4.0	13	High
59.	**Agriculture**	0° to < 30°	5 - 10	1	3.0	4.0	8	Moderate
60.	**Agriculture**	0° to < 30°	Non Soil	1	1.5	4.0	6.5	Low
61.	**Agriculture**	>30° to 40°	Non Soil	2	1.5	4.0	7.5	Moderate
62.	**Barren**	0° to < 30°	<5	1	1.5	3.0	5.5	Low
63.	**Barren**	>30° to 40°	<5	2	1.5	3.0	6.5	Low
64.	**Barren**	> 40°	<5	3	1.5	3.0	7.5	Moderate
65.	**Barren**	0° to < 30°	>40	1	7.5	3.0	11.5	High
66.	**Barren**	>30° to 40°	>40	2	7.5	3.0	12.5	High
67.	**Barren**	> 40°	>40	3	7.5	3.0	13.5	High
68.	**Barren**	0° to < 30°	10 - 20	1	4.5	3.0	8.5	Moderate
69.	**Barren**	>30° to 40°	10 - 20	2	4.5	3.0	9.5	Moderate
70.	**Barren**	> 40°	10 - 20	3	4.5	3.0	10.5	High
71.	**Barren**	0° to < 30°	20 - 40	1	6.0	3.0	10	Moderate
72.	**Barren**	>30° to 40°	20 - 40	2	6.0	3.0	11	High
73.	**Barren**	> 40°	20 - 40	3	6.0	3.0	12	High
74.	**Barren**	0° to < 30°	Non Soil	1	1.5	3.0	5.5	Low
75.	**Barren**	>30° to 40°	Non Soil	2	1.5	3.0	6.5	Low
76.	**Barren**	> 40°	Non Soil	3	1.5	3.0	7.5	Moderate
77.	**Others**	> 40°	5 - 10	3	3.0	1.0	7	Low
78.	**Others**	0° to < 30°	<5	1	1.5	1.0	3.5	Low
79.	**Others**	>30° to 40°	<5	2	1.5	1.0	4.5	Low
80.	**Others**	> 40°	<5	3	1.5	1.0	5.5	Low
81.	**Others**	0° to < 30°	>40	1	7.5	1.0	9.5	Moderate
82.	**Others**	>30° to 40°	>40	2	7.5	1.0	10.5	High

Sr. No.	LULC	Slope	Erosion	Weightage (Slope)	Weightage (Erosion)	Weightage (LULC)	Total	Priority
83.	**Others**	> 40°	>40	3	7.5	1.0	11.5	High
84.	**Others**	0° to < 30°	10 - 20	1	4.5	1.0	6.5	Low
85.	**Others**	>30° to 40°	10 - 20	2	4.5	1.0	7.5	Moderate
86.	**Others**	> 40°	10 - 20	3	4.5	1.0	8.5	Moderate
87.	**Others**	0° to < 30°	20 - 40	1	6.0	1.0	8	Moderate
88.	**Others**	>30° to 40°	20 - 40	2	6.0	1.0	9	Moderate
89.	**Others**	> 40°	20 - 40	3	6.0	1.0	10	Moderate
90.	**Others**	0° to < 30°	5 - 10	1	3.0	1.0	5	Low
91.	**Others**	0° to < 30°	Non Soil	1	1.5	1.0	3.5	Low
92.	**Others**	>30° to 40°	Non Soil	2	1.5	1.0	4.5	Low
93.	**Others**	> 40°	Non Soil	3	1.5	1.0	5.5	Low
94.	**Settlement**	0° to < 30°	<5	1	1.5	2.0	4.5	Low
95.	**Settlement**	0° to < 30°	10 - 20	1	4.5	2.0	7.5	Moderate
96.	**Settlement**	0° to < 30°	20 - 40	1	6.0	2.0	9	Moderate
97.	**Settlement**	0° to < 30°	5 - 10	1	3.0	2.0	6	Low

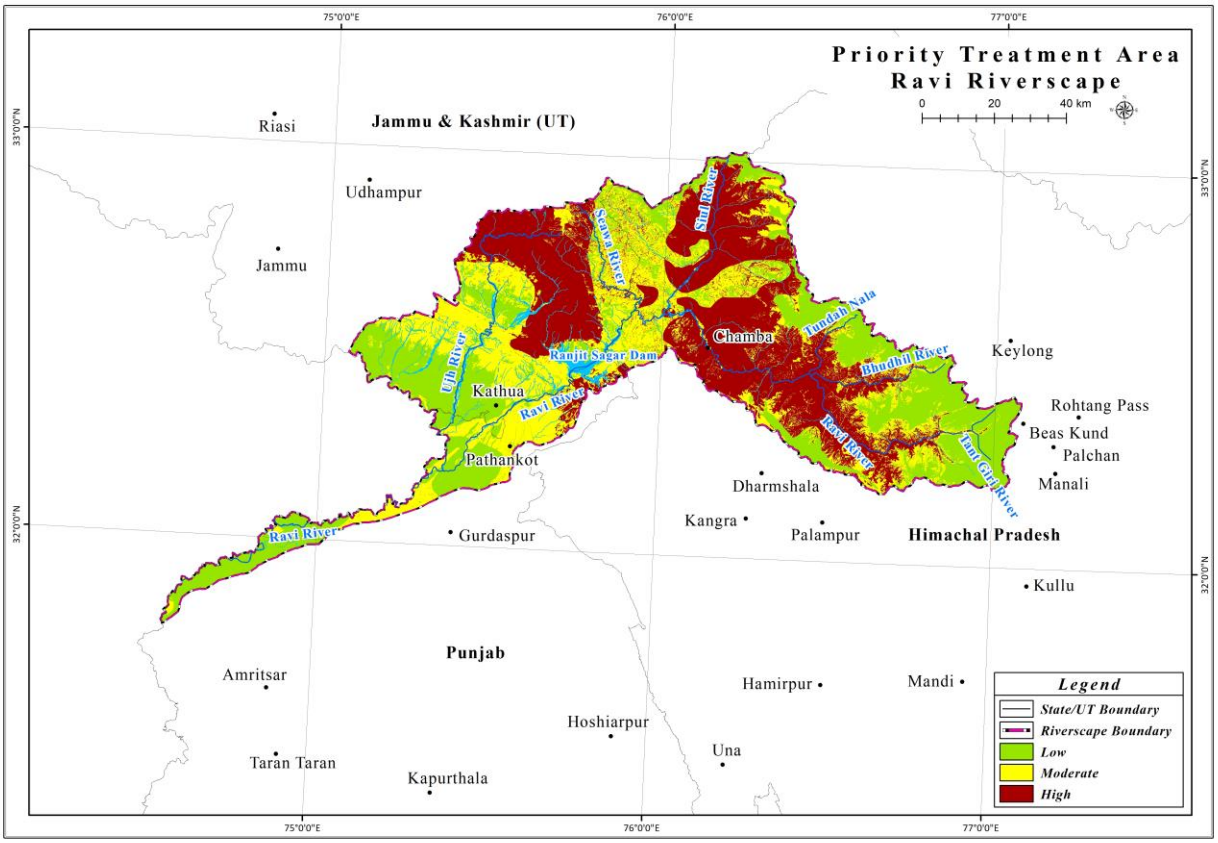


Fig. 3.13 - Priority Zones for Forestry Interventions in Ravi Riverscape

3.4.7 Riverscape – Secondary Information, Collation and Synthesis

Climate, topography, geological substrate, land cover and human disturbances along the river course control overall environment of the riverscape. An understanding of the overall environment of the riverscape from the perspective of river restoration, forestry interventions, biodiversity conservation, community engagement, awareness, livelihoods and sustainable development is the prerequisite. Much of the information on the physical, biological and social environment of the Ravi River Basin and the riverscape in particular are widely available in existing literature on Chapter-2. Much of the information on the biological sub-environment i.e., biodiversity, forests, alpine pastures, wetlands, floodplain, wildlife and their habitats, threatened species, protected areas, conservation initiatives, etc. was collected from the MoEF&CC, ICFRE, FSI, FRI, HFRI, WII, GBPNIHESD, WWF-India, State Department(s) – Forest, Agriculture, Animal Husbandry, Fisheries, Science Technology and Environment, Medicinal Plants Board, etc., and State Level Universities. Information thus, obtained from departments/ agencies or collected from respective websites were optimally used for the synthesis of an insight on the biological sub-environment of the riverscape. Hence, a large number of studies and reports were referred in the synthesis. The demographic and other socio-economic information was either

obtained from the state government's websites or downloaded from the primary web source of *censusindia.gov.in.*

3.5 SWOT Analysis of Ravi River Ecosystem and its Environment

SWOT analysis of the Ravi River ecosystem and its environment is summarized below:

(a) Strengths

The Ravi River is one of the five tributaries of the Indus River. It is an integral part of the Indus River Basin and forms the headwaters of the Indus River Basin. It originates in Himalaya and formed by melting of ice. Being the most prominent part of the Himalayan River System, the Ravi River and most of its tributaries have optimal advantage of snow and glacial melt as well as monsoonal rain fed waters.

In Ravi Riverscape, there is a wide diversity of forests in high altitude Himalayan zone and in Shivalik region despite heavy biotic pressures and deterioration. A variety of wetlands exist in the vicinity of Ravi River which directly add to its aesthetic and biodiversity values and contribute to the overall health of the river and its continued water flows. Ravi River Basin is home to many threatened and sensitive ecosystem viz., glaciers, alpine meadow, grasslands, with a large variety of rare, endangered and threatened species of plants and animals.

The valley formed by the Ravi River is a major source of various economic values i.e., fishing, recreation activities, hydro power projects, rafting, etc. and much exploited for its rich timbers /trees. The crops are grown in large terraces and dry fruits were exported to other countries. In the absence of a single agency responsible for regulation and uses of various resources, the river ecosystem is degrading. Hence, the GoI taking into cognigence of issues related to the river conservation as priority created the MoWR,RD&GR exclusively for the management, rejuvenation and conservation of rivers (e.g. fish, irrigation, drinking water, hydropower, sand, boulders, recreation, etc.) in the country. Ravi River System has a rich geographical, environmental, socio-economic, cultural and religious diversity for the State.

(b) Weaknesses

Ravi River is highly burdened by human exploitation. Being a trans-boundary river of small space 450 km in India. It is even neglected as compared to other major Tributaries of Indus River. Biological and water resources already show signs of deterioration while ecological integrity is being challenged.

The Ravi River Basin Glaciers show fragmentation and enhanced sign of retreat forests grasslands unsustainable experienced and unscientific harvesting pressure enhanced landslides and soil erosion, high rate of sedimentation, fragmentation and drying of the river, reduced

connectivity, e-flows and ever increasing pollution from agriculture landscapes, towns and cities, and industrial and pilgrimage centers are some of the main concerns.

For proper use and regulations of river resources, several policies and laws there but encroachment and illegal constructions on lands is close vicinity of the Ravi River and its tributaries, besides illegal mining in river beds for sand and boulders remains a continuous issue.

(c) Opportunities

Ravi River is associated with great plant and animal biodiversity which have enormous potential to flourish and recover. Many high altitude sites have great gene pool/biodiversity values in all types of ecosystems which are not that much explored yet and diversity is still intact in many fragments. The Ravi riverscape has great ability to reduce adverse impacts of various disturbances and pollution and continue to provide subsistence, prosperity, spiritual healing and fulfillment of aspirations of masses. Thus, the Ravi River remains a source of inspiration and provides an opportunity for the masses to contribute for its rejuvenation and conservation in several ways. Several Civil Societies are working on Ravi Riverscape for ecological restoration, but many more Civil Societies can be involved for the awareness of local people and restoration of natural ecosystems.

There are various innumerable opportunities for various organizations research and monitoring in the field of its various landscapes especially Natural Agriculture and Urban Landscapes of multifaceted, complex and dynamic Ravi River ecosystem and its tributaries. Successful experiences and expertise relevant to River management and restoration by way of appropriate retrofitting/engineering measures, bio-remediation, etc. available around the globe could be optimally tapped for restoration of a major river like the Ravi in the country. The current favorable environment wherein the present governments at the Centre/States, various law enforcement agencies (Apex Court, NGT, NGRBA, etc.), Scientific Organizations, technocrats, corporates, religious leaders and the masses have come together in a big way for a priority focused agenda which provides a great opportunity for the revival of the Ravi River and its conservation.

(d) Threats

The Ravi River and most of its tributaries originates from Bhadal and Tantgiri glaciers and snow-capped Himalaya and the area fall under the Ravi Riverscape in HP comes under high seismic zone and experienced seismic activity in the part and vulnerable to earthquake, landslide exercise rainfall at a time, floods and the situation is expected to aggravate due to likely climate change and its impact. Natural ecosystems in the Himachal Pradesh Himalaya and the Ravi Plain are expected to be influenced in several ways.

There are several HEP on Ravi River in Hilly parts of Himachal Pradesh and still new HEPs and developmental activities are in pipeline which are expected to further fragment the river, causing loss of longitudinal, horizontal and lateral connectivity. Land degradation and high rates of sedimentation owing to various factors remain major challenges for the maintenance of e-flows and ecosystem integrity of the river and various tributaries. Being a Trans boundary International i.e., India and Pakistan river system, water diversion and resultant disputes in times to come could be major threats for conservation of Ravi River. The geographic location of the river and its tributaries is across multiple states within the country. Issues related to Inter-State/Centre-State coordination and any change in policies and priorities could severely impact planned activities of rejuvenation of Ravi River.

3.6 Geospatial Analysis and Modeling of the Ravi Riverscape - Sites for Forestry Interventions

Extensive consultations were organized for the preparation of DPR. On the basis of these consultations planning and assessment of intervention areas within the Ravi River Basin which extends in two States (HP and Punjab) and one UT (Jammu & Kashmir) of India along the cores of Ravi River was selected and delineated. Further, the preceding section has described the physical and biological sub-environments of the Ravi Riverscape so as to comprehend the existing situation of the physical conditions and biological diversity within the Riverscape and at the same time to appreciate the factors responsible for the current state of the environment and degradation of natural resources, particularly the river ecosystem, the analysis of river environment also helped in understanding the past trends and in recognizing the major challenges, issues, threats and constraints relevant to conservation of Ravi River ecosystem. The following section presents the findings based on geospatial analysis of the Ravi Riverscape and priority sites identified for forestry interventions on the basis of multi-criteria modeling performed for the purpose.

(i) Altitude and Digital Elevation Model (DEM)

The Riverscape generally flows in westerly direction depicts large altitudinal variation from plains to very high altitude of 6076m amsl. Altitude plays an important role in the physical characteristics, biological diversity and its distribution, socio economic uses and consumption patterns. In particular, higher altitudes greatly influence river flow, rate of sedimentation, vegetation, wild animal use and even human settlements and their uses. Advanced Land Observing Satellite Based Digital Elevation Model (ALOS-DEM) data was downloaded from http://www.asf.alaska.edu/ and was used to derive the elevation classes in the Ravi Riverscape (Fig. 3.14).

The different elevation classes were regrouped and a total of 12 elevation classes have been derived (Fig. 3.15). The distribution of areas under different elevation classes within the Riverscape is given in Table 3.11 revealed that the entire area of alluvial plains in Punjab falls

under the lowest altitudinal class of <250 m. Thus, substantial area of about 8,20,740 km^2 or 89.46% area of the riverscape lies in the Himalayan State of Himachal Pradesh and J&K UT that harbours diverse forests scrub, Tropical dry deciduous forest to dry alpine forest. However, most of these forests are under severe influence of biotic pressure. They need efforts towards protection, enhanced regeneration and gap plantations. Degraded forests or areas presently devoid of vegetation owing to past activities or in sides in close proximity to hydro-electric projects (HEPs), townships, riverine habitats or roadsides have ample opportunities for suitable forestry interventions. The maximum extent of 1860.57 or 20.28% area of the Riverscape lies between 2500 - 3000 m amsl (Table 3.11).

Areas above 3,000 m amsl representing nearly 27.44% area of the Riverscape have little opportunities for forestry interventions except in lower parts of this elevation class that is >3,000 m to 3,500 m due to steep slopes with poor soil conditions, snow-covered and avalanche prone areas exhibiting cold desert like conditions. Nevertheless, there is opportunity for limited plantations of select species, improvement of alpine pastures or cultivation of medicinal plants in the lower elevations of this DEM class.

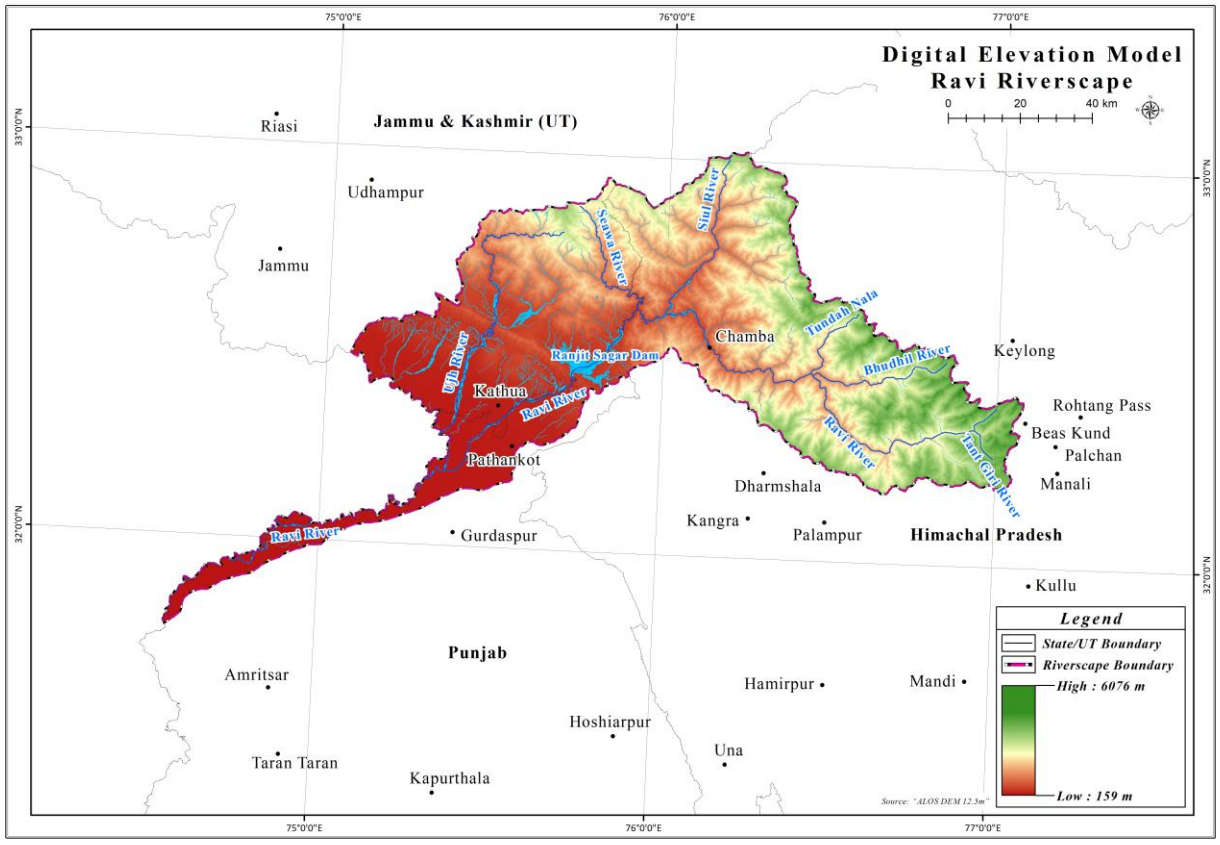


Fig. 3.14 – Digital Elevation Model of Ravi Riverscape

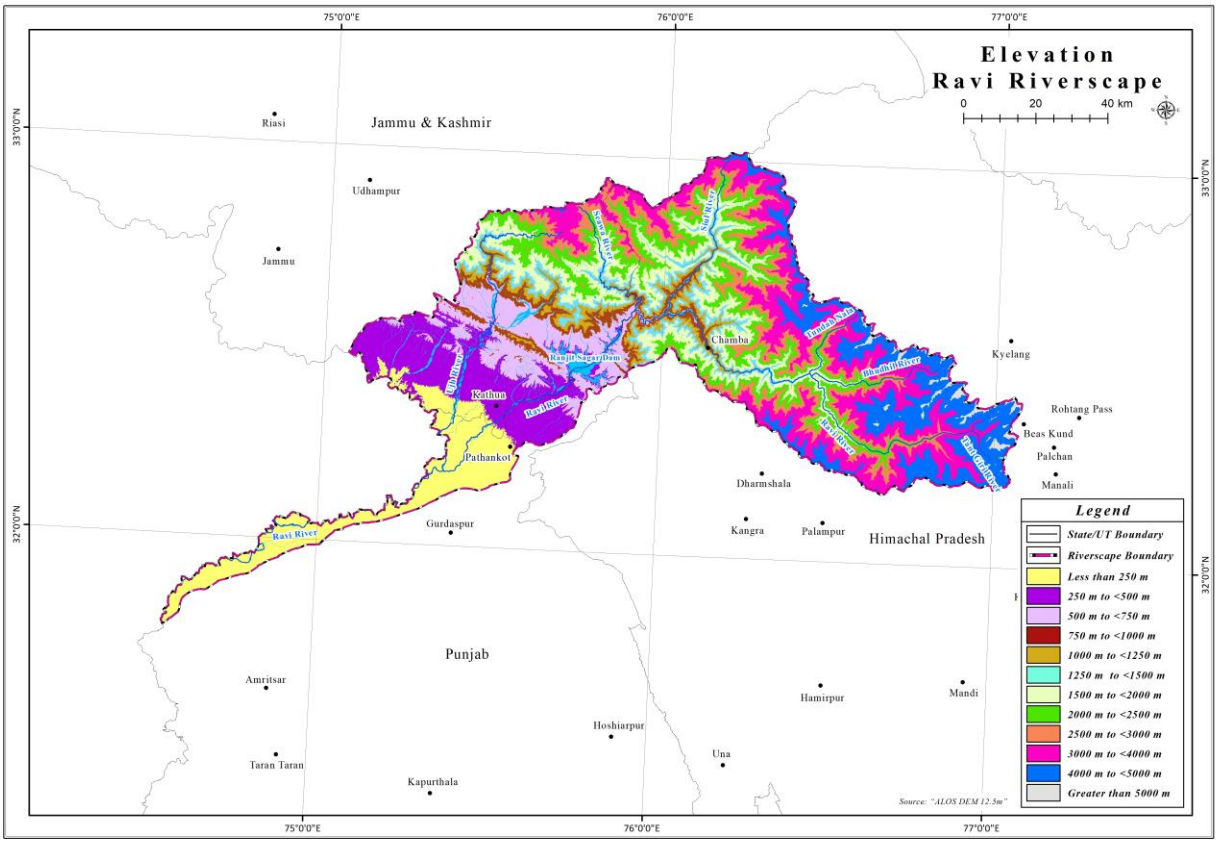


Fig. 3.15 – Ravi Riverscape Elevational Variation

Table 3.11- Distribution of Area under Different Elevation Categories in Ravi Riverscape

Sr.No.	Elevation Classes	Area (in km^2)	Representation of the Class (%)
1.	< 250 m	966.21	10.53
2.	250 -<500 m	1128.8	12.3
3.	500 -< 750 m	735.96	8.02
4.	750 -<1000 m	314.83	3.43
5.	1000 -<1250 m	319.85	3.49
6.	1250-<1500 m	390.1	4.25
7.	1500 -<2000 m	448.32	4.89
8.	2000 -<2500 m	491.37	5.36
9.	2500 -<3000 m	1860.57	20.28
10.	3000 -<4000 m	1413.68	15.41
11.	4000 -<5000m	1005.94	10.97
12.	5000 m	97.98	1.07
Total		**9173.61**	**100**

(ii) Slope

Slope information is considered vital while suggesting suitability of areas for forestry interventions, particularly plantations. The higher degree of slopes (>30°) usually cause a lot of soil erosion and are prone to landslides, greater runoff, etc. Thus, areas with slopes >30° to 45° require safeguards from erosion while raising plantations of multiple values (i.e., fuel wood, fodder, small timber, etc.). These types of forest resources are in heavy demand in higher reaches by increasing pressure of pilgrimage, presence of paramilitary forces, transhumance pastorals and widespread human settlements. A total of 10 classes of slope have been derived in the riverscape. The distribution of areas under different slope classes is given in Table. 3.12. Nearly 39% area of the riverscape lies in slope category >30°. About 15% area of the riverscape has slopes ≥40°. About 14% area of the riverscape lies in slope class <2.5° or nearly level slope category. A reasonable area of about 27% of the riverscape that lies southwest direction has lower categories of slope <10° (Fig. 3.16).

Table 3.12–Distribution of Area under Different Slope Categories

Sr. No.	Slope	Area (in km^2)	Percentage of Total Area (%)
1	$< 2.5^0$	1293.98	14.11
2	2.5^0 to $<5^0$	663.95	7.24
3	5^0 to $<10^0$	506.56	5.52
4	10^0 to $<15^0$	534.59	5.83
5	15^0 to $<20^0$	694.98	7.58
6	20^0 to $<25^0$	787.8	8.59
7	25^0 to $<30^0$	1052.42	11.47
8	30^0 to $<35^0$	1163.18	12.68
9	35^0 to $<40^0$	1064.68	11.61
10	$\geq 40^0$	1411.47	15.39
Total		**9173.61**	**100**

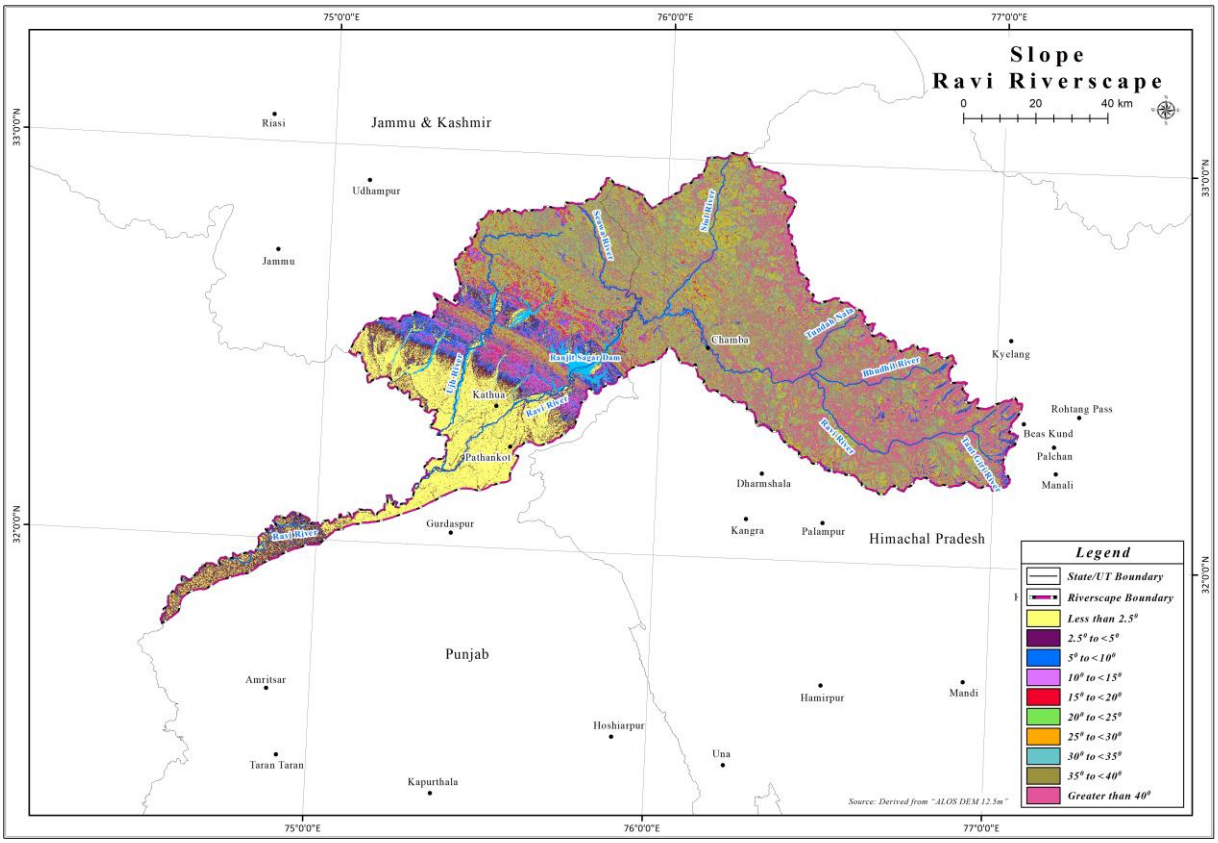


Fig. 3.16 – Map Showing Distribution of Area under Different Slope Categories in Ravi Riverscape

(iii) Aspect

Aspect, particularly in the Himalaya, influences the diversity and distribution of vegetation and microclimate. In the Himalaya, this effect can be seen to an extreme degree. North and South facing opposing slopes vary in their microclimate; light intensity, soil and air temperature, humidity, soil moisture and evaporation and duration of growing periods and these differences are closely associated with differences in vegetation composition and structure. The aspect map has been derived from the ALOS DEM. A total of nine categories viz., North, North-East, East, South-East, South, South-West, West, North-West and the Flat land has been analyzed in the study area. The distribution of areas under different aspect classes is given in Table 3.13 and Fig. 3.17.

Table 3.13-Percentage Distribution of Total Area in Different Aspect Categories of Ravi Riverscape

Sr.No.	Aspect	Area (in km^2)	Percentage of Total Area (%)
1.	Flat (-1)	400.44	4.37
2.	North (0-<22.5, 337.5-360)	968.35	10.56

3.	Northeast (22.5- <67.5)	936.79	10.21
4.	East (67.5-<112.5)	953.08	10.39
5.	Southeast (112.5-<157.5)	1172.19	12.78
6.	South (157.5-<202.5)	1246.62	13.59
7.	Southwest (202.5-<247.5)	1322.97	14.42
8.	West (247.5-<292.5)	1128.94	12.31
9.	Northwest (292.5-<337.5)	1044.23	11.38
Total		**9173.61**	**100**

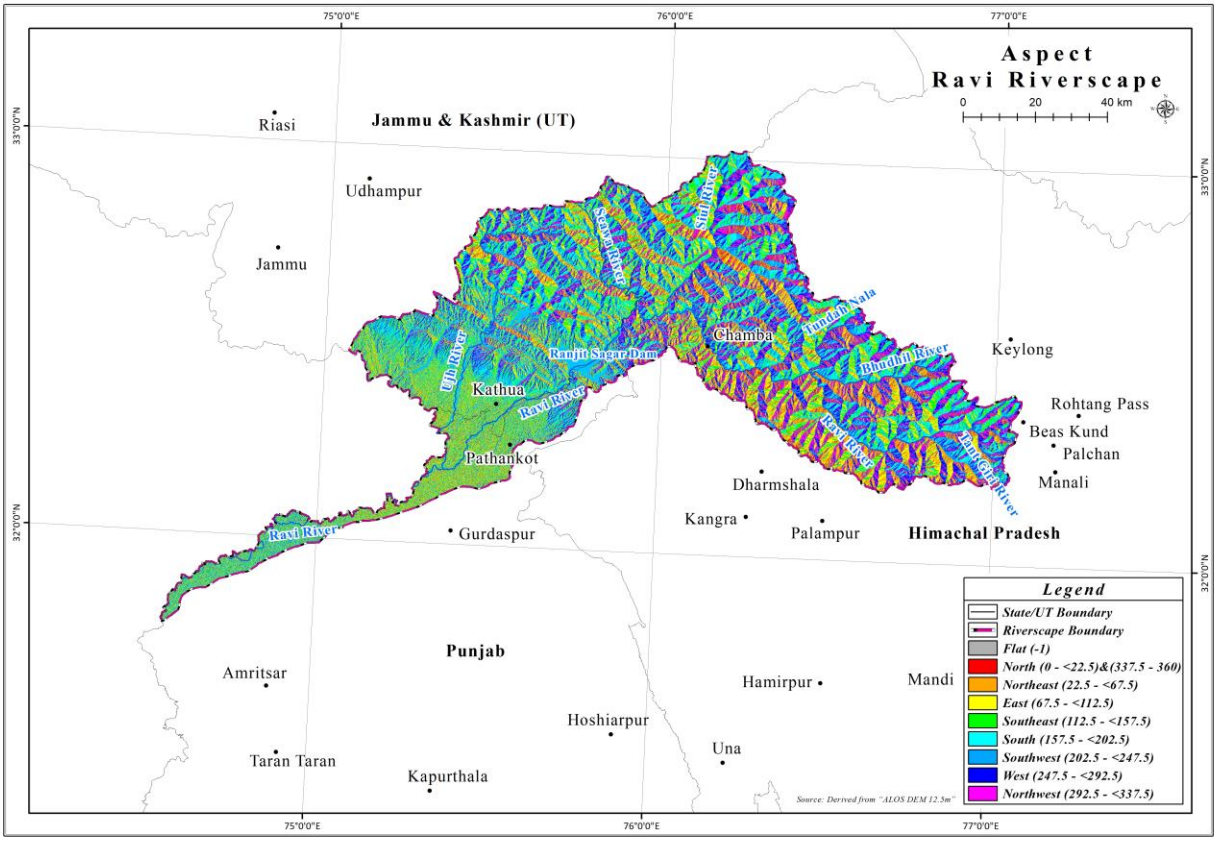


Fig. 3.17 - Aspect Map of Ravi Riverscape

(iv) Soil Types

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together supports life. The earth's body of soil is called as the pedosphere and has four important functions to perform. These functions are: (a) provide medium for plant growth, (b) serves as a means of water storage, supply and purification, (c) help as a modifier of earth's atmosphere and store carbon, and (d) provide habitat for a wide range of organisms including invertebrates, microorganisms, etc. Soil is a product of several factors *viz*., the

influence of climate, relief (elevation), orientation, and slope of terrain), organisms, and the soils parent materials (original minerals) interacting over time. Soils continuously undergo development by way of numerous physical, chemical and biological processes including weathering and associated erosion. Natural ecosystems (i.e., forests, grasslands, wetlands and agro ecosystems) are impacted in far reaching ways by the various processes carried out in the soil. Hence, from the perspective of present DPR, understanding of soils in the riverscape is critical as they form an important biotic variable that determines the suitability of site conditions for proposed forestry interventions, mainly tree and other plantations (i.e., grass, herbs, shrubs, medicinal plants, orchids, etc.). Soil is considered as one of the most important parameter for modelling suitability of forest plantation zones. Since choice of species mainly depend upon the soil type and soil depth these parameters have been derived from Soil map prepared by NBSS-LUP for further use in modelling in the present study. A total of 16 soil type classes have been recorded in the riverscape. Various soil types and their proportionate area estimates are given in (Table 3.14). The soil type – Dystic Eutrochrepts was the most dominant soil type in the Ravi Riverscape as this soil type coverd nearly 33% area of the riverscape. This was followed by Typic Udorthents occupying 24.68% of the riverscape and they are characterized as moderate acidic, moderate to strong stony and found on moderate to steep slopes (Fig. 3.18).

Table 3.14- Distribution of Area under Different Soil Types and Other Land Attributes in Ravi Riverscape

Sr.No.	Soil type	Area (in km^2)	Percentage of Total Area (%)
1.	Dystric Eutrochrepts	3027.01	33
2.	Dystric Fluventic Eutrochrepts	3.63	0.04
3.	Fluventic Eutrochrepts	330.7	3.6
4.	Lithic Cryorthents	138.2	1.51
5.	Lithic Udorthents	1352.74	14.75
6.	Mollic Udorthents	1.63	0.02
7.	Typic Cryorthents	620.49	6.76
8.	Typic Eutrochrepts	175.94	1.92
9.	Typic Udifluvents	96.69	1.05
10.	Typic Udorthents	2263.77	24.68
11.	Typic Ustifluvents	296.96	3.24
12.	Typic Ustipsamments	137.56	1.5
13.	Typic Ustochrepts	144.11	1.57

14.	Typic Ustorthents	20.32	0.22
15.	Udic Ustochrepts	205.24	2.24
16.	Udic Ustorthents	148.83	1.62
17.	Non-Soil	209.79	2.29
Total=		**9173.61**	**100**

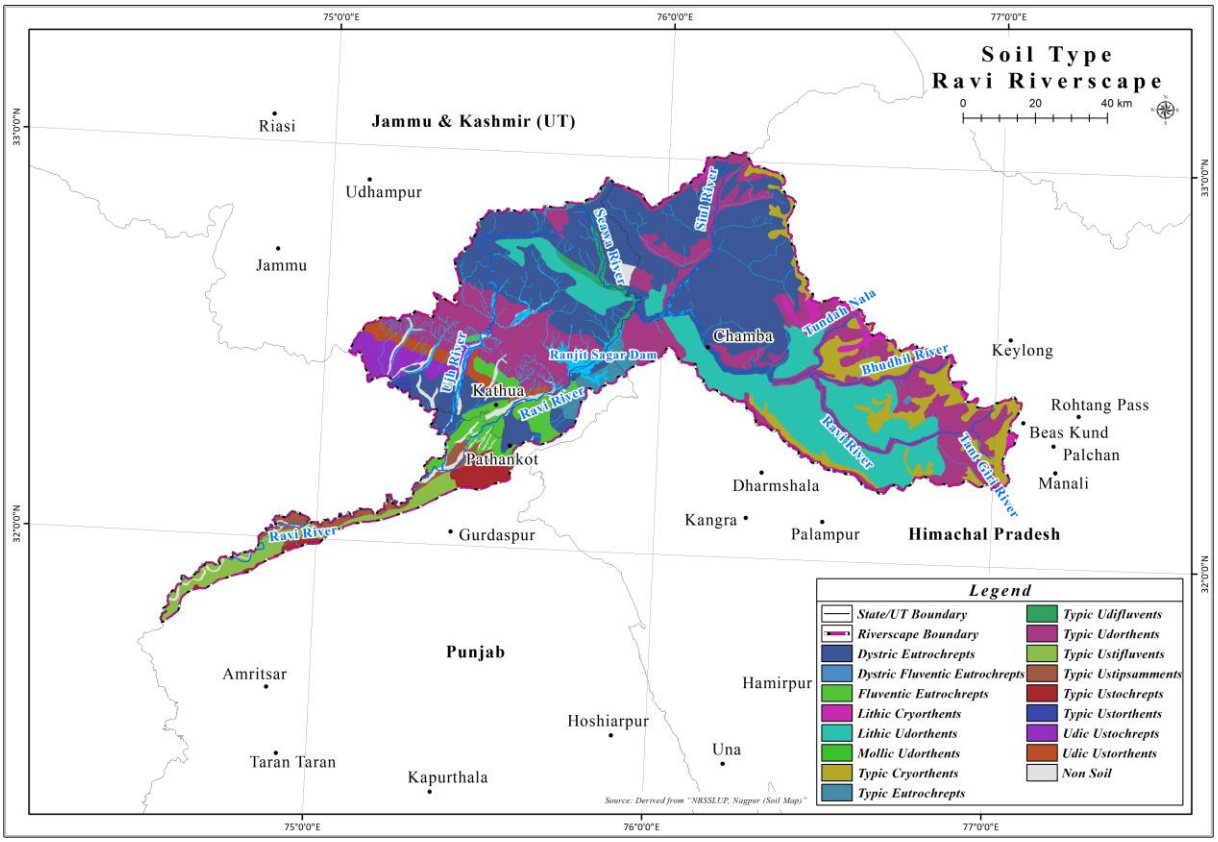


Fig. 3.18 - Map showing Distribution of Soil Types in Ravi Riverscape

(v) Soil Depth

Soil depth, in addition to soil type, texture and structure can influence water availability, limit root growth and can influence nutrient access. Soil depth can greatly influence the type of plants that can grow in them. Deeper soils generally provide more water and nutrients to plants than more shallow soils. Soil depth is another important variable for suggesting suitability of tree species for a plantation. The depth is important for the penetration of the roots of plant or tree species. Five depth classes, *vis*., Very Deep, Moderately Deep, Deep, Shallow, and Very Shallow have been mapped in Ravi Riverscape (Table 3.15). Nearly 33% area of the riverscape has shallow soils while deep soils accounted for 26.78% area of the riverscape.

About 21.05% area of the riverscape has moderate soils while 10.67% area harbour very deep soils (Fig. 3.19).

These areas could be suggested as suitable for plantations based on other ground parameters. The distribution of area under different soil depth classes is given in Table. 3.15.

Table 3.15-Distribution of Area under Different Soil Depth Categories in Ravi Riverscape

Sr.No.	Soil depth	Area (in km^2)	Percentage of Total Area (%)
1.	Very Deep	978.71	10.67
2.	Moderately Deep	1931.34	21.05
3.	Deep	2456.91	26.78
4.	Shallow	3047.7	33.22
5.	Very Shallow	549.16	5.99
6.	Non-Soil	209.79	2.29
	Total	**9173.61**	**100**

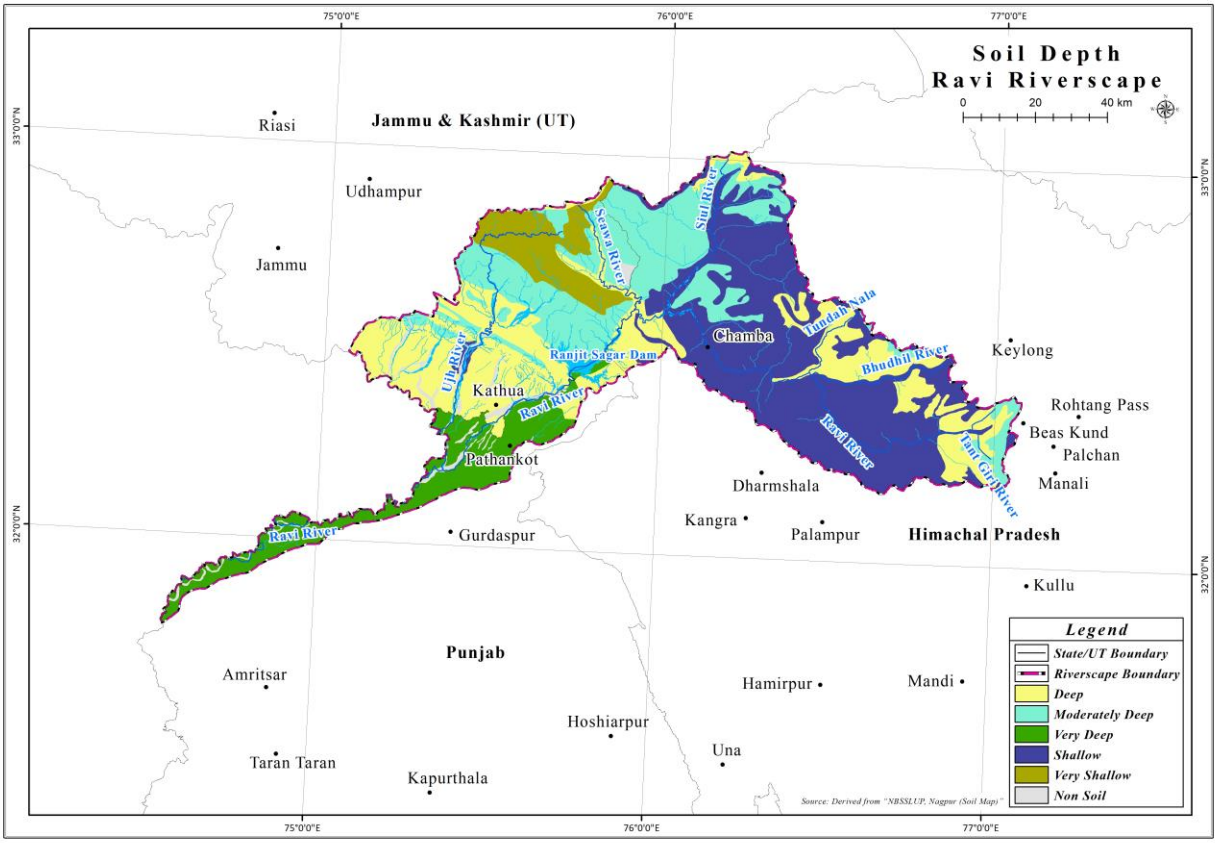


Fig. 3.19 - Map showing Soil Depth Variation in Ravi Riverscape

(vi) Soil Erosion

Soil erosion is the displacement of the upper layer of soil and it is one form of soil degradation. Soil erosion is a naturally occurring process caused by the dynamic activity of erosive agents i.e., water, ice, snow, air, plants, animals and humans that affects all landforms. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of top soil. Human activities caused by intensive agriculture, deforestation, construction/ widening of roads, construction of HEPs, urban sprawl and erratic climatic conditions are some of the prominent factors responsible for soil erosion in the mountainous catchment of Ravi river. Based on information obtained from the Indian Institute of Soil and Water Conservation, Dehra Dun an insight on the status of soil erosion has been developed. A total five categories of erosion classes have been mapped in the riverscape, *viz*., < 5 t ha^{-1} yr^{-1}; 5 t ha^{-1} yr^{-1} to <10 t ha^{-1} yr^{-1}; 10 t ha^{-1} yr^{-1} to < 20 t ha^{-1} yr^{-1}; 20 t ha^{-1} yr^{-1} to <40 t ha^{-1} yr^{-1}; and 40 t ha^{-1} yr^{-1}. Nearly 33% area of the riverscape was recorded under high and very high soil erosion categories. Only 3.34% area of the riverscape was under the category of very low erosion (Fig. 3.20). An area of 1628.96 km^2 falls under non-soil category. These areas may not be suitable for forest plantations. The distribution of areas under different erosion classes and their area is given in Table 3.16.

Table 3.16 - Distribution of Area under Different Soil Erosion Categories

Sr.No.	Soil Erosion(tons/hectare/year)	Erosion Intensity Class	Area (in km^2)	Percentage of Total Area (%)
1.	<5	Very Low	2875.2	31.34
2.	5 - <10	Low	520.3	5.67
3.	10 - <20	Medium	1093.18	11.92
4.	20 - <40	High	1200.43	13.09
5.	≥40	Severe	1855.54	20.23
6.	Non Soil	-	1628.96	17.76
Total			**9173.61**	**100**

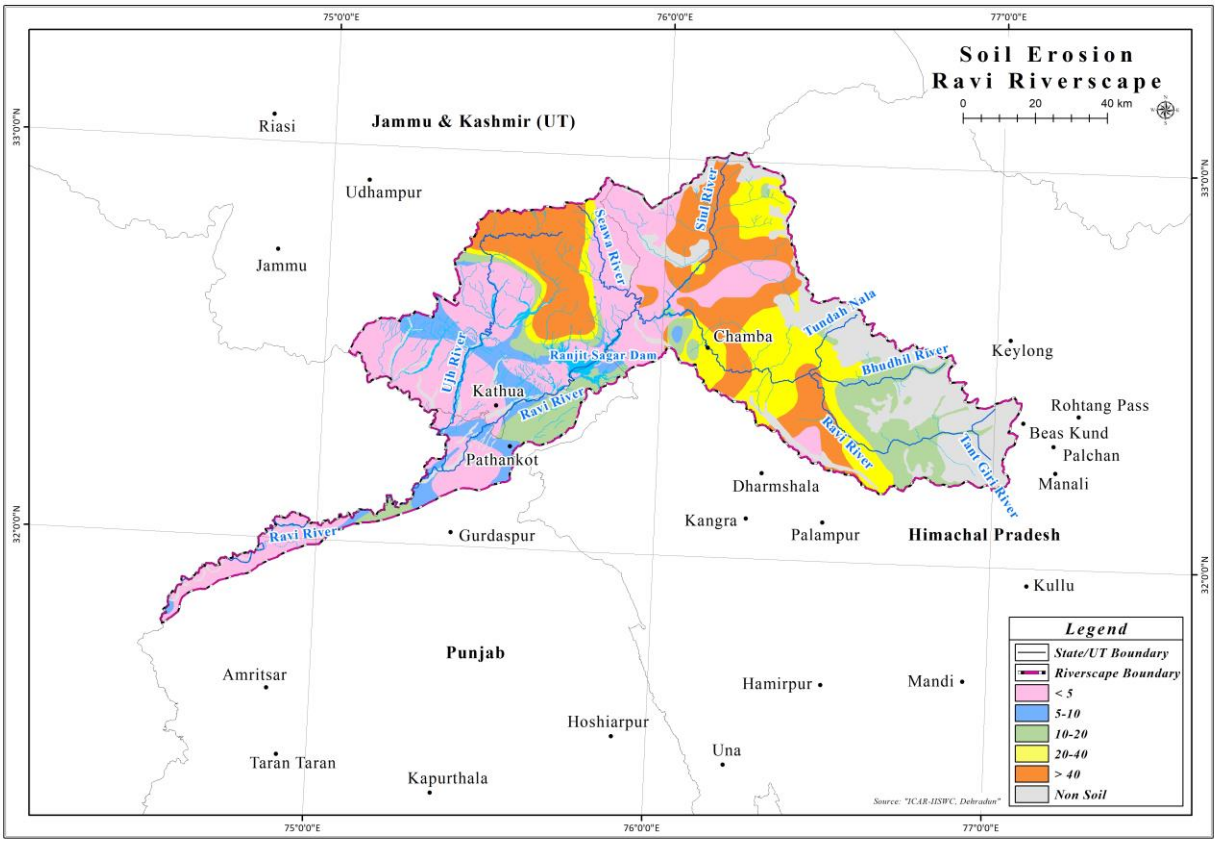


Fig. 3.20 - Soil Erosion Map of Ravi Riverscape

(vi) Forest Types and Forest Density

The forest types are most important in suggesting suitable sites for forestry interventions based on areas which do not have dense forest cover or which fall in scrub and riverine habitats along the river banks. The forest type and cover map was been prepared using reference of the data provided by Forest Survey of India. The vegetation type is most important in suggesting suitable sites based on areas which do not have dense forest cover or which are falling in scrubs and grasslands along the river banks. It is observed that 5607.26 km^2 area is falling under non-forest category and Himalayan Moist Temperate Forests recorded the maximum area amongst various forest types and represented about 11.22% area of the riverscape. The Tropical Dry Deciduous Forest represented about 9.65% area of the riverscape. Sub-tropical dry deciduous forests covered 735.79 km^2 and covered 8.02% area of the riverscape. Scrubs covered nearly 5.16% area of the riverscape The Dry Alpine Forests represented 4.24% area of the riverscape (Table 3.17 & Fig. 3.21). Table 3.18 on distribution of different forest cover categories in the Ravi Riverscape revealed that a greater proportion of the riverscape falls under Non-Forest category (5607.26 km^2). Out of remaining area under different forest cover categories, the moderately dense forest occupied the highest cover and represented 11.81% of all forest types. Dense forests constituted 11.59% of all forest cover categories.

The open forests represented 10.31% area of all forest types while scrub represented a meager proportion of 5.16 of all forest types (Table 3.18 & Fig. 3.22). The Administrative divisions of forests falling in the riverscape are given in Table 3.19 and Fig. 3.23. However, there is a gap in beat data for Jammu region of Jammu and Kashmir UT. Forests within the riverscape belonging to (Himachal Pradesh and Punjab) and (Jammu & Kashmir UT) are managed by 16 Forest Divisions, 47 Forest Ranges, and 293 Forest Beats (Beat data J&K not provided). Out of total 14 Forest Divisions, 6 Forest Divisions are in Himachal Pradesh, 6 Forest Divisions are in J&K UT while remaining 4 Forest Divisions are in Punjab (Table 3.19).

Table 3.17- Distribution of Area under Different Forest Type Categories in Ravi Riverscape

Sr. No.	Forest type	Area (in km^2)	Percentage of Total Area (%)
1.	Dry Alpine Forests	388.59	4.24
2.	Himalayan Dry Temperate Forests	3.28	0.04
3.	Himalayan Moist Temperate Forests	1029.44	11.22
4.	Moist Sub-Alpine Forests	2.15	0.02
5.	Sub-Alpine Forests	48.42	0.53
6.	Sub-tropical Pine Forests	735.79	8.02
7.	Tropical Dry Deciduous Forests	885.59	9.65
8.	Scrubs	473.09	5.16
9.	Non-Forest	5607.26	61.12

Table 3.18- Distribution of Area under Different Forest Cover Categories in Ravi Riverscape

Sr. No.	Forest Cover	Area (in km^2)	Percentage of Total Area (%)
1.	Dense Forests	1063.45	11.59
2.	Moderately Dense Forests	1083.63	11.81
3.	Non Forests	5607.26	61.12
4.	Open Forests	946.18	10.31
5.	Scrubs	473.09	5.16
Total		**9173.61**	**100**

Table 3.19-Administrative Divisions of Forests in Ravi Riverscape

Sr. No.	State and UTs	Division	Range	Beat
1.	Jammu and Kashmir UT	6	14	Data not provided
2.	Himachal Pradesh	6	21	192
3.	Punjab	4	12	99
Total		**16**	**47**	**293**

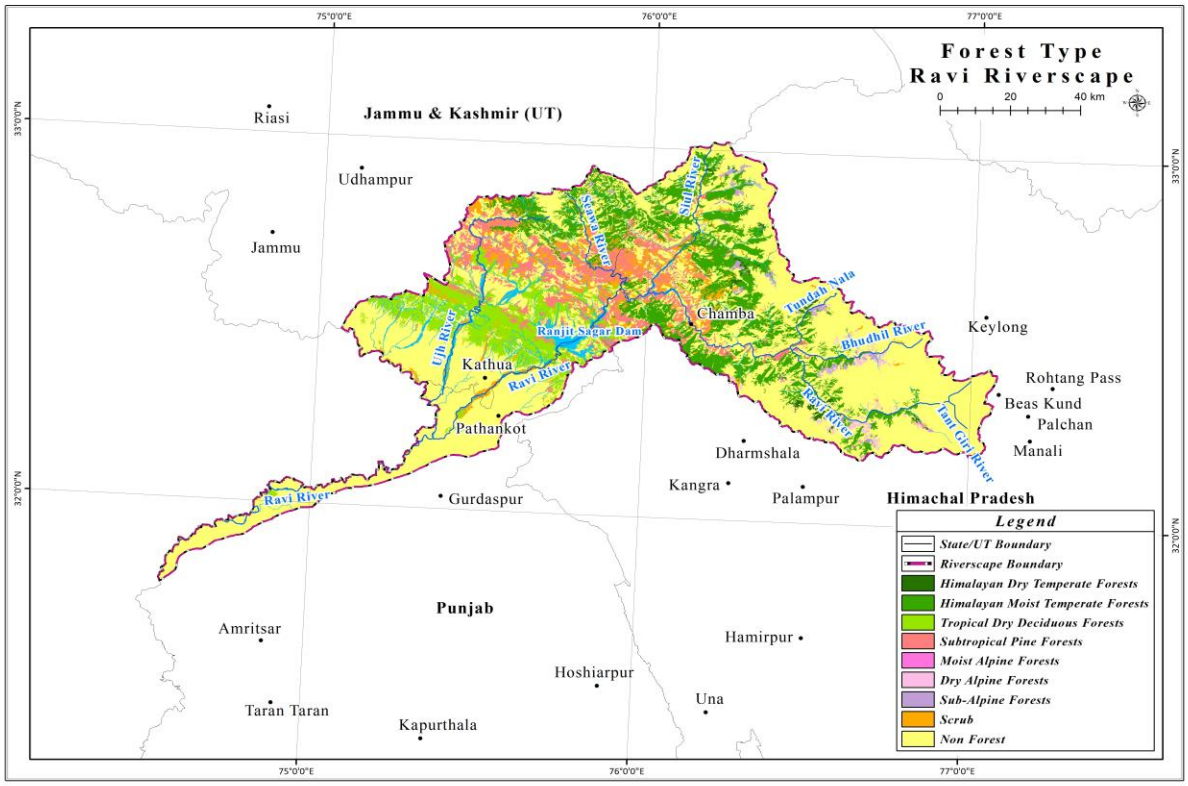


Fig. 3.21 - Forest Types Map of Ravi Riverscape

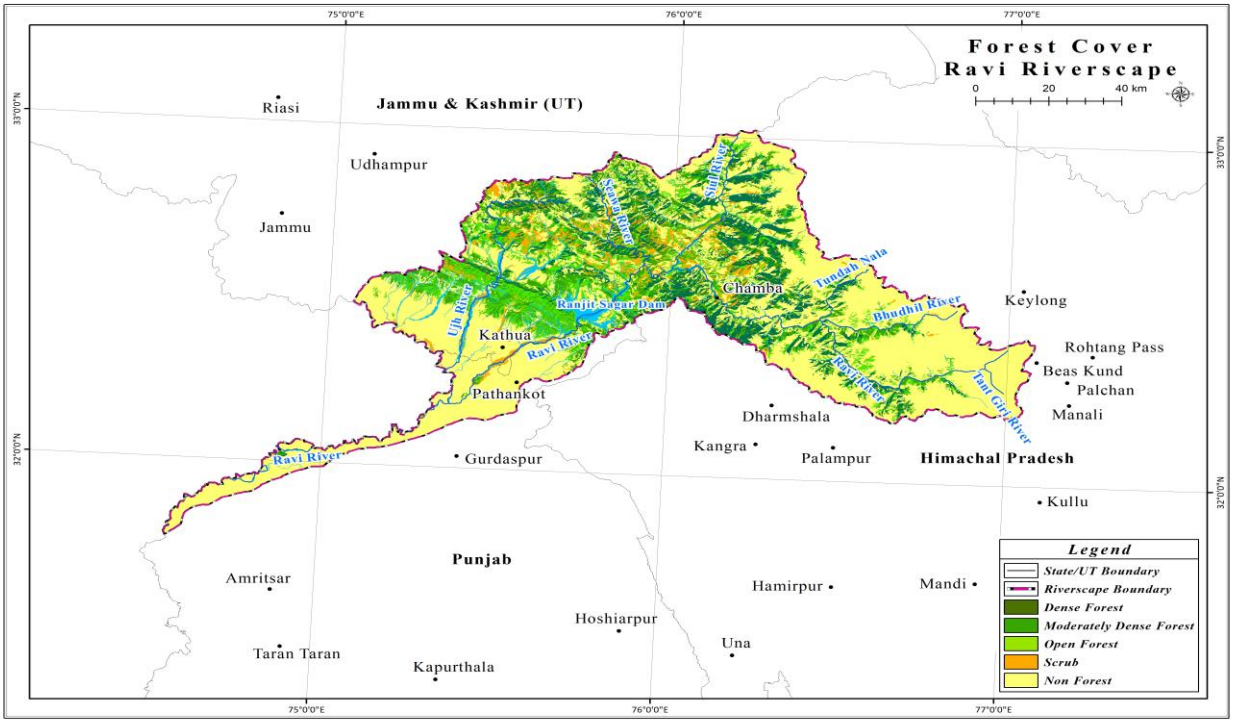


Fig. 3.22 - Forest Density Map of Ravi Riverscape

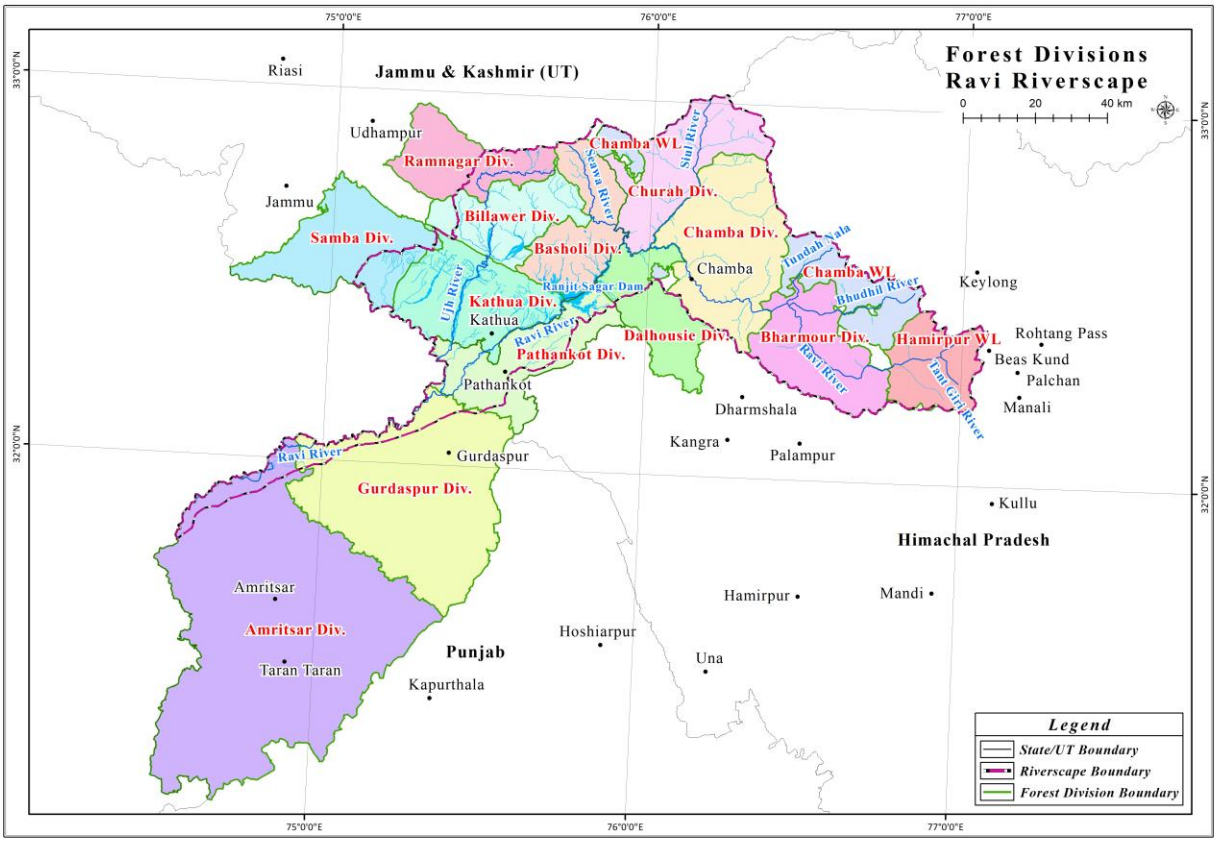


Fig. 3.23 - Administrative Divisions Map of Forests in Ravi Riverscape

(viii) Land Use and Land Cover

Land information is important to a wide variety of human activities such as agriculture, forestry, water resources, as well as other types of land resource management. The forgoing sections have provided an insight on diversity of forest types, extent of forest cover and changed in forest cover in the context of Himachal Pradesh, Jammu & Kashmir UT and Punjab based on the information made available by FSI in its biennial assessments since 1987 (FSI, 2019). The present section specifically provides baseline information on land use land cover in the Ravi Riverscape. The preprocessed geometrically and radio-metrically corrected PAN merged satellite datasets were displayed on screen for attempting visual interpretation of various land use classes. Standard image interpretation keys, viz., shape, size, color, tone, texture, pattern, shadow, site, association, and phenology have been used to generate Image Interpretation scheme. The geospatial analysis of Ravi Riverscape identified altogether 16 Land Use and Land Cover categories (Table 3.20). The maximum area of the riverscape was covered by agriculture, representing 25.27% extent of the total area. Snow and Glaciers accounted for nearly 18.93% area of the riverscape. Moderately Dense Forests accounts for 11.81% area. Alpine Pastures and water bodies accounts lowest proportion of Riverscape area (1.01%, each).

Two categories of rivers i.e., perennialriver and dry river and sand represented 1.31% area of the riverscape. Barren area within the riverscape represented 11.06%, Settlements covered 1.1% area of the riverscape. The distribution of Land Use and Land Cover categories in Ravi Riverscape is depicted in Fig. 3.24.

1. Agricultural Land

These are the lands primarily used for farming and for production of food, fiber, horticulture, etc. They are mainly the lands with standing crops i.e., cropland bright red to red color on satellite image, fallow land i.e., uncropped for one or more season; yellow to greenish blue tone, agriculture plantation i.e., tea, coffee, etc., plantation i.e., herbs, nurseries, orchards, etc, dark red to red and regular sharp edged shapes).

2. Natural/Semi-natural Grassland

These are the areas of having grass type (Monocots) vegetation, they appear in light red to light brown of varying sizes and irregular shapes.

Alpine/Sub-alpine are the places between the coniferous forest and permanent snow covered areas. An alpine zone commences is variable and line between 3000-5600 m asl (Above sea level).

3. Barren

This can clearly be delineated of the image having bright white to light blue to yellow to brown color tone depending upon the rock type. These are located on isolated hill slopes, plateau, etc.

4. Water Bodies

This category comprises areas with surface water i.e., ponds, lakes, rivers, canals, etc. these can clearly be seen on a satellite image in blue to dark blue or cyan color depending on the depth of water.

Rivers (Perennial/Dry) are natural course of water flowing on the land surface along a definite channel/slope regularly or intermittently towards another water body in most cases, sea, another river, lake, marsh, etc. They appear in light to dark blue, irregular shape (nonlinear). There are two major categories of rivers, perennial i.e., flow continuously throughout the year and dry i.e., flow only during monsoon period.

Canal is artificial water course constructed for irrigation purposes it has a regular linear shape on image.

5. Forests

These are the areas bearing an association predominantly of trees and other vegetation types (within the notified forest boundaries).

Dense areas includes canopy cover/density of > 70%. (Dark red to red color tone)

Moderately Dense forest areas includes the canopy cover/ density of 40-70%. (Red to light red in color tone)

Open forest areas includes the canopy cover/density of 10-40%. (Light red color tone)

6. Scrubs

This land is prone to deterioration due to erosion. These land generally occupy higher locations (excluding mountains and hills). They appear light yellow to brown to greenish blue depending upon the surface moisture and vegetation cover. It varies in sizes from small to large and generally surrounded agriculture, river area, and forests.

7. Built-up/Settlement

It is an area of human habitation developed due to non-agricultural use and that has a cover of buildings, transport, and communication utilities associated with water, vegetation and vacant lands. They appear in dark bluish green in the core and bluish in the periphery; the size varies from small to big; can be centered, clustered, or in scattered form.

8. Snow Covered/Glacial Area

These are the areas under perpetual snow cover confined to the Himalayan region. It appear bright white to white in color depending on the moisture and thickness of snow. It poses irregular shape and located in mountain peaks (higher altitudinal areas).

Onscreen visual interpretation technique has been used for delineating major Land Use and Land Cover types i.e., Agriculture, Alpine pastures, Barren, Canal, Cloud, Cloud shadow, Dense

forest, Moderately dense forest, Open forest, Plantation, River (Dry)/River Sand, River (Perennial), Scrub, Settlement, Snow/Glaciers and Water body in the riverscape is given in Table 3.20 and Fig. 3.24.

Table 3.20- Distribution of Area under Different Land Use and Land Cover Categories in Ravi Riverscape

Sr. No.	Land Use and Land Cover	Area (in km^2)	Percentage of Total Area (%)
1.	Agriculture	2318.27	25.27
2.	Alpine Pastures	0.99	0.01
3.	Barren	1014.89	11.06
4.	Canal	5	0.05
5.	Cloud	135.63	1.48
6.	Cloud Shadow	0.81	0.01
7.	Dense Forest	1063.45	11.59
8.	Moderately Dense Forest	1083.63	11.81
9.	Open Forest	946.18	10.31
10.	Plantation	39.68	0.43
11.	River (Dry)/River Sand	119.73	1.31
12.	River (Perennial)	134.04	1.46
13.	Scrub	473.09	5.16
14.	Settlement	100.96	1.1
15.	Snow/Glaciers	1736.54	18.93
16.	Waterbody	0.72	0.01
Total		**9173.61**	**100**

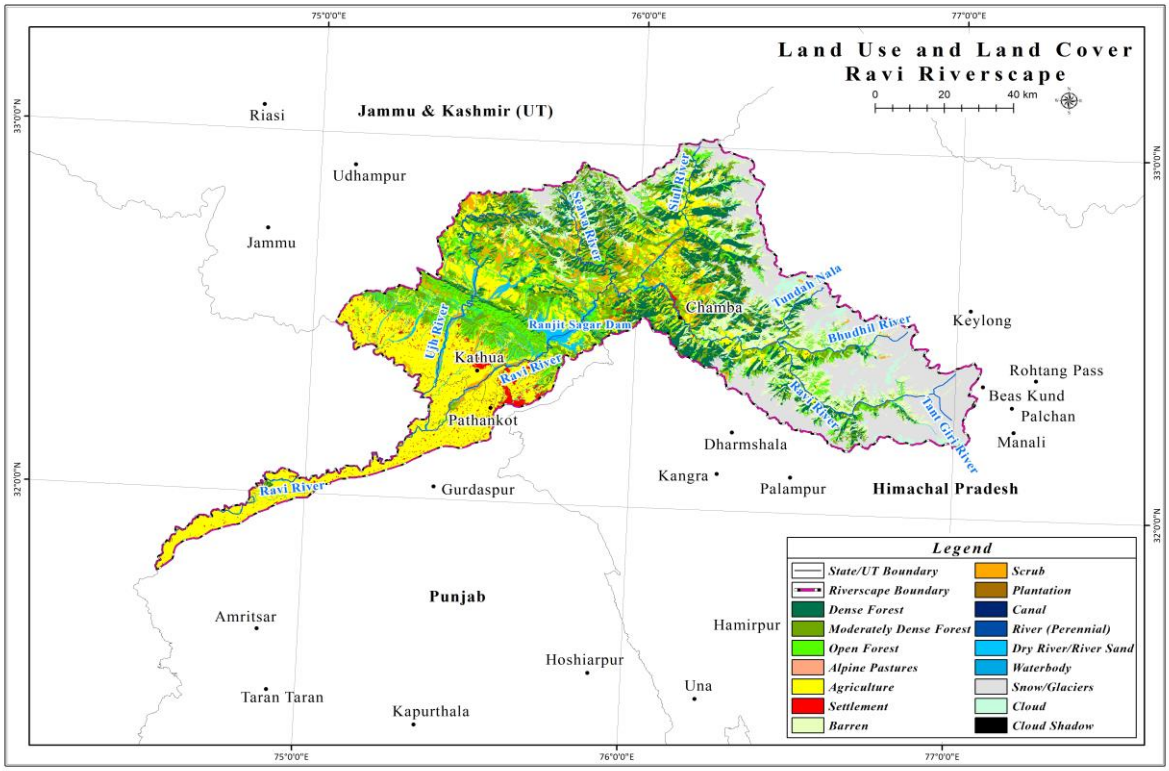


Fig. 3.24 – Map showing Land Use and Land Cover Categories of Ravi Riverscape

(ix) Number of Patches in Major Land Use Categories

Number of patches and their size of a particular Land Use category provide great insight on the process of fragmentation. Patches of six land use categories were assessed. These Land Use categories are: Dense Forest, Moderately Dense Forest, Open Forest, Scrub, Agriculture and Barren and others were reclassified according to geometric interval. After reclassification number of patches and area of each class have been calculated. The maximum number of patches, being 2676 was recorded in case of Open Forest while the minimum number of patches, being 875 was registered in Barren Category (Table 3.21). Table 3.21 presents number of patches in select natural and man-made Land Use and Land Cover categories (Fig. 3.25 to Fig. 3.32). In case of Dense Forests category, 884 patches were recorded. These patches ranged from 0.00 $km^2$to 0.14 km^2; 0.14 km^2 to 0.33 km^2; 0.33 km^2 to 0.87 $km^2$and > 0.87 km^2. Altogether, 1938 patches of Moderately Dense Forests were recorded. Out of this, nearly 25.75% patches were 0.00 km^2 to 0.10km^2 in size. The patches of this category were widely distributed all through the mountainous part of the Ravi Riverscape. In case of Open Forest category, in all 2676 patches were registered. Out of this, nearly 28% patches were 0.00 km^2 to 0.10km^2. About 50.00% patches were in 0.13 km^2 to 0.30 km^2 and >0.30 km^2 size. In all, 1120 patches in case of scrub category were recorded. In the case of agriculture category, 944 patches were recorded.

Nearly, 26% patches were of 0.00 km^2 to 0.10km^2. In yet another man-made category, 875patches of barren class were registered in the entire riverscape.

Table 3.21- Distribution of Patches in Various Natural and Manmade LULC Categories in Ravi Riverscape

Sr.No.	Area (in km^2)	Number of Patches	Percent Representation (%)
Dense Forest			
1	0.00-< 0.14	232	26.24
2	≥0.14 -< 0.33	211	23.87
3	≥0.33-<0.87	219	24.77
4	> 0.87	222	25.11
Total		**884**	
Moderate Dense Forest			
1	0.00 -< 0.10	499	25.75
2	≥0.10-< 0.21	465	23.99
3	≥0.21-<0.50	487	25.13
4	≥0.50	487	25.13
Total		**1938**	
Open Forest			
1	0.00 -< 0.07	736	27.5
2	0.07 -<0.13	582	21.75
3	0.13 -<0.30	682	25.49
4	≥0.30	676	25.26
Total		**2676**	
Scrub			
Sr.No.	**Area (in km^2)**	**Number of Patches**	**Percent Representation (%)**
1	0.00 -< 0.06	284	25.36
2	0.06 -<0.13	276	24.64
3	0.13 -<0.34	282	25.18
4	≥0.34	278	24.82
Total		**1120**	

Agriculture			
1	0.00 -< 0.11	245	25.95
2	0.11 -<0.26	230	24.36
3	0.26 -< 0.82	235	24.89
4	≥0.82	234	24.79
Total		**944**	
Barren			
1	0.00 ->0.08	224	25.6
2	0.08 -> 0.21	212	24.23
3	0.21 -> 0.73	221	25.26
4	≥0.73	218	24.91
Total		**875**	

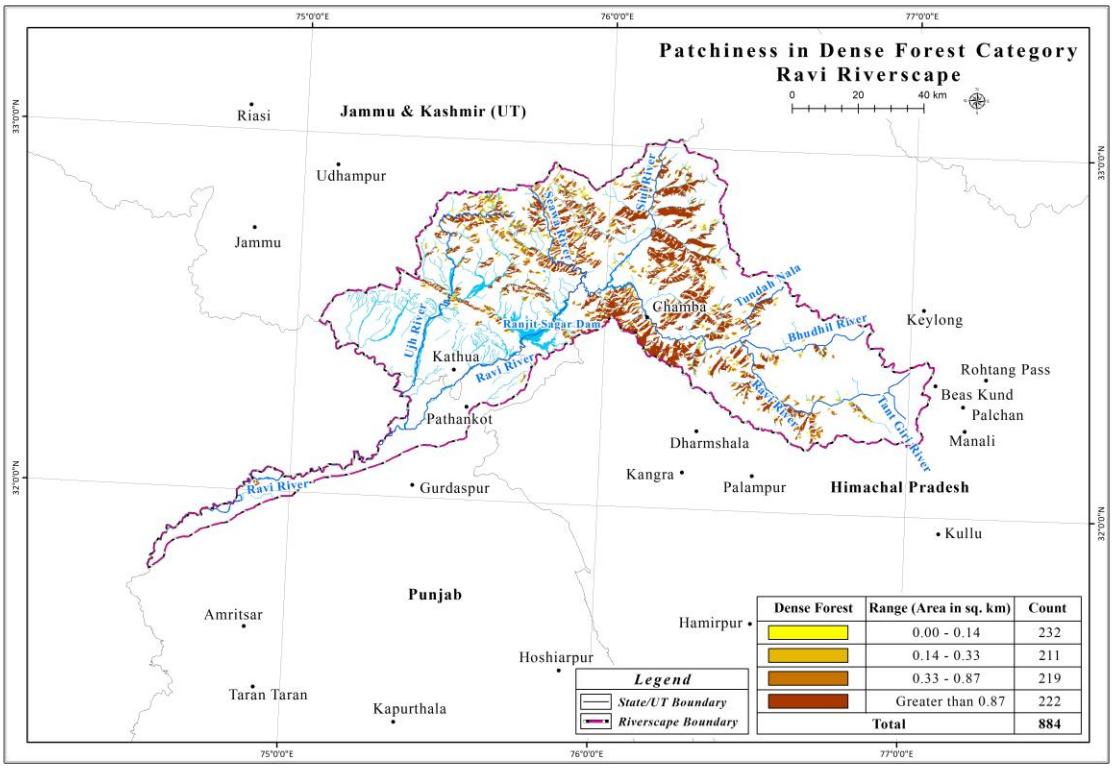


Fig. 3.25 – Map showing Patchiness in Dense Forests of Ravi Riverscape

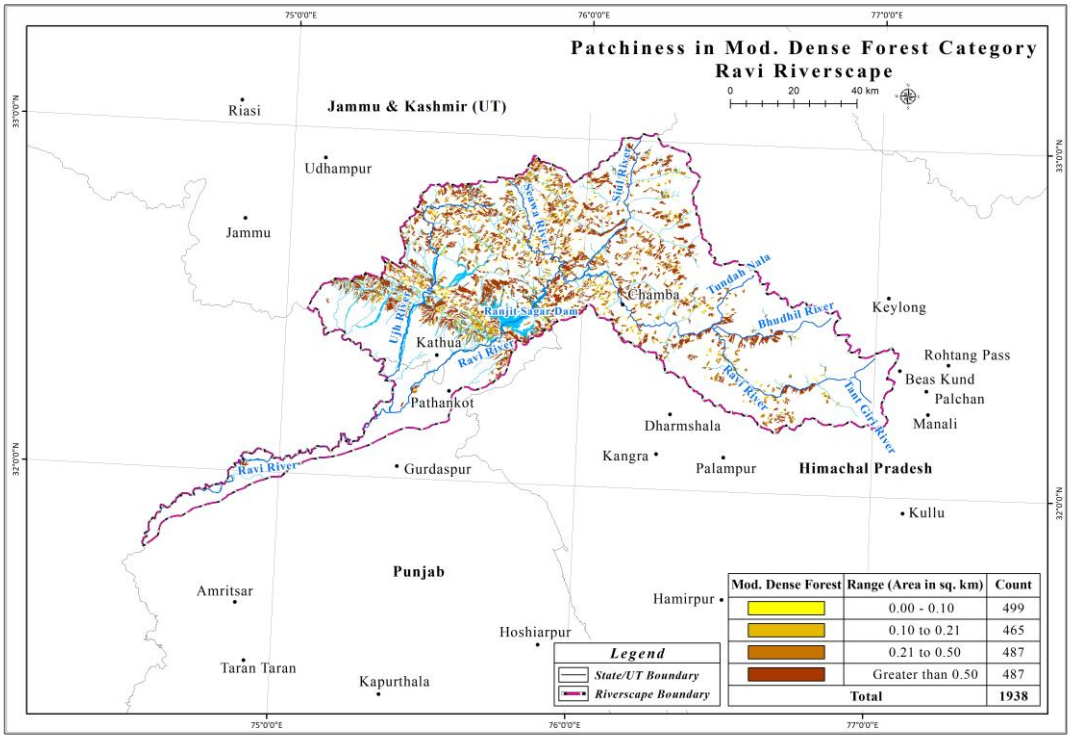


Fig. 3.26 - Map showing Patchiness in Moderately Dense Forests of Ravi Riverscape

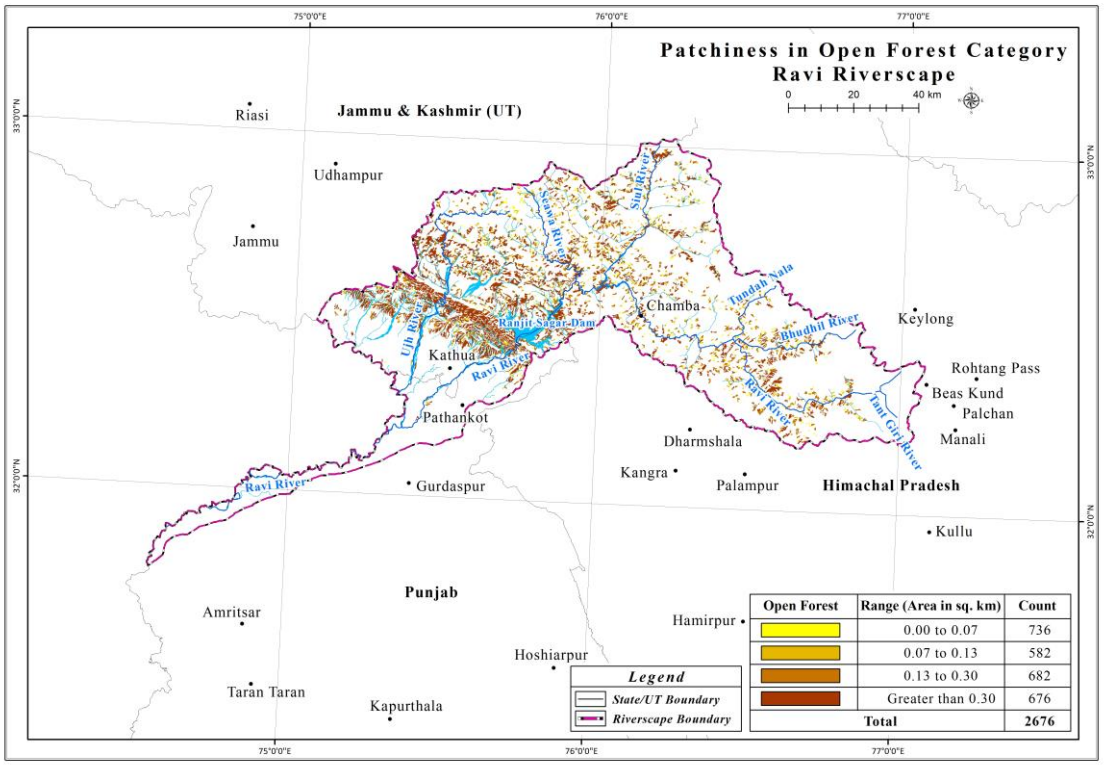


Fig. 3.27 - Map showing Patchiness in Open Forests of Ravi Riverscape

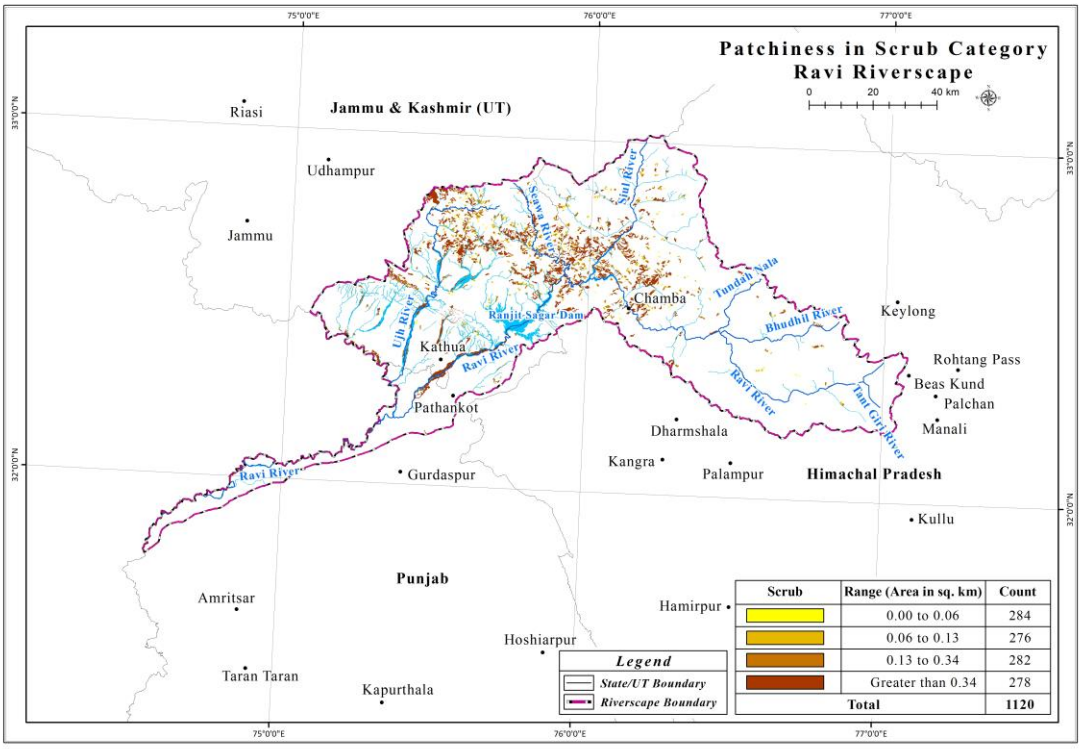


Fig. 3.28 - Map showing Patchiness in Scrub Forests of Ravi Riverscape

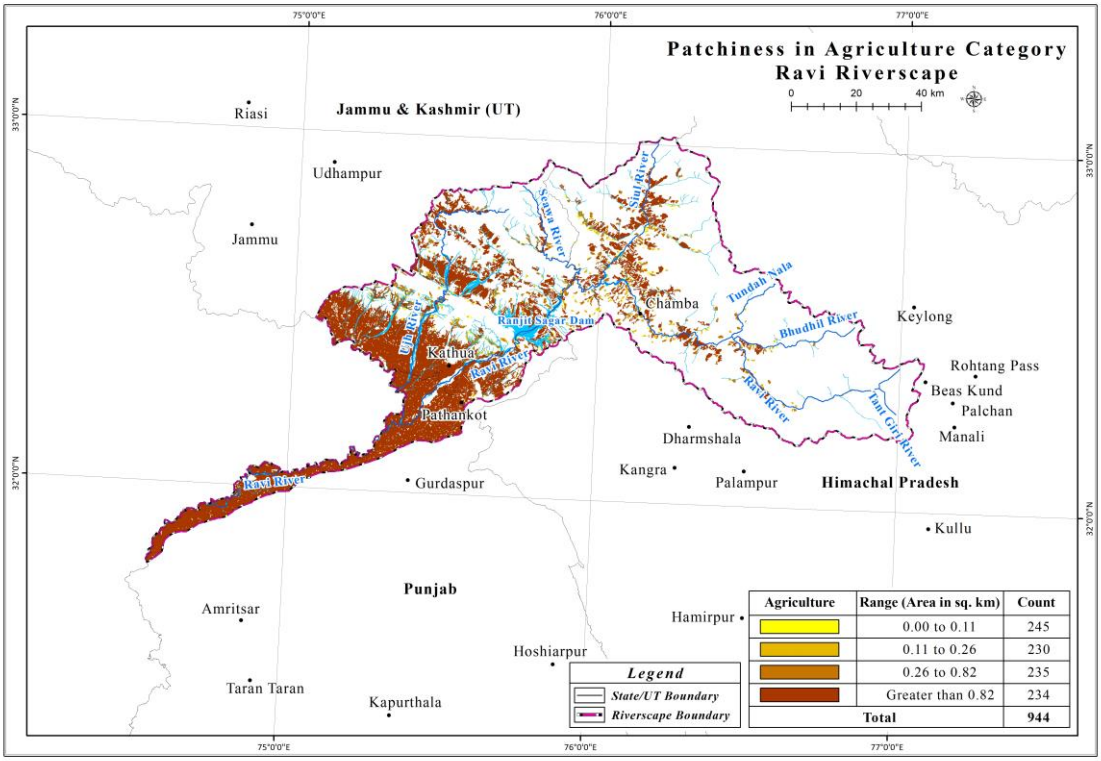


Fig. 3.29 - Map showing Patchiness in Agriculture of Ravi Riverscape

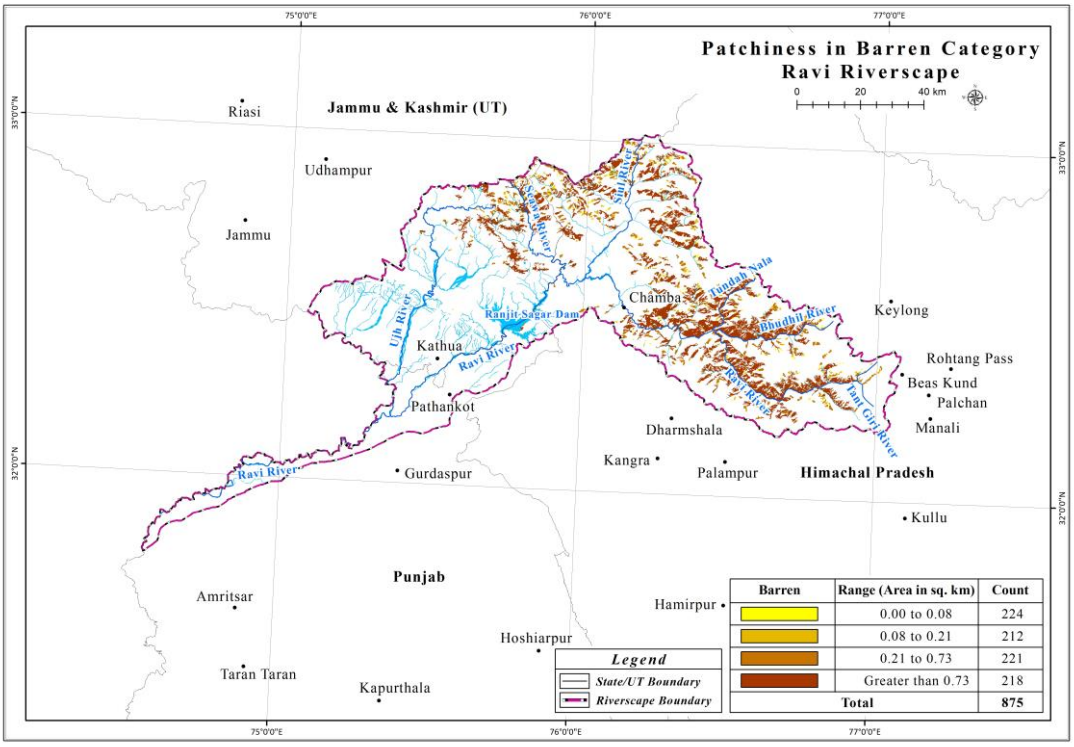


Fig. 3.30 - Map showing Patchiness in Barren category of Ravi Riverscape

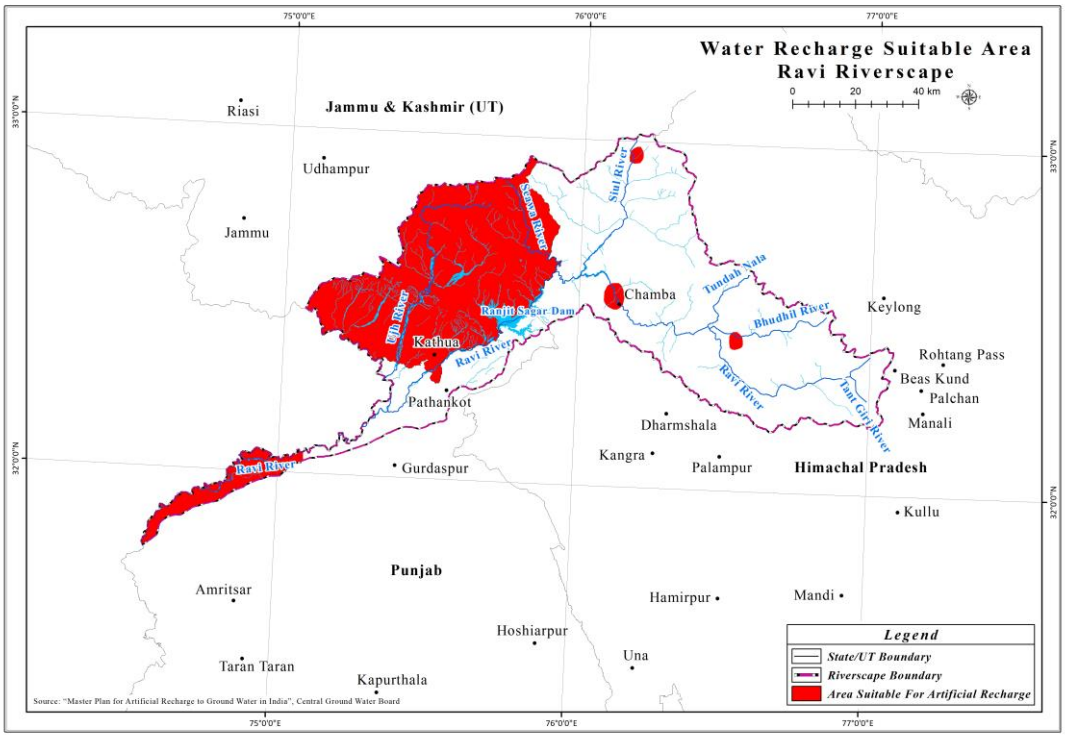


Fig. 3.31 – Water Recharge Suitability Area of Ravi Riverscape

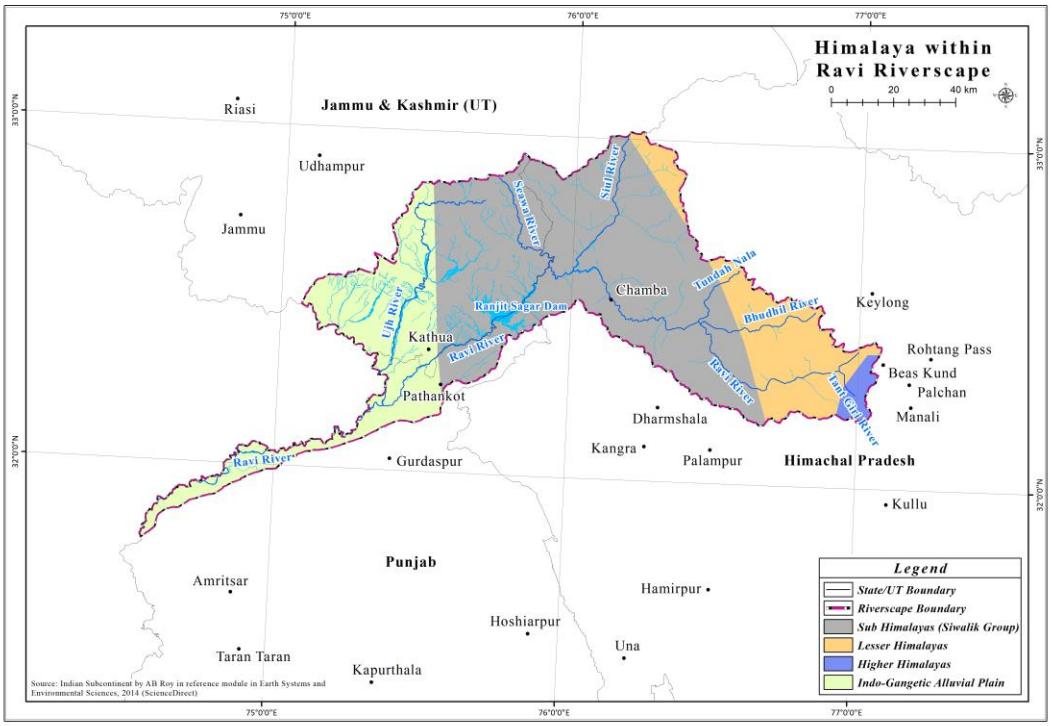


Fig. 3.32 – Himalayas within Ravi Riverscape

(x) Prioritization of suitable areas for proposed forestry intervention

For identifying of priority areas in three priority categories, viz., 'High', 'Medium' and 'Low' for the proposed treatments/forestry interventions in the Ravi Riverscape and selection of appropriate models, GIS-assisted geospatial analysis and modeling were used. Priority areas were delineated in Himachal Pradesh, Punjab, and Jammu & Kashmir UT, and are presented in Table 3.22.

Further, availing the benefit of above GIS assisted geospatial analysis and modeling for prioritization of areas in the riverscape for facilitating effective decision making from the perspective of adoption of appropriate treatment models/forestry interventions, superimposition of the GPS locations of the areas selected for treatment on the basis of various ground based models adopted/recommended by the SFDs revealed that overall nearly one third (34.6%) selected/recommended sites by SFDs for proposed treatment correspond with earlier delineated high priority areas of the riverscape (Table 3.23). In summary, geospatial analysis on prioritization of sites and overlaying of selected sites in different priority areas revealed that SFDs as IAs have been careful in selection of sites for various treatments and adoption of afforestation models and local knowledge of the areas has been appropriately applied. In other words, the geospatial analysis of priority areas complemented the sites selected by the SFDs for suitable treatment as per various ground based field conditions.

Table 3.22-Total Prioritized Area in Himachal Pradesh, Punjab and Jammu & Kashmir UT

Sr. No.	States	High Priority Area (km^2) (%)	Medium Priority Area km^2 (%)	Low Priority Area km^2 (%)	State Area in three Prioritized categories(km^2)
1	**Himachal Pradesh**	2247.93 (24.50%)	1204.66 (13.13%)	1588.41 (17.31%)	5041.00 (54.95%)
2	**Jammu & Kashmir UT**	927.99 (10.11%)	1079.91 (154.59%)	963.01 (10.50%)	2970.91 (32.39%)
3	**Punjab**	73.77 (0.80%)	464.98 (5.07%)	622.95 (6.79%)	1161.70 (12.66%)
Grand Total		**3249.69 (35.42%)**	**2749.55 (29.97%)**	**3174.37 (34.60%)**	**9173.61 (100%)**

Table 3.23- Prioritized Areas As Per Selected Sites in Himachal Pradesh, Punjab and Jammu & Kashmir UT

Sr. No.	States/UT	Divisions	Natural Landscape area (ha)			SMC area (m^3)		
			Low	Mid	High	Low	Mid	High
1	**Himachal Pradesh**	Chamba	23	139	386	27263.335	44612.73	173493.95
		Chamba W/L	-	-	-	152649.89	55022.36	40126.67
		Churah	149	404	1073	54799.19	74131.48	118868.14
		Dalhousie	19	98	43	36384.15	161101.52	50313.24
		Bharmour	0	9	17	44860.57	57178.53	144446.1
		Hamirpur W/L	-	-	-	206036.45	31080.2	10707.05
2	**Jammu &Kashmir UT**	Basohli	20	0	0	3663.33	7081.78	8840.96
		Billawar	25	53	11	5073.81	3514.44	10999.78
		Kathua	15	96	0	9830.26	9168.12	587.7

		Samba	15	5	0	13497.51	6061.14	29.38
		Ramnagar	-	-	-	33.3	1612.25	17942.48
3	**Punjab**	Pathankot	0	0	160	70063.35	95458.3	19959.8
		Gurdaspur	227.35	339	0	110465.25	74366.95	630.7
		Amritsar	69	0	0	174073.2	11408.25	-

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Chapter-4

Ravi River Basin- Legislative, Policy and Institutional Context

4.1 Legislative, Policy and Institutional Context

The Legislative policy, institutional and programming context have important role in restoration of glory of Ravi River. A river is the sum of rivers, floodplains and catchments. These entire factors collectively indicate the health of a river. Rivers are not bound by territories, they flow and pass through cities, rural areas, pristine landscapes, and also between States and Nations. Rivers are subjected to severe anthropogenic pressures such as pollution from urbanization, industrialization; capturing fertile floodplains for construction/real estate development, etc. The circumstances and the ground realities of each river basin are very distinct, complex and dynamic. They influence the restoration plan. It has to be remembered that any river restoration programme should not only involve restoration of the water channel of the river, but also involve catchment and floodplain areas also. Thus, it is difficult to find in isolation one solution, which can be applied to every river.

The Ravi River flows through Himachal Pradesh, parts of UT of Jammu and Kashmir and Punjab before flowing into Pakistan. Thus, it is not just an inter-state river, but also a trans-boundary river whose water is shared between India and Pakistan (IWT, 1960). In the Himachal Pradesh as well as UT of Jammu and Kashmir, the biggest collective threat to the Ravi River Basin is from the hydropower sector (Himdhara Collective, 2016). Other threats include sand mining, boulder extraction and related activities including operation of stone crushing units, road construction, waste and untreated effluents dumping, etc. Real estate and tourism related construction activities have also started to prove disastrous to basin as floodplains are getting exploited by these sectors increasing flood risk. In the State of Punjab, the issues relate to over extraction of water for the purpose of irrigation, commercial and industrial purpose as well as dumping of industrial waste into the river. Most importantly, the Ravi River Basin has already started witnessing climate change related impacts including glacial melt and increasing threat of Glacial Lake Outburst Floods (GLOF) (HPSCSTE, 2014). Therefore, the law and institutions need to gear itself to the realities of climate change. India's law on natural resources have focussed on meeting mostly the developmental needs of the nation to a large extent and meeting local aspirations to a very limited extent. This needs to be changed by focussing on both the sustainability of resources and vulnerability of the resources. The institutional mechanism and legal system must focus on the risk facing the river systems and the dependent communities in view of receding glaciers and hotter climate. The biggest issue which has resulted from severe anthropogenic pressure, is the adverse impacts of climate change. The key issue is whether the law, policy and institutions are able to meet, the challenges arising out due to human demands and the reality of climate change.

These issues have been dealt with in the present chapter, presenting issue wise relevant legislative, policy and institutional framework in order to achieve the ultimate purpose of the present DPR to restore Ravi River. Owing to the fact that Ravi River also flows through the UT of Jammu and Kashmir, a separate section in the present chapter also looks into the legal impact of the Jammu and Kashmir Reorganization Act, 2019.

4.1.1 Mandate under the Constitution of India

Article 48A of the Constitution of India puts an obligation on the State to protect and improve the environment and safeguard the forests and wildlife of the country. The Supreme Court (SC) has emphasized on the role of the State in protecting the environment in several cases by bringing it under the ambit of Right to Life under Article 21 of the Constitution. In a recent judgment, the Court has taken a strict view on the constitutional mandate on the State under Article 48A by holding that '*in cases pertaining to environmental matter the State has to act as facilitator and not as obstructionist'* (SC, 2019). A corresponding duty has also been cast upon every citizen under Article 51 A (g), in the form of 'fundamental duties', to protect and improve the natural environment, including forests, lakes, rivers and wildlife, and to have compassion for living creatures. The Supreme Court has invoked Article 48A and intrinsically connecting it with the 'Public Trust Doctrine' while directing for demolition of an illegal hotel construction on the banks of Periyar River in Kerala (SC, 2013).

With respect to rivers, it is important to locate this subject under the Constitutional scheme, i.e., power to legislate on rivers. The 7th Schedule to the Constitution, drawing on the provisions of Article 246 classifies subjects into three different lists i.e., the Union List, State List and the Concurrent List. Whereas 'regulation and development of inter-state rivers and river valleys' finds mention at Entry *56* of the Union List, the subject of 'water' falls within the State List at Entry 17. This dichotomy in the Constitutional set-up calls for a concerted effort between the Central and State Governments with respect to restoration, especially in the Ravi River context, since it flows through Jammu and Kashmir UT, Himachal Pradesh as well as Punjab.

4.1.2 National Forest Policy, 1988

The National Forest Policy was developed by the Central Government as a basic document enumerating the principles to be followed while undertaking any activity in forest areas as well as in conservation/restoration efforts of forest areas in the country. Therefore, the National Forest Policy is an important guide to have an effective restoration programme in place. The policy was relied on by the Supreme Court in the *Lafarge Umium* Supreme Court: *Lafarge Umiam* case wherein the Court directed that the National Forest Policy must be read as part of the Environment (Protection) Act, 1986 and the Forest (Conservation) Act, 1980 (SC, 2011). The directions of the court are noteworthy:-

"The time has come for this Court to declare and we hereby declare that the National Forest Policy, 1988 which lays down far-reaching principles must necessarily govern the grant of permissions under Section 2 of the Forest (Conservation) Act, 1980 as the same provides the road map to ecological protection and improvement under the Environment (Protection) Act, 1986.The principles/guidelines mentioned in the National Forest Policy, 1988 should be read as part of the provisions of Environment (Protection) Act, 1986 read together with the Forest (Conservation) Act, 1980. This direction is required to be given because there is no machinery even today established for the implementation of said National Forest Policy, 1988 read with the Forest (Conservation) Act, 1980. Section 3 of the Environment (Protection) Act, 1986 confers a power coupled with duty and, thus, it is incumbent on the Central Government, as hereinafter indicated, to appoint an appropriate authority, preferably in the form of regulator, at the State and Central levels for ensuring implementation of the National Forest Policy, 1988.'

One of the important principles given in the National Forest Policy included checking soil erosion and denudation in the catchment areas of rivers, lakes, reservoirs in the 'interest of soil and water conservation, for mitigating floods and droughts and the retardation of siltation of reservoirs (MoEF&CC, 1988). The National Forest Policy also emphasises on the need to include community and ensure their active participation in conservation and restoration efforts of the forest areas (MoEF&CC, 1988).

4.1.3 National Water Policy 2012

The Central Government has issued an overarching policy on utilisation and conservation of water resources of the country. The first such policy was issued in 1987 which had laid down the hierarchy of use of water resources for drinking, irrigation, hydro-power, navigation industrial and other purposes. This policy was revised/amended in 2002 and again in 2012- which is the policy currently in force (MoWR, 2012). The National Water Policy lists out the guiding principles for implementation of laws relating to sustainable utilisation and conservation of water resource. The Policy identifies that water must not be simply considered as a scarce resource but also a sustainer of life and ecology.

'Such a system law must not only regard water as a scarce resource but also as a provider of healthy environment and life. Therefore, water, especially, groundwater, needs to be treated as state-owned public resources, under public education to rely on achieving food security, livelihoods, and equitable shairing and sustainable development for all. Existing rules may need to be amended accordingly (NWP, 2012).*'*

Therefore, water needs to be managed as a community resource held by the state, under public trust doctrine to achieve food security, livelihood, and equitable and sustainable development for all. The Policy also recognises the need for encompassing issues relating to climate change while planning and appraising any activity which involves utilisation of water. These overarching

principles, especially relating to community participation as well as climate adaption become critical when formulating and implementing a restoration scheme for the Ravi River.

4.1.4 Indus Water Treaty, 1960

The Indus Water Treaty is one of the oldest trans-boundary river water sharing treaties to be signed in the World. It has been widely accepted being one of the most successful treaties on trans-boundary water sharing (Hanes, 2017). According to this treaty, India and Pakistan have agreed to demarcate the six rivers which fall within the Indus River Basin for their respective use, management and exploitation of resources. Thus, as per the Agreement, India has full rights to use and exploit the three Eastern Rivers, i.e. Beas, Ravi and Sutlej; whereas, Pakistan has unfettered rights of exploitation of the Western Rivers, i.e. Indus, Chenab and Jhelum and India has limited rights on the catchment area of these rivers within Indian territory.

As per the provisions of Treaty, if either party wants to exploit resources of a river which has been assigned to the other party, an elaborate mechanism has been laid down-this includes consultations, filing of objections, sharing of data, etc. The Indus Permanent Commission was also set up as per the Treaty which has been tasked with ensuring proper implementation of the Treaty (IWT, 1960). In case of any dispute regarding any activity, the Treaty has specific provisions for dispute resolutions. For the purposes of the current chapter, the Indus Treaty does not have much relevance, as India has unfettered rights over the Ravi River.

4.1.5 Hydropower Sector: Need for Cumulative Impact Assessment as well as Regulation of State Hydro-electric Projects (SHPs)

As of 2016, there were 167 hydro-electric projects commissioned, under construction and in various stages of planning in the Ravi Sub-Basin in Himachal Pradesh (Himdhara Collective, 2016). These include Chamera Stage I, Stage II and Stage III, Baira-Siul HEP, Ranjit Sagar Multipurpose Project, Budhil Hydropower Project, etc. In addition as per the official information available on the website of the Himachal Pradesh Government, there are about 135 mini-hydro power projects (under 5 MW) in different stages of construction in Ravi River Basin which are completely outside the purview of the environmental legal regime.

Similar to the case of basins of other Himalayan rivers, the problem is magnified in light of the cascade model of hydro-power development being adopted in Himachal Pradesh. In contrast to a reservoir-based dam, recent trends show a shift towards run of the river hydro-electric projects in India. This cascade model means that at the tail of one project, the head of the next is located, thereby creating a cascade/series of these projects built bumper to bumper on the streams and rivers to harness the capacity of the rivers to produce power to its maximum. Such projects have led to the river and its tributaries to flow in tunnels, and have adversely impacted aquatic fauna as well as traditional irrigation channels (*kuhls*) used by local communities. Thus, it becomes imperative that cumulative impact of these HEPs are assessed properly in terms of impact on the

river ecology as well as impact on the local communities, after consulting the local communities. This becomes even more important in light of the fact that it has been found that around 10 Mega Hydropower projects of Himachal Pradesh are under maximum threat of landslides followed by large hydropower projects which fall under medium landslide hazard risk (GoHP, 2015). Other significant impacts of hydropower projects are the associated impacts of road and other infrastructure development. (H.P. High Court, 2009). Special emphasis on this sector has to be given in light of climate change related discussion.

While regulating HEPs, the following laws become important:-

(a) Environmental Clearance under the EIA Notification 2006

As per the scheme under the EIA Notification, 2006, a HEP proposing >50 MW power generation would require obtaining prior Environmental Clearance from the Ministry of Environment, Forest and Climate Change (MoEF&CC) and if the power generation is 25 MW or more but,< 50 MW, clearance has to be obtained from the State Level Impact Assessment Authority (SEIAA). While applying for such clearance, the project proponent must undertake an 'Environment Impact Assessment' (EIA) study and conduct public consultations and submit the report to the Expert Appraisal Committee (EAC) or the State Expert Appraisal Committee (SEAC). Before grant of such clearance, the concerned EAC or SEAC and the regulatory Authority is mandated to conduct a 'detailed scrutiny' of the documents submitted and then recommend for grant or rejection of the Environmental Clearance Para 7 (IV) (i) of the EIA Notification, 2006. An Environmental Clearance if granted is valid for a period of ten years (MoEF&CC, 2006).

It is mandatory for the project proponent to submit six monthly compliance reports of the conditions of environmental Clearance (MoEF&CC, 2006). The environmental clearance for HEPs usually has specific conditions with respect to the construction phase of the dam i.e. muck disposal plans, height of the dam, etc. These conditions need to be strictly monitored at the construction stage. During operation phase, the conditions relating to release of minimum Environmental Flows, Catchment Area Treatment Plan, etc. also need to be visited and monitored. Thus, the environmental clearance becomes an important instrument to ensure minimal damage to the river system.

(b) Cumulative Impact Assessment

While Cumulative Impact Assessment (CIA) of HEPs for Beas, Sutlej and Chenab are in different stages of finalisation, no work has begun with regard to the Ravi River. As early as 2010, the need for a CIA was recommended by the one man Committee to the High Court of Himachal Pradesh. The said report had raised serious concern with respect to the impact of the proliferation of hydro-projects in the Ravi River Basin (H.P. High Court, 2009).

'*Hydel projects have been/are being allotted along the rivers and their tributaries in a cascading manner, that is, one project after another in a series along the entire length of the river. Since these are all Run of the River projects the waters are being repeatedly diverted from the river bed into HRTs (Head Race Tunnels), rendering the river itself dry for huge stretches (the 15% mandatory discharge is not being followed in most cases as mentioned in my report, or, where complied with, the discharge is so small that it makes no material difference.) …This emerging environmental disaster-in-the-making is established by the survey of the Ravi River Valley carried out by us. The approximate length of the Ravi River between Chamba and Bajoli (upstream in Bharmour) is 70 km. There are 4 HEPs sanctioned along this stretch- starting from the top these are: Bajoli-Holi (at clearances stage), Kuther (at clearance stage), Chamera III (under execution) and Chamera II (commissioned). When all these projects are commissioned there shall be only 500 m of open river between Bajoli-Holi and Kuther,500 m between Kuther and Chamera III, and 2 km, between Chamera III and Chamera II. In other words, in this entire 70 km stretch only 3 km of the river shall flow in its original bed and 67 kms shall disappear underground. This cannot be anything but an unmitigated disaster, for a river is not just a flowing mass of water-it is an entire ecosystem, sustaining human, animal and rich aquatic life within it and along its banks, creating green belts of vegetation on both sides, recharging underground aquifers, feeding surface streams, creating micro-climates along its path. And yet, the state and central governments have not carried out any EIAs of such a cascading pattern from independent experts before allowing this cascade of projects. …'*

It has to be noted that the` purpose of undertaking such a study is to gauge the carrying capacity of the basin and against the same, consider the impact of the existing and operational projects and consider whether more projects may be permitted to be developed as per the capacity. The purpose is not to justify the 167 projects which have been either commissioned, or are under construction or are under planning stage. Therefore, it is important that no new projects are considered for approval until such a study is conducted and approved by the Ministry of Environment, Forest and Climate Change.

(c) Forest Clearance under the Forest (Conservation) Act, 1980

In addition to obtaining Environmental Clearance, in most cases HEPs require prior forest clearance under Section 2 of the Forest (Conservation) Act, 1980 for diversion of forest land. As mentioned earlier, around 40% of the land use in the basin in Himachal Pradesh falls under forest category. Under the forest clearance process, what is most critical is the 'Cost-Benefit Analysis' which has to be undertaken by the User-Agency which is to be scrutinised by the Central Government before granting forest clearance. As per the Guidelines of the Ministry of Environment, Forest and Climate Change, (MoEF&CC, 2017) while considering a proposal for

diversion of forest land, it is essential that ecological and environmental losses and eco-economic distress caused to the people who are displaced, are weighted against economic and social gains. Thus, the cost ecosystem services, and fragmentation of wildlife and economic distress to the displaced communities and cost of settlement of these communities should be added as cost of diversion in addition to the project cost.

(d) Settlement of Forest Rights of Forest Dwelling Communities under the Forest Rights Act, 2006

An important aspect of forest clearance process is the mandatory requirement of settling forest rights of tribal communities and obtaining consent from the *Gram Sabhas* concerned under the provisions of the 'Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006'. In this regard, the Ministry has issued letter dated 3.08.2009 wherein the Ministry has listed out the necessary compliances to be undertaken by the User-Agency and State Government before grant of forest clearance under Section 2 of the Forest (Conservation) Act, 1980. The said condition has now been categorically brought under the purview of Forest conservation Act which has become now mandatory as per the Forest (Conservation) Rules, 2003, vide amendment dated 06.03.2017(MoEF&CC, 2003).

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 can also be used as an effective tool to empower and engage with tribal communities for participation in the restoration efforts of Ravi River. Forest dwelling tribal communities and traditional forest dwelling communities have community forest rights whereby they are empowered to protect, regenerate, conserve and manage a community forest resource (GOI, 2006). By acknowledging title of communities to the forested areas in the catchment of the river, the State Government can actively engage in specific conservation and restoration measures for Ravi River Basin, especially in Himachal Pradesh.

(e) Dealing with Prolific Growth of Small Hydro-projects (SHPs)

As mentioned earlier, there is a serious need to relook at the issue of mini-hydro power projects in the Himachal Pradesh. It may be noted that small hydropower projects (SHEPs) (1MW to 25MW) are not included under the purview of the EIA Notification, 2006 of the Environmental (Protection) Act, 1986. Hence, all SHEPs are legally exempted from requiring environmental clearances and conducting environment impact assessments and public hearings. Further, the said category of HEPs have also been exempted from the need to obtain consent under the provisions of the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974 (MoEF&CC, 1974 & 2016). This is primarily due to the assumption that SHEPs, on account of being 'small' will have minimal or no adverse environmental and social impacts. Contrary to such assumptions, there is enough documentation to conclude that these SHEPs also have adverse environmental as well as social impacts. In fact, they are also capable of influencing micro-climate as well as spatial distribution of macro-invertebrates of the project site and surrounding area of HEPs (Lata *et al.*, 2017). Thus, with

respect to SHPs, the only permissions that are required by the project proponent include the techno-economic clearance and those from the Irrigation and Public Health, Fisheries and Public Works Departments (PWD). However, there are no procedures and regulations in place at the state level to ensure a cost benefit analysis with an environmental and social impact assessment of these HEPs. Similarly, no CIA is ever conducted (Sarkar, 2017).

In the Ravi Sub-Basin of Himachal Pradesh, as per official records, there are 135 small hydropower projects with less than 5 MW in various stages of planning, construction and some are in operation (Himurja, 2018). All these activities exist or are proposed to be in the Chamba District. Thus, it is noteworthy that small projects not only emerge from the great river basin, but also from small streams that maintain the local life of poor communities away from fragile and diverse ecosystems in many ways.

Such a proliferation of these mini hydropower projects is probably due to the favourable initiatives undertaken by the Government to encourage private sector participation in development of small hydroelectric power plants. Attractive incentives for independent power producers, in the form of easy land acquisition procedures and speedy clearances have been ensured. However, this had a very negative impact on the local communities as well as the environment. There have been several instances where poor affected families are awaiting various legal clearances and compensations (Sharma and Rana, 2014). In addition to these issues, SHPs have resulted in loss of traditional water mills and irrigation channels or *kuhls*. These water mills support traditional hill culture known as *hatt* and *gharaat* culture of the hill people which have also been adversely impacted. When looked at from a larger basin perspective, there is a need for assessing the cumulative impacts of SHPs and bringing the same under a definite legal regime which looks at cumulative impacts of the project as well as ensures that the project is being permitted with the consent of the local people.

> *'It is generally believed that Mini and Micro-hydel, projects are ecofriendly, and have very little or no negative impact on the environment, river flow and water availability. We now see how baseless this belief is. Especially in our country where strict monitoring of environmental laws is not available and where it is very difficult for weak stakeholders to know the full picture and to resist unequal changes. Small-scale Hydel projects can measure their environmental and social impacts only if they include planning that involves all stakeholders of the area from the planning stage and if they are in direct compliance with environmental laws. While these requirements do not exist, small Hydel projects can also lead to serious negative impacts'* (Ganeriwal and Bhardwaj, 2011).

(f) Climate Change: Flash Floods and Threat of GLOF

The Ravi River Basin in Himachal Pradesh, and Jammu and Kashmir UT is becoming more and more susceptible to adverse impact of climate change induced disasters. Studies have shown that

there has been a significant loss in glacial area in the Ravi River Basin since 1971. There have been also reports of increased lake formations in the basin.

> *'In the Ravi River Basin, 66 lakes were documented in 2018, while only 54 had been mapped in 2017. Studies indicate that three lakes had an area above 10 hectares, two lakes had an area between five to 10 hectare and 61 lakes were spread over less than five hectares '(HIMCOSTE, 2019).*

Similar studies have found that glacial melting is a reality for Sutlej Basin as well (Prasad *et al*., 2019). Further, it has been found that the loss of glaciers would also be coupled with increased frequency of disaster events such as glacier lake outburst flood (GLOF). In fact, the said study calls for an *'extensive investigation and improvement in existing water management practices and new investments to improve resilience of mountain community to climate change.'* In 2018, the Ravi River Basin in Himachal Pradesh also witnessed flash floods due to heavy rains.

In the legislative domain, it may be noted that there is no National level or State level legislation which directly deals with Climate Change issue. On the policy level, Himachal Pradesh has constituted a State Level Governing Council on Climate Change, under the Chairmanship of Chief Minister and a State Level Action Plan on Climate Change was brought out in the year 2012. However, the said policy needs to be updated and target based action plan is required to be prepared to deal with the alarming situation as mentioned above. It is highly 'inadequate in many respects, particularly in terms of capacity and well-designed institutional mechanisms at the stage of implementation and monitoring (EPW, 2019). The 2012 Policy document derive from the eight missions, identified under the National Action Plan on Climate Change which was adopted in the year 2008 needs updatation. There is a critical need for the Himachal Pradesh to take into account the harsh realities of impacts of Climate Change on the river systems, and come out with a more realistic and practical policy document which can be implemented within the current legal framework.

(g) Protecting the 'Protected Areas' in the Basin

There are six protected areas within the Ravi Sub-Basin in Himachal Pradesh declared under the provisions of the Wildlife (Protection) Act, 1972. However, it may be noted that there are no Community Reserves or Conservation Reserves or Biodiversity Heritage Sites under the Biological Diversity Act, 2002. Under the provisions of the Section 35 (6) of the Wildlife (Protection) Act, 1972, there is a specific prohibition on destroying or damaging or diverting the habitat of any wild animal by any act or diverting, stopping or enhancing the flow of water inside or outside the National Park. Similar provision for protection of Wildlife Sanctuaries has been given in Section 29. These activities are allowed on the exception that a permit is granted by the Chief Wildlife Warden and that no such permit granted unless the State Government is satisfied in consultation with the National Board that such removal of wildlife from the national park or

the change in the flow of water into or outside the National Park is necessary for the improvement and better management of wildlife therein.

(h) Eco - Sensitive Zones: An Effective Conservation Tool for Ravi River

Eco-Sensitive Zones (ESZs) around protected areas are declared and notified under section 3(v) of the Environment (Protection) Act, 1986 and Rule 5 (viii) and (x) of the Environment (Protection) Rules. The purpose of notifying Eco-Sensitive Zones (ESZ) around Protected Areas is to create a kind of 'shock absorber' for such areas, and they would also act as a transition zone from areas that are highly protected to areas requiring less protection. The status of ESZ around the protected areas in Ravi Sub-Basin is given in Table 4.1.

Table 4. 1- The Statistics of Eco Sensitive Zones Around Protected Area

Sr. No.	Protected Areas	Area (km^2)	Status of ESZ Notification	Extent of ESZ As Per Notification
1.	Dhauladhar WLS	982.6	Draft Notification (22/12/2015)	To an extent up to 1.0 km along the southern and south west boundary of Dhauladhar Wildlife Sanctuary
2.	Gamgul Siyabehi WLS	108.0	Draft Notification (03/06/2016)	The ESZ shall be to an extent up to 3.30 km from the boundary of Gamgul Siyabehi Wildlife Sanctuary except on the North-Eastern and North-Western side, as the boundary of the Wild life Sanctuary is co-terminus with the State boundary of Jammu and Kashmir UT
3.	Kalatop-Khajiar WLS	17.7	Draft Notification (03/06/2016)	An extent up to 500 m from the boundary of Kalatop-Khajjiar Wildlife Sanctuary
4.	Tundah WLS	64	Draft Notification (03/06/2016)	Extent up to 1.00 km from the boundary of Tundah Wildlife Sanctuary except on the northern and north-eastern side where lies the district boundary of Lahaul and Spiti having snow bound mountains with glaciers and inaccessible terrain
5.	Kugti WLS	405.49	Draft Notification (19/05/2016)	To an extent up to 1.00 km from the boundary of Kugti Wildlife Sanctuary except on the north-eastern and north-western side where lies the district boundary of Lahaul and Spiti exhibiting snow bound mountains with glaciers and inaccessible terrain
6.	Sechu-Tuan Nala WLS	390.29	Final Notification (28/09/2017)	Up to 1 km from the western boundary of the WLS. No ESZ on north, south and eastern sides due to inter-State boundary with Jammu and Kashmir UT and high altitude areas

As can be seen from the above Table, most of the protected areas do not have a finally notified ESZ. Further, it is ponderable, if the extent of the proposed ESZ would be sufficient to act as a 'shock absorber'. With respect to the proposed prohibited activities, most of the Draft Notifications stipulate a conditional prohibition- for instance 'construction of major thermal power project or HEPs' find mention in the list of prohibited activities. However, the Notification states that it is 'prohibited, (except as 'otherwise provided as per applicable law). Here, it may be noted that otherwise provided as per applicable law" has no legal implication, since the applicable law such as the EIA Notification, 2006 or the Forest (Conservation) Act, 1980 does not protect specific landscapes. There is a definite need to strengthen these provisions and ensure that the activities permitted in this 'buffer zone' are minimal. The Ravi River and its tributaries are flowing through these PAs, or their ESZs. While the provisions of the Wildlife (Protection) Act, 1972 do provide certain safeguards, ensuring properly demarcated ESZ is a much more effective conservation tool for restoring rivers, since it covers not only the river and its ecology, but also the catchment area, in terms of regulation of permissible activities. This is so because the Notification which is issued under the provisions of the Environment (Protection) Act, 1986 have mandatory provisions with respect to activities which are prohibited and permissible but, with conditions. In most cases, river sand/boulder mining and setting up of stone crusher units within the notified ESZ are prohibited. The Himachal Pradesh needs to take proactive steps and consult the Ministry of Environment, Forest and Climate Change for notifying the ESZ Notifications for the protected areas falling within the Basin.

(i) Conservation of Wetlands

Riverine wetlands are an important component of a river system and play a critical role in improving flood protection, recharging ground water and increasing the biodiversity, thus providing several ecological services. The State is under a legal obligation both under the Wetland Rules, 2017 issued under the provisions of the Environment (Protection) Act, 1986 as well as under India's International obligation under the Convention on Migratory Species (CMS), the Ramsar Convention and the Convention on Biological Diversity to protect and preserve wetlands as well as the avian ecology that they support.

Himachal Pradesh has notified the constitution of the State Wetland Authority in 2017 itself (HIMCOSTE, 2017). However, it is not clear as to how much progress there has been with respect to identification and notification of wetlands in the State as per the Wetland Rules, 2017. The timeline as per the Rules for various steps in the identification of wetlands as well as notification is given in the Table below in the Table 4.2.

Table 4.2 – The Wetland Rules, 2017- Key Steps and Relevant Timelines

Activity	Timeline as per Rules
Constitution of technical committee to review brief documents, management plans and advise on any technical matter referred by the Wetland	3 months from date of publication of Rules.

Authority; and constitution of Grievance Committee consisting of four members to provide a mechanism for hearing and forwarding the grievances raised by public to the Authority;	
Prepare a list of all wetlands of the State or Union Territory	3 months from date of publication of Rules.
Prepare a list of wetlands to be notified,	6 months from date of publication of Rules.
prepare a comprehensive digital inventory of all wetlands	1 year from date of publication of Rules.

From the information available in public domain, it is clear that the Himachal Pradesh and Punjab are far from complying with these timelines stipulated under the Wetland Rules, 2017. It is therefore necessary to initiate and complete, in a time bound manner, the process of identification and notification of wetlands under the provisions of the Wetland Rules, 2017 so that they come under legal protection. It may be noted that the main river channel is specifically excluded from the legal definition of Wetland under the Rules (MoEF&CC, 2017). However, the Wetlands which are part of the basin, or which form part of the larger catchment area of the river are important from the perspective of a holistic exercise for river restoration. HP, J&K and Punjab can refer to the Guidelines issued by the MoEF&CC in this regard.

(j) Urbanisation/Infrastructure Development:

Floodplains of Ravi River and its tributaries are under major stress due to large scale reclamation for construction or infrastructure development in the form of road construction and other developmental activities. The river, especially in Chamba district in Himachal Pradesh has witnessed many new towns and villages coming up along its course. During the last few years, the river course has narrowed due to dumping of muck generated by hydropower projects. During flood like situations, gushing water and muck can cause extensive damage to population downstream. In Chamba, the Forest Department had even imposed penalty on erring companies, but damage has already been done to the river (Himdhara, 2013).

The Town and Country Planning Department as well as concerned Municipal Corporations need to take a proactive role in ensuring that licenses or permissions are granted under the Municipal laws as well as the Town and Country Planning Act, 1977 after careful serutiny. Stringent measures have to be taken against violators and the river bank and floodplains need to be freed of encroachments.

(k) Tourism Woes- How Green is 'Eco-tourism'?

One of the serious challenges threatening the health of Ravi River, especially in State of Himachal Pradesh, is the tremendous impact and stress on the river due to unsustainable tourism activities. It may be noted that there is no legal definition under law for the term 'eco-tourism'. In the causes of degradation of rivers, urbanisation and the heavy inflow of tourists both are emerging as problems because of the disposal of solid waste, encroachment upon the river waterways and water extraction involved (Himdhara, 2013).

To ensure that tourism activities are sustainable, and achieves the true meaning of 'eco-tourism', it is critical that the concerned Authorities local government, Municipal Corporations as well as the Pollution Control Board take effective steps to comply with laws relating to issuance of construction licenses (GoI, 1977) consents under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974, compliance with the various Waste Management Rules including the Solid Waste Management Rules, 2016, Plastic Waste Management Rules, 2016, Construction and Demolition Waste Rules, 2016, etc. In 2017, the National Green Tribunal had imposed a ban on dumping of municipal solid waste into the Ravi River (NGT, 2017). However, the said prohibition is being flouted and violated. Thus, need strict enforcement.

Amongst all tourism related activities in the Ravi River Basin, one remains largely unregulated camping and river rafting. The unsustainable practices arising out of these activities have received judicial notice in the past with respect to Ganga River in the State of Uttarakhand. The NGT has discussed in detail the adverse impacts of unsustainable rafting and camping activities on the river as well as the forest areas along the banks of the River (NGT, 2015). Holding that beach camping would constitute a 'non-forest' activity, the NGT held that the provisions of the Forest (Conservation) Act, 1980 would be applicable to these activities. Further, the State of Uttarakhand was directed to develop a regulatory regime for such activities to ensure minimum damage to the river as well as its floodplains. A similar approach may be adopted by the Himachal Pradesh in ensuring that such activities have minimal impact on the Ravi River and its floodplains.

(l) Water Quality- Ensuring No Untreated Sewage/Industrial Effluent Falls into the River.

Water Pollution is predominantly dealt with by the Water (Prevention and Control of Pollution) Act, 1974. This is done by mandating a process of regulating discharge of domestic sewage or industrial effluent through a regime of grant of 'prior consent' by the State Pollution Control Board (SPCB). Thus, the Act stipulates a mandatory regime for every industry, process, activity, etc. to obtain prior consent from the concerned SPCB for such a discharge of sewage or industrial effluent (GOI, 1974). The provision lays down a two-pronged consent regime a prior consent to be obtained before establishing the unit/industry and a consent to be obtained after setting up of the unit/industry, but before starting operations. These consents are referred to as Consent to Establish (CTE) and Consent to Operate (CTO). The CTE is granted on the basis of location of the proposed site, its pollution potential, proximity to sensitive areas, etc. Once the

plant/unit/industry is set up, on the basis of compliance status of the conditions stipulated in the CTE, the SPCB grants the CTO. The SPCB may also initiate penal proceedings against the violator for the harm caused to the environment due to violation/non-compliance of the consent conditions.

The Ravi River on the whole especially in the State of Punjab is not subjected to much industrial and municipal effluents as the catchment as well as adjoining area of river does not have many heavy or small-scale industries. Moreover, the river flows some 20 to 30 km away from big cities and towns, with the result is not subjected to much municipal effluents too. However, there is a need to ensure that industrial growth in this area happens in a planned manner which ensures minimal impact on the river.

(m) Floodplain Protection and Conservation

Floodplain protection is critical to river conservation and ensuring good river health. They also support ecological diversity in a river system by providing carbon and nutrients supply to river channel, which finally governs productivity of the entire river system and by providing geomorphic (habitat) diversity in river space to support biodiversity (Richards *et al*, 2002) Gurnell and Petts, 2002; Thoms, 2003). It is thus, very important that floodplains are correctly demarcated and protected. The importance of floodplain demarcation has been highlighted in several cases before the National Green Tribunal with regard to rivers in Maharashtra and Yamuna River in Delhi and Agra. Zoning of the floodplain by demarcating prohibited and regulatory zones is an efficient tool for protecting and conserving floodplains. For instance in the State of Maharashtra, as early as 1989, the Government had issued an order directing for demarcation of the floodplain into prohibited zone (blue zone) (GoM, 1989).

(n) Involving Communities in River Restoration Efforts

Any efforts of restoration would not be successful unless and until local communities, dependent upon the river are actively consulted and involved. There are several legal policy tools which can be referred to and employed to achieve this key process. In fact, the National Forest Policy, 1988 and the National Water Policy, 2012 recognises the critical role played by communities in ensuring conservation as well as the restoration of the forest land and water resources in the country.

(o) Biological Diversity Act, 2002: As per the Biological Diversity Act, 2002, it is mandatory for every local self-governing institution in both rural and urban areas to constitute Biodiversity Management Committee (BMC) within their area of jurisdiction. The objective behind BMC constitution is promotion of conservation, sustainable use and documentation of biological diversity. One of the important functions of the BMC is to prepare and maintain the Peoples' Biodiversity Register (PBR) in consultation with the local people. A PBR comprehensively documents information on the availability and knowledge of local biological resources (those falling within the territorial jurisdiction of the BMC), their medicinal or any other use of

traditional knowledge associated with them. The PBR thus, prepared then serves as a legal document which confirms the sovereign rights of that BMC over the resources documented in the PBR. In addition to preparation of a PBR, the roles and responsibilities of a BMC takes various forms such as eco restoration of the local biodiversity, management of sacred groves and sacred water bodies, conservation of traditional varieties/breeds of economically important plants and animals. The BMC can be thus actively consulted while undertaking specific measures to restore the river. Further, the PBRs can be a good source of knowledge of indigenous species of plants and trees which can be considered while undertaking plantation drives, or afforestation/reforestation measures.

As per certain studies, PBRs help the State and the local community to become aware of the valuable resources being harvested in their area which can be utilised for the overall social and economic development of the State. Furthermore, PBRs also help in conservation of the traditional practices and knowledge of the local community. Studies on the issue of Access and Benefit Sharing (ABS) show that non-establishment of BMCs and absence of PBRs deprive the local communities of the advantage of the biological resources. PBRs not only document the knowledge, but also help in identification of benefit claimers.'

The NGT is also monitoring the implementation of the provisions of the Biological Diversity Act, 2002 (NGT, 2016). As per the latest report of the MoEF&CC to the NGT as on August 2019, in Himachal Pradesh, out of 3370 local bodies, BMCs have been constituted in 730 only, which implies the compliance rate is only 21.66%. With respect to preparation of PBRs, only six BMCs have prepared the same. With respect to State of Punjab, out of 1477 local bodies, BMCs have been constituted only in 74, i.e. 5% compliance rate. 43 BMCs have prepared PBRs. In a series of orders, the Tribunal has issued strict directions to all State Governments and Union Territories to ensure 100% compliance with respect to constitution of BMCs and preparation of PBRs by 31.01.2020. In case of non-compliance, the Tribunal has imposed a hefty penalty of 10 lakhs per month on the defaulting States. The Tribunal in August 2019 emphasised on the importance of the Act of 2002 as follows (NGT, 2016).

(p) Impact of the Jammu and Kashmir Reorganisation Act, 2019

In terms of the Jammu and Kashmir Reorganisation Act, 2019, the erstwhile State of Jammu and Kashmir has ceased to exist and in its place UT of Jammu and Kashmir and UT of Ladakh have been created. Prior to passing of the said Act, the State of Jammu and Kashmir had its own constitution and most of the laws which were applicable to the rest of the country was not applicable to the State. However with the passing of 2019 Act, this legal dichotomy has been removed and all enactments which were not applicable to the State has been made applicable to the UTs of Jammu and Kashmir and Ladakh.

In terms of environmental legislations, the Environment (Protection) Act, 1986; Water (Prevention and Control of Pollution) Act, 1974 as well as the Air (Prevention and Control of Pollution) Act, 1981 being special legislations were applicable.

However, the enactments such as the Forest (Conservation) Act, 1980 as well as the Forest Rights Act, 2006 and Wildlife (Protection) Act, 1972 all have been made applicable to these newly created UTs.

The implementation mechanism for these laws needs to be developed effectively in the newly created UTs especially in light of the several announcements made by the Central Government with respect to infrastructure projects as well as projects in the river basins including that of Ravi River.

4.2 Identifying Stakeholders

This Section identifies the various Govt. Departments and their role in ensuring that the restoration of Ravi River is effective and successful. It is also important to have an active co-ordination between these Departments and ensure that there is no overlapping of functions. Table 4.3 below discusses the role of each of the Department that has been identified on the basis of the discussion in the preceding section.

Table 4.3 – Identified Stakeholders Concerning River

Stakeholder	**Activity**
State Pollution Control Board(SPCB)	- Consent should not be granted as a matter of routine. - Consent to Establish should not be granted in areas which are ecologically sensitive. - The practice of granting standalone Consent should be done away with and should be based on carrying capacity assessment. - The Renewal of Consent to operate should not be a mechanical process but, should be based on proper ground verification. - The SPCB should put special focus on the main objective of the Water Act, 1974 i.e., maintaining the wholesomeness of water. Any project seeking approval must show how the proposed activity is not in contradiction to the said objective. - Projects which are granted Environmental or Forest Clearance should not be granted Consent to Establish as a matter of routine. The SPCB should play a proactive role

	in examining the impact the project will have on the water quality including flow. - The small HEPs are currently exempted from the requirement of obtaining Consent under the Water Act, 1974. This has to change, and the SPCB must ensure the protection of riparian rights of the people as well as maintaining the flow. There needs to be an objective assessment of the level of compliance with these conditions. - Monitoring water quality under Water (Prevention and Control of Pollution) Act, 1974 and Rules.
State Water Department/ Sewerage Board	- Proper maintenance of Sewage Treatment Plants and ensuring that no untreated sewage is discharged into the river or its tributaries. - Ensuring that the treated water is meeting the standards set under the Environment (Protection) Act, 986 and Water (Prevention and Control of Pollution) Act, 1974.
State Environment Impact Assessment Authority (SEIAA)	- The SEIAA along the SEAC are key bodies for protection of the Ravi River Basin. However, the SEIAA and SEAC grant approvals to project without a thorough assessment of its likely impact on the ecology. No consideration is given as to what impact the proposed project will have on the river and the riverine ecosystem. It is essential that before any project is allowed, the SEAC and SEIAA should conduct a thorough assessment of the proposed site; examine the project along with other projects which have similar effect and take a decision keeping the totality of environmental situation into account. Both ground truthing and GIS application should be relied on. - There is a need to make the SEAC and SEIAA as robust institutions which have both the capacity and ability to take decision that protect the environment rather than favouring destructive projects. Areas which have crossed the threshold in terms of its cumulative impacts should have a moratorium in place. In this regard, the recent SC directive in the Goa Airport case[1] is crucial which

	highlights the need for Expert Appraisal Committees to co-opt members to ensure that the Committee reflects a cross section of persons drawn from different specialties having a bearing on environmental protection (SC, 2020). - Instead of general compliance condition, site specific and project specific conditions should be imposed. - Third party monitoring which also involves the local community should be done by SEIAA specifically for those projects which are seeking expansion of the production capacity.
Regional Office, Ministry of Environment, Forest and Climate Change	- Monitoring of compliance of conditions stipulated in the Environmental Clearance granted under the EIA Notification, especially with respect to e-flow from HEPs.
Forest Department	- Ensuring proper implementation of forestry measures including- catchment area treatment, compensatory afforestation, etc. - Ensuring active synergies and via-media between the communities and other departments in restoration efforts.
Irrigation Department/Revenue Department	- Floodplain demarcation for one in 25 years and one in hundred years. - Issue directions demarcating proper setbacks, and developing a prohibitory and regulatory regime for activities permissible within the river bank and floodplains.
Municipal Corporations/Panchayats	- Compliance and monitoring of the Waste Rules, 2016 under the Environment (Protection) Act, 1986., especially segregation of waste at source and ensuring plastic waste is disposed of as per the provisions of the Plastic Waste Rules, 2016 and does not find its way into the river. - Ensuring no buildings or construction activities are permitted on the active floodplains or banks of the river.
Town and Country Planning	- Ensuring proper setbacks are provided for the river in

	Development Plans of the cities on banks of the river.
Tourism Department	- Preparation of an effective policy on eco-tourism which emphasises on mandatory setbacks from the river bank, and prohibits any construction on the river bank, and its active floodplain - To develop proper guidelines/regulatory regime to regulate the river rafting and camping activities in line with the judgment of the National Green Tribunal in SAFE vs. Union of India & Others.
Biodiversity Management Committees (BMC)	- Preparation of PBRs and utilising traditional knowledge of communities for ensuring better catchment area treatment measures in the form of afforestation, etc. - Ensuring PBRs are used as an effective tool in terms of documentation of the biodiversity and thereby ensuring proper impact assessment of any developmental activity that is proposed in the river basin.

Table 4.4 - List of Relevant Legislations, Policies and Other Documents

Sr. No.	Legislation/Policy/Guidelines
1.	Wildlife (Protection) Act, 1972
2.	Water (Prevention and Control of Pollution) Act, 1974
3.	Himachal Pradesh Town and Country Planning Act, 1977
4.	Forest (Conservation) Act, 1980 Forest (Conservation) Rules, 2003
5.	Air (Prevention and Control of Pollution) Act, 1981
6.	Environment (Protection) Act, 1986 a) EIA Notification, 2006 b) District Survey Reports prepared under the EIA Notification, 2006 c) Notification dated 29.05.2014 issued by Government of Himachal Pradesh for siting criteria for stone crushers. d) Solid Waste Management Rules, 2016 e) Plastic Waste Management Rules, 2016 f) Wetland (Conservation and Management) Rules, 2017
7.	National Forest Policy, 1988
8.	Biological Diversity Act, 2002
9.	Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006
10.	National Action Plan on Climate Change 2008

11.	National Water Policy, 2012
12.	Himachal Pradesh State Climate Change Action Plan 2012
13.	MoUD Guidelines on Urban Greening, 2014
14.	CGWA Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction, 2015
15.	River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016. (as a reference to see how Basin level management has been proposed for River Ganga)
16.	MoEF&CC Guidelines on Sustainable Sand Mining, 2016
17.	Guidelines for implementation of Wetland Rules, 2020

Table 4.5 - Terms, Definition and Implications in Context of River Management

Definitions			
Sr. No.	**Term**	**Definition**	**Implications in Context of River Management**
1	Forest Land	The term 'Forest land' defines; the land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. (FRA, 2015) The term 'forest' is not be applicable on the plantations raised on private lands (Guidelines for the application of the Forest (Conservation) Act, 1980, 2003).	The definition of what constitutes 'Forest land' is important for the decision-making in relation to felling of trees for use/ diversion of land.
2	River	A river is a hydrological and ecological system, which is a natural, living and organic whole. A river system has to be understood in terms of its sediments and nutrients transported by it, its catchment, the river bed, river bank, floodplain as well as the vegetation on the floodplain.	The conceptual understanding of a river should include both its components (which includes the river bed and nutrients, biodiversity, sediment besides water), as well as its functions. The close interrelation between land use and river systems should be emphasized.

Definitions			
Sr. No.	**Term**	**Definition**	**Implications in Context of River Management**
		(Delhi Declaration at India Rivers Week, 2014) The term 'river basin' encompasses the surface and subsurface water resources, soil and land resources, wetlands and associated ecosystems, including those coastal and near shore marine systems that are hydrologically or ecologically linked to the river basin (Handbook on Ramsar Convention, 2010).	
3	River corridor	Land area adjacent to a river that is required to accommodate the dimensions slope, plan form and buffer of the naturally stable channel and that is necessary for the maintenance of natural restoration of a dynamic equilibrium condition and for minimization of fluvial erosion hazards, as delineated by the Agency in accordance with river corridor protection procedures (Rule 29-201, Vermont Flood Hazard Area and River Corridor Rule)	The National Water Policy, 2012 specifically mentions the preservation of river corridors.
4	Environment -al flow (E-flow)	Environmental flows, or E-flows, describe the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems (Brisbane Declaration, 2007).	Hydro-engineering structures lead to large scale impoundment or diversion of water. Maintaining environmental flows is essential for ensuring that rivers are able to continue their ecological functions. A three Member Committee (which includes the MoWR,RD&GR and the MoEF&CC) recommended arriving at an e-flow regime on the

Definitions			
Sr. No.	**Term**	**Definition**	**Implications in Context of River Management**
			basis of temporal versions in depth of flow required for the survival of keystone species, longitudinal connectivity in all seasons and lateral connectivity of active flood plain (March, 2015).
5	Biodiversity or Biological diversity	Biodiversity or "Biological diversity" means the variability among living organisms from all sources and the ecological complexes of which they are part, and includes diversity within species or between species and of eco-systems (Section 2(b), Biological Diversity Act, 2002).	River systems support, and provide habitat to a wide range of life forms and habitats. Rivers also provide important connectivity and migration paths.
6	Wildlife	Includes any animal, aquatic or land vegetation which forms part of any habitat (Section 2(37), Wildlife (Protection) Act, 1972.	In addition to the specific species referred to in the Wildlife (Protection) Act, river systems and vegetation along rivers, especially those declared to be 'protected areas' would also constitute wildlife.
7	Wetland	'An area of marsh, fen, peatland or water; natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six m and includes all inland waters such as lakes, reservoir, tanks, backwaters, lagoon, creeks, estuaries and man-made wetland and the zone of direct influence on wetland that is to say that drainage area or catchment region of the wetlands as determined by the authority	Wetlands serve as a link between the land and the water, and provide a range of services that benefit all aspects of river activities. The critical linkage between wetlands, water and river basin management is emphasized in the Ramsar Convention on Wetlands.

Definitions			
Sr. No.	**Term**	**Definition**	**Implications in Context of River Management**
		but, does not include main river channels, paddy fields and coastal wetlands (Section 2(g), Wetlands (Conservation and Management) Rules, 2010).	
8	Cumulative Impact Assessment	Cumulative Impact Assessment effects generally refer to impacts that are additive or interactive (synergistic) in nature and result from multiple activities over time, including the project being assessed. (NGT, Vimal Bhai *vs*. MoEF&CC& Others, 2011)	The natural flow of rivers is severely altered through hydro-engineering structures, as well as associated land use. The cumulative impact assessment of all existing and proposed activities should be factored into the decision-making of clearance for projects, as well as river basin management.
9	Eco-centrism	There is a 'Moral imperative to respect intrinsic value, inter dependence and integrity of all forms of life. Eco-centrism supports the protection of all life forms, not just those which are of value to humans or their needs and underlines the fact that humans are just one among the various life forms on earth' (Supreme Court, T.N. Godavarman Thirumalpad *vs*. UOI, 2005)	Rivers should be viewed as critical ecosystems, rather than merely a 'water resource'. This is fundamental to the premise of river basin management.

Table 4.6 - Relevant Authorities and Their Functions

Sr. No.	Relevant Authorities	
	Authority	**Functions**
1	National Ganga River Basin Authority	Authority constituted under the Environment (Protection) Act. Planning, Financing, Monitoring, and Coordinating bodies of the Centre and States responsible for the conservation and abatement of pollution of the Ganga.
2	Central Empowered Committee	Constituted under the Environmental (Protection) Act pursuant to the Order of the Supreme Court in 2002 for all matters relating to the application of the Forest (Conservation) Act, 1972.
3	Expert Appraisal Committee	Constituted under the EIA Notification to appraise and grant clearance for projects.
4	Pollution Control Board	The Central Pollution Control Board is entrusted with promoting the cleanliness of the streams (including rivers and sea). And laying down the standards of quality of water. State Pollution Control Board can establish standards for discharge of effluents. It is also responsible for minimizing water pollution through granting consent for the establishment and operation of units.
5	Water Quality Assessment Authority	Constituted under the Environment (Protection) Act to standardize methods for monitoring of water quality and ensuring quality of data generation and utilization. The powers and functions of the authority include preparing schemes for restriction of discharge of treated sewage/ trade effluent on land, rivers and other water bodies with a view to mitigate crisis of water quality. The authority can also review the status of quality of national water resources (both surface and ground water) and identify 'hot spots' for taking necessary actions for improvement in water quality.
6	Central Water Commission	**Central Water Commission (CWC)** is a premier Technical Organization of India in the field of Water Resources and is presently functioning as an attached office of the Ministry of Jal Shakti, Department of Water

Sr. No.	Relevant Authorities	
	Authority	**Functions**
		Resources, River Development and Ganga Rejuvenation, Government of India. The Commission is entrusted with the general responsibilities of initiating, coordinating and furthering in consultation of the State Governments concerned schemes for control, conservation and utilization of water resources throughout the country, for purpose of Flood Control, Irrigation, Navigation, Drinking Water Supply and Water Power Development.
7	National Green Tribunal	The **National Green Tribunal (NGT)** has been established under the National Green Tribunal Act, 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues.

4.2.1 Implications and the Way Forward

The management issues those are involved in the conservation and restoration of the Ravi River are numerous, intricate and challenging. The policy and legal provisions need to facilitate the management of rivers and factors affecting them. It is pertinent to address and fulfil the gaps in the existing regulatory mechanism. Some of the gaps can be potentially addressed within the existing regulatory framework while others may require a fresh look and inclusion of appropriate provisions or revision of existing once. The past experience illustrates that the piece mill and fragmentary approach to river conservation, particularly the environmental impact assessment has not yielded desired insight and failed to reflect a true and comprehensive picture of the range of impacts. The relationships between upstream and downstream, forests and their hydrological functions, river and surrounding lands have been poorly understood. Until the studies or decision-making process factor in the intricate relationships and incorporate cumulative assessment of impacts and evaluate carrying capacity of rivers, outcomes will continue to remain sub-optimal.

The degraded river ecosystems require restoration and efficient management for not only the long term sustainability of the river but also for the associated biodiversity and the ecosystem services they offer. A comprehensive approach towards management of forests is essential. It is necessary to apply the provisions of the various existing laws relevant to forest, environment and the biological diversity collectively so as to accomplish the goals of long term protection of forests along with the rivers. The existing legal and policy framework can immensely help in the following:

(a) Declaration of select biodiversity rich river stretches of conservation priority as protected areas under the Wildlife (Protection) Act, 1972.
(b) Declaration of biodiversity rich areas as the biodiversity heritage sites under the Biological Diversity Act, 2002.
(c) Declaration of identified areas as the ecologically sensitive sites under the Environment (Protection) Act, 1986.
(d) Ensuring cumulative EIA as well as comprehensive EIA with respect to any developmental project or biotic interference such as sand and bolder mining.
(e) Facilitating implementation of the Wetland Rules, 2010, particularly in demarcation of the zone of influence as far as wetland areas are adjacent to rivers.

The maintenance of environmental flow is critical for ensuring the river connectivity and various ecological processes. Therefore, it is important to enforce the rules/ directives relevant to e-flow issued from time to time. It is important that any proposal for diversion of forest land in close proximity to the river or its tributary is examined thoroughly and carefully to avoid any adverse implications on river ecosystem. Considering the vast extent of river from its origin to confluence/ mouth, a wide range of stakeholders (agencies, departments, users, etc.) involved, and intricate nature of river, it would be desirable to designate an appropriate river authority in case of each of the prominent river of the country. Undoubtedly, there is a strong mandate and available avenues within the existing legal framework to develop proactive interventions with adequate legal backing for river restoration and conservation. Moreover, the existing legal framework has been adequately supplemented with insightful judicial interpretations and specific directives for implementation and to develop a rich body of environmental jurisprudence. The above overview has amply reflected that the existing legal and policy framework is adequate to take care of the complexities of rivers in human dominated country like India.

4.3 Institutions and Implementing Agencies – Central and State Governments

The preceding chapters and the forgoing sections have given ample idea about the wide array of government and non-governmental agencies at the centre and state levels besides diverse stakeholders and the civil society those are involved with the prominent disciplines/ sectors of forest management, wildlife conservation, environmental management, water resource management, river development and restoration of rivers in the country. The Chapter 2 on the Ravi riverscape and its environment has appropriately highlighted the intricacies of the physical,

biological and socio-economic sub-environments in the context of river besides numerous sectors and agencies directly connected and responsible for the maintenance of uninterrupted e-flows and clean water of Ravi River. In general, the Union Ministry of Jal Shakti and the Ministry of Environment, Forest and Climate Change at the centre are the two prominent ministries those are directly concerned with the Ravi River, its environment, and much desirable restoration process. Details of the Ministry of Jal Shakti, its mandate, programmes and activities have already been provided. From the perspective of proposed forestry interventions, details of the implementing agencies at the National and State levels are much desirable. Hence, the following section provide details on the MoEF&CC as the Nodal Agency for overseeing and steering the programme implementation; the ICFRE, Dehra Dun and its regional institute i.e. the HFRI, Shimla as the National Partner Organization for capacity development and monitoring; and the pivotal role of the concerned Forest Department in two States and one UT as the Implementing Agencies.

4.3.1 The Ministry of Environment, Forest and Climate Change (MoEF&CC)

The MoEF&CC at the centre is the Nodal Ministry responsible for the planning, promotion, coordination and overseeing the implementation of country's environmental and forestry policies and programmes aiming for sustainable management of wide range of natural ecosystems i.e., forests, grasslands, wetlands including lakes and rivers, and coastal and marine, associated biodiversity, ensuring the welfare of animals, and the prevention and abatement of pollution. While implementing various policies and programmes related to forests, environment and wildlife, the Ministry is guided by the principle of sustainable development and enhancement of human well-being. The Ministry also serves as the nodal agency in the country for the United Nations Environment Programme (UNEP), South Asia Cooperative Environment Programme (SACEP), and International Centre for Integrated Mountain Development (ICIMOD), and for the follow up of the strategies and programmes of the United Nations Conference on Environment and Development (UNCED). The Ministry is also interested important tasks related to multilateral bodies such as the Commission on Sustainable Development (CSD), Global Environmental Facility (GEF), and of regional bodies like the Economic and Social Council for Asia and Pacific (ESCAP) and the South Asian Association for Regional Cooperation (SAARC) on matters related to the environment. The Ministry is also entrusted to implement programmes related to various international conventions *viz*., the United Nations Convention on Biological Diversity (UNCBD), United Nations Convention on Combat of Desertification (UNCCD), United Nations Framework on Climate Change (UNFCC), Ramsar Convention on Wetlands, Convention on Control of International Trade in Endangered Species of Wild Fauna and Flora (CITES), etc. for which the country is signatory and thus, committed. Till recent past the MoEF&CC also dealt with the various programmes and activities related to river Ganga *viz*., the Ganga Action Plan, National Ganga River Basin Authority (NGBRA), and National Mission for Clean Ganga. These subjects and activities were transferred to the Ministry of Water Resources (presently Ministry of Jal Shakti) with it's enlarge mandate. The MoEF&CC is supported in its

mandate, functions and responsibilities by wide range of Authorities, Agencies, Organizations/ Institutions and Sub-ordinate offices.

4.3.2 Indian Council of Forestry Research and Education (ICFRE) and Himalayan Forest Research Institute (HFRI)

The Indian Council for Forestry Research and Education (ICFRE), an autonomous Council under the MoEF&CC is supported by nine regional institutes and four advanced Field Research Centres in performing the wide range of functions across the country those include conduct of forestry research; transfer of innovative technologies in the field of forestry relevant to the different biogeographic regions of the country to the States/UTs and other agencies; and to impart forestry education. The Himalayan Forest Research Institute (HFRI) at Shimla is one of the regional institutions under the umbrella of ICFRE and mandated to generate, preserve, disseminate and advance knowledge, technologies and solutions for addressing issues arising out of interactions between people and forests and environment on a sustained basis through research, education and outreach and the specific goal of contributing research relevant to the conservation of Western Himalayan forests and forest ecosystems. The HFRI has been assigned the jurisdiction of two Union Territories – Jammu and Kashmir and Ladakh, and one State i.e. Himachal Pradesh. As stated earlier in the Chapter 1, the MoEF&CC has entrusted a major task to ICFRE on the preparation of DPRs on forestry interventions for rejuvenation of major Indian rivers. Considering the expertise and appropriate location of HFRI in the Himalayan State of Himachal Pradesh, the ICFRE assigned the responsibility of preparing the DPR on the Ravi River along with four other DPRs on major rivers of the Indus River system. The HFRI with its long standing for past more than three decades and expertise in the field of forestry relevant to the western Himalaya, multi-disciplinary scientific staff including practising professional foresters, well-placed vast campus amidst deodar forests and adequately equipped various laboratories and other physical infrastructure is the most appropriate Government of India's scientific agency not only for the preparation of present DPR but for its effective implementation, capacity development and monitoring through the Forest Department (s) of two States and one UT. The HFRI has strong network with various forestry related sister institutions under the umbrella of ICFRE as well as other organizations and other sister institutions under the MoEF&CC.

4.3.3 Institutional Framework of State Forest Departments

As per the Constitution of India, the subjects of Forests, Wildlife and Environment are in the Concurrent List. Accordingly, the MoEF&CC is the Nodal Agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental, forestry and wildlife policies and programmes. However, the Forest Department (SFD) in each State/UT is the custodian of forests and wildlife

of the State, besides being responsible for management, conservation, and protection of the environment i.e, land, water and air. The State Forest Department is also responsible for the management of forest lands or Recorded Forest Area, irrespective the type of vegetation these lands harbour. The State Governments and SFDs area mandated for the enforcement of laws and implementation of various policies and strategies enacted/ formulated by the Central Ministry from time to time.

(A) Mandate of State Forest Departments

The history of scientific management of forests in India is older more than 154 years as in 1864, the British Regime established the 'Imperial Forest Department'. The stated mandate of the Department was scientific management of the forests to exploit it on a sustained basis for primarily timber products. The Forest Department is one of the oldest organized Departments formed in the country. Today the Forest Departments in the States/UTs are managing the forests under the respective State Governments/UT Administration. Since the subject of forestry was shifted to the concurrent list in the year 1977, the Central Government plays an important role, particularly at the policy level in the management of the forests. The Forest Department has been credited as the oldest institution adopting the principle of sustainability by way of natural timber yield estimates which subsequently matured into the elaborate Working Plans as early as the nineteenth century (FRI, 2016). During 150 years or so, both the disciplines of forestry as well as the mandate, objectives, strategies and working have undergone vast changes. Since then, emerging needs led to paradigm shift in forest management. Thus, the forest management gradually moved from exploitation to conservation, multiple use to multiple benefits, sustainable yield to sustainable management, species to ecosystem management, authoritative (policing) type of management to participatory approaches to management, just silviculture to modern technologies like Remote Sensing, GIS and GPS. Obviously, the SFDs have evolved into multi-purpose, adaptable and dynamic organizations, ready to tackle multifarious challenges relevant to forestry, wildlife management, biodiversity conservation, rural development, human environment, integrated watershed management, eco-restoration, river restoration/rejuvenation, climate change mitigation and adaptation, and sustainable development.

The primary mandate of SFDs is Protection of forests, enforcement of various laws, and management of forests pests, implementation of silviculture-based forest management, afforestation and restoration activities, conservation of forests and other natural ecosystems, Integrated watershed management, Wildlife management and conservation of biodiversity and Eco development, joint forest management, improvement of livelihoods, management of sustainable livelihoods in forest fringe villages and protected areas.

(B) Multi- Sectoral Convergence

The newer requirements of above stated enlarged scope, mandate and adopted holistic approaches to conservation and sustainable management of forests for multiple values, demand that SFDs work in close cooperation with various line agencies, Gram Panchayats and other local self-governance bodies at the grassroot level, NGOs and local communities. The new mandate

has made the SFDs a focal point of convergence among various allied departments. Accordingly, in recent decades, increasingly SFDs have worked in partnership with the Department of Agriculture and Horticulture, Department of Animal Husbandry, Public Works Department, Public Health Department, Department of Tribal Development, Panchayati Raj, Revenue Department, Irrigation Department, District Rural Development Agency, Department of Science and Technology, etc. The SFDs have made considerable contribution in various centrally sponsored schemes relying on inter-sectoral convergence. In past 3-4 decades, the SFDs have implemented several externally funded forestry and conservation projects by various international agencies *viz*., the World Bank, International Development Agency (IDA), Global Environmental Facility (GEF), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United States Agency for International Development (USAID), Japan International Cooperation Agency (JICA), German Developmental Agency (GIZ), etc. and gained considerable experience. Majority of these externally funded projects required working with various stakeholders including Line Departments and local communities seeking multi-sectoral convergence. In addition, SFDs extensively consult and either avail expertise or resources from various Forestry Institutions, other state/ national level scientific organisations, Universities, State Biodiversity Boards, National Medicinal Plant Board, National Bamboo Mission, National Afforestation and Eco development Board in meeting various R&D needs or capacity development programmes.

(C) Decentralised Approach

The National Forest Policy, 1988 and the National Wildlife Action Plan, 1984 envisaged people-centric approach towards management of forest and wildlife resources in the country and laid emphasis on participatory and decentralized approaches involving local communities, both in decision making as well as in programme implementation. In past four decades or so, the SFDs witnessed a paradigm shift from top down approach to bottom up approach. The SFDs adopted the concept and approach of the Joint Forest Management (JFM), promoting the creation of Joint Forest Management Committees (JFMCs) so as to restore degraded forest areas and elicit people's support in forest and wildlife conservation. JFMCs are known by different names in various States, such as Van Sanrakshan Samiti (VSS), Village Forest Development Committees (VFDCs), Village Forest Protection Committees (VFPCs) and Village Forest Development Societies (VFDSs). However, their functions were essentially similar to each other. These Community Based Organisations (CBOs) included the local representatives in the executive body and all the adult villagers as member in the general body. The CBOs were either registered as Societies under the Society Registration Act, 1860 or as a constituent of the Division-level Forest Development Agency (FDA) which in turn is registered under the Society Registration Act. The MoEF&CC has issued detailed rules and Operational Guidelines of National Afforestation Project (NAP) including benefit sharing mechanism under JFM. In accordance with these guidelines, the respective State/UT Government has also framed resolutions and rules for implementation. The JFMCs across the country along with SFDs carried out forestry activities related to protection, regeneration, afforestation, utilization and sustainable

management of forest areas allotted to them. Certainly, the initiative on the formation of CBOs by the SFDs was a significant move towards the process of decentralization and people's empowerment. Already existing JFMCs and their variants in two States (Himachal Pradesh and Punjab) and one UT (Jammu & Kashmir) can be optimally utilized for ensuring public participation and eliciting their support at all the stages *viz*., planning, implementation, monitoring and evaluation of any major project related to management of forests, wildlife or river restoration.

(D) Forest Administration and Management Units

From the foregoing description, it is evident that forestry discipline and the SFDs in the country have long history and the Forest Department is amongst the well organised and well evolved Departments. SFDs are hierarchical in their organisational setup and field functioning. For smooth and efficient functioning, each SFD is divided into several forest circles. Each Forest Circle includes a few Forest Divisions. Each Division consists of several Forest Ranges constituted by a few Blocks/Sections. Each Block/Section is sub-divided into several Forest Beats. Each Beat generally has an average jurisdictional area of a few km^2 to even larger block up to 50-60 km^2. The SFD is generally headed by the senior most Indian Forest Service (IFS) Officer in the apex pay scale and rank of the Principal Chief Conservator of Forests (PCCF) who is also the Head of Forest Force (HoFF). The larger State may have 2-4 PCCFs to support the HoFF in specific roles *viz*., Planning and Administration, Wildlife, Working Plan, JFM, etc. The Forest Circles are being supervised and commanded by a team of senior officials at the rank of Conservator of Forests. In addition, there could be CFs for specific functional thematic areas. In larger States, the senior forest official at the level of the Chief Conservator of Forest (CCF) or Additional Principal Chief Conservator of Forests (APCCF) may be assigned responsibility to supervise the forest functioning in a region incorporating jurisdiction of multiple forest circles. Usually, the administrative units are mostly delineated on the ground in accordance with boundaries of the watershed. The smallest unit of administration and forest management is the Forest Beat under the charge of a Forest Guard (FG), supported by a few forest watchers and casual labourers. The Beat Officer or a Forest Guard is usually having a jurisdiction over 4-6 forest compartments, each having area of 2-4 km^2. Each forest block/section is looked after by a Deputy Range Officer/ Forester while a Range Forest Officer is the supervisor of 2-5 DROs. In the hierarchy of the Forest Department, generally from FG to RFO are considered as the field level implementing officials while officials above RFO are involved in planning and decision making.

(E) Projects and Schemes Operated by SFDs

The SFDs have been executing a wide array of projects and schemes in order to accomplish entrusted mandates and fulfil the requirements of various goals and objectives. These projects and schemes can be grouped as: (a) the State Government funded schemes, (b) the Centrally Sponsored Schemes (CSS), and (c) the Externally Aided Projects (EAPs) (Table 4.7). The funding source is amply clear as reflected in the nomenclature of stated categories projects/

schemes. Predominantly, the World Bank was the first international agency to support EAPs on forestry in select States of the country in late 1980s. The World Bank supported forestry projects provided a new focus on the incorporation of modern technologies *viz*., Information Technology, Remote Sensing and GIS, people-centric and participatory approaches in the fields of forestry and forest managements. The IDA funded Forestry Research, Education and Extension Project (FREEP) was primarily implemented to enhance the capacity in the field of forestry research, education and extension, and the five year programme supported various activities at forestry institutions under the umbrella of ICFRE and also facilitated comprehensive, multidisciplinary research and monitoring projects in two PA sites in the States of Himachal Pradesh and Tamilnadu.

Indeed, it was the pioneer effort in two large PAs (the Great Himalayan National Park Conservation Area and the Kalakad-Mundanthurai Tiger Reserve) of significant biodiversity values wherein concurrent researches on various physical, biological and socio-economic aspects were carried out. The project attempted to demonstrate the eco-development approach in the context of these two priority conservation PA sites. Based on the success of this pilot project on Eco development and various initiatives on capacity building, the World Bank executed the GEF/IDA supported yet another major EAP on the theme of Eco development in seven prominent PA sites across the country. The project was named as the 'India Eco development Project'. Subsequent to these pioneer projects, various International Agencies (UNDP, USAID, JICA, GIZ, etc.) came forward to support several new EAPs on different themes *viz*., wildlife management, biodiversity conservation, sustainable land and ecosystem management, climate change mitigation and adaptation, and sustainable livelihoods in different SFDs.

Hence, over the years, SFDs have gained considerable experience in execution of major projects on wide range of emerging themes involving different stakeholders including local communities. The Government of India, MoEF&CC has also been formulating and implementing a variety of CSSs in different States/UTs covering priority themes of afforestation, Eco development, tiger conservation (Project Tiger/NTCA), elephant conservation (Project Elephant), snow leopard conservation (Project Snow Leopard) wetland conservation, protected area management, management of threatened species and their habitats, biosphere reserve programme, Ganga Action Plan, etc. Fig. 4.1 presents a broad nature and components of schemes implemented by SFDs. Thus, it is amply clear that SFDs have diversified their activities over the past decades so as to implement numerous projects/schemes sponsored by the State/Central Government or different international agencies. Hence, the SFDs in two States and one UT along the course of Ravi have adequate experience in implementing the present DPR on proposed forestry interventions.

Table 4.7 – Diversity of Projects and Schemes Implemented by SFDs

State Government Schemes	Centrally Sponsored Schemes	Externally Aided Projects
Afforestation/ Reforestation	Afforestation/Reforestation (National Afforestation Programme-NAP, Green India Mission–GIM, Compensatory Afforestation Fund Management and Planning Authority-CAMPA)	The World Bank supported Forestry Projects
Soil and Water Conservation Structures	Livelihood Improvement (NAP, GIM)	IDA/GEF supported India Eco development Project and 'Biodiversity Conservation and Rural Livelihood improvement Project – BCRLIP'
Public Distribution of Plants	Planting and Restocking Bamboo (National Bamboo Mission – NBM)	IDA funded Forestry Research, Education and Extension Project
Cultivation and Plantation of Medicinal Plants	Augmenting Medicinal Plants (National Medicinal Plants Board - NMPB)	UNDP/GEF supported Projects on 'Sustainable Land and Ecosystem Management (SLEM)' and 'Securing Livelihoods, Conservation, Sustainable Use and Restoration of High Range Himalayan Ecosystems-SECURE Himalaya'
	Watershed Management and Livelihoods (Integrated Watershed Development Programme- IWDP, Integrated Watershed Management Programme– IWMP)	Carbon Sequestration and Climate Change
	Soil and Water Conservation (NAP, GIM, IWMP, CAMPA)	Watershed Management and Integrated Development of Landscapes
	Integrated Development of Wildlife Habitats - IDWH	
	Project Tiger– PT, Project Elephant – PE	

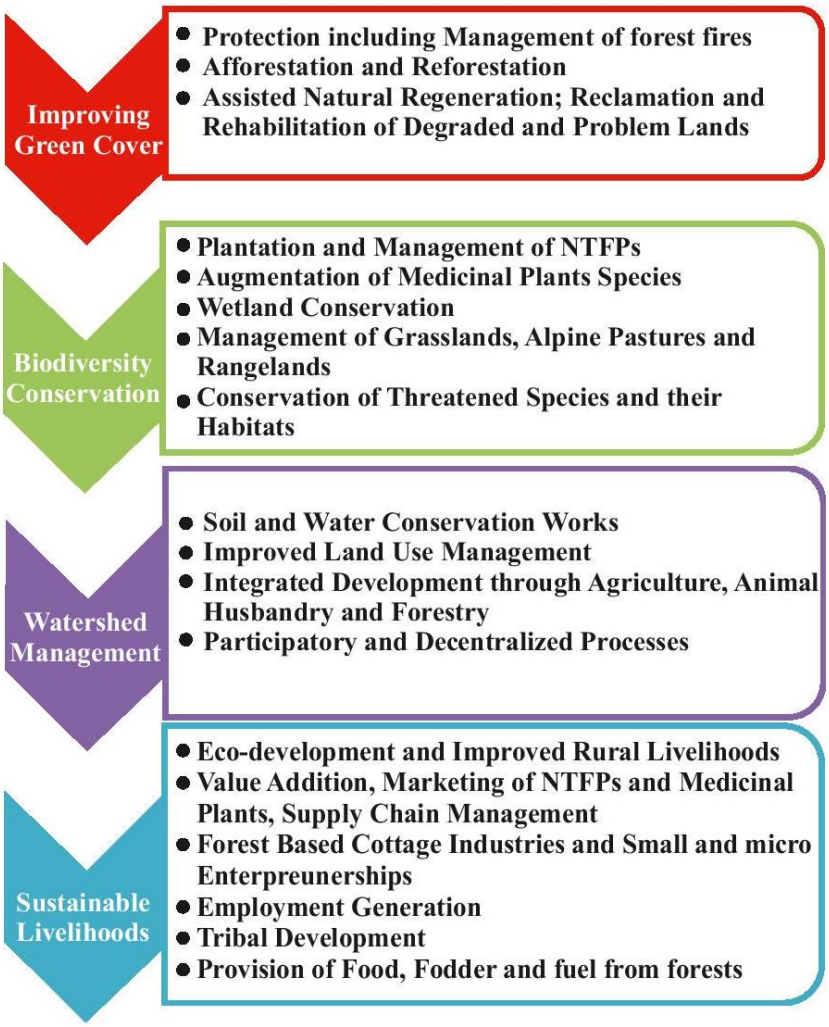


Fig. 4. 1 - Broad Nature and Components of Schemes Implemented by SFDs

Schemes operated by SFDs in Ravi River Basin:-

(A) Sanjhi Van Yojna Scheme (2001)

Sanjhi Van Yojana Scheme was started in 2001 after merging various schemes such as Sanjhi Van Yojna Scheme of 1998, the Parisharam Hamara Van Hamara Scheme, 2000 and the Apna Van, Apna Dhan Scheme (Gouri *et al.*, 2004; HPFD, 2014). The objective of the policy was to streamline participatory forest management efforts in the state. It envisaged a greater role of local institutions such as Village Forest Development Societies and Gram Panchayats in management of forest resources. It gave 100% income from plantations and usufruct rights to people through local institutions (ibid). It emphasised the involvement of women and other marginalised sections in management decisions. From the year 2001-02, a new scheme namely Sanjhi Van Yojana has been introduced in tribal areas to have the participation to communities in

the natural resources management in general and forests in particular. The scheme instead of being individual oriented, as was the case in the past similar schemes, now is community oriented. It aims at empowering people and the communities, in accepting a greater role and responsibility in management of the natural resources. The progress would be determinated by the commitment and awareness shown by the communities and the staff. The main objectives are:

1. Involvement of grass root level institutions such as Gram Panchayats, *Mahila Mandals*, Yuva Mandals, Schools, Village Development Committees (VFDSs), NGOs etc. in eco-restoration.
2. Regeneration of degraded forest areas through community involvement.
3. Creation of social assets for the benefit of the communities.
4. Increasing productivity of the forest areas by improvement of nursery stock through adoption of modern nursery techniques.
5. Re-orientation of the forest staff for facilitating community participation.
6. Generation of employment opportunities in rural areas.
7. To bring more area under tree cover by encouraging rehabilitation/plantation of private wastelands on cost/benefit sharing basis.

(B) Integrated Watershed Management Programme (IWMP)

It has been observed that Watershed Projects have been implemented in the state with the objective of management of land and water resources keeping their relationship strong and maintaining the balance between man and environment. These Watershed Projects are being implemented with different names from time to time and have been improvised with the passage of span. Now, Integrated Watershed Management Programme (IWMP), after consolidation of all previous watershed programmes i.e. Drought Prone Area Programme (DPAP, Desert Development Programme (DDP) and Integrated Wasteland Development Programme (IWDP) has been incorporated and is being implemented by Rural Development Department. Different stakeholders are involved in the implementation of the projects. These stakeholders should have a proper understanding and knowledge of the IWMP for effective implementation of the same. Hence, in order to make the stakeholders understand, the capacity building through trainings, both in-house and off- campus, have to be placed appropriately. H.P. State Institute of Rural Development (HPSIRD) is an Apex Training Institute of the state meant for imparting trainings to different stakeholders on rural development. This Capacity Building Plan has been attempted with a view to helping the watershed stakeholders to meet their requirements through training interventions.

(C) Joint Forest Management

Himachal Pradesh has around two decades of experience with the JFM approach. The State Government issued the first JFM Notification in 1993 for constitution of Village Forest Development Committees (VFDCs). In 2001, Himachal Pradesh Participatory Forest

Management Rules were issued for registration of Village Forest Development Societies (VFDSs) under the Societies Registration Act. Subsequently - 2002-03 onwards - JFMCs were constituted and federated into FDAs at the Forest Division level with support from NAP. The JFMCs are registered with HPFD as per the provisions of the NAP guidelines, whereas FDAs are registered as Societies. The SFDA was constituted in 2010 in accordance with the central guidelines. People's participation in joint forest management in higher hills of Himachal Pradesh. Joint Forest Management (JFM) is an effort which involved people to participate for the protection, conservation and rehabilitation of forests whilst safeguarding the rights of forest dwellers. In Himachal Pradesh, more than 66 per-cent of the area is under forest which in one way or the other is supporting the rural population of the state which constitutes around 89 per cent of the total population of the state. JFM began in the state during 1993-94 when state government issued first notification for constitution of Village Forest Development committees (VFDCs). In 2001, Himachal Pradesh Participatory Forest Management Rules were issued for registration of Village Forest Development Societies (VFDSs) under the Societies Registration Act. Subsequently 2002-03 onwards – Joint Forest Management Committees (JFMCs) were constituted and federated into Forest Development Authority (FDA) at the Forest Division level with support from National Afforestation Program (NAP)(Guleria *et al*., 2017).

(D) Institutional Work

In Schools and Colleges, Van Mahotsav is celebrated so that people can learn to consereve the trees and start planting more and more trees. It is celebrated on 5th June and almost in the first week of July of every year. Van Mahotsav is celebrated in many schools, colleges and universities of the country. Especially schools celebrate this occasion to make children understand the value of trees and its importance. On this day, children are provided with saplings which they are instructed by their teachers to plant. Slogans and poster writing competitions are organized in the schools on the occasion of Van Mahotsav. Free saplings are distributed all over the country on this specific day or throughout the week by the forest department, the state governments and farmers. This in a way grows the love for trees and nature among the children. Children are the future of the country. If they learn how to keep the environment free from smog and love the nature then nothing can stop a country from the rapid development. Half of the trees and plants die because of pollution, heat, grazing and of course deforestation. But with the help of this forest festival we can take a step forward to save our planet.

(E) Catchment Area Treatment Plan

The study of soil erosion and sediment accmulation from catchment is very important as the deposition of sediment into the reservoir reduces its capacity, thus affecting the available water for use. Soil sediment when deposited in rivers and banks, results in weaving access to the river. Removal of top fertile soil negatively affects agricultural production and silt laden

water affects the turbine blades of the engine which ultimately affects hydropower production. Uncontrolled grazing of animals also act as another important factor that adds to the sediment load. A large number of cattle, sheep and goats graze continuously for about six months in the mountainous region. Lack of proper vegetation cover is a factor, causing damage, and thus leading to severe erosion/soil erosion, which has led to the siltation of the reservoir prematurely. Therefore, a well-designed Catchment Area Treatment (CAT) system is required to improve above including process of soil erosion. The treatment of the catchment area involves understanding the signs of erosion and identifying/proposing remedial measures to reduce erosion. For this reason, the catchment area responsible for directly draining rivers, streams, tributaries, etc. are treated and the cost is included in the project cost (EIA, 2020).

(F) Expertise and Capacity

The SFDs manned by the Indian Forest Service (IFS) and State Forest Service (SFS) Officers not only have the well-organized hierarchical organizational setup, state-wide infrastructure, and long experience of managing diverse forests alongside other natural ecosystems, but also have much desired capacity, multi-disciplinary expertise and well equipped with modern equipment, tools and technologies. This makes the SFDs more amenable to capacity development at even short notice to adopt newer approaches and improved methods and also to diversify as per the emerging needs in the fields of ecosystem management, climate change mitigation and adaptation, river conservation and sustainable development.

4.3.4 Indian Armed Forces and Central Armed Police Forces

The Republic of India has the military force represented by the Indian Armed Forces (IAFs) consisting of three professional uniformed services *viz*., the Indian Army, the Indian Navy and the Indian Air Force. In addition, the Indian armed forces supported by the Central Armed Police Forces (CAPFs), formerly referred as the Paramilitary Forces. However, the Union Ministry of Home Affairs (MoHA) adopted uniform nomenclature of CAPF in the case of six forces *viz*., CRPF, BSF, ITBP, CISF, SSB, and the NSG. As such, the primary mandates of the IAFs and CAPFs include, protection of the frontiers to safeguard the country's sovereignty, and important and sensitive establishments (i.e., airports, sea ports, industrial units, hydroelectric projects, temples, etc.), but these forces have also been helping in conservation of nature and wildlife resources in difficult terrain and harsh climatic conditions all along the frontiers of the country whether on the land or in coastal and marine water. Further, under the ages of MoEF&CC and Ministry of Defence (MoD), dedicated force such as the Eco Task Force (ETF) was raised as the Territorial Army Unit in conjunction with States to take on challenging assignments in the ecologically fragile and sensitive areas. The ETF battalions have successfully achieved twin objectives of their establishment: (a) eco-regeneration of degraded areas, and (b) rehabilitation of ex-serviceman. Presently, nine infantry battalions (TA), comprising 22 operational companies are carrying out afforestation in difficult and degraded areas in States/UTs of Uttarakhand, Rajasthan, J&K, Ladakh, Delhi, Himachal Pradesh, Assam and Maharashtra. In addition, a

Composite ETF (CETF) for National Mission for Clean Ganga has also been raised at Allahabad. One company each at Kanpur, Varanasi and Allahabad have been planned for the said mission. Till date, various ETF battalions across the country have planted nearly 60.8 million saplings and covered an area of 727.4 km^2, with 75-80% of survival rate. The CETF is supposed to patrol the sensitive river areas for the protection of biodiversity and other tasks such as safeguarding the river from pollution and sand mining, etc. The 127 ETF Battalion in Uttarakhand was awarded the Indira Priyadarshini Paryavaran Puruskaar by the MoEF&CC for the commendable work in the field of ecological restoration. Recognizing the past contributions and experiences of ETFs in ecological restoration of degraded land and protecting rivers like Ganga, the potential of ETF battalions can be utilized in forestry interventions in difficult areas of Chamba in Himachal Pradesh and Basohli in Jammu & Kashmir UT for the protection of biodiversity, particularly Critically Endangered species.

4.3.5 Ravi River and the Civil Society

The civil society represents the collective group of individuals, non-governmental organizations and institutions in a society that mark interests and will of citizens, and also referred as the 'third sector' of the society, distinct from the government and corporate. The civil society plays a wide variety of roles by way of development of social institutions at various levels for specific purposes *viz*., promotion of cultural and religious values, campaigns against social evils, protection and conservation of nature, and other social welfare measures including relief operations during natural disasters and other stresses and disturbances. Since, the Ravi River flows through cities and towns and the river and its tributaries throughout their journey from origin to confluence are surrounded by densely populated human habitations, therefore the civil society can play vital role in creation of mass awareness, protection of river and river resources, and allied activities. The religious bodies (e.g. village devta, temples, gurdwaras, Radha Soami Satsang, etc.) can also play vital role in efforts towards river restoration. Likewise, numerous organizations and institutions (e.g., *Panchayats*, JFMCS, Eco development Committees, Biodiversity Management Committees–BMCs, Aanganwari Workers, Nehru Yuva Kendras (NYKs), National Service Scheme–NSS, etc.) can be of utmost importance and can be involved in awareness campaigns, cleaning drives for river and surrounding lands, protection and monitoring, and also implementation of proposed forestry interventions.

(A) Nehru Yuva Kendras

The Ministry of Youth Affairs and Sports (MoYA&S), Government of India is the Nodal Ministry responsible for the establishment of Nehru Yuva Kendras since 1972 with the objective of providing rural youth avenues to take part in the process of nation building as well as offer opportunities for the development of their personality and skills. In 1987-88, the MoYA&S set up the Nehru Yuva Kendra Sangathan (NYKS), an Autonomous Organization under the Ministry to oversee working of NYKs. The NYKS is the largest grassroots level voluntary organization

that channelizes the power of youth in the age group of 13-35 years on the principles of voluntarism, self-help and community participation. The NYKs has a country wide network of village-based Youth Clubs and *Mahila Mandals*. Its network of 28 Zonal offices, 501 District level offices, and more than 1.25 lakh Youth Clubs in nearly half of the villages of the country constitute a large force of voluntary movement under the auspices of the MoYA&S. The vast network youth and *Mahila Mandals* operating at village level could be meaningfully involved in the effective implementation of proposed forestry interventions.

(B) National Service Scheme

Yet another student voluntary group named as the National Service Scheme (NSS), under the MoYA&S exists. The NSS was launched in 1969 during the Mahatma Ghandhi's Birth Centenary Year. Today, NSS has more than 3.2 million student volunteers enrolled in over 298 Universities and +2 Senior Secondary Councils and Directorate of Vocational Education all over the country. The community service rendered by NSS volunteers undertakes varied works related to intensive development in adopted villages, conduct of medico-social surveys, setting up of medical centres, programmes of mass immunization, cleaning, afforestation, etc. Thus, the NSS can be involved in proposed forestry interventions for rejuvenation of Beas and its tributaries and also in creation of mass awareness campaigns.

(C) Himalayan Nitti Abhiyan – NGO

Himalaya Niti Abhiyan (HNA) is a collective of grass root people's resistance defending local livelihoods, environment and social equity with the idea of sustainable mountain specific development model. HNA was formed in January 2004. Prior to this the same group of people was working under the banner of Navrachana, a collective of NGO's and some of independent activists on the issue of Natural Resource Management and local self-government since 1994.

HNA has been campaigning for sustainable mountain specific development model, which we call Himalaya Niti. The conceptual understanding of the Himalaya Niti is Livelihood through conservation. The development strategy shall be formalized for the conservation with the active control of locals.

(D) Green Valley Clean Valley

Green Valley Clean Valley is a NGO which provide awareness regarding nashamukti in rural and urban areas of Chamba district of Himachal Prades. It is also involved in tree plantationprogrammes.

(E) *Mahila Mandals*

Mahila Mandals (MMs) which are the women social groups (CBOs) have been found to be effective communicators and channels of information with their near universal presence in the rural areas of Himachal Pradesh. *Mahila Mandals* are registered bodies (under Registration of

Societies Act, 1860). About 8500 *Mahila Mandals* are registered in Himachal Pradesh at present. A *Mahila Mandal* generally consists of around 15 to 20 members and has a Chairman and Secretary. The *Mahila Mandals* are generally involved in cleanliness and hygiene activities; camps against alcoholism; eradication of Social evils and awareness regarding trees in villages.

4.4 Incorporation of Laws, Policies and Institutions in DPR

The present Chapter has allowed the broad based understanding of pertinent laws, policies and institutions in the context of management and restoration of river and proposed forestry interventions. At the same time, the elaborate description on wide range of central and state government organisations including the SFDs, Central Armed Police Forces and civil society those have vital role in implementation of the present DPR has been narrated.

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Chapter 5

Forestry Interventions - The Objectives and Strategies

5.1 Ravi River Ecosystem- Environmental Trends

The past patterns of environmental degradation of various associated natural ecosystems i.e., forests, grasslands and wetlands along the course of Ravi River profoundly reflected that human activities have perilously influenced not only the river but also all its tributaries and associated natural ecosystems, and in turn the vital life support systems. Therefore, factors responsible for destruction, deterioration and degradation resulting in decline of ecological integrity of river, ecosystem and the poor river health were adequately documented. The degradation of land and water resources, erosion of biodiversity, enhanced levels of resource use and pollution, and likely implications of climate change were emphasized. The appraisal also revealed that extensive environmental degradation is the precursor to reduced ecosystem services, resultant poverty, unsustainable livelihoods, growing conflict, damage of property and physical assets, water crisis, food insecurity, and overall vulnerability of communities and the natural ecosystems. The need of the hour is to ensure that rapid development and rising prosperity in the basin/riverscape occur in such a way that they do not jeopardize the natural ecosystems offering multiple ecosystem services on which the human survival depends.

5.2 Key Thrust Areas

Alarmed at growing environmental concerns and depleting state of natural ecosystems in the country, India has undertaken a large number of policy and legislative initiatives during the past four decades or so, and launched multi-focal area programmes so as to address biodiversity loss, land and ecosystem degradation, pollution and climate change that are inter-linked and share common drivers. India is not alone in its fight against global environmental challenges and has, therefore, joined global conventions and commitments such as UNCBD, UNFCCC, UNCCD, Ramsar Convention, etc. India is internationally obliged and committed to address issues emerging because of exhaustion of global commons and resultant rising worldwide concerns *viz*., degradation of land and water assets, water emergency, hunger, ailing health, environmental change, and so forth besides other social issues of rights, security and peace. Keeping in view growing environmental concerns and depleting state of natural ecosystems, particularly rivers, the GoI has undertaken several policies and legislative initiatives and launched multi-focal area programmes so as to address priority concerns about land and ecosystem degradation, dwindling biodiversity, ever increasing pollution and implications of climate change that are closely inter-twined and in most instances share common drivers and stressors. In the past four to five decades, India has initiated actions to either halt or reverse the process of environmental degradation by way of numerous country-wide programmes and implementation of global and national level

strategies relevant to different sectors *viz*., sustainable land and ecosystem management, conservation of biodiversity, watershed management, urban environment, climate change, rural livelihoods, and sustainable development. It is evident that the vast subjects of water resources, rivers and river restoration are not only amongst the highest priority agendas of the current government, but also the Government is fully committed to achieve their mission goals in a time bound manner. Further, the present DPR and concurrent preparation of DPRs of other major Indian Rivers testify the priority and commitment of the Union Government towards restoration of rivers.

5.3 Vision, Mission, Goals and Objectives

In the broad sense, the proposed forestry intervention plan aims to contribute towards uninterrupted flow of clean water of Ravi River, besides maintenance of ecological and geological integrities. Based on extensive consultative process carried out as a part of this DPR, the following shared vision emerged for the implementation plan.

Vision: To maintain and restore the ecological integrity of Ravi River so that Aviral and Nirmal Dhara is ensured and sustained benefits of ecosystem services. Conservation and sustainable use of biodiversity of Ravi River ecosystem is fundamental to ecologically sustainable development. Biodiversity is part of human lives and livelihood and constitute resources upon which families, communities, nation and future generation depend.

Mission: The mission is to accomplish the above shared vision by adopting multi-pronged strategy and pursue of five specific strategic priorities: (a) address drivers of environmental degradation and arrest biodiversity loss, (b) adopt integrated, innovative and nature based solutions, (c) enhance resilience and adaptation, (d) build alliances and foster synergies, and (e) opt for the right influential models and interventions so as to achieve reduced pressure on biodiversity, restore degraded ecosystems, promote sustainable use of biological and water resources, enhance capacities, mainstream biodiversity, augment policy and law support, and facilitate science based efficient decision making.

Goals: To manage human and ecological needs and advocate conservation goals within the context of human health, economic and other community needs, and their connection to ecosystem, healthy rivers and clean water and to develop a comprehensive understanding of entire river system.

In view of the above and in accordance with the National and Global level priorities, commitments, agendas, strategies, and approaches, the Implementation Plan on proposed forestry interventions seeks to address the following focal areas or goals in an integrated manner:

(a) **Riverscape Management:** Aiming a holistic riverine landscape (riverscape) approach for sustainable management of Ravi River, its banks, or its riparian areas, within its fluvial system.

(b) ***Aviral Dhara, Nirmal Dhara,*** **Ecological Rejuvenation and Biodiversity Conservation:** Aim to address the drivers and stressors of river ecosystem and promote sustainable use by balancing ecological requirements with the needs of sustainable livelihoods.

(c) **Improved Ecosystem Services and Sustainable Livelihoods**: This goal aims to specifically seek enhanced ecosystem services so as to maintain sustainable livelihoods.

(d) **Effective Implementation, Knowledge Management and Innovative Approaches:** This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches i.e., nursery techniques, afforestation, bio-filters and bioremediation and adoption of appropriate modern technologies.

Project Objectives, Outputs and Outcomes: This Plan aims to fulfill the requirements of above stated four focal areas in a phased manner and visualizes specific outputs and outcomes. Hence, the following objectives are set-forth.

Project Objectives

1. To promote an environment conducive to sustainable land and river eco-based management approaches focusing on reduced soil erosion and to conserve the representative biodiversity of the Ravi Riverscape.
2. To carry out appropriate forestry interventions to restore river connectivity, enhance e-flow, improve water quality, and conserve the terrestrial and aquatic biota within the Ravi Riverscape.
3. To promote improved ecosystem services and support sustainable livelihood opportunities for local communities, particularly forest dwellers, fishermen and other vulnerable groups.
4. To adopt, integrate and implement innovative approaches and modern technology aiming knowledge management, enhancing capacity along with proper monitoring and evaluation for rejuvenation of the Ravi and its tributaries.

Above objectives will be achieved through the following outcomes.

1. Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands) and floodplain ecosystem management.
2. Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other allied interventions demonstrated in adequate extent(s) of Natural, Agriculture, and Urban Landscapes of the Riverscape.
3. Enhanced ecosystem services from natural i.e., forest, grassland, river and wetland) ecosystems, agro-ecosystems and urban landscapes.
4. Sustainable livelihoods, particularly of forest dwellers, fishermen and other vulnerable groups.

5. Capacities for adaptive management, learning and replication of project lessons are developed.

The following specific outputs are foreseen under the above stated outcomes.

Outcome 1: Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands) and floodplain ecosystem management

The purpose of this significant outcome is to build an appropriate environment wherein multiple agencies/sectors working for various production sectors i.e., forest, watershed, agriculture, livestock, mining, tourism, tribal welfare, infrastructure development hydropower, communication, highways and waterways) converge and adopt climate resilient and sustainable approaches of terrestrial, aquatic and floodplain ecosystem management by mainstreaming biodiversity concerns. These sectors shall also work together so as to address gaps and inadequacies in realizing global and national policy objectives relevant to the environment, biodiversity, water resources and climate change. Following outputs are envisaged to accomplish above broad based outcome.

Output 1.1*:* Enhanced levels and enabling environment created for:

(a) Multi-sector convergence, alliances and integration.

(b) Favorable National and State Level policies i.e., forest, agriculture, animal husbandry, watershed management, river management, tribal welfare, infrastructure development, tourism, etc.) those reflect principles of climate resilience, sustainable land and ecosystem management, and mainstreaming biodiversity concerns in production sectors.

A wide range of policies and legislative acts concerning the above stated different production/ environment sectors already exist. The Chapter 4 has adequately elaborated on the existing laws and policies and also provided a comprehensive list of relevant laws and policies. So far, fragmentary and preliminary efforts have been made for inter-agency cooperation and convergence and even adoption of landscape/riverscape approaches to conservation and ecosystem management. Nevertheless, the current experience on the sectoral convergence is grossly inadequate. The appraisal of river environment in the context of Ravi River amply revealed for the urgent requirements of adopting a comprehensive and holistic approach for river restoration, inter-agency cooperation and sectoral convergence, mainstreaming biodiversity concerns in production sectors, and the need for harmonization amongst competing and conflicting sectors through adequate support of relevant policies and enforcement of laws. This Plan on the proposed forestry interventions will provide an opportunity to bring diverse stakeholders/agencies/sectors/civil society organizations together for the realization of above stated vision and goals relevant to healthy river and sustainable ecosystem. SFDs in two concerned States and one UT would be the primary Implementing Agencies (IAs) and they would facilitate the process for this vital output while working with different agencies/sectors and CSOs. The National Level Nodal Organization (HFRI) would be responsible for technical backstopping, and monitoring and evaluation besides the current role being played on planning

and preparation of the present DPR. A highly consultative and co-operative approach is being planned in creating the enabling policy environment, and developing recommendations and mechanisms for programme implementation. The Nodal Institution (HFRI) and three primary IAs (SFDs) in Himachal Pradesh, J&K and Punjab would be required to play a major role in addressing the threats arising from the climate change and suitably integrate them with current land use, production sectors and ecosystem management.

Output 1.2 Capacity of government officials and civil society organizations is developed in promoting community driven, climate resilient, sustainable land and ecosystem approaches, and holistic approach to management of river ecosystem.

The project aims to propose extensive plantation activities in natural, agriculture and urban landscapes so as to enhance the forest cover, provide multiple benefits to local communities and help in the processes relevant to retention of water, recharge of ground water, functioning of bio-filters and bioremediation. In addition, varied activities *viz*., soil and moisture conservation works, grassland, wetland management, cultivation of medicinal and aromatic plants, weed management, conservation of threatened species, riverfront development, etc. are also being considered and planned. Obviously, various proposed activities will be undertaken on the Government as well as community/private lands. SFDs will be the IAs in case of planned activities on the Government owned forest lands and protected areas. However, large scale efforts those are being planned on private agriculture lands and other lands i.e., revenue, urban, riverfronts owned by the various government agencies, proposed activities are being planned through CAPFs (ITBP, Eco -Task Force) and CSOs (*Panchayats*, *Gram Sabhas*, JFMCs, EDCs, BMCs, NYKS-Youth Clubs and *Mahila Mandals*, NGOs, Religious Organizations, etc.). Inter-agency cooperation and sectoral convergence are essential for the success of project of this nature. Awareness campaigns for masses, particularly women and youth are being planned. Capacity development of government officials, CSOs and local communities is being planned. Innovative approaches *viz*., bio-filters and bio-remediation are being considered alongside incorporation of modern technologies i.e., RS and GIS, meteorological, water quality, monitoring of aquatic animals, etc. has been envisaged. The project includes the logical framework analysis and results-based monitoring. Capacity development of officials and CSOs in these aspects is vital and thus, being appropriately addressed in the plan.

Outcome 2: Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other allied interventions demonstrated in adequate extent(s) of Natural, Agriculture and Urban Landscapes of the riverscape.

The riverscape includes wide ranging natural ecosystems i.e., terrestrial, aquatic and floodplain besides vast agriculture and urban Landscapes. Forestry interventions in such landscapes are envisaged.

Output 2.1 *Plans to reduce/check erosion in the mountainous region and floodplains of Ravi River and its tributaries by appropriate soil and moisture conservation works and development of optimal strategy for riverbed mining. Sites of landslides are adequately treated and stabilized.*

The DPR plans for considerable inputs by way of appropriate soil and moisture conservation works so as to check and reduce erosion and treating specific sites of landslides within the riverscape. At the same time, convergence of related sectors, development of policy framework on sand mining in river beds would be initiated and guidelines developed.

Output 2.2 *Plans for restored and sustainably managed forest lands, agriculture lands in targeted villages and forestry interventions in urban environment for improved forest/vegetation cover achieved. Enhanced assisted natural regeneration through improved protection and other measures is also accomplished.*

The main focus of DPR is on an integrated ecosystem management approach in the context of Ravi River by taking into account all diverse natural i.e., forest, grassland and wetland) ecosystems by adopting sustainable land and ecosystem management principles. The primary objective of this output would be to improve the forest/vegetation cover in the mountainous part of the riverscape in Himachal Pradesh, Jammu and Kashmir UT and Punjab Plains. In addition, this output envisages appropriate tree cover and Trees Outside the Forests (TOFs), through suitable plantations on private agriculture lands and various other government lands i.e., along canals, cantonments, schools, institutions, public facilities, riverfronts, and urban landscapes. Enhanced forest and vegetation cover will directly help in improved biodiversity, productivity, reduction in erosion and efficient functioning of bio-filters.

Output 2.3 *Plans for improved protected area management by implementing appropriate protection strategies, habitat management (e.g., weed control and water management), research and monitoring inputs, and enhanced capacity.*

The Ravi Riverscape includes several small and widely scattered protected areas along the altitudinal gradient in its mountainous part as well as in the lower part of alluvial plains. These protected areas include Wildlife Sanctuaries *viz*., Jasrota Wildlife Sanctuary, Tundah Wildlife Sanctuary, Kugti Wildlife Sanctuary, Kalatop-Khajjiar Wildlife Sanctuary, Dhauladhar Wildlife Sanctuary, Gamgul Siahbehi Wildlife Sanctuary and various wetlands *viz*., Khajjiar wetland, Manimahesh wetland, Ranjit Sagar wetland, Keshopur and Jastarwal wetland.

Majority of these PAs suffer on account of smaller size, large PA-People interface, traditional resource dependence, proliferation of invasive alien species and incompatible land use in their surrounds. It is pertinent to protect and improve these PAs from the perspective of biodiversity values and a wide range of ecosystem services they offer to the local peoples including serving as an important catchment area in the context of Ravi River and its tributaries. Therefore, the plan envisages multiple activities aiming to support the protection of these PAs, management of threatened species and their habitats including weeds, development of essential physical

infrastructure, eco-development, research and monitoring, awareness campaign and ecotourism, and capacity development.

Output 2.4 *Plans for improved management of prominent wetlands in the riverscape by protection, restoration, zoning, habitat management and wise use of wetland resources.*

The riverscape harbours diverse natural and manmade wetlands along the river course as well as in proximity to the main channel of Ravi River or its tributaries. They are not just biological supermarkets but have vital role in maintenance of environmental flow, water purification, groundwater recharge, and control of floods besides majority of them are major attraction for tourism activities. Most wetlands are threatened on account of enhanced siltation, chemical pollutants from agriculture landscapes, and influence of industrial effluents and sewage disposal from cities/towns. The plan visualizes a wide range of activities for management and conservation of wetlands within the riverscape and continues to provide multiple benefits to the society as well as to the river ecosystem. The monitoring of wetlands, particularly the resident and migratory birds is an important planned activity in the present DPR.

Output 2.5 *Plans for improved riverfronts and development of Eco-Parks*

The Ravi River and its prominent tributaries traverse through various towns within two States and one UT besides important locations of pilgrimage and tourism activities. The plan envisages the development of Riverfronts and Eco-Parks in select locations so as to enhance the potential of eco-tourism in such sites, provide improved livelihoods to local people by way of eco-tourism, and ultimately to help the river ecosystem from pollutants and other biotic disturbances in prominent stretches.

***Output* 2.6** *Plans for development of forests and river-based eco-tourism.*

In past four to five decades, there has been exponential increase in tourism activities all along the Ravi River and its tributaries, and adjoining forested tracts and particularly pilgrimage sites. Concerned States/UT within the riverscape are major attractions for such activities. Moreover, in past, local inhabitants have primarily relied on natural resources from terrestrial and aquatic ecosystems for their subsistence and commercial activities and obviously there has been an excessive pressure on harvest and collection of scarce forest and river resources. Hence, it is essential to provide Alternate Income Generation (AIG) activities to local communities and engage them meaningfully in various efforts towards protection and conservation of natural ecosystems. Thus, the Plan envisages activities those promote and provide support for the development of alternate income generation activities by way of eco-tourism, and allied Small and Micro Entrepreneurships (SMEs) so as to enhance income of communities, traditionally dependent on forests and other natural resources for their subsistence.

Outcome 3: Enhanced ecosystem services from natural i.e., forest, grassland, river, and wetland ecosystems, agro-ecosystems and urban landscapes

Since time immemorial, varied natural ecosystems have been offering a wide range of ecosystem services to the human society and in most instances these services have drastically declined owing to the fact the very foundation and existence of natural ecosystems have been severely impacted by growing population, unplanned development and other human disturbances. Thus, there is an urgency not only to curb adverse human activities, restore degraded ecosystems including man made agro-ecosystems and even the built up environment. Hence, planned activities by way of protection, afforestation, reforestation, assisted natural regeneration, weed control and management, water management, etc. have been envisaged in the plan.

Output 3.1 *Plans for reduced traditional forest dependence, developed alternate income generation activities, improved livelihoods, and facilitate establishment of viable Small and Micro-Enterprises (SMEs).*

The rural population in remote, rugged terrain and harsh climatic conditions of the upper mountainous part constitutes maximum population of riverscape. Traditionally, the rural population has primarily depended on forests and livestock for majority of their daily requirements. Gradual expansion of agriculture and horticulture and various developmental activities in the region enhanced opportunities for improved livelihoods. However, a substantial section of the rural society is either the 'Below the Poverty Line (BPL)' or continues to solely depend upon natural resources, primarily diverse forests including alpine pastures, wetlands and rivers. A significant portion of the rural population depends upon the collection of medicinal herbs and other NTFPs. There is ample opportunity to reduce traditional resource dependence by way of AIGs and SMEs. Over past few decades, various ethnic groups, particularly women have been engaged in area specific handicrafts and allied cottage industries. However, there is enormous scope to organize communities in AIGs and SMEs by developing and supporting appropriate mechanisms for linkages with markets and supply chain management.

Output 3.2 *Plans for enhanced levels of protection, conservation and sustainable harvests of medicinal and aromatic plants and development of herbal gardens.*

Specifically, the mountainous tract of Himachal Pradesh in middle and higher altitudes has been bestowed with enormous diversity of Medicinal and Aromatic Plants (MAPs). Traditionally, local people have been collecting and using such plants for their own consumption and varied uses in remote areas. However, once the road network was created and avenues for commercial requirements were opened up, there was sudden spurt in activities related to harvest, collection, cultivation and marketing of MAPs. In turn, these activities have expanded human disturbances in high altitude natural areas. The plan envisages select treatment models related to the cultivation of MAPs in natural and agriculture landscapes, and development of herbal gardens within the riverscape. The plan also envisages to create awareness and scientific technique to harvest, collection and cultivation of MAPs so as to enhance the productivity and reduce degradation of natural areas.

Outcome 4: Sustainable livelihoods, particularly of forest dwellers, fishermen and other vulnerable groups

One of the major outcomes expected from the implementation of present DPR pertains to improved rural livelihoods, particularly, of forest dwellers, fishermen specifically in Himachal Pradesh, Jammu and Kashmir and Punjab and other vulnerable groups inhabiting the remote mountainous tract or living along the stretches of Ravi River and its tributaries. The concept of sustainable livelihoods provided by the Department for International Development (DFID), UK emphasized on the maintenance of five livelihood assets *viz*., human, natural, financial, physical, and social. The uncertain climatic conditions and other natural exigencies pose enormous challenges, risks and vulnerability of forest dwellers, fishermen and other susceptible and weaker groups. The plan lays equal emphasize on ecological restoration and the sustainable livelihoods. Hence, essential and priority activities supporting the sustainable livelihoods of local populace are being planned. Efforts will be made to make them aware about the significance of natural capital besides other prominent livelihoods assets such as human and social.

Outcome 5: Capacities for adaptive management, learning and replication of project lessons are developed

One of the five outcomes envisaged from the implementation of the project pertains to enhanced capacity for adaptive management of natural resources including the river ecosystem. The following two outputs are foreseen.

Output 5.1 *Plans developed for integrated, science based and community-based monitoring, and assessment of impacts, as well as periodic evaluation of the project*

The natural resource management demands comprehensive and holistic approaches besides adoption of the principle of adaptive management. Increasingly, the International and National development agencies emphasize on the Results-Based Monitoring (RBM) as an essential and integral activity of a developmental project related to any sector. Considering the long stretches of the Ravi River and its tributaries, vast extent of the riverscape, diverse natural resources and stakeholders involved, and wide range of activities planned in natural, agriculture and urban landscapes besides several conservation and supporting activities across concerned States and UT along huge investments, it is essential to devise science, evidence and indicator-based diagnostic concurrent monitoring so as to ascertain the impact of planned activities on the river ecosystem, its wider environment and the rural livelihoods. The concept of adaptive management requires monitoring, learning and adaption. Thus, the plan aims to incorporate participatory and community driven monitoring system.

Output 5.2 *Plans for documentation of lessons learned and preparation of information dissemination products for wider audience and applicability.*

The wider subject of river conservation and restoration in India is relatively much newer and visibly, there is hardly any evidence of successful and well documented experiences. Indeed, the river restoration is a herculean task in human dominated country like India wherein there is the

presence of human all around and their varied intensive activities have adversely impacted the natural environment. The only little experience available is from the implementation of ambitious *Namami Gange* programme on the Ganga River. Hence, it is important to document the experiences and lessons learned in the planning, implementation and monitoring of project execution of this nature. Accordingly, the plan envisages activities related to documentation of project execution, lessons learned and wider dissemination of knowledge gained for appropriate replication in case of other rivers and their tributaries. Till date, there is no singular agency in the country that provides comprehensive and holistic insight as well as information on the river ecosystem. The appraisal of river environment evidently reflected this shortcoming. Hence, there is an urgency to develop the Knowledge Management Centre on the much desired and priority subject of river conservation and restoration. At the same time, there is vast opportunity to develop innovative approaches for execution of forestry interventions along the river, its tributaries and the catchment. Thus, this specific output pertains to development of innovative approaches suitable for different agro-climatic conditions within the riverscape besides documentation of experiences and lesson learned, dissemination and replication of similar efforts as either the part of proposed Phase II of the project or elsewhere.

5.4 Problems in Achieving Objectives

The various actual and potential problems achieving different project objectives are enumerated below.

a) Harsh climatic conditions, erratic and changing patterns of snowfall, rainfall, and ambient temperature, unpredictable avalanches, retreat of glaciers, increase snowmelt and runoff, and prevailing uncertainties.
b) Fragility of the Himalayan environment owing to increased seismic activity and active landslides, wide spread soil and riverbank erosion, and enhanced sedimentation.
c) Rugged terrain, steep slopes, inaccessible areas, shallow soil depth and low soil fertility.
d) Alteration in river course by linking river or diversion of water; sequential physical barriers by construction of dams, barrages, and establishments of HEPs.
e) Widespread and extensive land use changes and faulty land use; expansion and intensification of agriculture and horticulture; and excessive use of fertilizers, pesticides, weedicides, etc.
f) Traditional resource dependence, enhanced biotic activities, and human disturbances on natural ecosystems; limited opportunities for alternate occupation and income generation; unsustainable harvest practices; illiteracy; lack of awareness; and poverty and vulnerable communities.
g) Encroachment of forest lands, PAs, and other natural ecosystems; and all round rapid developmental activities i.e., expanding highways, widening of road network,

mushrooming of cities/towns, irrigation and hydro-power projects, transmission lines, etc.

h) Forest fragmentation, enhanced patchiness, habitat loss and degradation of terrestrial and aquatic ecosystems by proliferation of invasive alien species, and decline in productivity and lack of regeneration of native species.
i) Erosion of biodiversity value, smaller and isolated populations of threatened species and reduced distributional range of prominent faunal species.
j) Fragmentary approach of environmental impact assessment in case of sequential developmental projects and inadequate efforts for cumulative assessments.
k) Enhanced pilgrimage, mass congregation, and unplanned and unregulated tourism activities, and allied developmental activities and their impact on terrestrial and aquatic ecosystems including rivers, their flow and water quality.
l) Multiplicity of policies and laws, isolationist, conflicting or counterproductive strategies/ approaches adopted by different agencies/sectors, lack of sectoral convergence, and lackadaisical law enforcement and implications of judiciary activism.
m) Inadequate researches, databases, baseline information, ineffective monitoring, lack of technological support, innovations, and inadequate capacity.

5.5 Strategies

There are four broad goals aiming to address three distinct thrust areas relevant to the river conservation and restoration under the Implementation Plan. These thrust areas are (a) Sustainable land and riverscape management through appropriate forestry interventions, (b) Conservation of biodiversity in the terrestrial and aquatic environment of the river, (c) Enhanced benefits and sustainable livelihoods. In order to achieve three goals through proposed DPR on forestry interventions, important supporting activities such as policy level interventions, strategic adaptive research and development, innovative and low cost bioengineering methods for stream/riverbank stabilization, participatory monitoring, evaluation, awareness, capacity development, and project management are also envisaged. The Implementation Plan has incorporated four project objectives with five broad outcomes and twelve specific outputs.

The developed understanding on the riverscape environment has amply revealed that the riverscape is a mosaic of varied land uses and it includes: (a) natural ecosystems, (b) rural system predominated by agro-ecosystems, and (c) built-up urban environment represented by cities and towns. Each of these broad land use category represents significant area of the riverscape with unique conditions and situation, and varied use patterns, ownerships and management needs. Hereafter, three broad land use categories within the riverscape are being referred as the ‘Natural’, ‘Agriculture’ and ‘Urban’ Landscapes. These three landscapes immensely influence the intricate and vibrant nature of Ravi River ecosystem, especially the environmental flow, water quality, aquatic biota besides terrestrial biodiversity in surrounding lands, and the various

ecological and fluvial processes of the *lotic* system. Hence, in view of the prominence of three types of landscape elements within the riverscape, a multipronged strategy for proposed forestry interventions addressing specific requirements of each of the land use type/landscape category has been planned for the execution as a part of the implementation plan during the Phase I (5-year duration). The Phase I will be followed by Phase II (Maintenance Phase). As a part of the broader strategy, zoning within the riverscape is visualized keeping in view three distinct landscape categories and specific targeted forestry interventions those are being planned in each of the zone.

5.5.1 Zoning and Lower Order Zone Plans

Three broad and distinct landscape types or 'three zones' have been deciphered within the riverscape for the purpose of proposed forestry interventions. The following section presents an elaborate account of specific forestry interventions in each of the zone represents the self-contained 'Lower Order Zone Plan' for the Natural, Agriculture and Urban Landscapes, respectively within the riverscape.

Following three lower order zone plans/landscape plans in the riverscape are incorporated for the purpose of proposed forestry interventions.

(a) Natural Landscape (NL)

For developing treatment models, insight obtained from the consultative process, field acquaintance, professional judgment, forest working plans and CAT plans was optimally used. Suggested models for the Natural Landscape are segregated into two broad groups: (a) models for the Himalayan Mountainous tract in Himachal Pradesh and Jammu and Kashmir (b) models for the alluvial plains of Punjab. Each recommended treatment model includes background information on site characteristics, recommended plant species for the proposed plantation besides details on spacing, quantity of different activities and man days of work during the establishment year as well as in subsequent years of maintenance. Details of potential treatment models were shared with SFDs of concerned States/UT seeking feedback for appropriate finalization of 44 models in three types of landscapes (NL, AL and UL) were selected and incorporated in the present DPR. Altogether, 13 models were selected for natural landscapes in the hilly region of Himachal Pradesh were numbered from RV/HP/NL/01 to RV/HP/NL/13. 13 models were selected for Natural landscape in the hilly region of Jammu and Kashmir UT and named as RV/JK/NL/01 to RV/JK/NL/13 while 02 models for Natural Landscape in alluvial plains of Punjab State, numbered from RV/PB/NL/01 to RV/PB/NL/02 were included. Details of these models in Natural Landscape relevant to hills and alluvial plains along with incorporated abbreviations/code are summarized in Table 5.1.

Table 5.1- Proposed Plantation/ Treatment Models in Different Landscapes in Ravi Riverscape of Himachal Pradesh, Punjab and Jammu & Kashmir UT

Sr. No.	Model Type	Model Number
I	**Natural Landscape (NL)**	
A	**Hills - Himachal Pradesh**	
1	Sub-Alpine Conservation	RV/HP/NL/01
2	Sub-Alpine Enrichment	RV/HP/NL/02
3	Temperate Conifer Forest	RV/HP/NL/03
4	Temperate Mixed Forest	RV/HP/NL/04
5	Pasture and Grazing Land Development	RV/HP/NL/05
6	Himalayan Chir Pine Forest	RV/HP/NL/06
7	Himalayan Mixed Forest	RV/HP/NL/07
8	Sub-Tropical Dry Deciduous Forest	RV/HP/NL/08
9	Eradication of *Lantana* (> 50%)	RV/HP/NL/09
10	Control/ Removal of Invasive Species or <50% *Lantana*	RV/HP/NL/10
11	Protection Model for Natural Regeneration	RV/HP/NL/11
12	Fire Protection Model	RV/HP/NL/12
13	Plantation by Eco-Task Force in Temperate region	RV/HP/NL/13
B	**Jammu and Kashmir UT**	
14	Alpine Conservation	RV/JK/NL/01
15	Sub- Alpine Enrichment	RV/JK/NL/02
16	Temperate Conifer Forest	RV/JK /NL/03
17	Temperate Mixed Forest	RV/JK/NL/04
18	Pasture and Grazing Land Development	RV/JK/NL/05
19	Himalayan Chir Pine Forest	RV/JK/NL/06
20	Himalayan Mixed Forest	RV/JK/NL/07
21	Sub-Tropical Dry Deciduous Forest	RV/JK/NL/08
22	Eradication of *Lantana* (> 50%)	RV/JK/NL/09
23	Control/ Removal of Invasive Species or <50% *Lantana*	RV/JK/NL/10
24	Protection Model for Natural Regeneration	RV/JK/NL/11
25	Fire Protection Model	RV/JK/NL/12
26	Plantation by Eco - Task Force in Temperate Forests	RV/JK/NL/13
C	**Alluvial Plains – Punjab**	
27	Restoration of Degraded Forests Model	RV/PB/NL/01
28	Road Side Plantation	RV/PB/NL/02
II	**Agriculture Landscape(AL)**	
A	**Hills-Himachal Pradesh**	
29	Boundary Plantations	RV/HP/AL/01
30	Planting of Economic Trees in Block Plantations	RV /HP/AL/02
B	**Jammu and Kashmir UT**	
31	Planting of Economic Trees	RV/JK/AL/01
32	Planting of Economic Trees in Block plantation	RV/JK/AL/02
C	**Alluvial Punjab**	
33	Boundary Plantations	RV /PB/AL/01
34	Block Plantations	RV/PB/AL/02
III	**Urban Landscape (UL)**	
A	**Hills – Himachal Pradesh**	

Sr. No.	Model Type	Model Number
35	Riverfront Development	RV/HP/ UL/01
36	Institutional and Industrial Estate Plantation	RV /HP/ UL/02
37	Eco-Park Development	RV/HP/UL/03
B	**Jammu and Kashmir UT**	
38	Riverfront Development	RV /JK/ UL/01
39	Institutional and Industrial Estate Plantation	RV /JK/ UL/02
40	Eco-park Development	RV / JK/UL /03
C	**Alluvial-Punjab**	
41	Bio-remediation and Bio-filtration	RV/PB/UL/01
42	Riverfront Development	RV/ PB/UL/02
43	Institutional and Industrial Estate Plantation	RV/PB/UL/03
44	Eco-Park Development	RV/PB/UL/04

(b) Agriculture Landscape (AL)

The second lower order zone i.e., the Agriculture Landscapes largely in the rural environment constitutes the matrix of the riverscape. The activities in this zone mainly seek enhanced agricultural production. Within the Ravi Riverscape, in terms of extent the Agriculture Landscape was widely distributed; firstly, along the altitudinal gradient in Himachal Pradesh and Jammu and Kashmir UT secondly, in the vast expanse of alluvial plains of Punjab along the main channel. The primary activity in this zone is agriculture and horticulture production. A wide range of agricultural and horticulture crops are being undertaken by farmers on their private lands. The purpose of this lower order zone (Agriculture Landscape) is to enhance productivity of agricultural lands by appropriate soil and moisture conservation measures and planting of economic and fruit trees so as to support the overall conservation values and other expected ecological functions and ecosystem services. 2 models for the Agriculture Landscape in the hill State of Himachal Pradesh are proposed. These are: (a) Model RV/HP/AL/01, and (b) Model RV/HP/AL/02 relevant to boundary plantations and Planting of Economic Trees in Block plantation, respectively. In case of Jammu and Kashmir, Union Territory, 2 Models i.e., RV /JK/AL/01 and RV/JK/AL/02 are proposed. In alluvial plains of Punjab, two models (RV/PB/AL/01 and RV/PB/AL/02) specifically designed for plantations along the boundaries of crop fields and plantations in blocks, respectively have been proposed.

(c) Urban Landscape (UL)

Proposed forestry interventions in the third lower order zone i.e., the Urban Landscapes. The built up environment represented by the land use and land cover category of ‘Settlement’ of the riverscape. This category of land use and land cover was widely distributed throughout the riverscape, predominantly all along the main channel and its tributaries and formed the third lower order zone referred as the ‘Urban Landscape (UL)’. Under this lower order zone, altogether three models (RV/HP/UL/01 to RV/HP/UL/03) focusing on Riverfront Development, plantations in Institutional and Industrial Estates, Eco-Park Development, have been proposed in

the mountainous tract of Himachal Pradesh. Likewise, for Jammu and Kashmir UT, three models have been proposed viz., Riverfront Development (RV /JK/ UL/01), Institutional and Industrial Estate Plantations (RV /JK/ UL/02) and Eco-Park Development (RV / JK/UL /03). Within the alluvial plains of Punjab, four models *viz*., Bio-remediation and Bio-filtration (RV/PB/UL/01), Riverfront Development (RV/ PB/UL/02), Institutional and Industrial Estate Plantations (RV/PB/UL/03), Eco-Park Development (RV/PB/UL/04) are proposed in Urban Landscape.

5.5.2 Model-Wise Treatment Plans under Three Lower Order Zones

The treatment plans for 44 proposed models (Natural-28; Agriculture-06;and Urban-10) meant for above described three lower order zones or landscapes within the riverscape are elaborated below one by one. In case of each model, the treatment plan includes the details on site characteristics, recommended species for plantations, specific activities and cost norms.

In general, following guidelines would be applicable to all proposed Plantation Models meant for three different Landscapesviz. Natural, Agriculture and Urban Landscape and Three types of Conservation Interventions viz. Soil & Water Conservation, Riverine and Riparian Management, and Wetland Management within the riverscape:

a) All the Models/ Interventions are prescribed which come under Forestry Interventions in proposed DPR of Rivers.
b) Native species of trees, shrubs, herbs and grasses would be selected for proposed treatment models/ plantations in consultation with stakeholders of the respective States/UT. Traditional and prominent horticultural and ornamental species those under cultivation in the region for quite sometime, are proposed in the Agriculture and Urban Landscapes. Mixed plantations are proposed as far as possible instead of monoculture for enhancing plant diversity and greater ecosystem services. The species are proposed according to their occurrence in the altitudinal zones however, Implementing Agencies may plant site specific species also.
c) Suitable native species suggested for different plantation models are finalized after due consultation with Forest Department and other stakeholders of concerned States/UTs. Native species proposed for plantation under each treatment models are provided in the following section. In addition, landscape-wise model description has been further supplemented with the species-wise attributes and model-wise listing in Annexure 3 and Annexure 4, respectively
d) The necessary preparations for planting works including digging of pits would be completed two-three months before the onset of monsoon or planting season. However, the period between pit digging and scheduled planting time would not be more than four months so that run-off of soil by wind and water could be minimized.
e) Appropriate quantity of farmyard or organic manure or AM would be applied to boost plant growth in nurseries and plantation sites. Eco-friendly measures (i.e. physical or

mechanical methods, use of natural products, etc.) for weed and pest control would be adopted without resorting to the use of synthetic chemicals

f) Plantation sites would be protected against all types of biotic disturbances and abiotic stresses so as to effectively safeguard planted material for three years through fence, watch and ward, as well as local public awareness programmes and their active involvement.

g) The Implementing Agency should either develop modern and centralized nurseries or identify various certified Research Institutes, Universities, NGOs, Institutions and progressive farmers for supply of best quality planting material.

h) The Schedule of Rates (SoR) is adopted from prevailing SoR of respective States/UTs. For Himachal Pradesh, SoR of Shimla Forest Circle for the year 2012-13 @ wage rate of Rs.150/ with increase of 66.66% i.e., Rs. 250/-, for J&K UT SoR of 2017 @ Rs. 225/- has been applied. Also an increase of 7% has been added each year i.e., 2nd year onwards to compensate inflation.

i) The budget will be provided after submission of Annual Plan Operations (APO) for each year. So the prevailing wage rate will be applicable whenever DPR is implemented. Also site can be changed as per the availability at the time of implementation wherever required.

j) In Himachal Pradesh, further 25% hike in wage rates would be applied for Tribal Areas

k) The fencing cost has been calculated on average basis of enclosure of area to the extent of 5 hectare and average carriage lead is taken as 1 km (up & down)

l) The nursery time for plants in multitier model is taken on average basis i.e., 1.5 – 4.5 year so average is 3 years, for calculating the norm. Also the plant cost is taken from the norm prescribed by the Forest Department of respective States.

m) These cost Norms indicate the upper limits. The expenditure will be booked under various items shown in the detailed models as per actual work done in the field as per Schedule of Labour rates of the respective States/UTs and will not exceed these Departmental Norms.

n) The suggestive cost models are to create multistoried forest cover for improving the bio-diversity of the area which in turn conserves the water and soil in-situ.

o) In *Lantana* eradication models or wherever Lantana removal is involved, the Cut Root Stock (CRS) method should be adopted.

p) The fencing work includes the 4-strands of barbered wire with interlacing of thorny bushes.

q) In Fire Protection Model, as area is virtually targeted, hence Implementing Agency should rotate fire protection operations in areas of the Division so that each selected area takes operations after 3 years.

r) In Agriculture models the guidelines of Sub-Mission on Agroforestry (SMAF) of Central Government should be considered as being adopted in States and UT.

s) Under Urban Landscapse, the Seechewal Model (Punjab) for bio-remediation and bio-filteration may be taken into consideration.

t) Also in Urban Landscape, Eco-Park Development, Institutional Plantation and Riverfront Development models can be converged with Nagar Van Yojna as launched by GoI.

u) In Soil and water conservation models, the watershed approach and techniques should be adopted for desired results. For this intervention the Annual Plan Operation (APO) should be submitted each year with the proposal of micro plan of specific sites with detailed estimates.

v) In Riverine and Riparian Management and Wetland Management models, areas shown in budgetary provisions are virtual and concerned Implementing Agency (IA) should clearly mention the proposed activities in Annual Plan operation (APO) to be taken up in particular area with detailed microplan and estimates.

w) Plantation models are for the general areas as proposed by the Territorial Divisions but for the protected areas, two models under Conservation Intervention *viz*. Riverine and Riparian Management and Wetland Management are propsed.

x) The prescribed models, identified sites, area of the sites, species and rates may be modified to suit local conditions at the time of implementation of project and the concerned conservators of forests shall exercise the power to approve such changes as and when requires.

y) **Cost Indexing:** The project costs have been worked out on the basis of rate prevalent during year 2019-20 in the respective State/UTs and 7% escalation in the project cost during the subsequent years has been incorporated in anticipation of the cost escalation in future. However, actual project cost at the time of implementation on yearly basis shall need revision as per the change in Wholesale Price Index (WPI) on year to year basis. The Conservator of Forest may be empowered to revise the project cost accordingly for the quality desired output of the project.

(I) Natural Landscape (NL)

Proposed treatment models in Natural Landscape are broadly grouped in three categories: (a) in mountainous tract/hills of Himachal Pradesh, (b) Mountainous tract/hills of Jammu Region (J&K UT), and (c) Alluvial plains of Punjab. Elaborate details on various treatment models are presented in the following section.

(A) Treatment Models for Natural Landscape in Himachal Pradesh

As already stated, various natural land use and land cover categories together constitute the largest area of the Ravi Riverscape and it is represented by diverse forests, alpine pastures, scrubs, snow cover/glaciers, rivers, wetlands, etc. Thus, the maximum number of treatment models has been proposed in the mountainous/hill portion of the riverscape. Interventions are proposed to be implemented in the entire upper basin of the Ravi River and its tributaries. Primarily, these models would be applied on forest lands under the control of SFD. The proposed treatment sites would mainly include areas under open forests, scrubs, grasslands, and alpine

pastures or along the river and its tributaries. Details of each of the 13 treatment models prescribed in the Natural Landscape of Himachal Pradesh are presented below.

Model No. - RV/HP/NL/01	**Sub-Alpine Conservation**
Zone	**Sub-Alpine and Moist Alpine Areas**

The Sub-Alpine and Moist Alpine zones are located between 3,600 to 4,500 m amsl, and are mostly snow-bound. The temperature remains below 5°C for 6 months in a year. The active plant growth season is of almost 4-6 months. This region is above the tree line with varied rock formations. Vegetation is dominated by grasses and herbs with scattered shrubs. A low deciduous scrub formation usually about 1 m high forms a dense cover in some patches.

Under this model, it is proposed to conserve and augment vegetation of the alpine meadows. The major focus will be on conservation of native species and livelihood generation for local communities. The conservation practices as prescribed in the Working Plan of respective Territorial Forest Division and Wildlife Management Plan of protected areas will be applicable. The collection of medicinal and aromatic plants would be regulated as per the State's policy on the medicinal and aromatic plants and accordingly the benefit will be shared with local communities. Under this model, medicinal plants will be planted at the rate of 2,400 plants/ha in the blank areas. Root slips/ seeds of native grasses will be put in continuous contour strips immediately after melting of snow in 600/ha patches. The high altitude medicinal and aromatic plants require at least two years nursery period and third year planting in the field along with grasses. It will be followed by two years maintenance. Harvesting can be started after 5th year onwards in sustainable manner.

List of species for plantation

Herbs/Medicinal Plants: *Aconitum heterophyllum, Aconitum violaceum, Ainsliaea aptera, Arnebia benthamii, Dactylorhiza hatagirea, Heracleum candicans, Polygonatum verticillatum, P.cirrhifolium, P. multiflorum, Fritillaria roylei, Picrorhiza kurroa, Selinum tenuifolium, Allium humile, Geranium wallichianum, Rheum australe, Rheum moorcroftianum, Sinopodophyllum hexandrum, Anemone polyanthes* and *A. tetrasepala*.

Grasses and Forbs: *Festuca pratensis, F. valesiaca, Trifolium pratense, Poa pratensis, Poa annua, Dactylis glomerata, Agrostis gigantea, A. pilosula, A. munroana, Agropyron* spp., *Calamagrostis montanensis, Koeleria* spp., *Brachypodium sylvaticum, Bromus himalaicus, B. ramosus, Danthonia cachemyriana, D. cuminsii* and *Stipa roylei.*

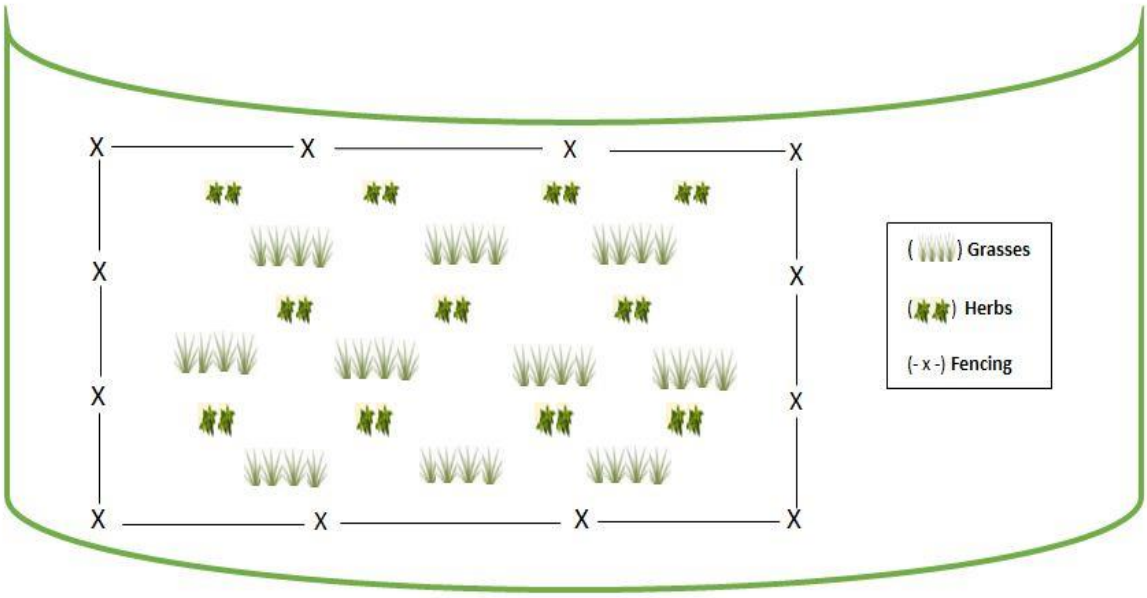


Fig. 5.1 - Schematic Diagram of Sub-Alpine Conservation Model

Herbs: Patch number - 600, Patch size (cm) - 30 x 30 x 5, Spacing (m) - 2 x 8, Plant per patch - 4, Spacing (cm) – 20 x 20 (planting in 3rd Year)

Grasses: Patch number - 600, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 8, Seed per patch (gm) – 6gm, Spacing (cm) – 10 x 10

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Labour Rate Rs. 250 in Ist year and Annual Increase @ 7% in Subsequent Year

Table 5.2 - Cost Norms of RV/HP/NL/01 (Alpine Conservation)

Year	Item	Detail of work	Amount (Rs)/ ha	Tentative Man days
	Number of Plants (No.)	2400 herbs , 600 patch of Grasses.		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	12,000	48
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	10,200	38
		Site Preparation, site preparation i/c survey & demarcation , Bush Cutting in strips , collection of debris , burning of debris, preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205

	Advance Work Material	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole.	55,600	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1st and 2nd year.	9,000	31
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching, etc.	25,087	88
Total Establishment Cost =				**410**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	22,517	68
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	17,515	49
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	13,199	35
7th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	582	2
Total Maintenance Cost =			**53,813**	**154**
Total cost of Plantation =			**2,20,610**	**564**

Model No. – RV/HP/NL/02	**Sub-Alpine Enrichment**
Zone	**Sub-Alpine Zone**

The Sub-Alpine zone occurs between 2,900 - 3,600 m amsl in the Ravi Riverscape, and is covered with snow for 4-5 months. The temperature remains below 5° C for around 4 months in a year. Vegetation in sub-alpine zone is dominated by herbs, grasses and shrubs of *Rhododendron* spp., *Rosa* spp., *Salix* spp., *Lonicera* spp., Bhoj Patra *(Betula utilis)*,etc. Area is sloppy and generally soil depth is very low.

Under this model, it is proposed to conserve and augment vegetation in sub-alpine zone by adopting specific interventions to enrich such areas. The major focus will be on conservation and enrichment of native species besides generation of sustainable livelihoods for local communities. Conservation and enrichment practices as prescribed in the Working Plan of respective Territorial Forest Division/Wildlife Management Plan of a protected area will be applicable. The collection of medicinal and aromatic plant species would be regulated as per the State's policy

on medicinal plants and accordingly the accrued benefit will be shared with local communities. In this model, native trees @ 200 plants/ha at 6 m x 8 m spacing and medicinal plant species @ 800 plants/ha at 6 m x 8 m spacing in 200/ha patches will be planted in blank areas. The high altitude tree species requires around 2.5 years nursery period and planting will be done in the 3rd year. To synchronize planting of trees and medicinal plants in the 3rd year, nursery of high attitude medicinal plants will be raised in 3rd year onwards. The plants will be maintained in the field during 4th, 5th, 6th and 7th year of project implementation.

List of species for plantation

Trees: *Betula utilis, Pinus wallichiana, Acer acuminatum, Corylus jacquemontii, Prunus cornuta, Quercus semecarpifolia,* etc.

Herbs/Medicinal Plants: *Aconitum heterophyllum, Arnebia benthamii, Dactylorhiza hatagirea, Heracleum candicans, Polygonatum verticillatum, P. multiflorum, Selinum tenuifolium, Allium humile, Geranium wallichianum, Bergenia stracheyi, Phytolacca acinosa, Hyoscyamus niger, Angelica glauca, Picrorhiza kurroa, Fritillaria roylei, Sinopodophyllum hexandrum, Trillium govanianum,* etc.

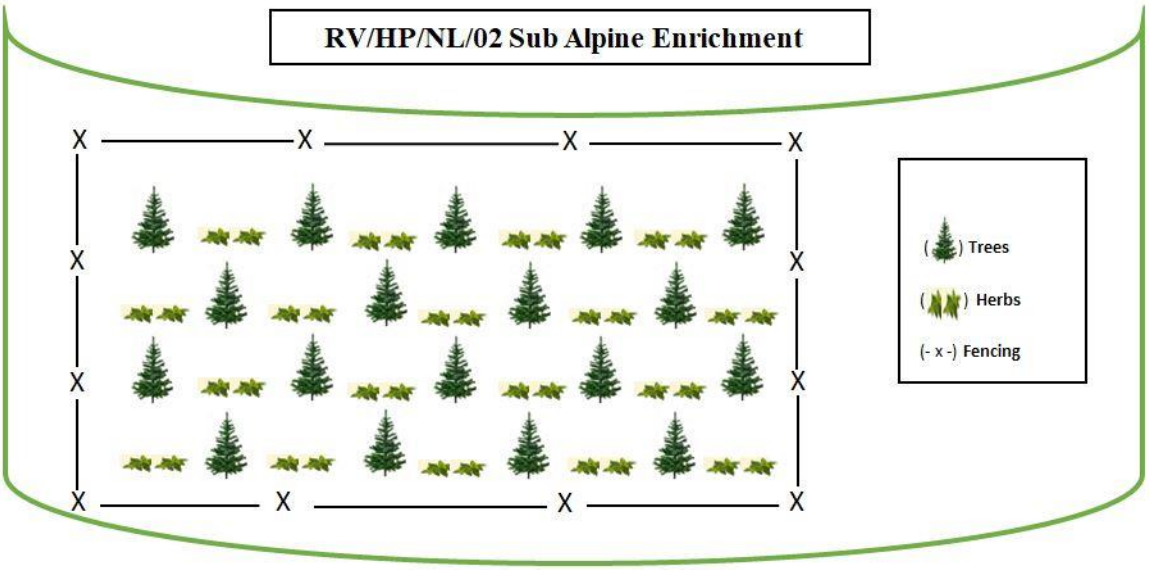


Fig. 5.2 - Schematic Diagram of Sub-Alpine Enrichment Model

Trees: Plants: 200 /ha., Spacing (m) - 6 x 8, Pit size (cm) – 30 x 30 x 30

Herbs: Plants- 800/ha, Patch no – 200/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 6 x 8, plant per patch - 4, Spacing (cm) – 20 x 20

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.3 - Cost Norms of RV/HP/NL/02 (Sub-Alpine Enrichment)

Year	Item	Detail of works	Amount (Rs)/ ha	Tentative Man days
	Number of Plants (No.)	Trees: 200, Herbs- 800		
1st Year	N-Advance Work Labour Cost	Establishment of Nursery.	400	2
2nd year	N-Advance Work Labour Cost	Establishment of Ist year maintenance of plant.	3,746	14
3rd year	N-Advance Work Labour Cost	Maintenance of Nursery of herbs+ Ist and IInd year maintenance of plant nursery.	10,650	37
4th year	A-Advance Work Labour Cost	Nursery 1st of herbs+ 1st, 2nd and 3rd year maintenance of trees nursery.	17,787	12
		Site Preparation, Site preparation i/c survey & demarcation , Bush Cutting in strips, collection of debris , burning of debris, preparation inspection path, Carriage of fence RCC pole and RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	62,867	205
	Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	55,000	0
5th year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance works 1st and 2nd year.	12,805	39
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	7,659	23
Total Establishment Cost (Rs.) =			**1,70,914**	**332**
MAINTENANCE				
6th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	13,793	35
7th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	8,993	20
8th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	3,305	6
Total Maintenance Cost (Rs.) =			**26,091**	**61**
Total cost of Plantation =			**1,97,005**	**393**

Model No. – RV/HP/NL/03	**Temperate Conifer Forest**
Zone	**Moist Temperate Area**

The moist temperate area lies between 1,800 - 3,500 m amsl. This zone is characterized by dense forests, mainly of conifer species. However, blank patches too occur at several places which will be taken up for proposed treatment. In some areas, especially in fir and spruce forests, soil is covered with a thick layer of humus as the decomposition rate is very slow in these areas. The suggested treatment model for these areas is being referred as the Temperate Conifer Forest Model.

Planting of 300/ha plants of various tree species and 300/ha shrub species will be carried out per ha. In addition, 300/ha patches of medicinal plants with 1200 plants/ha will also be planted out in the treatment site. The small stream or *Nallah* facing side of the treatment area will be planted with two rows of hill bamboo at 2 m x 2 m spacing with 200/ha plants of hill bamboo. The major focus will be on the conservation and development of native species and livelihood generation for local communities. The collection of medicinal and aromatic plant species in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4th year. To synchronize planting of trees, medicinal herbs and shrubs in 4th year, the nursery for selected herbs and shrubs will be raised 2nd year onwards. The plants will be maintained in the field during 5th, 6th and 7th year of the project implementation.

List of species for plantation

Trees: *Cedrus deodara, Pinus wallichiana, Picea smithiana, Taxus wallichiana, Cupressus torulosa,* etc.

Shrubs: *Sinarundinaria falcata, Daphne papyracea, Prinsepia utilis, Rosa moschata, Debregeasia hypoleuca, Cotoneaster bacillaris, Viburnum grandiflorum, V. cotinifolium, Cornus oblonga, Syringa emodi, Indigofera heterantha, Desmodium elegans, Hypericum oblongifolium,* etc.

Herbs: *Aconitum heterophyllum, Picrorhiza kurroa, Heracleum candicans, Angelica glauca, Geranium wallichianum, Polygonatum verticillatum, Bergenia ciliata, Viola serpens, Trillium govanianum, Phytolacca acinosa, Valeriana jatamansi* and *Hedychium spicatum*

Plantation Design: RV/HP/NL/03 – Temperate Conifer Forest

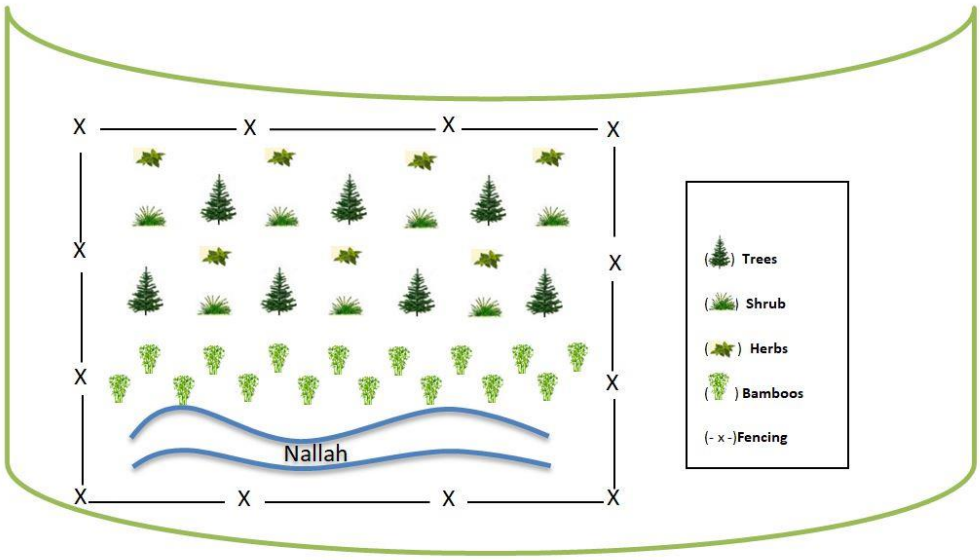


Fig. 5.3 - Schematic Diagram of Temperate Conifer Forest Model

Trees: 300/ha, Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo (hill): 200/ha, Spacing (m)-5 x 5, Pit size (cm) – 45 x 45 x 45 (along *Nallah*)

Shrubs: Plants: 300/ha., No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30 (gap filling)

Herbs: Plants: 1,200/ha, Patch no – 300/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) – 5 x 5, plant per patch - 4, Spacing (cm) – 20 x 20

Fencing : Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.4 - Cost Norms of RV/HP/NL/03 (Temperate Conifer Forest)

Year	Item	Detail of work	Amount/ ha (Rs)	Tentative Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-200, Shrubs-300 no., Herbs- 1200 no (300 no. patches).		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	10,000	40
2nd year	Advance Work Labour Cost	Maintenance, of Nursery+ Establishment of Ist year maintenance.	38,879	145

		Site Preparation- Site Preparation i/c survey & demarcation , Bush Cutting in strips, Collection of debris, Burning of debris, Preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205
	Advance Work Material	Cost of Seed, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	52,000	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance works 1st and 2nd year.	28,603	100
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	45,157	158
Total Establishment Cost (Rs.) =			**2,29,549**	**648**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	37,034	118
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	20,711	61
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	16,107	44
7th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	582	2
Total Maintenance Cost (Rs.) =			**74,434**	**225**
Total cost of Plantation =			**3,03,983**	**873**

Model No. – RV/HP/NL/04	**Temperate Mixed Forest**
Zone	**Moist Temperate Area**

The moist temperate forest area occurs between 1,800 - 3,500 m amsl. Dominant species of the area are: *Aesculus indica, Quercus oblongata, Q. floribunda, Q. semecarpifolia, Alnus nitida, Acer caesium, A. pictum, A. cappadocicum, Betula utilis, Betula alnoides, Ulmus wallichiana, Pinus wallichiana, Cedrus deodara, Picea smithiana, Abies pindrow, Abies spectabilis* and *Cupressus torulosa*. Most of these species form pure forests, but also found in association of each other. This zone is often characterized by degraded stretches along the river banks running close to the area of dense temperate forests, mainly of conifers. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains.

Annual precipitation in this zone is between 1,500 - 2,000 mm. In some areas, snow lasts till spring season. The soil in many places is shallow, exposed and prone to erosion. This zone is heavily grazed by domestic animals and cause huge damage to the vegetation. Besides this, road construction and other developmental activities also cause severe soil erosion, resulting in damage to vegetation. There is heavy dependence of local communities on Oak fodder within Ravi Riverscape. Further, owing to several famous tourist spots *viz*., Chamba, Dalhousie, Khajiar, Dharamshala, etc. and the enhanced tourism activities in such areas within the riverscape cause damage to vegetation and disturbance to wild fauna.

Temperate mixed forest treatment model has been proposed specifically for the blank and degraded patches within the temperate zone. Planting of trees @300/ha belonging to conifers and broadleaved species will be carried out in the blank and degraded patches. In this model preferably broadleaved species will be planted in general and conifer species can be planted on the ridges and shallow soil depth area. The native shrubs @300 plants/ha will be carried out in between the tree planted. The medicinal plants will also be planted in patches @ 4 plants/patch and that means planting of total of 1,200 medicinal plants/ha. The small stream or *Nallah* facing side of the treatment site will be planted with two rows of hill bamboo @ 200/ha at 2 m x 2 m spacing. The major focus of the proposed treatment model will be on the conservation and propagation of native species alongside improved livelihoods for local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4^{th} year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium. To synchronize planting of trees, medicinal herbs and shrubs in 4^{th} year, the nursery for selected herbs and shrubs will be raised 2^{nd} year onwards. The plants will be maintained in the field during 5^{th}, 6^{th} and 7^{th} year of the project implementation. The collection of medicinal and aromatic plant in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities.

List of species for plantation

Trees: *Cedrus deodara, Pinus wallichiana, Picea smithiana, Taxus wallichiana, Aesculus indica, Juglans regia, Prunus cornuta, P. cerasoides, Acer caesium, A. pictum, A. cappadocicum, Carpinus viminea, Betula alnoides, Myrica esculenta, Cornus macrophylla, Alnus nitida, Ulmus wallichiana, Quercus oblongata, Q. floribunda, Q. semecarpifolia, Cornus capitata, Neolitsea pallens, Lyonia ovalifolia, Pistacia integerrima* etc.

Shrubs: *Drepanostachyum falcatum, Daphne papyracea, Prinsepia utilis, Rosa moschata, Debregeasia hypoleuca, Cotoneaster bacillaris, Viburnum grandiflorum, Elaeagnus conferta, Hypericum oblongifolium, Rubus biflorus, R. niveus, R. ellipticus, R. foliolosum, Zanthoxylum armatum, Deutzia staminea, D. corymbosa, Spiraea canescens, Berberis* spp.,etc.

Herbs: *Aconitum heterophyllum, Heracleum candicans, Angelica glauca, Geranium wallichianum, Polygonatum verticillatum, P. cirrhifolium, Sinopodophyllum hexandrum, Bergenia ciliata, Viola serpens, Valeriana jatamansi, Hedychium spicatum, Trillium govanianum, Ajuga* spp., etc.

Plantation Design: RV/HP/NL/04 – Temperate Mixed Forest

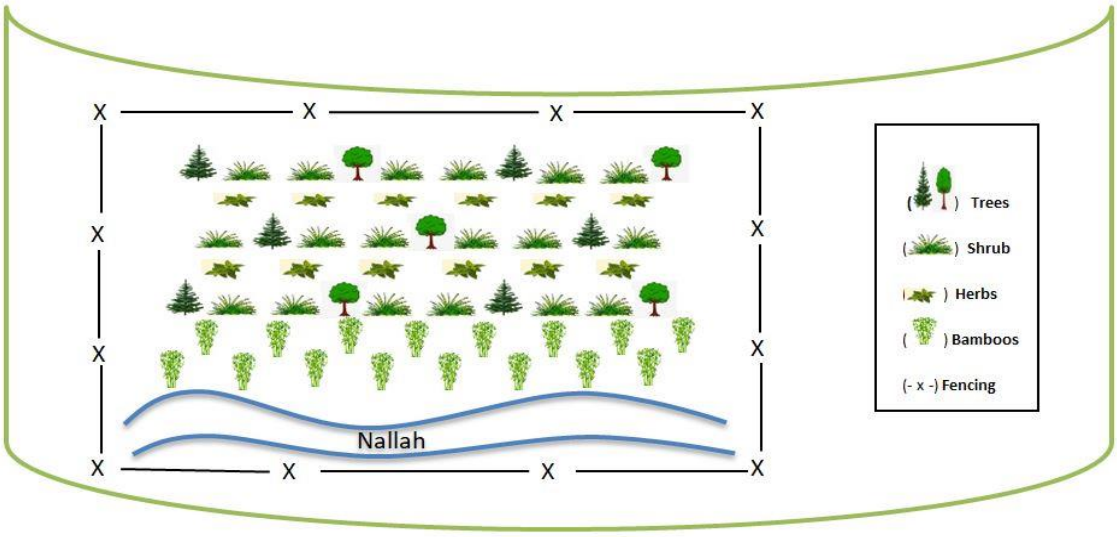


Fig. 5.4 - Schematic Diagram of Temperate Mixed Forest Model

Trees: 300/ha., Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45 (50;50 of Broadleaved& Conifers)

Bamboo (hill): 200, Spacing (m) -5 x 5, Pit size (cm) – 45 x 45 x 45 (along Nallah)

Shrubs: Plants: 300 no., No. of Pit - 300, Spacing (m) - 2 x 5, Pit size (cm) – 30 x 30 x 30

Herbs: Plants: 1200 Patch no. – 300, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 3 x 5, plant per patch - 4, Spacing (cm) - 20 x 20

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.5 - Cost Norms of RV/HP/NL/04 (Temperate Mixed Forest)

Year	Item	Detail of works	Amount/ha (Rs)	Tentative Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-200, Shrubs-300 no., Herbs- 1200 no (300 no. patches).		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	14,491	58
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	33,045	124
		Site Preparation- Site Preparation i/c survey & demarcation, Bush Cutting in strips, Collection of debris , Burning of debris, Preparation inspection path, Carriage of fence RCC pole and RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205
	Advance Work Material	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	52,000	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance works 1st and 2nd year.	28,925	101
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	45,157	158
Total Establishment Cost (Rs.) =			**2,28,528**	**646**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	38,815	117
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	20,711	61
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	16,107	44

7th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	582	2
Total Maintenance Cost (Rs.) =			**76,215**	**224**
Total cost of Plantation =			**3,04,743**	**870**

Model No. – RV/HP/NL/05	**Pasture and Grazing Land Development**
Zone	**Sub-Tropical to Temperate Areas**

These areas located between 800 - 2,800 m amsl, particularly on southern slopes and around habitations are characterized by pasture and grazing lands. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains. Annual precipitation is around 1,500 - 2,000 mm. In some areas, snow lasts till spring season. The soil is shallow, exposed and prone to erosion, particularly in moderate to steep slopes. This zone is heavily grazed by livestock and cause huge damage to the vegetation and results into heavy soil erosion. Besides disturbance by livestock, road construction and other developmental activities also cause significant soil degradation and damage to native flora by proliferation of invasive alien species. The local communities are heavily dependent on these grasslands in the Ravi Riverscape. This zone also severely suffers on account of enhanced tourism activities in several popular tourist destinations *viz*., Chamba, Dalhousie, Khajjiar, Dharamshala, etc. causing damage to flora and disturbance to fauna.

Under this model, pasture and grazing land development are proposed by protection, development and enrichment of areas within this zone. Suitable grass species will be planted/ sowing of seeds after carrying out necessary land development works like trenching/ terracing/ moisture conservation measures, etc. besides removal of weeds and unpalatable grasses. The proposed treatment model mainly includes plantation of native and nutritionally important grass species. In this model, grass sowing in furrows/ strips of 100 cm x 30 cm x 5 cm along contours at interval of 2 m apart is proposed. Selected species will be raised / maintained in the nursery during 1st year and planting will be done in the second year. The grasses will be replenished in the field during 3rd and 4th year.

List of species for plantation

Grasses and Forbs: *Festuca pratensis, Trifolium pratense, Poa pratensis, Poa annua, Dactylis glomerata, Erianthus* spp., *Agrostis* spp., *Agropyron* spp., *Danthonia* spp. *Calamagrostis* spp., *Koeleria* spp., *Saccharum spontaneum, Chrysopogon gryllus, Arundinella nepalensis, A. pumila, Themeda anathera, Cymbopogon distans, Setaria glauca, Alopecurus aequalis, A. nepalensis, Bothriochloa pertusa, B. parviflora*, etc.

Plantation Design: RV/HP/NL/05 - Pasture and Grazing Land Development

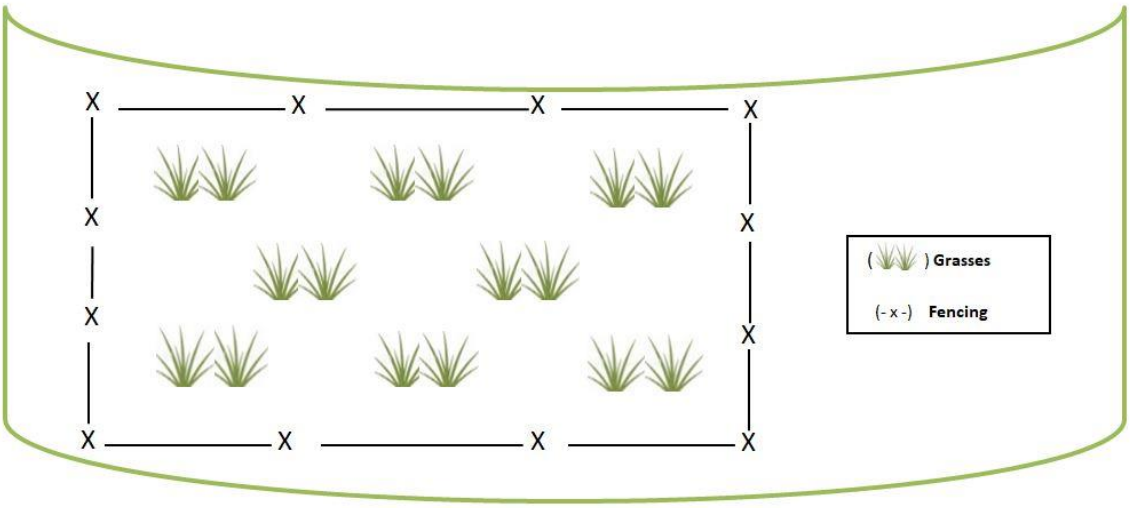


Fig. 5.5 - Schematic Diagram of Pasture and Grazing Land Development Model

Grasses: Patch no. -2000, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed per patch (gm) - 6, seed, Spacing (cm) – 10 x 10, Type - Staggered

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.6 - Cost Norms of RV/HP/NL/05 (Pasture and Grazing Land Development)

Year	Item	Detail of works	Amount/ ha (Rs)	Tentative Man days
	Number of Plants (No.)	Grasses-2000 no. patches.		
1st Year	Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	66,400	0
	Advance Work Labour Cost	Site Preparation- Site Preparation i/c survey & demarcation, Bush Cutting in strips, Collection of debris, Burning of debris, Preparation of inspection path, Carriage of RCC Poles and RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205
2nd year	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	40,850	143
Total Establishment Cost (Rs.) =			**1,62,160**	**348**

MAINTENANCE				
3rd year	Maintenance Cost - I Year i/c Material	Material cost, planting cost & other maintenance work.	27,994	67
4th year	Maintenance Cost - II Year	Material cost, planting cost & other maintenance works.	20,711	61
5th year	Maintenance Cost - III Year	Material cost, planting cost & other maintenance works.	16,107	44
6th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	582	2
Total Maintenance Cost (Rs.) =			**65,394**	**174**
Total cost of Plantation =			**227554**	**522**

Model No. – RV/HP/NL/06 **Himalayan Chir Pine Forest**

Zone **Sub-Tropical to Lower Temperate Area**

This zone occurs in mid hill region of Himachal Pradesh on southern aspect, and is dominated by Chir pine. The altitude range is between 800 -1,800 m amsl and annual rainfall varies from 1,200 - 1,800 mm. In these areas, high temperatures and humidity conditions prevail during summer. Ground is densely covered with pine needles during winter to summer season and such areas are prone to forest fires. Grasses flush during monsoon season. Heavy rains in monsoon lead into severe soil erosion in this zone, ultimately results into high rate of sedimentation in Ravi River and its tributaries. This is one of the major causes of siltation of dams and floods in Punjab plains. Open and degraded forests on southern aspect with sparse vegetation coupled with agriculture on steep slopes, construction and developmental activities are prominent reasons behind large scale soil erosion in this zone. These areas experience heavy rainfall during monsoon season and modest rainfall during the winter season. Snowfall rarely occurs in cooler aspects of higher reaches, but the snow stays for a few days only. Most of the rainwater flows down the streams washing away top soil especially on sloppy sites. The soil is acidic in nature and shallow on steep slopes while valleys have deep soil. The biotic pressure in terms of livestock grazing, and fuel wood and tree fodder collection is conspicuous. Suitable forestry interventions in this zone can immensely help in improvement of pastures and grazing lands besides checking soil erosion and siltation into Ravi River and its tributaries.

For such areas in this zone, the Himalayan Chir Pine Forest Model is proposed. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. are proposed to be sown in the treatment site, particularly towards the river or *Nallah* side. The area will be planted with *Pinus roxburghii* mainly in drier sites with shallow soil depth whereas broadleaved species like *Quercus oblongata*, *Lyonia ovalifolia*, Bamboo spp., etc. on moist sites are proposed to be

planted at 5 m x 5 m spacing. A total of 300 plants of tree/ha, 100 bamboo species /ha along with 300 plants of shrubs/ha and 800 patches of grasses will be planted 2m apart in staggered fashion. Chir pine and associated broadleaved species require around 2 years nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herbs either species specific or as consortium. The plants will be maintained in the field during 4th, 5th and 6th year. The fire lines of 5m width both sides along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Tree: *Pinus roxburghii, Quercus oblongata, Lyonia ovalifolia, Dendrocalamus strictus, D. hamiltonii, Holoptelea integrifolia, Ficus benghalensis, F. racemosa, F. rumphii, Albizia* spp., *Phyllanthus emblica, Diospyros montana, Bauhinia variegata, Grewia optiva, Pyrus pashia, Mallotus philippinensis, Aegle marmelos, Punica granatum,Cinnamomum tamala, Celtis australis, Toona ciliata, Flacourtia indica and Bombax ceiba.*

Shrubs: *Justicia adhatoda, Myrsine africana, Murraya* spp., *Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo, Carissa opaca, Berberis* spp., *Ziziphus* spp., *Desmodium* spp., *Tephrosia hamiltonii,* etc.

Grasses and Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhavia diffusa, Festuca pratensis,Festuca arundinacea***,** *Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense***,** *Themeda anathera,Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binate, Calamagrostis spp., Thysanolaena maxima,* etc.

Plantation Design: RV/HP/NL/06 Himalayan Chir Pine Forest

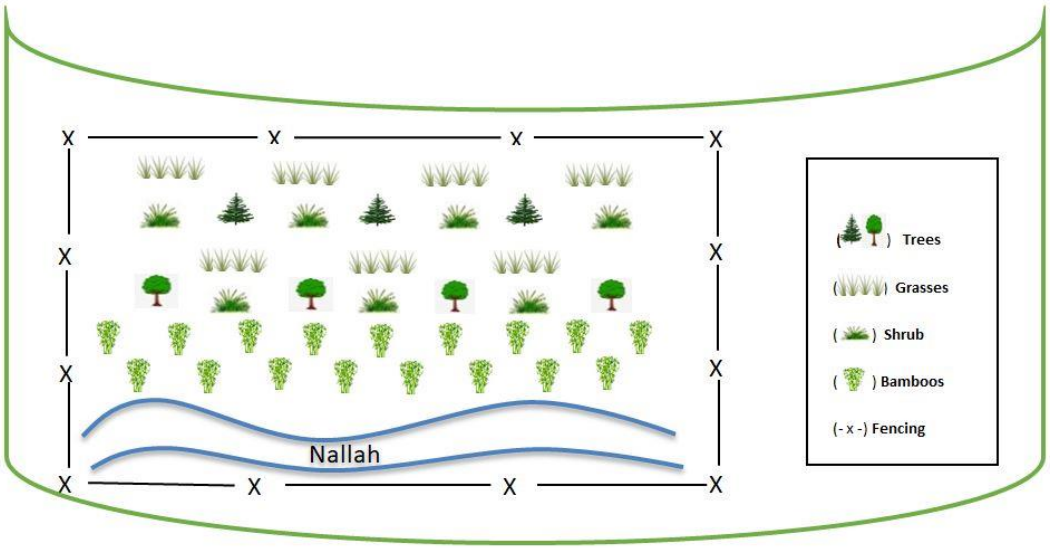


Fig. 5.6 - Schematic Diagram of Himalayan Chir Pine Forest Model

Trees: 300/ha., Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo: 100, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45 along Nallah (if available)

Shrubs: Plants: 300 no., No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no.- 800, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 5, Seed per patch (gm) - 6, seed, Spacing (cm) - 10 x 10, Type – Staggered

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.7 - Cost Norms of RV/HP/NL/06 (Himalayan Chir Pine Forest)

Year	Item	Detail of works	Amount/ha (Rs.)	Tentative Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-100, Shrubs-300 no., Grasses- 800 no. patches.		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	8,397	34
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year Maintenance.	11,861	44
		Site Preparation, Site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205
	Advance Work Material	Cost of Seed, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	58,000	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance. works 1st and 2nd year.	11,890	42
	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	52,006	182
Total Establishment Cost (Rs.) =			**1,97,064**	**507**
		MAINTENANCE		
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance,, Material cost, planting cost & other maintenance works.	39,786	118
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	31,875	90
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	26,144	70

7th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	8588	24
Total Maintenance Cost (Rs.) =			**106,393**	**302**
Total cost of Plantation =			**3,03,457**	**809**

Model No. – RV/HP/NL/07	**Himalayan Mixed Forest**
Zone	**Sub-Tropical to Lower Temperate Area**

This zone occurs in mid hill region on the northern aspect, and is dominated by broadleaved species with some Chir pine in exposed areas. The altitudinal variation is between 800 - 1,800 m amsl and the zone receives annual rainfall ranging from 1,200 -1,800 mm. It experiences high temperatures and humidity during the summer season. In areas wherein Chir pine species is around 50%, the ground is mostly covered with pine needles and area is prone to forest fires. Grasses in slopes flush during the monsoon season. Heavy rains in the monsoon season cause severe soil erosion and sedimentation in Ravi River or its tributaries. Moderately dense to open forests on the northern aspect coupled with agriculture on terraces along moderately steep slopes, and construction and development activities are primary reasons for large scale soil erosion in this zone. These areas experience heavy rainfall during the monsoon season and modest rainfall during the winter season. Most of the rainwater flows down the streams washing away top soil especially on sloppy sites. The soil is neutral to acidic in nature and shallow on slopes while valleys have deep soils. The biotic pressure i.e., livestock grazing, and collection of fuelwood and tree fodder) is severe. Appropriate forestry interventions in this zone can immensely help in improvement of the zone and also river flow.

The Himalayan Mixed Forest Model is recommended for this zone. Grass species such as *Heteropogon contortus, Chrysopogon fulvus,C. serrulatus* etc. will be sown in the part of treatment site, particularly on the ridges. The treatment area will be planted with broadleaved species like *Quercus oblongata, Lyonia ovalifolia, Toona ciliata, Syzygium cumini, Grewia optiva, Pyrus pashia, Albizia* spp., *Phyllanthus emblica, Holoptelea integrifolia, Ficus* spp., *Punica granatum, Bauhinia variegata*,etc. Plants will be planted at 5 m x 5 m spacing. A total of 300 plants of tree species/ha., 300 plants of shrubs/ha and 200 patches of 2 m x2 m apart grasses on the ridges/degraded sites will be planted. Broadleaved species of this zone require around one and half year of nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. The plants will be maintained in the 4th to 6th year. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Trees: *Quercus oblongata, Lyonia ovalifolia, Holoptelea integrifolia, Ficus* spp., *Albizia* spp., *Phyllanthus emblica, Bauhinia variegata, Grewia optiva, Pyrus pashia, Toona ciliata, Syzygium cumini, Punica granatum, Pistacia integerrima, Celtis australis,Cinnamomum tamala, Mallotus philippinensis, Anogeissus latifolia, Flacourtia indica,* etc.

Shrubs: *Rosa* spp., *Debregeasia hypoleuca, Elaeagnus conferta, Zanthoxylum armatum, Deutzia staminea, D. corymbosa, Berberis* spp., *Ziziphus* spp., *Carissa opaca, Murraya* spp., *Desmodium* spp., *Tephrosia hamiltonii, Justicia adhatoda, Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo,* etc.

Grasses and Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhavia diffusa, Festuca pratensis, F. arundinacea***,** *Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense***,** *Themeda anathera, Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binata, Calamagrostis* spp., *Thysanolaena maxima,* etc.

Plantation Design : **RV/HP/NL/07 Himalayan Mixed Forest**

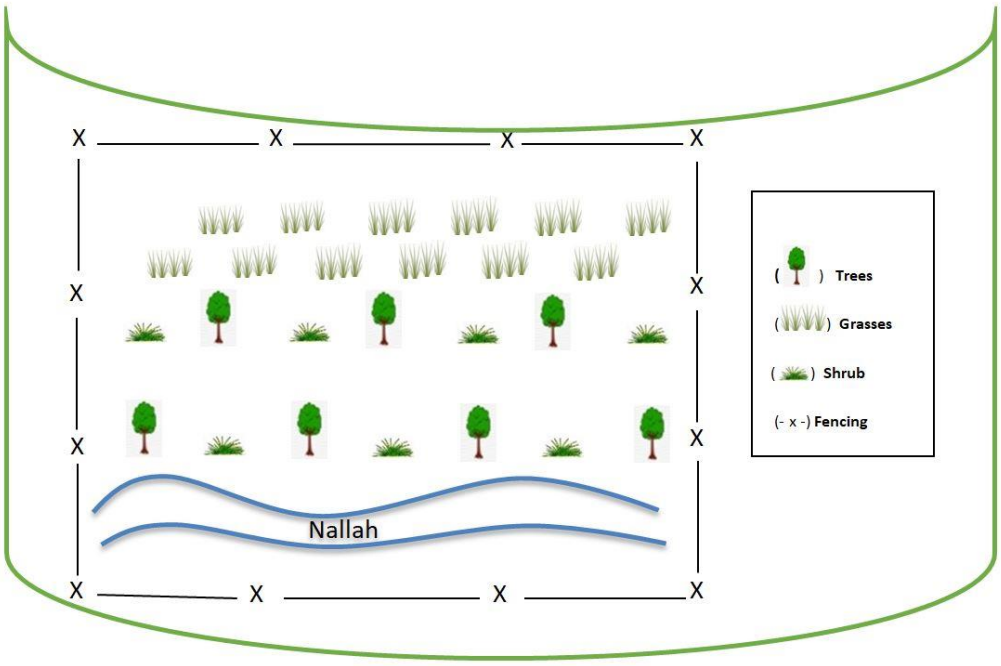


Fig. 5.7 - Schematic Diagram of Himalayan Mixed Forest Model

Trees: 300/ha., Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300 no., spacing (m) – 5 x 5, Pit size (cm) – 30 x 30 x 50.

Grasses: Patch number – 200, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed per patch (gm) – 6gm, Spacing (cm) – 10 x 10, Type –Staggered,

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.8 - Cost Norms of RV/HP/NL/07 (Himalayan Mixed Forest)

Year	Item	Detail of works	Amount/ha (Rs.)	Tentative Man days
	Number of Plants (No.)	Plants- 300 No., Shrubs-300 no., Grasses- 200 no. patches.		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	8,397	34
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	11861	44
		Site Preparation- Site preparation i/c survey & demarcation, Bush Cutting in strips, Collection of debris, Burning of debris, Preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	54,910	205
	Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	52,600	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance works 1st and 2nd year.	11,890	42
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	39,849	139
Total Establishment Cost (Rs.) =			**1,79,507**	**464**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	34,284	108
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance	27,652	81

		works.		
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	22,920	63
7th year	Maintenance Cost - IV Year	Maintenance cost of fencing	8,588	23
Total Maintenance Cost (Rs.) =			**93,444**	**275**
Total cost of Plantation =			**2272951**	**739**

Model No. – RV/HP/NL/08	**Sub-Tropical Dry Deciduous Forest**
Zone	**Sub-Tropical Area**

This zone occurs in low hill region of Himachal Pradesh and dominated by broadleaved deciduous species. The altitude ranges between 300 - 900 m amsl and the zone experiences annual rainfall varying from 1,200 - 2,000 mm. Several broadleaved species grow in this zone which shed their leaves during summer months. The zone is represented by deep soil and moderate slope and experiences heavy rainfall during the monsoon season and modest rainfall during the winter season. Heavy rains during the monsoon season transport silt from these areas through number of seasonal water channels, *Nallahs*, rivulets, etc. to the Ravi River causing siltation and floods in downstream areas. Besides this, agriculture on slopes and construction and developmental activities are the main reasons for soil erosion from these areas. A large part of rainwater flows down the streams within a few hours of rainfall as surface run off. The soil is shallow on slopes while valleys have deep soil depth. The biotic pressure i.e., livestock grazing, fuel wood and tree fodder collection is significant in this zone. Appropriate forestry interventions in this zone would not only check soil erosion and improve vegetation, but would also help in improvement in the e-flow of the Ravi River and its tributaries.

The Sub-Tropical Dry Deciduous Forest Model is recommended in this zone. Under this model, it is proposed to plant 300 plants of broadleaved tree species or bamboo species. 300 shrubs at 5 m x 5 m in between the tree rows and strong soil binding grasses like *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus* and sedges like *Carex* spp., *Cyperus* spp., etc. will be planted on the river or *Nallah* facing side of the treatment site. In case of trees, a mixture of timber species like *Dalbergia sissoo*, *Senegalia catechu*, *Haldinia cordifolia*, etc. along with medicinal trees like *Terminalia* spp., *Phyllanthus emblica*, *Oroxylum indicum*, *Sapindus mukorossi*, etc. will be planted at 5 m x 5 m spacing. Management practices and conservation

measures as prescribed in the Working Plan of the respective Territorial Forest Division or the Wildlife Management Plan of the protected area will be applicable. Collection of medicinal plants and other NTFP's along with sharing of accrued benefits to local communities would be regulated as per the State's policy on medicinal plants. Nursery of selected trees/shrubs etc. will be established during the 1st year and 2nd year and planting will be done in 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. Subsequently, the plantation will be managed during next three years. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Trees: *Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippinensis, Syzygium cuminii, Oroxylum indicum, Sapindus mukorossi, Dendrocalamus strictus, D. hamiltoni, Bambusa bambos, B. arundinacea, Holoptelea integrifolia, Ficus* spp., *Albizzia* spp., *Celtis australis, Litsea chinensis, Alstonia scholaris, Phyllanthus emblica, Diospyros montana, Bauhinia variegata, Grewia optiva, Cassia fistula, Cinnamomum tamala, Anogeissus* spp., *Bombax ceiba,* etc.

Shrubs: *Rosa* spp., *Debregeasia hypoleuca, Zanthoxylum armatum, Myrsine africana, Deutzia staminea, D. corymbosa, Ziziphus* spp., *Carissa opaca, Desmodium gangeticum, Tephrosia hamiltonii, Justicia adhatoda, Murraya* spp., *Tinospora cordifolia,Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo,* etc.

Grasses and Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhavia diffusa, Festuca pratensis, Festuca arundinacea, Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense, Themeda anathera,Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binata, Calamagrostis* spp. and *Thysanolaena maxima.*

Plantation Design: RV/HP/NL/08 - Sub-Tropical Dry Deciduous Forest

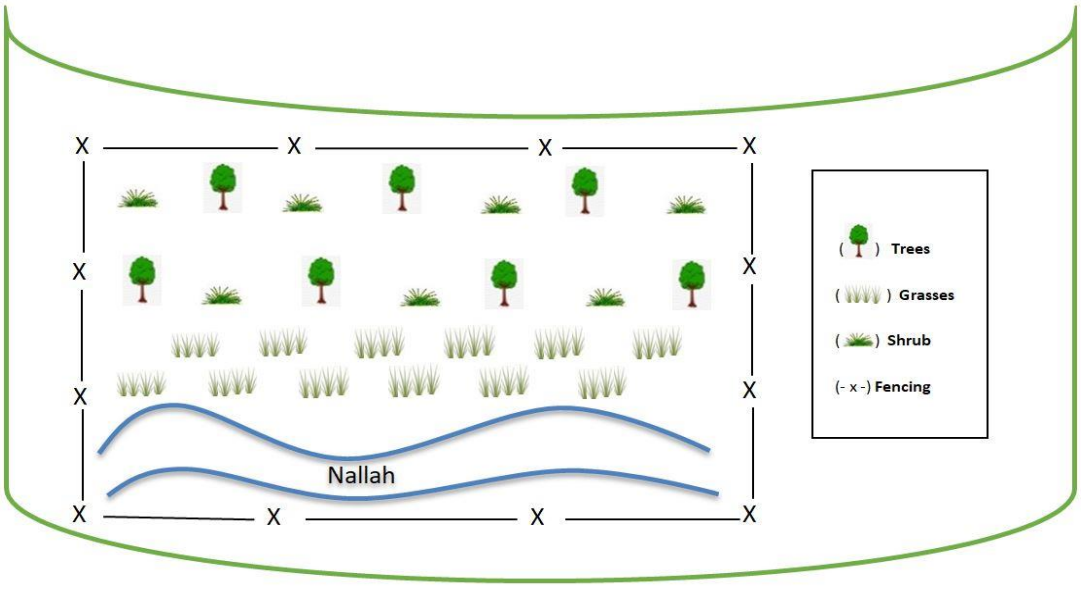


Fig. 5.8 - Schematic Diagram of Sub-Tropical Dry Deciduous Forest Model

Trees: 300/ha., Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300 no., spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no. - 200, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 2 x 2, Seed per patch (gm) - 6, seed, Spacing (cm) - 10 x 10, Type –Staggered, along *Nallah*/depressions (if available)

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.9 - Cost Norms of RV/HP/NL/08 (Sub-Tropical Dry Deciduous Forest)

Year	Item	Detail of works	Amount/ ha (Rs.)	Tentative Man days
	Number of Plants (No.)	Plants- 300 No., Shrubs-300 no., Grasses- 200 no. patches.		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	7,940	32
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	11,657	44
	Advance Work Labour Cost	Site Preparation- Site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris , burning of debris, preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of Barbed wire.	54,910	205
	Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole/ Angle Iron Pole.	52,600	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1st and 2nd year.	9,544	33
	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding and mulching.	39,849	139
Total Establishment Cost (Rs.) =			**1,76,500**	**453**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works.	33,563	105
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting	27,154	80

		cost & other maintenance works.		
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works.	22,521	62
7th year	Maintenance Cost - IV Year	Maintenance cost of fencing.	8,588	23
Total Maintenance Cost (Rs.) =			**91,826**	**270**
Total cost of Plantation =			**2,68,326**	**723**

Model No. – RV/HP/NL/09	**Eradication of *Lantana* (> 50%)**
Zone	**Lower Temperate to Sub-Tropical Areas**

Invasive alien species are plants those hamper regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species. Owing to considerable area of this zone under the influence of lantana, tangible and intangible benefits from lower temperate to sub- tropical forests within the Ravi Riverscape have been adversely affected.

The area for the proposed model referred as 'Eradication of *Lantana* (>50%)' covers forest sites between 300 - 1,200 m amsl wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with around 1,000 - 1,500 mm annual rainfall. Soils are generally fertile and moderately deep. The propose treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of *Lantana camara* forms dense undergrowth in the forest suppressing the native vegetation of that area.

It is proposed to cut and manually uproot above stated invasive species in treatment sites as per the prescription of CRS (Cut Root Stock) method for complete eradication of this obnoxious weed. These areas after *Lantana* eradication will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon serrulatus*, etc. will be sown in the part of treatment site. The treatment area will be planted with broadleaved species like *Toona ciliata, Syzygium cumini, Grewia optiva, Pyrus pashia, Albizzia* spp., *Phyllanthus emblica, Holoptelea integrifolia, Ficus* spp., *Punica granatum, Bauhinia variegata, Dendrocalamus* spp. and *Bambusa* spp. etc. Plants will be planted at 4 m x 4 m spacing. A total of 600 plants of trees and bamboos /ha along with 600 patches of 4x4 m apart grasses on sites will be planted. Alternate rows of bamboo and Broadleaved species will be planted throughout the treatment area. Broadleaved species of this zone require around two and half years of nursery period to produce sturdy plants and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. The plants will be maintained in the 4th to 6th years.

List of species for plantation

Trees: *Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippinensis, Syzygium cumini, Oroxylum indicum, Sapindus Mukorossi, Dendrocalamus* spp., *Bambusa* spp., *Holoptelea integrifolia, Ficus* spp., *Albizzia* spp., *Celtis australis, Litsea chinensis, Pyrus pashia, Phyllanthus emblica, Diospyros montana, Bauhinia variegata, Grewia optiva, Anogeissus* spp., etc.

Grasses/Forbs: *Arundinella nepalensis, Apluda mutica, Chrysopogon fulvus, Boerhavia diffusa, Heteropogon contortus, Trifolium repens, Eragrostis nigra, Deschampsia* spp., *Panicum maximum, Phleum pratense, Cymbopogon citrullus, Arundo donax, Phragmites karka, Themeda arundinacea, Eulaliopsis binata, Dichanthium annulatum, Sporobolus diander, Thysanolaena maxima, Hierochloe laxa,* etc.

Plantation Design: RV/HP/NL/09 – Eradication of *Lantana* (> 50%)

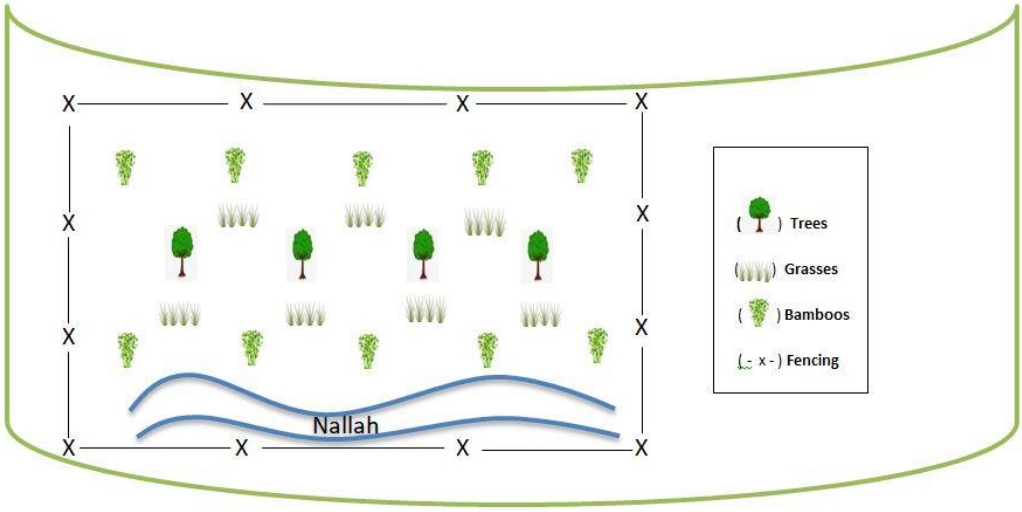


Fig. 5.9 - Schematic Diagram of Eradication of *Lantana* (> 50%)Model

Trees/Bamboo: 600 No., Spacing (m) - 4 x 4, Pit size (cm) – 45 x 45 x 45

Grasses: Patch No. - 600, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 4 x 4, Seed per patch (gm) – 6gm, Spacing (cm) - 10 x 10, Type –Staggered

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.10 - Cost Norms of RV/HP/NL/09 (Eradication of *Lantana* (> 50%)

Year	Item	Detail of works	Amount/ha (Rs)	Tentative Man days
	Number of Plants (No.)	Plants/ Bamboo- 600 No., Grasses- 600 no. patches.		

1st Year	Advance Work Labour Cost	Establishment of Nursery.	5,955	24
		Lantana by Cut Root Stock method and Cleaning of *Lantana*(sprouts) and seedlings, one times (100%) and @15% one cut in Ist year.	31501	126
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	8,743	33
		Site preparation includes *Lantana* by Cut Root Stock method and Cleaning of *Lantana*(sprouts) and seedlings 3 times a year @15% in 2nd year @ 15% of unit cost (estb.) preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire.	62609	234
	Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole.	55,600	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1st and 2nd year.	7,158	25
	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, *Lantana* by Cut Root Stock method and Cleaning of *Lantana*(sprouts) and seedlings in 2 times in 3rd year @ 15% of unit cost (establishment).	49258	172
Total Establishment Cost (Rs.) =			**220,824**	**614**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing, *Lantana* by Cut Root Stock method and Cleaning of *Lantana* (sprouts) and seedlings in 2 times in 4th year @ 15% of unit cost (establishment).	41842	128
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works and Clearing of Fire line along fencing.	26028	74
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works and Clearing of Fire line along fencing.	21812	59

7th year	Maintenance Cost - IV Year	Maintenance cost of fencing and Clearing of Fire line along fencing.	8588	23
Total Maintenance Cost (Rs.) =			**98270**	**284**
Total cost of Plantation (Rs.) =			**319,094**	**898**

Model No. – RV/HP/NL/10	**Control/ Removal of Invasive Species or <50% *Lantana***
Zone	**Lower Temperate to Sub-Tropical Areas**

Invasive alien species are plants those hamper regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species. Owing to considerable area of this zone under the influence of invasive and alien species, tangible and intangible benefits from sub- tropical to sub-temperate forests within the Ravi Riverscape have been adversely affected.

The area for the proposed model referred as 'Control/ Removal of Invasive Species' covers forest sites between 300 - 1,200 m amsl wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with 1,000 - 1,500 mm annual rainfall. Soils are generally fertile and moderately deep. The proposed treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of weed species including *Lantana camara* (<50%) forms considerably dense undergrowth in the forest suppressing the native vegetation of that area. *Ageratum conyzoides* and *Parthenium hysterophorus* also cause considerable hazard especially near agriculture fields and settlements.

It is proposed to cut and manually uproot above stated invasive species in treatment sites prior to their flowering, and immediately to be followed by planting of native plant species. In case of *Lantana* infested areas, Cut Root Stock (CRS) method will be used for control of this obnoxious weed. In case of other weeds, cuttings and removal of infested plants will be done at such a time and such a way as to cause least disturbance to soil and provide opportunity to the nearby native, economically important plants to occupy the space vacated by weeds. These areas after plantation will be intensively managed subsequently for two years to minimize the chances of their re-growth. For controlling herbaceous weeds like *Ageratum conyzoides* and *Parthenium hysterophorus*, eco-friendly measures (e.g., physical or mechanical methods, use of natural products, etc.) will be adopted without resorting to the use of synthetic chemicals. These areas after *Lantana* removal will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon serrulatus*, etc. will be sown in the part of

treatment site. The treatment area will be planted with broadleaved species like *Quercus oblongata*, *Toona ciliata*, *Syzygium cumini*, *Grewia optiva*, *Pyrus pashia*, *Albizia* spp., *Phyllanthus emblica*, *Holoptelea integrifolia*, *Ficus* spp., *Punica granatum*, *Bauhinia variegata*, *Dendrocalamus* spp. and *Bambusa* spp.,etc. Plants will be planted at 5 m x 5 m spacing. A total of 400 plants of trees and bamboo/ha- a mixture of broad leaved species and bamboos will be planted. In additions, 400 patches of grasses 5x5 m apart will be planted on the proposed sites. The rows of trees and grasses will be planted alternatively. Broadleaved species of this zone require around two and half year of nursery period to produce sturdy plants and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium in the potting media. The plants will be maintained in the 4th to 6th year.

List of species for plantation

Trees: *Toona ciliata, Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippinensis, Syzygium cumini, Sapindus mukorossi, Dendrocalamus* spp., *Bambusa* spp., *Holoptelea integrifolia, Albizzia* spp., *Celtis australis, Pyrus pashia, Alstonia scholaris, Phyllanthus emblica, Diospyros montana, Bauhinia variegata, Grewia optiva, Anogeissus* spp., *Morus alba,*etc.

Grasses and Forbs: *Arundinella nepalensis, Apluda mutica, Chrysopogon fulvus, Boerhavia diffusa, Heteropogon contortus, Trifolium repens, Eragrostis nigra, Deschampsia spp., Panicum maximum, Phleum pratense, Cymbopogon citrullus, Arundo donax, Phragmites karka, Themeda arundinacea, Eulaliopsis binata, Dichanthium annulatum, Sporobolus diander, Thysanolaena maxima, Hierochloe laxa,*etc.

Plantation Design: RV/HP/NL/10 – Control/ Removal of Invasive Species or <50% *Lantana*

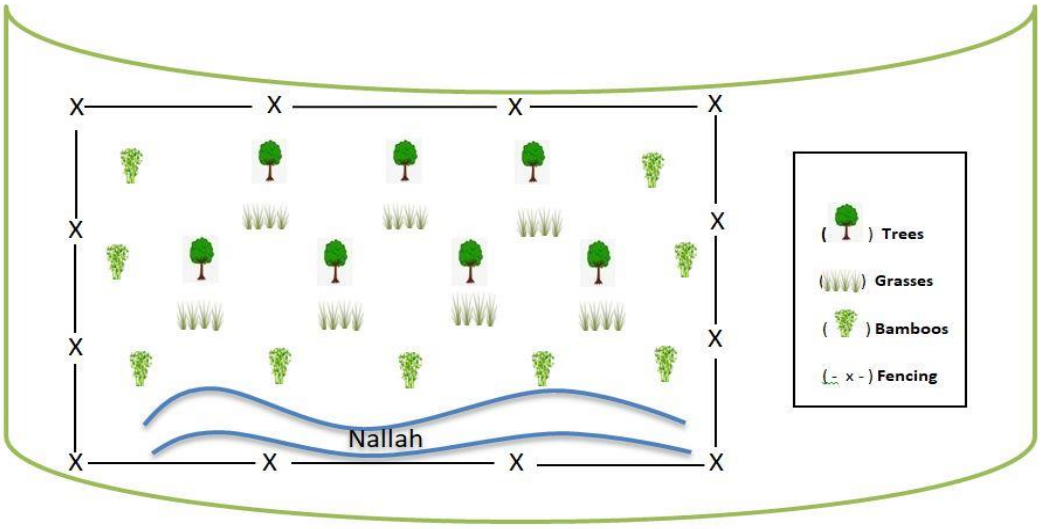


Fig. 5.10 - Schematic Diagram of Eradication of *Lantana* (<50%)Model

Trees/Bamboo: 400 No., Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Grasses: Patch No. - 400, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 5 x 5, Seed per patch (gm) - 6, seed, Spacing (cm) - 10 x 10, Type –Staggered

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.11 - Cost Norms of RV/HP/NL/10 (Eradication of *Lantana* (<50%)

Year	Item	Detail of works	Amount/ha (Rs)	Tentative Man days
	Number of Plants (No.)	Plants/ Bamboo- 400 No., Grasses- 400 no. patches.		
1st Year	Advance Work Labour Cost	Establishment of Nursery.	3970	16
		Lantana by Cut Root Stock method and Cleaning of *Lantana* (sprouts) and seedlings, one times (100%) and @15% one cut in Ist year.	31501	126
2nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of Ist year maintenance.	5829	22
		Site preparation includes *Lantana* by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings 3 times a year @15% in 2nd year @ 15% of unit cost (estb.) preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles and Stretching & fixing of Barbed wire.	62609	234
	Advance Work Material	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole.	54400	0
3rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1st and 2nd year.	4772	17
	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of plants, Patches & Planting of herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, *Lantana* by Cut Root Stock method and Cleaning of *Lantana* (sprouts) and seedlings in 2 times in 3rd year @ 15% of unit cost (Establishment).	49258	172
Total Establishment Cost (Rs.) =			**212339**	**587**

MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing, *Lantana* by Cut Root Stock method and Cleaning of *Lantana*(sprouts) and seedlings in 2 times in 4th year @ 15% of unit cost (estb.).	39675	123
5th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing.	25046	72
6th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works Clearing of Fire line along fencing.	21372	58
7th year	Maintenance Cost - IV Year	Maintenance cost of fencing and Clearing of Fire line along fencing.	8588	23
Total Maintenance Cost (Rs.) =			**94681**	**276**
Total cost of Plantation (Rs.) =			**307020**	**863**

Model No. – RV/HP/NL/11	**Protection Model for Natural Regeneration**
Zone	**All Hill Areas**

All the hill areas between 1,300 - 4,500 m amsl is characterized by dense forests, mainly conifers and Oak forests, Sub-Alpine vegetation i.e., herbs, grasses, shrubs and scattered small trees and Alpine pastures. However, blank patches too occur at several locations that can be taken up for the proposed treatment. In selected areas, especially in Deodar, Blue pine, Fir, Spruce, Oak forests and even the Sub-Alpine and Alpine areas, adequate regeneration can be observed under favorable conditions. Owing to varied disturbances by human and livestock in such areas, establishment of natural regeneration is generally poor and need immediate attention. Often, a thick layer of humus is typically present and the soil is generally moist and conducive for natural regeneration.

Under this treatment model, it is proposed to protect and conserve vegetation so as to promote ample establishment and recruitment of natural regeneration. The major focus will be on protection of special areas like patches of good natural regeneration of various conifers, broadleaved species shrubs, etc. and thereby conserving native plant species, particularly herbs. In natural regeneration areas, cleaning operation twice a year in the month of September and

March be carried out *viz.*,climber cutting, obnoxious weeds, unwanted species, pruning of plants, removing dead and dying trees. The broadcasting of desired seed be done in the closed area to supplement the natural regeneration.

List of species for plantation

Trees: No plantation proposed

Shrubs: No plantation proposed

Herbs: No plantation propose

Cleaning Operations: Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area, debris collection and removal

Seed broadcasting: Seed (2 kg for conifer and 15 kg for broadleaved per hectare)

Fencing: Cement pole/angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5.12 - Cost Norms of RV/HP/NL/11 Protection Model for Natural Regeneration

Year	Item	Detail of works	Amount/ ha (Rs)	Tentative Man days
	Number of Plants (No.)	Seed Broadcasting - (2 kg for conifer and 15 kg for Broad leaved).		
1st Year	I-Advance Work Material	Cost of Seeds, Farm Yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles/ Angle Iron Pole.	50,400	0
	II-Advance Work Labour Cost	Site Preparation - Site preparation i/c survey & demarcation, Debris collection and burning, Preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles and Stretching & fixing of Barbed wire.	55,207	221
2nd year	III-Creation	Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area, Broadcasting sowing in plantation/ Regeneration area, Preparation of fire lines 2.5 m wide, Pruning of established saplings in plantation/regeneration 1/3 portion and Burning/maintenance of lines 2.5 m around the fencing.	22,694	85
Total Establishment Cost (Rs.) =			**1,28,301**	**306**
MAINTENANCE				
3rd year	Maintenance Cost - I Year i/c Material	Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area (50%),Broadcasting sowing in	15,389	50

		Plantation/Regeneration area(50%), Pruning of established saplings in plantation/ regeneration 1/12 portion, and Burning/ maintenance of lines 2.5 m around the fencing (2 times).		
4th year	Maintenance Cost - II Year	Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area (30%), Broadcasting sowing in Plantation/Regeneration area(30%), Pruning of established saplings in plantation/ regeneration 1/15 portion and Burning/maintenance of lines 2.5 m around the fencing (2 times).	14,216	44
5thyear	Maintenance Cost - III Year	Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area (20%),Broadcasting sowing in Plantation/Regeneration area(20%), Pruning of established saplings in Plantation/ Regeneration 1/18 portion and Burning/maintenance of lines 2.5 m around the fencing (2 times).	13,174	39
6th year	Maintenance Cost - IV Year	Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area (15%), Broadcasting sowing in Plantation/Regeneration area(15%) and Burning/maintenance of lines 2.5 m around the fencing (2 times).	8,146	23
Total Maintenance Cost (Rs.) =			**50,925**	**156**
Total Cost of Plantation (Rs.) =			**1,79,226**	**462**

Model No. – RV/HP/NL/12	**Fire Protection Model**
Zone	**Sub-Tropical Area to Lower Temperate Area**

This zone occurs in sub-tropical i.e., from foot hills to mid hill region of Himachal Pradesh. It is dominated by Chir pine in southern aspects and mixed vegetation in other aspects. The altitude is 800 – 1800 m amsl and annual rainfall is 1000 – 1500 mm and mostly during monsoon and some portion in winter months. This zone experiences 7-8 dry months every year making these forests highly vulnerable to fires. Even a small negligence during dry months in Chirpine dominated areas carries the great risk of igniting forest fires that spread very fast riding on the wind. Damage caused by the forest fire during 2016-17 was 19162.69 ha (HPSFD, 2017). Heavy monsoon rains in the burnt out areas transport huge qualities of silt to Ravi River carrying siltation of dams and floods in Punjab plains. Effective fire control measures can help significantly in reducing the silt load in Ravi and its tributaries.

For these fire prone forest areas, 'Fire Protection Model' is recommended. In this model, existing fire lines are cleared of vegetation and maintained all around the forest in such a way that a compact block or area is separated from adjoining areas. These fire lines are usually cleared before the start of the fire seasons in order to avoid the spread of fires from one forest to another. Engagement of fire watchers in fire sensitive beats, Procurement of firefighting equipments and use of elide fire extinguishing balls. Construction of water harvesting and storage structure with locally available materials will be done e.g., Ponds, *Khals*, etc. Besides these, awareness campaign among rural masses particularly about overall damage by forest fires to nature flora and fauna, soil and other ecosystem services of the forest such as hydrological functions, moderation of local climate, etc. influencing horticulture/ agriculture productivity of farmlands. Role of local communities in bringing down the forest fire incidences in Chir-pine zone and is very important and need to be highlighted at various levels.

Cleaning of fire lines
Prescribed burning
Engagement of fire watchers
Procurement of firefighting equipment/ Elide fire extinguishing balls
Constructions of Ponds/ water harvesting structures
Awareness campaigns and community awareness

Table 5.13 - Cost Norms of RV/HP/NL/12 Fire Protection Model

Year	Item	Detail of work	Amount /ha (Rs)	Tentative Man days
1st Year	Establishment Cost	Cleaning of Fire lines (2.5 m width),Control burning, Engagement of fire watchers, Constructions of Ponds/ water harvesting structures, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign and Community awareness.	32,863	131
MAINTENANCE				
2nd year	Maintenance Cost - I Year i/c Material	Cleaning of Fire lines (2.5 m width),Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign and Community awareness.	24,462	91
3rd year	Maintenance Cost - II Year	Cleaning of Fire lines (2.5 m width),Control	24,265	85

		burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign and Community awareness.		
4th year	Maintenance Cost - III Year	Cleaning of Fire lines (2.5 m width),Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign and Community awareness.	23,922	78
5th year	Maintenance Cost - IV Year	Cleaning of Fire lines (2.5mt width),Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign and Community awareness.	23,411	71
Total Maintenance Cost (Rs.) =			**96,060**	**325**
Total cost of plantation (Rs.) =			**1,28,923**	**456**

Model No – RV/HP/NL/13	**Plantation by Eco-Task Force in Temperate Forests**
Zone	**Sub-Tropical to Lower Temperate Areas**

Some sites in the upper Ravi River Basin have rugged topography, harsh conditions, shallow soils with low moisture content, etc. Such areas are mostly located on the southern slopes. These sites require continued presence and close supervision by planting and maintenance teams. The Eco Task Force (ETF) in the past has exhibited great success in regeneration of such harsh sites. It is proposed to utilize this unique ability of ETF in planting on such difficult sites under this DPR. A total of 1,000 ha land in such areas will be identified in the Ravi Riverscape in liaison with Himachal Pradesh State Forest Department. The selected areas may not necessarily be contiguous. The task of establishment and maintenance of proposed plantations will be carried out by the raising one more unit under this DPR to be established in Dalhousie area of district Chamba with over all Command Headquarters at Kufri in Shimla district already looking after the affair of two such units in Sutlej and Beas Rivers catchments in Himachal Pradesh and can handle two more with existing Headquarters. The unit will work in close coordination with Himachal Pradesh State Forest Department. One or more of the proposed plantation models amongst suggested models (RV/HP/NL/01 to RV/HP/NL/10) will be selected for replication by the ETF under this model.

Table 5.14 - Nursery Rate in Himachal Pradesh and rate after including inflation factor

Nursery rate				Year	Rate per day (Rs.)	Rate per day (Rs.) for Tribal area (increase 1.25%)	Factor after inflation of 7% each year
Ban	(BL+ Conifer)	Tree/Shrub (avg.)	Herbs		150	188	
11	10	10.5	5	1st	250	313	1.667
6	6	5.7	3	2nd	267.5	334	1.784
6	3	4.3	2	3rd	286	358	1.909
				4th	306	383	2.042
				5th	327.7	410	2,185
				6th	350.7	438	2.338
				7th	375,3	469	2,502
				8th	401.5	502	2.677
				9th	450	537	2.864

(B) Treatment Models for Natural Landscape in Jammu Region of J&K UT

As already stated, various natural land use and land cover categories together constitute the largest area of the Ravi Riverscape and it is represented by diverse forests, alpine pastures, scrub, snow cover/ glaciers, rivers, wetlands, etc. Thus, the maximum number of treatment models has been proposed in the mountainous/ hill portion of the Riverscape in Jammu region. Interventions are proposed to be implemented in the entire upper basin of the Ravi River and its tributaries. Primarily, these models would be applied on forest lands under the control of SFD, J&K UT. The proposed treatment sites would mainly include areas under open forests, scrubs, grasslands, and alpine pastures or along the river and its tributaries. Details of each of the 12 treatment models prescribed in the Natural Landscapes are presented below.

Model No. - RV/JK/NL/01	**Alpine Conservation**
Zone	**Sub-Alpine and Moist Alpine Areas**

The Sub-Alpine and Moist Alpine zones are located between 3,600 - 4,100 m amsl and are mostly snow-bound. The temperature remains below 5° C for 6 months in a year. The active plant growth season is of almost 4-6 months. This region is above the tree line with varied rock formations. Vegetation is dominated by grasses and herbs with scattered shrubs. A low deciduous scrub formation usually about 1 m high forms a dense cover in some patches.

Under this model, it is proposed to conserve and augment vegetation of the alpine meadows. The major focus will be on conservation of native species and livelihood generation for local communities. The conservation practices as prescribed in the Working Plan of the respective Territorial Forest Division and Wildlife Management Plan of protected area will be applicable. The collection of medicinal and aromatic plant species would be regulated as per the State's policy on the medicinal plants and accordingly the benefit will be shared with local communities. Under this model, medicinal plant species will be planted at the rate of 2,400 plants/ha in the blank areas. Root slips/ seeds of native grasses will be put in continuous contour strips immediately after melting of snow in 600/ha patches. The high altitude medicinal plants require two years nursery period and third year planting in the field along with grasses. It will be followed by two years of maintenance phase. Harvesting can be started after 3rd year onwards in sustainable manner.

List of species for plantation

Herbs/Medicinal Plants: *Delphinium cashmerianum, Hypericum cernuum, Aconitum heterophyllum, Aconitum violaceum, Ainsliaea aptera, Arnebia benthamii, Dactylorhiza hatagirea, Heracleum candicans, Polygonatum verticillatum, P. multiflorum, Fritillaria roylei, Picrorhiza kurroa, Selinum tenuifolium, Allium humile, Geranium wallichianum, Rheum australe, Rheum moorcroftianum* and *Sinopodophyllum hexandrum.*

Grasses and Forbs: *Festuca pratensis, F. valesiaca, Trifolium pratense, Poa pratensis, Poa alpina, Dactylis glomerata, Agrostis gigantea, A.pilosula, sphaeralcea munroana, Danthonia* spp., *Calamagrostis montanensis, Koeleria* spp., *Brachypodium sylvaticum, Bromus himalaicus, B. ramosus, Stipa roylei,* etc.

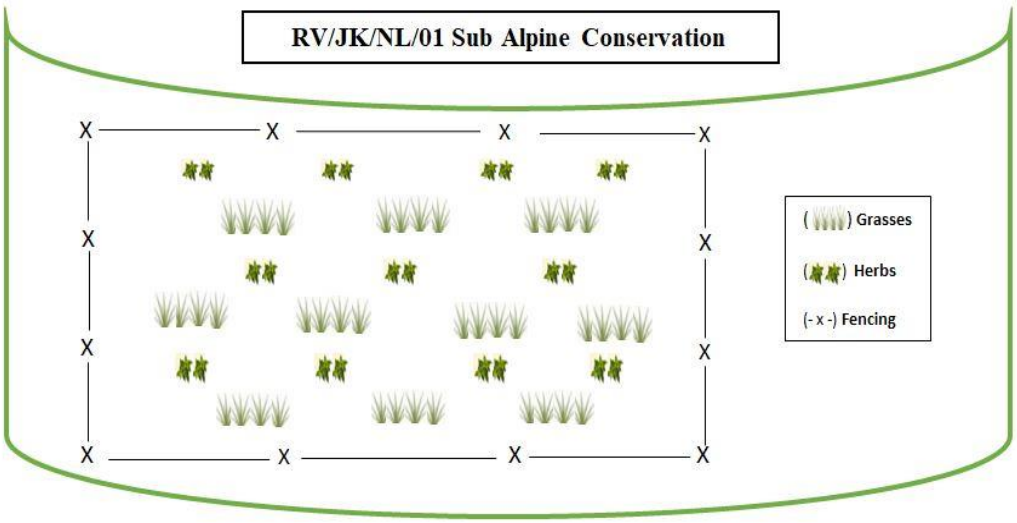


Fig. 5.11 - Schematic Diagram of Alpine Conservation Model

Herbs: Patch number - 600, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 2 x 8, Plant per patch - 4, Spacing (cm) – 20 x 20 (planting in 3rd Year)

Grasses: Patch number - 600, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 8, Seed per patch (gm) – 6gm, Spacing (cm) – 10 x 10

Fencing: Cement pole/local material - wood/ branches

Labour Rate Rs 225, 1st year and Annual Increase @ 7% in Subsequent Years

Table 5.15 - Cost Norms for RV/JK/NL/01 (Alpine Conservation)

Year	Item	Detail of work	Amount/ Ha (Rs)	Tentative Man days
1st Year	No of Plants (No.)	2400 Herbs, 600 Grass Patches .	3,600	
	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	12,000	53
2nd year	A!- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	8,089	34
	A1-Advance Work Labour Cost	Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing for poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbered wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	518
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	11,403	44
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	9,617	37
Total Establishment Cost (Rs.) =			**165,698**	**686**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance(30%), 2nd year maintenance(25%) and rising of plants for 3rd year maintenance (15%), Carriage of	9,261	34

		plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses , Watch and ward i/c repair of fencing, Weeding and mulching.		
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	5,741	19
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	2,777	9
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12155	36
Total Maintenance Cost (Rs.) =			**29,934**	**98**
Total cost of plantation (Rs.) =			**195,632**	**784**

Model No. – RV/JK/NL/02	**Sub- Alpine Enrichment**
Zone	**Sub-Alpine Zone**

The Sub-Alpine zone occurs between 2,900 - 3,600 m amsl in the Ravi Riverscape of Jammu Region J&K UT and is covered with snow for 4-5 months. The temperature remains below 5° C for around 4 months in a year. Vegetation in sub-alpine zone is dominated by herbs, grasses and shrubs of *Rhododendron* spp., etc. Area is sloppy and generally soil depth is very low.

Under this model, it is proposed to conserve and augment vegetation in sub-alpine zone by adopting specific interventions to enrich such areas. The major focus will be on conservation and enrichment of native species besides generation of sustainable livelihoods for local communities. Conservation and enrichment practices as prescribed in the Working Plan of respective territorial Forest division/wildlife Management Plan of a protected area will be applicable. The collection of medicinal and aromatic plant species would be regulated as per the State's policy on medicinal plants and accordingly the accrued benefit will be shared with local communities. In this model, native trees @ 200 plants/ha at 6 m x 8 m spacing and medicinal plant species @ 800 plants/ha at 6 m x 8 m spacing in 200/ha patches will be planted in blank areas. The high altitude tree species as well as high altitude temperate medicinal plants require around 2 years nursery period and planting will be done in the 3rd year. The plants will be maintained in the field during 4^{th}, 5^{th}, 6^{th} and 7^{th} year of project implementation.

List of species for plantation

Trees: *Betula utilis, Pinus wallichiana, Acer caesium, Corylus jacquemontii, Prunus cornuta, Quercus semecarpifolia*, etc.

Herbs/Medicinal Plants: *Saussurea costus, Aconitum heterophyllum, Arnebia benthamii, Dactylorhiza hatagirea, Heracleum candicans, Polygonatum verticillatum, Selinum tenuifolium, Allium humile, Geranium wallichianum, Bergenia stracheyi, Phytolacca acinosa, Hyoscyamus niger, Angelica glauca, Picrorhiza kurroa, Fritillaria roylei, Sinopodophyllum hexandrum, Trillium govanianum,*etc.

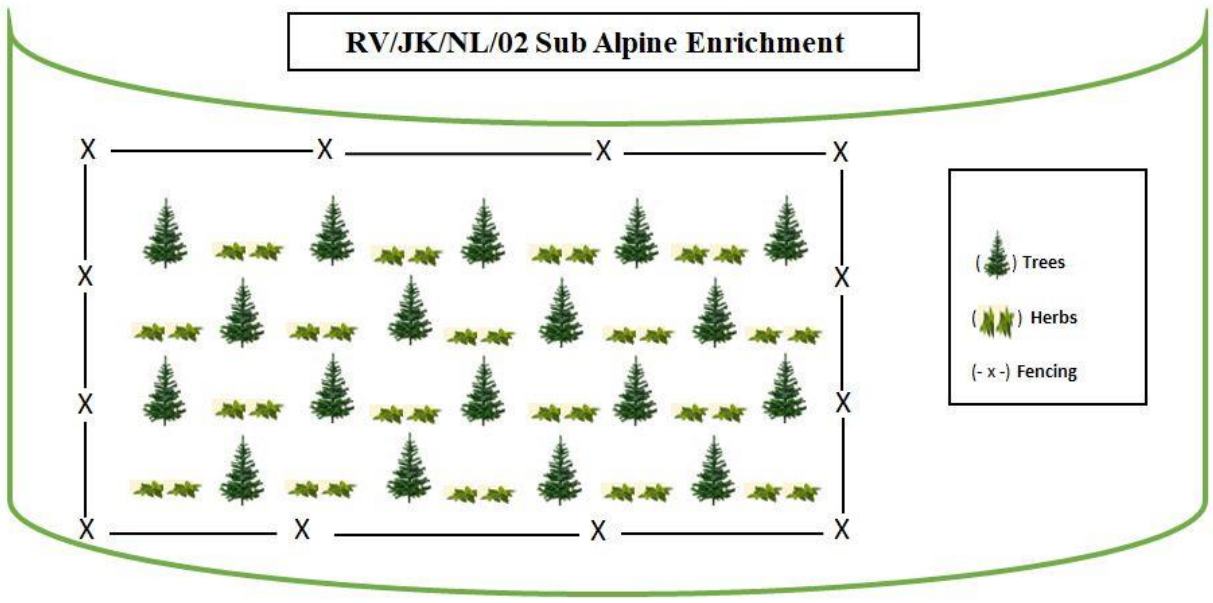


Fig. 5.12 - Schematic Diagram of Sub Alpine Enrichment Model

Trees: Plants- 200 No./ha., Spacing (m) - 6 x 8, Pit size (cm) – 30 x 30 x 30

Herbs: Plants- 800/ha, Patch no. – 200/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 6 x 8, plant per patch - 4, Spacing (cm) – 20 x 20

Fencing: Cement pole/local material- wood/ branches

Table 5.16 - Cost Norms for RV/JK/NL/02 Sub Alpine Enrichment

Year	Item	Detail of work	Amount/ ha (Rs.)	Tentative Man days
	No of Plants (No.)	200 Plants , 800 Herbs.		
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	6,400	28

2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	4,920	20
2nd year	A1-Advance Work Labour Cost	Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	554
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance(25%).	5,610	22
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	1,603	6
		Carriage of Plants, Lay out pit, digging & filling of pit, Planting of plants and shrubs in pits.	6,718	26
Total Establishment Cost (Rs.) =			**149,840**	**656**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including Maintenance of plants for Ist year Maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance (15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses , Watch and ward i/c repair of fencing, Weeding and mulching.	15,571	56
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of Plants, Pitting & Planting of Plants & Planting of Herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	14,375	49
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance., Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	13,395	42
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12155.9158	36
Total Maintenance Cost (Rs.) =			**55,497**	**183**
Total cost of plantation (Rs.) =			**2,05,337**	**839**

Model No. – RV/JK /NL/03	**Temperate Conifer Forest**
Zone	**Moist Temperate Area**

The moist temperate area lies between 1,700 - 3,500 m amsl. This zone is characterized by dense forests, mainly of conifer species. However, blank patches too occur at several places which will be taken up for proposed treatment. In some areas, especially in fir and spruce forests, soil is covered with a thick layer of humus as the decomposition rate is very slow in these areas. The suggested treatment model for these areas is being referred as the Temperate Conifer Forest Model.

Planting of 300/ha plants of various tree species and 300/ha shrub species will be carried out per ha. In addition, 300/ha patches of medicinal plants with 1200 plants/ha will also be planted out in the treatment site. The small stream or *Nallah* facing side of the treatment area will be planted with two rows of hill bamboo at 2 m x 2 m spacing with 200/ha plants of hill bamboo. The major focus will be on the conservation and development of native species and livelihood generation for local communities. The collection of medicinal and aromatic plants species in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4th year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium To synchronize planting of trees, medicinal herbs and shrubs in 4th year, the nursery for selected herbs and shrubs will be raised 2nd year onwards. The plants will be maintained in the field during 5th, 6th and 7th year of the project implementation.

List of species for plantation

Trees: *Cedrus deodara, Pinus wallichiana, Picea smithiana, Taxus wallichiana, Cupressus torulosa,*etc.

Shrubs: *Drepanostachyum falcatum, Thamnocalamus spathiflorus, Daphne* papyracea, *Prinsepia utilis, Rosa* spp., *Debregeasia hypoleuca, Cotoneaster bacillaris, Viburnum* spp., *Cornus oblonga, Syringa emodi, Indigofera heterantha, Desmodium elegans, Hypericum oblongifolium, Sarcococca saligna,* etc.

Herbs: *Aconitum heterophyllum, Picrorhiza kurroa, Heracleum candicans, Angelica glauca, Geranium wallichianum, Polygonatum* spp., *Bergenia ciliata, Viola canescens, Trillium govanianum, Phytolacca acinosa, Valeriana jatamansi, Hedychium spicatum, Sinopodophyllum hexandrum, Thymus linearis, Achillea millefolium,* etc.

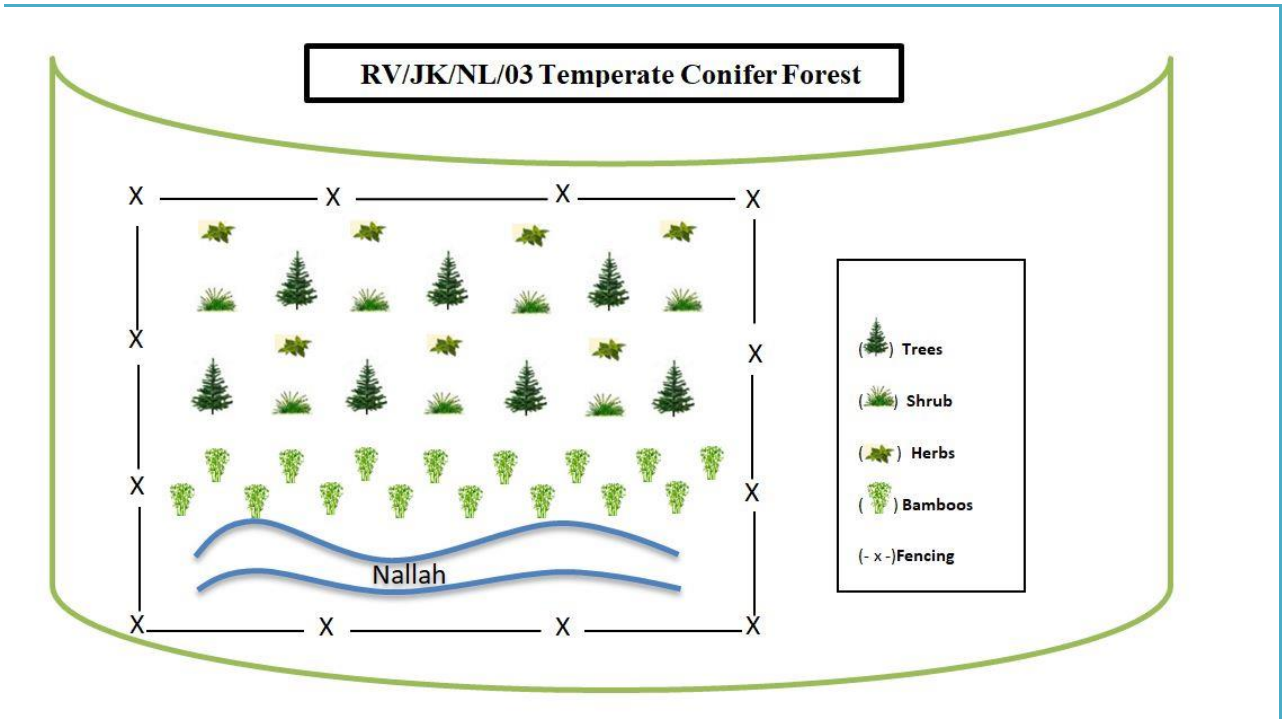


Fig. 5.13 - Schematic Diagram of Temperate Conifer Forest Model

Trees: 300 No/ha, Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo (hill): 200/ha, Spacing (m)-5 x 5, Pit size (cm) – 45 x 45 x 45 (along *Nallah*)

Shrubs: Plants: 300/ha., No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30 (gap filling)

Herbs: Plants: 1200/ha, Patch no – 300/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) – 5 x 5, plant per patch - 4, Spacing (cm) – 20 x 20

Fencing: Cement pole/local material wood/ Branches

Table 5.17 - Cost Norms for RV/JK/NL/03 – Temperate Conifer Forest

Year	Item	Detail of work	Amount/Ha (Rs)	Tentative Man days
	No of Plants (No.)	800 Plants, 1200 Herbs		
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	18,800	84
2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	14,060	58

2nd year	A1-Advance Work Labour Cost	Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing for poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbered wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	518
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%)	15,742	61
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	3,206	12
		Carriage of plants, Lay out pit, digging & refilling of pit, Planting of plants and shrubs in pits.	30,232	117
Total Establishment Cost (Rs.) =			**206,629**	**850**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance(15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses , Watch and ward i/c repair of fencing, Weeding and mulching.	28,907	105
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	23,891	81
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	18,936	60
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**83,890**	**282**
Total cost of plantation (Rs.) =			**2,90,519**	**1,132**

Model No. – RV/JK/NL/04	**Temperate Mixed Forest**
Zone	**Moist Temperate Area**

The moist temperate forest area occurs between 1,700 - 3,500 m amsl. Dominant species of the area are *Aesculus indica, Quercus oblongata, Q. floribunda, Q. semecarpifolia, Alnus nitida, Acer caesium, A. pictum, A. cappadocicum, Ulmus wallichiana, Pinus wallichiana, Cedrus deodara, Picea smithiana, Abies pindrow, Abies spectabilis,* etc. Sometime, one species may occur in form of pure stands. This zone is often characterized by degraded stretches along the river banks running close to the area of dense temperate forests, mainly of conifers. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains.

Annual precipitation in this zone is between 1,000 - 1,500 mm. In some areas, snow lasts till spring season. The soil in many places is shallow, exposed and prone to erosion. This zone is heavily grazed by domestic animals and cause huge damage to the vegetation. Besides this, road construction and other developmental activities also cause severe soil erosion, resulting in damage to vegetation. There is heavy dependence of local communities on Oak fodder within Ravi Riverscape. Further, owing to several famous tourist spots *viz*., Sarthal, etc. and the enhanced tourism activities in such fragile zone within the Riverscape cause damage to vegetation and disturbance to wild fauna.

Temperate mixed forest treatment model has been proposed specifically for the blank and degraded patches within the temperate zone. Planting of trees @300/ha belonging to conifers and broadleaved species will be carried out in the blank and degraded patches. In this model preferably broadleaved plant will be planted in general and conifer plants can be planted on the ridges and shallow soil depth area. The native shrubs @300 plants/ha will be carried out in between the tree planted. The medicinal plants species will also be planted in patches @ 4 plants/ patch and that means planting of total of 1,200 medicinal plants/ ha. The small stream or *Nallah* facing side of the treatment site will be planted with two rows of hill bamboo @ 200/ha at 2 m x 2 m spacing. The major focus of the proposed treatment model will be on the conservation and propagation of native species alongside improved livelihoods for local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4^{th} year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium. To synchronize planting of trees, medicinal herbs and shrubs in 4^{th} year, the nursery for selected herbs and shrubs will be raised 2^{nd} year onwards. The plants will be maintained in the field during 5^{th}, 6^{th} and 7^{th} year of the project implementation. The collection of medicinal and aromatic plant species in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities.

List of species for plantation

Trees: *Cedrus deodara, Pinus wallichiana, Picea smithiana, Taxus wallichiana, Aesculus indica, Juglans regia, Prunus cornuta, P. cerasoides, Acer* spp., *Carpinus viminea, Betula alnoides, Cornus macrophylla, C. capitata, Alnus nitida, Ulmus wallichiana, Quercus oblongata, Q. floribunda, Q. semecarpifolia, Neolitsea pallens, Lyonia ovalifolia*, etc.

Shrubs: *Drepanostachyum falcatum, Thamnocalamus spathiflorus, Daphne papyracea, Prinsepia utilis, Rosa* spp., *Debregeasia hypoleuca, Cotoneaster bacillaris, Viburnum* spp., *Elaeagnus conferta, Hypericum oblongifolium, Rubus* spp., *Zanthoxylum armatum, Deutzia* spp., *Spiraea canescens, Berberis* spp., *Desmodium elegans, Indigofera heterantha*, etc.

Herbs: *Aconitum heterophyllum, Heracleum candicans, Angelica glauca, Geranium wallichianum, Polygonatum verticillatum, P. cirrhifolium, Sinopodophyllum hexandrum, Bergenia ciliata, Viola serpens, V. canescens, Valeriana jatamansi, Hedychium spicatum, Trillium govanianum, Ajuga* spp., *Achillea millefolium, Swertia angustifolia, S.cordata, S. paniculata*, etc.

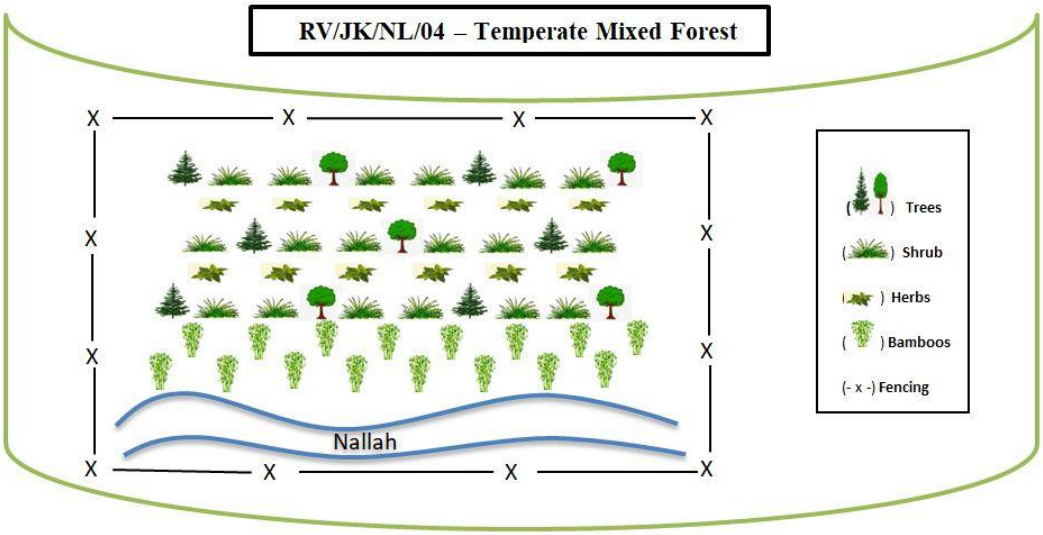


Fig. 5.14 - Schematic Diagram of Temperate Mixed Forest Model

Trees: 300 No, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45 (50;50 of B/L & Conifer)

Bamboo (hill): 200, Spacing (m) -5 x 5, Pit size (cm) – 45 x 45 x 45 (along *Nallah*)

Shrubs: Plants: 300 no., No. of Pit - 300, Spacing (m) - 2 x 5, Pit size (cm) – 30 x 30 x 30

Herbs: Plants: 1200 Patch no – 300, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 3 x 5, plant per patch - 4, Spacing (cm) - 20 x 20

Fencing: Cement pole/local material wood/ Branches

Table 5.18 - Cost Norms for RV/JK/NL/04 – Temperate Mixed Forest

Year	Item	Detail of work	Amount/Ha (Rs.)	Tentative Man days
	No of Plants (No.)	800 Plants , 1200 Herbs.		
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	21,500	96
2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	15,890	66
		Site preparation-Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of B/wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	518
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	16,824	65
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs, and Preparation of strips including (i/c) sowing of grasses in strips.	3,206	12
		Carriage of plants, Lay out pit, digging & refilling of pit, and Planting of plants and shrubs in pits.	30,232	117
Total Establishment Cost (Rs.) =			**212,241**	**874**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance (25%) and raising of plants for 3rd year maintenance(15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	29,679	108

5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance. (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	24,068	82
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance ., Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	18,936	60
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**84,839**	**286**
Total cost of plantation (Rs.) =			**2,97,080**	**1160**

Model No. – RV/JK/NL/05	**Pasture and Grazing Land Development**
Zone	**Sub-Tropical to Temperate Areas**

These areas are located between 600 - 3,200 m amsl, particularly on southern slopes and around habitations are characterized by pasture and grazing lands. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains. Annual precipitation is around 1,200 - 1,600 mm. In some areas, snow lasts till spring season. The soil is shallow, exposed and prone to erosion, particularly in moderate to steep slopes. This zone is heavily grazed by livestock and cause huge damage to the vegetation and results into heavy soil erosion. Besides disturbance by livestock, road construction and other developmental activities also cause significant soil degradation and damage to native flora by proliferation of invasive alien species. The local communities are heavily dependent on these grasslands in the Ravi Riverscape. This zone also severely suffers on account of enhanced tourism activities in several popular tourist destinations *viz*., Sarthal, Bani, Kathua, etc. causing damage to flora and disturbance to fauna.

Under this model, pasture and grazing land development are proposed by protection, development and enrichment of areas within this zone. Suitable grass species will be planted/ sowing of seeds after carrying out necessary land development works like trenching/ terracing/ moisture conservation measures, etc. besides removal of weeds and unpalatable grasses. The

proposed treatment model mainly includes plantation of native and nutritionally important grass species. In this model, grass sowing in furrows/ strips of 100 cm x 30 cm x 5 cm along contours at interval of 2 m apart is proposed. Selected species will be raised / maintained in the nursery during 1st year and planting will be done in the second year. The grasses will be replenished in the field during 3rd and 4th year.

List of species for plantation

Grasses and Herbs: *Festuca pratensis, Trifolium pratense, T. repens, Poa pratensis, Poa annua, Dactylis glomerata, Erianthus* spp., *Agrostis* spp., *Agropyron* spp. *Calamagrostis* spp., *Koeleria* spp., *Saccharum spontaneum, Chrysopogon gryllus, Arundinella nepalensis, A.pumila, Themeda anathera, Cymbopogon distans, Setaria glauca, Alopecurus aequalis, A. nepalensis, Bothriochloa pertusa, B. parviflora,* etc.

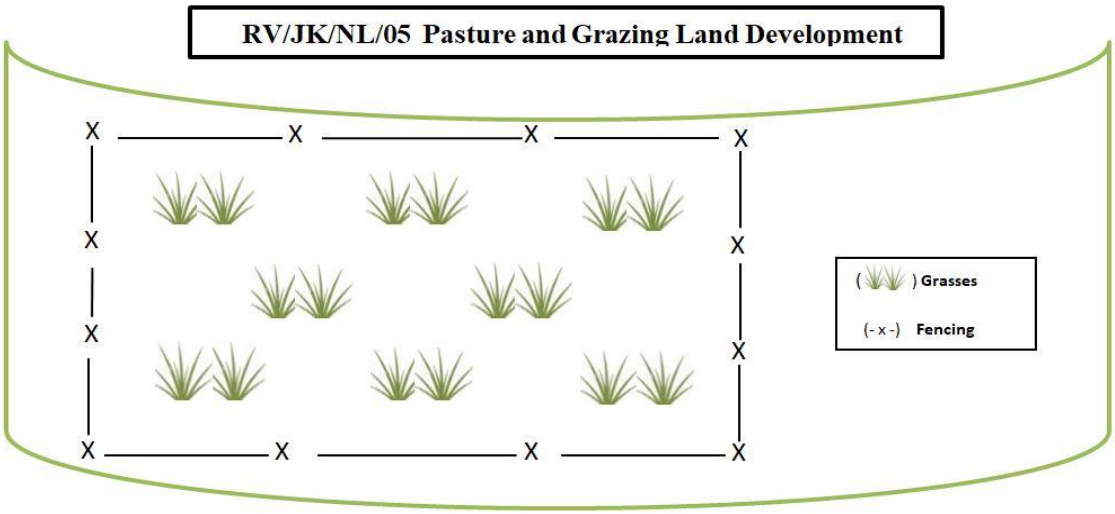


Fig. 5.15 - Schematic Diagram of Pasture and Grazing Land Model

Grasses: Patch no. - 2000, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed per patch (gm) - 6, Spacing (cm) – 10 x 10, Type - Staggered

Fencing: Cement pole/local material-wood/branches/ brushwood fencing

Table 5.19 - Cost Norms for RV/JK/NL/05 - Pasture and Grazing Land

Year	Item	Detail of work	Amount/ Ha (Rs)	Tentative Man days
	No of Plants (No.)	2000 Grass Patches.	12,000	
1st year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	0	0
2nd year		Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	0	

	A1- Advance Work Labour Cost	Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation of inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing for poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	554
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	0	0
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	16,029	62
		Carriage of plants, Lay out pit, digging & refilling of pit and Planting of plants and shrubs in pits.	0	0
Total Establishment Cost (Rs.) =			**1,40,618**	**616**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance (15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	15,068	55
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	15,205	52
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	14,306	45
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**56,735**	**188**
Total cost of plantation (Rs.) =			**1,97,353**	**804**

Model No. – RV/JK/NL/06	**Himalayan Chir Pine Forest**
Zone	**Sub-Tropical to Lower Temperate Area**

In this zone of Jammu region, J&K UT particularly on southern aspect, Chir pine is the dominant species. The altitude ranges between 800 -1,800 m amsl and annual rainfall varies from 1,200 - 1,800 mm. In these areas, high temperatures and humidity conditions prevail during summer. Ground is densely covered with pine needles during winter to summer season and such areas are prone to forest fires. Grasses flush during monsoon season. Heavy rains in monsoon lead into severe soil erosion in this zone, ultimately results into high rate of sedimentation in Ravi River and its tributaries. This is one of the major causes of siltation of dams and floods in Punjab plains. Open and degraded forests on southern aspect with sparse vegetation coupled with agriculture on steep slopes, construction and developmental activities are prominent reasons behind large scale soil erosion in this zone. These areas experience heavy rainfall during monsoon season and modest rainfall during the winter season. Snowfall occurs in cooler aspects of higher reaches but the snow stays for a few days only. Most of the rainwater flows down the streams washing away top soil especially on slopy sites. The soil is acidic in nature and shallow on steep slopes while valleys have deep soil. The biotic pressure in terms of livestock grazing, and fuel wood and tree fodder collection is conspicuous. Suitable forestry interventions in this zone can immensely help in improvement of pastures and grazing lands besides checking soil erosion and siltation into Ravi River and its tributaries.

For such areas in this zone, the Himalayan Chir Pine Forest Model is proposed. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. are proposed to be sown in the treatment site, particularly towards the river or *Nallah* side. The area will be planted with *Pinus roxburghii* mainly in drier sites with shallow soil depth whereas broadleaved species like *Quercus oblongata*, *Lyonia ovalifolia*, Bamboo spp., etc. on moist sites are proposed to be planted at 5 m x 5 m spacing. A total of 300 plants of tree/ha, 100 bamboo species /ha along with 300 plants of shrubs/ha and 800 patches of grasses will be planted 2m apart in staggered fashion. Chir pine and associated broadleaved species require around 2 years nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herbs either species specific or as consortium. The plants will be maintained in the field during 4th, 5th and 6th year. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Tree: *Pinus roxburghii, Quercus oblongata, Lyonia ovalifolia, Dendrocalamus strictus, Dendrocalamus hamiltonii, Holoptelea integrifolia, Ficus* spp., *Termilalia* spp., *Albizia* spp., *Phyllanthus emblica, Diospyros* spp., *Bauhinia variegata, Grewia optiva, Pyrus pashia, Mallotus philippinensis, Aegle marmelos, Bombax ceiba, Senegalia catechu, Dalbergia sissoo, Pistacia integerrima, Cinnamomum tamala, etc.*

Shrubs: *Justicia adhatoda, Myrsine africana, Murraya koenigii, Murraya paniculata, Ricinus communis, Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo, Carissa opaca, Berberis lycium, Ziziphus nummularia, Ziziphus jujuba, Desmodium* spp., *Tephrosia hamiltonii, Indigofera* spp.

Grasses and Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhavia diffusa, Festuca pratensis, Festuca arundinacea***,** *Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense***,** *Themeda anathera, Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binata, Calamagrostis spp., Thysanolaena maxima*, etc.

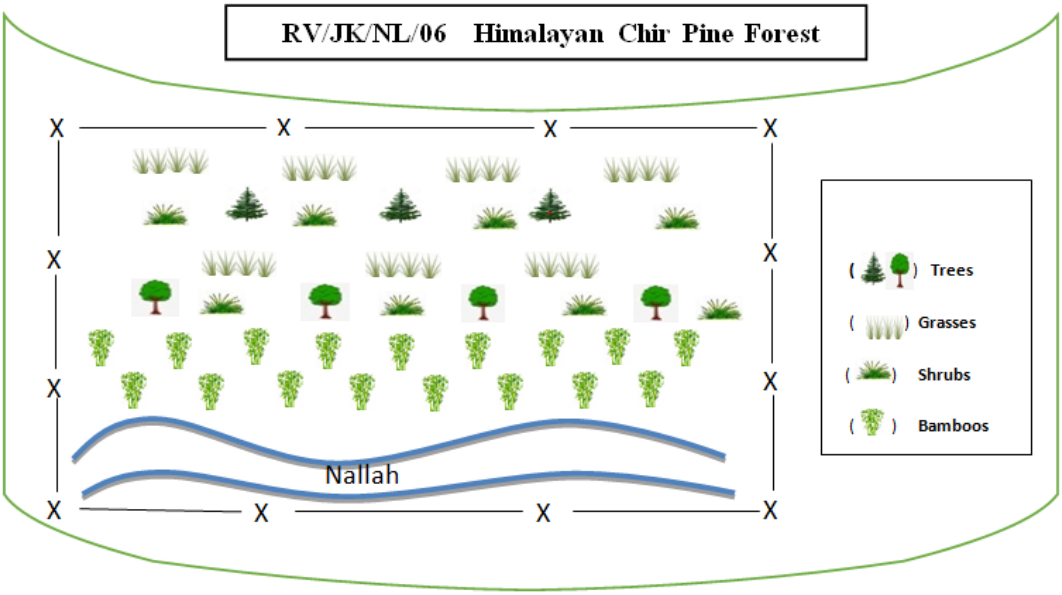


Fig. 5.16 - Schematic Diagram of Himalayan Chir Pine Forest Model

Trees: 300 No, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo: 100, Spacing (m) - 3 x 3, Pit size (cm) – 45 x 45 x 45 along *Nallah* (if available)

Shrubs: Plants: 300 no., No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no - 800, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 5, Seed per patch (gm) - 6, Spacing (cm) - 10 x 10, Type – Staggered

Fencing: Cement pole/local material wood/Branches/Brushwood fencing

Table 5.20 - Cost Norms for RV/JK/NL/06 Himalayan Chir Pine Forest

Year	Item	Detail of work	Amount/Ha (Rs)	Tentative Man days
	No of Plants (No.)	700 Plants and 800 Grass Patches.	4,800	
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	12,000	53
2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	6,800	28
2nd year	A1-Advance Work Labour Cost	Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	554
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	7,160	32
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	6,411	25
		Carriage of plants, Lay out pit, digging & refilling of pit, Planting of plants and shrubs in pits.	23,472	104
Total Establishment Cost (Rs.) =			**180,432**	**768**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance(15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	24,968	91

5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	21,822	74
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of Plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	18,150	58
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**77,096**	**259**
Total cost of plantation (Rs.) =			**257,528**	**1027**

Model No. – RV/JK/NL/07	**Himalayan Mixed Forest**
Zone	**Sub-Tropical to Lower Temperate Area**

This zone occurs in mid hill region on the northern aspect and is dominated by broadleaved species with some Chir pine in exposed areas. The altitudinal variation in this zone is between 800 –1,800 m amsl and the zone receives annual rainfall ranging between 1,000 - 1,500 mm. The zone experiences high temperatures and humidity prevails during the summer season. In areas wherein Chir pine species is around 50%, the ground is mostly covered with pine needles and area is prone to forest fires. Grasses in slopes flush during the monsoon season. Heavy rains in the monsoon season cause severe soil erosion and sedimentation in Ravi River and its tributaries. Moderately dense to open forests on the northern aspect coupled with agriculture on terraces along moderately steep slopes, and construction and development activities are primary reasons for large scale soil erosion in this zone. These areas experience heavy rainfall during the monsoon season and modest rainfall during the winter season. Snowfall occurs on cooler aspects of higher reaches but the snow stays for a short duration of few days. Most of the rainwater flows down the streams washing away top soil especially on slopy sites. The soil is neutral to acidic in nature and shallow on slopes while valleys have deep soils. The biotic pressure i.e., livestock grazing, and collection of fuel wood and tree fodder is severe. Appropriate forestry interventions in this zone can immensely help in improvement of the zone and also river flow.

The Himalayan Mixed Forest Model is recommended for this zone. Grass species such as *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus,* etc. will be sown or planted in the part of treatment site, particularly on the ridges. The treatment area will be planted with broadleaved species like *Quercus oblongata, Lyonia ovalifolia, Toona ciliata, Syzygium cumini, Grewia optiva, Pyrus pashia, Albizia* spp., *Phyllanthus emblica, Holoptelea integrifolia, Ficus* spp., *Punica granatum, Bauhinia variegata*, etc. Plants will be planted at 5 m x 5 m spacing. A total of 300 plants of tree/ha., 300 plants of shrubs/ha and 200 patches of 2x2 m apart grasses on the ridges/degraded sites will be planted. Broad leaved species of this zone require around one and half year to two years of nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. The plants will be maintained in the 4th to 6th year. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Trees: *Quercus oblongata, Lyonia ovalifolia, Holoptelea integrifolia, Ficus* spp., *Albizia* spp., *Phyllanthus emblica, Bauhinia variegata, Grewia optiva, Pyrus pashia, Toona ciliata, Syzygium cumini, Punica granatum, Pistacia integerrima, Bombax ceiba, Cinnamomum tamala, Anogeissus* spp., *Terminalia* spp., *Senegalia catechu, Dalbergia sissoo,* etc.

Shrubs: *Rosa* spp., *Debregeasia hypoleuca, Elaeagnus conferta, Zanthoxylum armatum, Deutzia staminea, D. corymbosa, Berberis lycium, Ziziphus* spp., *Carissa opaca, Murraya* spp., *Desmodium gangeticum, Tephrosia hamiltonii, Justicia adhatoda, Ricinus communis, Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo,* etc.

Grasses and Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhaavia diffusa, Festuca pratensis, Festuca arundinacea, Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense, Themeda anathera, Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binata, Calamagrostis* spp., *Thysanolaena maxima,* etc.

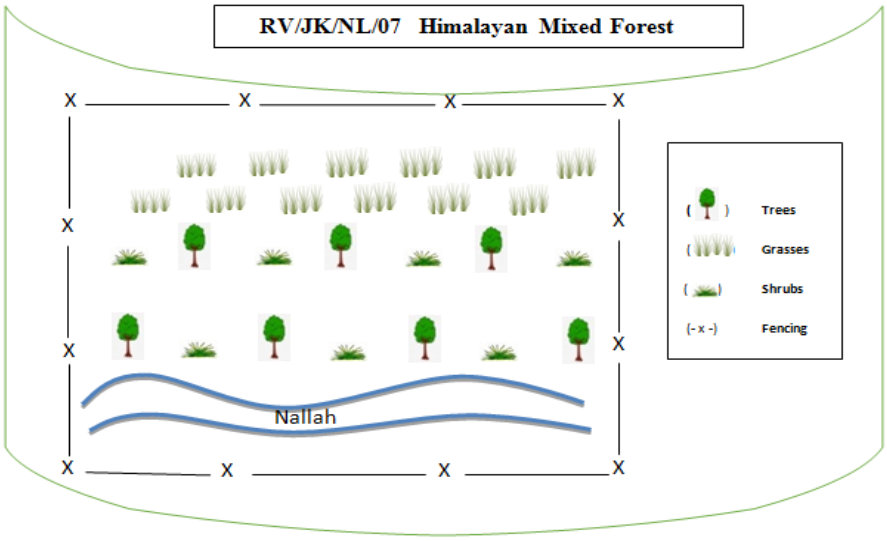


Fig. 5.17 - Schematic Diagram of Himalayan Mixed Forest Model

Trees: 300 No, Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300 no., spacing (m) – 5 x 5, Pit size (cm) – 30 x 30 x 5

Grasses: Patch number – 200, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed per patch (gm) – 6, Spacing (cm) – 10 x 10, Type –Staggered

Fencing: Cement pole/local material wood/Branches/Brushwood fencing

Table 5.21 - Cost Norms for RV/JK/NL/07 Himalayan Mixed Forest

Year	Item	Detail of work	Amount/Ha (Rs)	Tentative Man days
	No of Plants (No.)	600 Plants , 200 Grass Patches.	1,200	
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	12,000	53
2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	6,800	28
		Site preparation- Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation of inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	124589	554
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	7,160	32
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	1,603	6
		Carriage of plants, Lay out pits, digging & refilling of pits, Planting of plants and shrubs in pits.	23,472	104
Total Establishment Cost (Rs.) =			**175,624**	**777**

Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance(15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	23,425	85
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	20,446	69
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	17,267	55
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**73,294**	**245**
Total cost of plantation (Rs.) =			**248,918**	**1022**

Model No. – RV/JK/NL/08	**Sub-Tropical Dry Deciduous Forest**
Zone	**Sub-Tropical Area**

This zone occurs in foot hills of Jammu Region, J&K UT and dominated by broadleaved deciduous species. The altitude ranges between 300 - 900 m amsl and the zone experiences annual rainfall varying from 1,000 - 1,300 mm. Several broadleaved species grow in this zone which shed their leaves during summer months. The zone is represented by deep soil and moderate slope and experiences heavy rainfall during the monsoon season and modest rainfall during the winter season. Heavy rains during the monsoon season transport silt from these areas through number of seasonal water channels, *Nallahs*, rivulets, etc. to the Ravi River causing siltation in dams and floods in downstream areas. Besides this, agriculture on slopes and

construction and developmental activities are the main reasons for soil erosion from these areas. A large part of rainwater flows down the streams within a few hours of rainfall as surface runoff. The soil is shallow on slopes while valleys have deep soil depth. The biotic pressure (livestock grazing, fuel wood and tree fodder collection) is significant in this zone. Appropriate forestry interventions in this zone would not only check soil erosion and improve vegetation but would also help in improvement in the e-flow of the Ravi River and its tributaries.

The Sub-Tropical Dry Deciduous Forest Model is recommended in this zone. Under this model, it is proposed to plant 300 trees of broadleaved species or bamboos. 300 shrubs at 5 m x 5 m will be planted in between the tree rows. Strong soil binding grasses like *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus* and sedges like *Carex obscura* will be planted on the river or *Nallah* facing side of the treatment site. In case of trees, a mixture of timber species like *Dalbergia sissoo*, *Senegalia catechu*, *Haldinia cordifolia*, etc. along with medicinal trees like *Terminalia* spp., *Phyllanthus emblica*, *Oroxylum indicum*, *Sapindus mukorossi*, etc. will be planted at 5 m x 5 m spacing. Management practices and conservation measures as prescribed in the Working Plan of the respective territorial forest division or the wildlife management plan of the protected area will be applicable. Collection of medicinal plants and other NTFP's along with sharing of accrued benefits to local communities would be regulated as per the State's policy on medicinal plants. Nursery of selected trees and shrubs, etc. will be established during 1st year and 2nd year and planting will be done in 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. Subsequently, the plantation will be managed during next three years. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation

Trees: *Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippinensis, Syzygium cumini, Oroxylum indicum, Sapindus mukorossi, Dendrocalamus* spp., *Bambusa* spp., *Holoptelea integrifolia., Ficus* spp., *Albizzia* spp., *Celtis australis, Litsea chinensis, Alstonia scholaris, Phyllanthus emblica, Diospyros* spp., *Cinnamomum tamala, Bauhinia variegata, Grewia optiva, Cassia fistula, Anogeissus* spp.,etc.

Shrubs: *Rosa* spp., *Debregeasia hypoleuca, Zanthoxylum armatum, Myrsine africana, Deutzia staminea, D.corymbosa, Ziziphus* spp., *Carissa opaca, Desmodium gangeticum, Tephrosia hamiltonii, Justicia adhatoda, Murraya* spp., *Ricinus communis, Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo, Thysanolaena maxima,* etc.

Grasses/Forbs: *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhaavia diffusa, Festuca pratensis, Festuca arundinacea***,** *Poa pratensis, Erianthus filifolius, Erianthus rufipilus, Agrostis gigantea, Agropyron* spp., *Phleum pratense***,** *Themeda anathera, Arundo donax, Cymbopogon martinii, Phragmites karka, Bothriochloa pertusa, B. intermedia, Eulaliopsis binata, Calamagrostis* spp., etc.

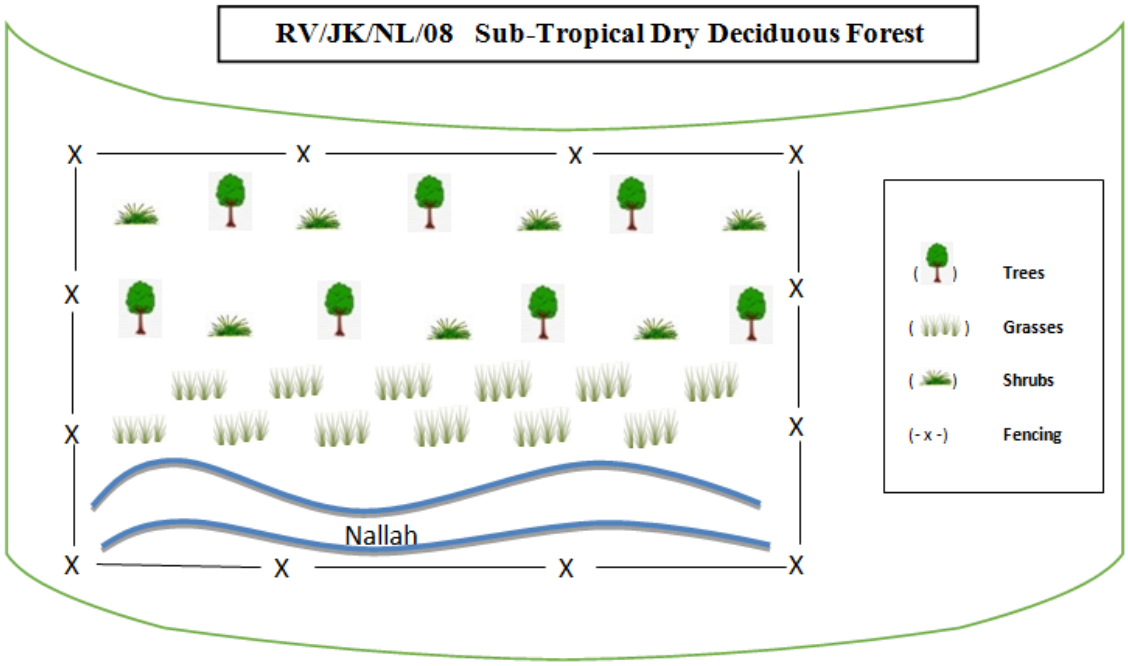


Fig. 5.18 - Schematic Diagram of Sub-Tropical Dry Deciduous Forest Model

Trees: 300 No, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300 no., spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no - 200, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 2 x 2, Seed per patch (gm) - 6, seed, Spacing (cm) - 10 x 10, Type –Staggered, along *Nallah*/depressions (if available)

Fencing: Cement pole/angle Iron pole local material wood/Branches/Brushwood fencing

Table 5.22 - Cost Norms for RV/JK/NL/08 - Sub-Tropical Dry Deciduous Forest

Year	Item	Detail of work	Amount/Ha (Rs)	Tentative Man days
	No of Plants (No.)	800 Plants , 200 Grass Patches.	1,200	
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	12,000	53
2nd year	A1-Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	6,800	
		Site preparation Site preparation i/c survey & demarcation, Cutting grubbing and removal of *Lantana* or other bushes, preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete	124589	554

		(PCC) poles / Angle Iron Pole.		
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	7,160	32
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	1,603	6
		Carriage of plants, Lay out pit, digging & refilling of pit and Planting of plants and shrubs in pits.	**23,472**	**104**
Total Establishment Cost (Rs.) =			**175,624**	**749**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance (25%) and raising of plants for 3rd year maintenance (15%), Carriage of plants, Pitting & Planting of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	23,425	85
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of Plants, Pitting & plant of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching.	20,446	69
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of pants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	17,267	55
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing.	12156	36
Total Maintenance Cost (Rs.) =			**73,294**	**245**
Total cost of plantation (Rs.) =			**248,918**	**994**

Model No. – RV/JK/NL/09	**Eradication of *Lantana* (> 50%)**
Zone	**Sub-Tropical to Lower Temperate Areas**

Invasive and alien species are plants those hamper regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species. Owing to considerable area of this zone under the influence of *Lantana*, tangible and intangible benefits from lower temperate to sub- tropical forests within the Ravi Riverscape have been adversely affected.

The area for the proposed model referred as 'Eradication of *Lantana* (>50%)' covers forest sites between 300 - 1,200 m amsl wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with around 1,000 - 1,300 mm annual rainfall. Soils are generally fertile and moderately deep. The proposed treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of *Lantana camara* forms dense undergrowth in the forest suppressing the native vegetation of that area.

It is proposed to cut and manually uproot above stated invasive species in treatment sites as per the prescription of CRS (Cut Root Stock) method for complete eradication of this obnoxious weed. These areas after *Lantana* removal will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, *Chrysopogon serrulatus,* etc. will be sown in the part of treatment site. The treatment area will be planted with broadleaved species like *Toona ciliata*, *Syzygium cumini, Grewia optiva, Pyrus pashia, Albizia* spp., *Phyllanthus emblica, Holoptelea integrifolia, Ficus* spp., *Punica granatum, Bauhinia variegata*, *Dendrocalamus strictus, D. hamiltonii, Bambusa bambos*, and *B. arundinacea*. Plants will be planted at 5 m x 5 m spacing. A total of 600 plants of tree species/ha., 600 patches of 4 m x4 m apart grasses on sites will be planted. Broadleaved species of this zone require around one and half year of nursery period and planting will be done in the 3rd year. The plants will be maintained in the 4th to 7th year.

List of species for plantation

Trees: *Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippensis, Syzygium cumini, Oroxylum indicum, Sapindus mukorossi, Dendrocalamus* spp., *Bambusa* spp., *Holoptelea integrifolia, Ficus* spp., *Albizzia* spp., *Celtis australis, Litsea chinensis, Pyrus pashia, Alstonia scholaris, Phyllanthus emblica, Diospyros* spp., *Bauhinia variegata, Grewia optiva, Pyrus pashia, Anogeissus* spp., and *Bombax ceiba,* etc.

Grasses/Forbs: *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus*, *Boerhavia diffusa, Heteropogon contortus, Trifolium repens, Eragrostis nigra, Deschampsia* spp., *Panicum maximum, Phleum pratense, Cymbopogon citrullus, Arundo donax, Phragmites karka, Themeda arundinacea, Eulaliopsis binata, Dichanthium annulatum, Sporobolus diander, Thysanolaena maxima, Hierochloe laxa*, etc.

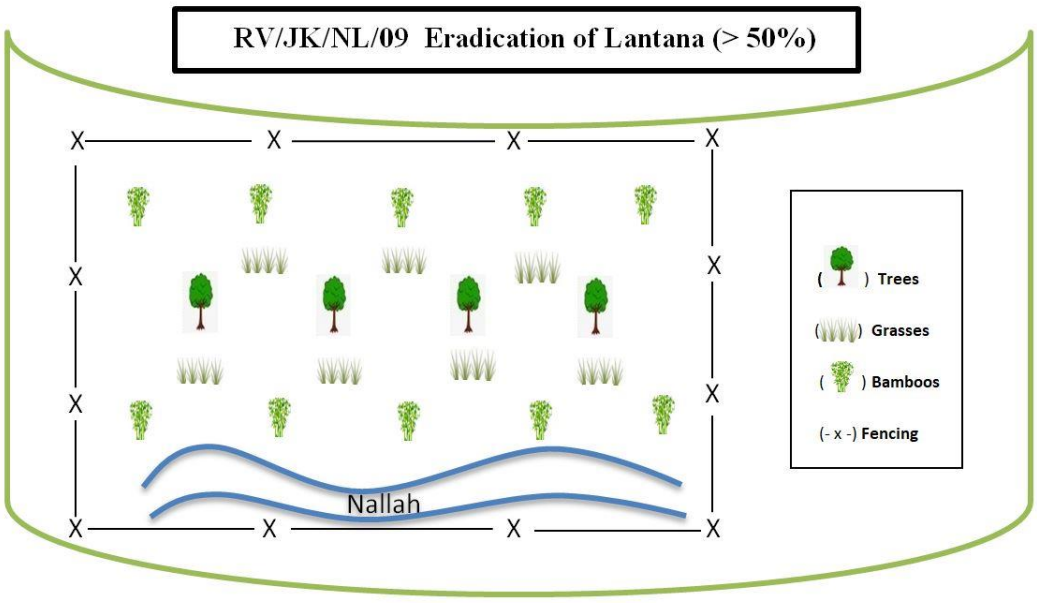


Fig. 5.19 - Schematic Diagram of Eradication of *Lantana* (> 50%) Model

Trees/Bamboo: 600 No., Spacing (m) - 4 x 4, Pit size (cm) – 45 x 45 x 45

Grasses: Patch no - 600, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 4 x 4, Seed per patch (gm) – 6gm, Spacing (cm) - 10 x 10, Type –Staggered

Fencing: Cement pole/local material-wood/branches/brushwood fencing

Table 5.23 - Cost Norms for RV/JK/NL/09 – Eradication of *Lantana* (> 50%)

Year	Item	Detail of work	Amount/Ha (Rs.)	Tentative Man days
	No of Plants (No.)	600 Plants, 600 Grass Patches .	3,600	
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	9,000	40
	N1-Ad work	Site Preparation includes *Lantana* by Cut Root Stock method and Cleaning of *Lantana*(sprouts) and seedlings, one times in Ist year	26,340	109
2nd year		Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	5,457	23

	A1- Advance Work Labour Cost	Cleaning of *Lantana*(sprouts) and seedlings,3 times a year @ 15% of unit cost (estb.), Preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	111110	462
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	6,148	24
	C- Lantana Cutting	Cleaning of *Lantana*(sprouts) and seedlings,3 times a year @ 15% of unit cost (establishment).	11,800	46
	C- Creation	Carriage of plants, Lay out patches, Patches & Planting of herbs and preparation of strips including (i/c) Sowing of grasses in strips.	4,809	19
		Carriage of plants, Lay out pits, digging & refilling of pits, and Planting of plants and shrubs in pits.	17,604	78
Total Establishment Cost (Rs.) =			**192,268**	**801**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance(25%) and raising of plants for 3rd year maintenance (15%), Carriage of plants, Pitting &Planting of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding, mulching, and Cleaning of *Lantana*(sprouts) and seedlings,3 times a year.	21,207	77
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding, mulching, Cleaning of *Lantana*(sprouts) and seedlings, 2 times a year.	19,021	64
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	16,453	52
7th year	Maintenance Cost - IV Year	Watch and ward i/c, repair of fencing, Cleaning of *Lantana*(sprouts) and seedlings, 2 times a year.	12156	36
Total Maintenance Cost (Rs.) =			**68,837**	**229**
Grand Total (Rs.) =			**2,64,704**	**1030**

Model No. – RV/JK/NL/10	**Control/ Removal of Invasive Species or <50% *Lantana***
Zone	**Sub-Tropical to Lower Temperate Areas**

Invasive and alien species are plants those hamper regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species. Owing to considerable area of this zone under the influence of invasive alien or weed species, tangible and intangible benefits from lower temperate to sub- tropical forests within the Ravi Riverscape have been adversely affected.

The area for the proposed model referred as 'Control/ Removal of Invasive Species' covers forest sites between around 300 - 1,200 m amsl wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with 1,000 - 1,500 mm annual rainfall. Soils are generally fertile and moderately deep. The proposed treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of weed species including *Lantana camara* (<50%) forms considerably dense undergrowth in the forest suppressing the native vegetation of that area. *Ageratum conyzoides* and *Parthenium hysterophorus* also cause considerable hazard especially near agriculture fields and settlements.

It is proposed to cut and manually uproot above stated invasive species in treatment sites prior to their flowering, and immediately to be followed by planting of native plant species. In case of *Lantana* infested areas, CRS (Cut Root Stock) method will be used for complete eradication/ control of this obnoxious weed. In case of other weeds, cutting and removal of infested plants will be done at such a time and such a way as to cause least disturbance to soil and provide opportunity to the nearby economically important plants to occupy the space vacated by weeds. These areas after plantation will be intensively managed subsequently for two years to minimize the chances of their re-growth. For controlling herbaceous weeds like *Ageratum conyzoides* and *Parthenium hysterophorus*, eco-friendly measures (e.g., physical or mechanical methods, use of natural products, etc.) will be adopted without resorting to the use of synthetic chemicals. These areas after *Lantana* removal will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. will be sown in the part of treatment site. The treatment area will be planted with broadleaved species like *Quercus oblongata, Toona ciliata, Syzygium cumini, Grewia optiva, Pyrus pashia, Albizia* spp., *Phyllanthus emblica, Holoptelea integrifolia, Ficus* spp., *Punica granatum, Bauhinia variegata, Dendrocalamus strictus, D. hamiltonii, Bambusa bambos, B. arundinacea,* etc. Plants will be planted at 5 m x 5 m spacing. A total of 400 plants of tree species/ha., 400 patches of 5 m x5 m apart grasses on sites will be planted. The rows of trees and grasses will be planted alternatively. Broadleaved species of this zone require around one and half year of nursery period and planting will be done in the 3rd year. The plants will be maintained in the 4th to 7th year.

List of species for plantation

Trees: *Dalbergia sissoo, Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Terminalia* spp., *Mallotus philippensis, Syzygium cumini, Oroxylum indicum, Sapindus mukorossi, Dendrocalamus* spp., *Bambusa* spp., *Holoptelea integrifolia, Ficus* spp., *Albizia* spp., *Celtis australis, Litsea chinensis, Pyrus pashia, Alstonia scholaris, Phyllanthus emblica, Diospyros* spp., *Bauhinia variegata, Grewia optiva, Pyrus pashia, Anogeissus* spp., *Bombax ceiba*, etc.

Grasses/Forbs: *Arundinella nepalensis, Apluda mutica, Chrysopogon fulvus, Boerhavia diffusa, Heteropogon contortus, Trifolium repens, Eragrostis nigra, Deschampsia* spp., *Panicum maximum, Phleum pratense, Cymbopogon citrullus, Arundo donax, Phragmites karka, Themeda arundinacea, Eulaliopsis binata, Dichanthium annulatum, Sporobolus diander, Thysanolaena maxima, Hierochloe laxa*, etc.

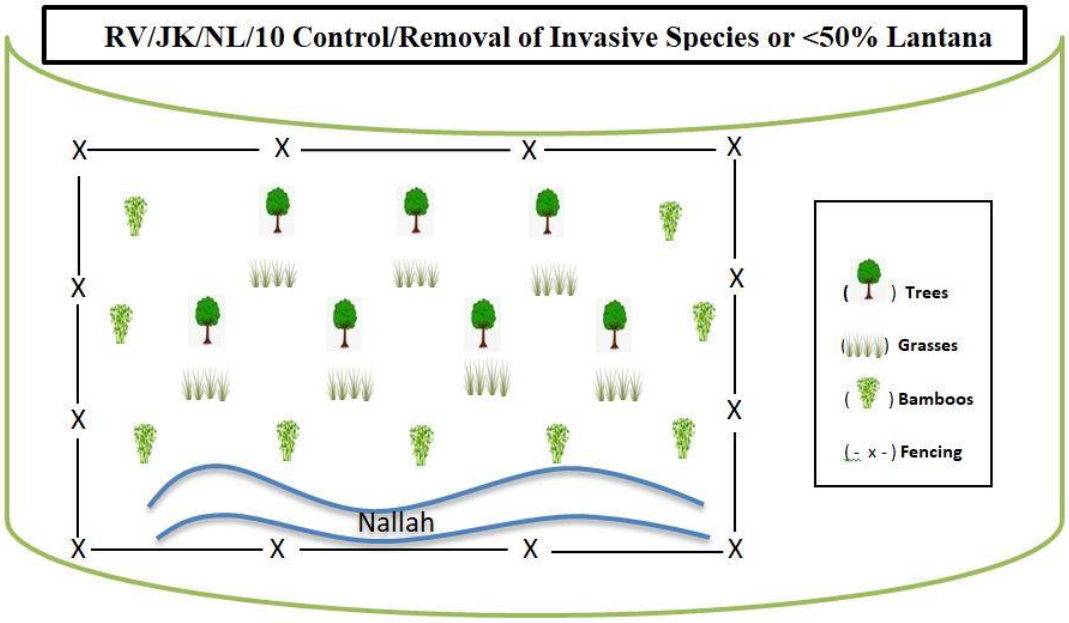


Fig. 5.20 - Schematic Diagram of Eradication of *Lantana* (< 50%) Model

Trees/Bamboo: 400 No., Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Grasses: Patch no - 400, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 5 x 5, Seed per patch (gm) - 6, seed, Spacing (cm) - 10 x 10, Type –Staggered

Fencing: Cement pole/local material-wood/branches/brushwood fencing

Table 5.24 - Cost Norms for RV/JK/NL/10 – Control/ Removal of Invasive Species or <50% *Lantana*

Year	Item	Detail of work	Amount/Ha (Rs.)	Man days
	No of Plants (No.)	400 Plants, 400 Grass Patches .	2,400	
1st Year	N1- Advance Work Labour Cost	Raising of Nursery including maintenance in Ist year.	6,000	27
	N1-Ad work	Site preparation includes *Lantana* by Cut Root Stock method and Cleaning of *Lantana* (sprouts) and seedlings, one times in Ist year.	26,340	109
2nd year	A1- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants and raising of plants for Ist year maintenance (30%).	3,638	15
2nd year	A1-Advance Work Labour Cost	Cleaning of *Lantana*(sprouts) and seedlings,3 times a year @ 15% of unit cost (establishment), preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	111110	462
3rd year	C- Advance Work Labour Cost	Maintenance of Nursery including maintenance of Ist year plants, plants for Ist year maintenance (30%) and raising of plants for 2nd year maintenance (25%).	4,099	16
	C- *Lantana* Cutting	Cleaning of *Lantana* (sprouts) and seedlings, 3 times a year @ 15% of unit cost (estb.).	11,800	46
	C- Creation	Carriage of plants, Lay out of patches, Patches & Planting of herbs and Preparation of strips including (i/c) Sowing of grasses in strips	3,206	12
		Carriage of plants, Lay out pits, Digging & refilling of pits and Planting of plants and shrubs in pits.	13,437	52
Total Establishment Cost (Rs.) =			**179,630**	**739**
Maintenance				
4th year	Maintenance Cost - I Year	Maintenance of Nursery including maintenance of plants for Ist year maintenance (30%), 2nd year maintenance (25%) and raising of plants	17,446	63

		for 3rd year maintenance (15%), Carriage of plants, Pitting &Planting of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching, and Cleaning of *Lantana*(sprouts) and seedlings,3 times a year.		
5th year	Maintenance Cost - II Year	Maintenance of Nursery including 2nd year maintenance, (25%) and 3rd year maintenance, (15%) Carriage of plants, Pitting & Planting of plants & Planting of herbs, Sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching, and Cleaning of *Lantana*(sprouts) and seedlings, 2 times a year.	16,220	55
6th year	Maintenance Cost - III Year	Maintenance of Nursery including maintenance of 3rd year maintenance, Carriage of plants, Pitting & Planting of plants & Planting of herbs, Watch and ward i/c repair of fencing, Weeding and mulching.	14,755	47
7th year	Maintenance Cost - IV Year	Watch and ward i/c, repair of fencing, Cleaning of *Lantana*(sprouts) and seedlings, 2 times a year.	12156	36
Total Maintenance Cost (Rs.) =			**60,577**	**201**
Grand Total (Rs.) =			**240,207**	**940**

Model No. – RV/JK/NL/11 **Protection Model for Natural Regeneration**

Zone **All Hill Areas**

All the hill areas between 800 - 4,100 m amsl are characterized by dense forests, mainly conifers and Oak forests, sub-alpine vegetation i.e., herbs, grasses, shrubs and scattered small trees and alpine pastures. However, blank patches too occur at several locations that can be taken up for the proposed treatment. In selected areas, especially in Deodar, Blue pine, Fir, Spruce, Oaks forests and even the sub-alpine and alpine areas, adequate regeneration can be observed under favorable conditions. Owing to varied disturbances by human and livestock in such areas, establishment of natural regeneration is generally poor and need immediate attention. Often, a thick layer of humus is typically present and the soil is generally moist and conducive for natural regeneration.

Under this treatment model, it is proposed to protect and conserve vegetation so as to promote ample establishment and recruitment of natural regeneration. The major focus will be on protection of special areas like patches of good natural regeneration of various conifers, broadleaved species shrubs, etc. and thereby conserving native plant species, particularly herbs. In natural regeneration areas cleaning operation twice a year in the month of September and March be carried out *viz.*,climber cutting, removal of obnoxious weeds, unwanted species and pruning of plants. The broadcasting of desired seed to be done in the closed area to supplement the natural regeneration.

List of species for plantation

Trees: No plantation proposed

Shrubs: No plantation proposed

Herbs: No plantation proposed

Cleaning Operations: Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area and debris collection.

Seed Broadcasting: Seed (2 kg for conifer and 15 kg for broad leaved per hectare)

Fencing: Cement pole/local material- wood/branches

Table 5.25 - Cost Norms for - RV/JK/NL/11 Protection Model for Natural Regeneration

Year	Item	Detail of work	Amount/Ha (Rs.)	Tentative Man days
	No of Plants (No.)	400 Plants, 400 Grass Patches.	2,400	
1st Year	N1- Advance Work Labour Cost	Pruning and training of existing root stocks (tending operations), Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area and Debris collection and burning.	1,905	8
2nd year	A1-Advance Work Labour Cost	C-Pruning and training of existing root stocks (tending operations) 300 no., preparation inspection path, Carriage of fence post and PCC poles, Digging of holes and Fixing of poles, Stretching & fixing of Barbed wire at spacing 20cm and 4 strands, Barbed wire and Cement Concrete (PCC) poles / Angle Iron Pole.	102120	424

3rd year	C- *Lantana* Cutting	Pruning and training of existing root stocks (tending operations) (150 plants), Cleaning and un-saleable thinning (non-commercial) in regeneration areas, Climber cutting in the forests/ plantation area, Debris collection and burning (15% area).	1,091	4
	C- Creation	Carriage of plants, Lay out of patches, Patches & Planting of herbs and Preparation of strips including (i/c) sowing of grasses in strips.	3,206	12
Total Establishment Cost (Rs.) =			**108,322**	**448**
Maintenance				
4th year	Maintenance Cost - I Year	Sowing of grasses, Watch and ward i/c, repair of fencing, Weeding and mulching and Cleaning of climbers ,3 times a year.	10,952	40
5th year	Maintenance Cost - II Year	Sowing of grasses, Watch and ward i/c repair of fencing, Weeding and mulching and pruning and training of existing root stocks (tending operations), 2 times a year.	11,535	39
6th year	Maintenance Cost - III Year	Watch and ward i/c repair of fencing, Weeding and mulching.	11,950	38
7th year	Maintenance Cost - IV Year	Watch and ward i/c repair of fencing, Pruning and training of existing root stocks (tending operations).	12156	36
Total maintenance cost (Rs.) =			**46593**	**153**
Grand Total (Rs.) =			**154,915**	**601**

Model No. – RV/JK/NL/12	**Fire Protection Model**
Zone	**Sub-Tropical Area to Lower Temperate Area**

This zone occurs in sub-tropical i.e., from foot hills to mid hill of Jammu Region, J&K UT. It is dominated by Chir pine in southern aspects and mixed vegetation in other aspects. The altitude is 800 - 1800 m amsl and annual rainfall is 1,200 - 1, 800 mm and mostly during monsoon and some portion in winter months. This zone experiences 7-8 dry months every year making these forests highly vulnerable to fires. Even a small negligence during dry months in Chirpine dominated areas carries the great risk of igniting forest fires that spread very fast riding on the wind. Damage caused by the forest fires in Jammu region is immense with loss to regeneration, pole crop, productivity, ecosystem services, wildlife, etc. Heavy monsoon rains in the burnt out

areas transport huge quantities of silt to Ravi River carrying siltation to dams and causing floods in Punjab plains. Effective fire control measures can help significantly in reducing the silt load in Ravi River and its tributaries.

For these fire prone forest area, a 'Fire Protection Model' is proposed. In this model, existing fire lines are proposed to be cleared of vegetation and maintained all around the forest in such a way that a compact block or area is separated from adjoining areas. These fire lines are usually cleared before the start of the fire seasons in order to avoid the spread of fires from one forest to another. Engagement of fire watchers in fire sensitive beats, procurement of firefighting equipments including use of elide fire extinguishing balls, construction of water harvesting and storage structure using locally available materials in the middle of fire sensitive zones *e.g.*, ponds, *Khal*, etc. Besides these, awareness campaign among rural masses particularly about overall damage by forest fires to native flora and fauna, soil and other ecosystem services of the forest such as hydrological functions, moderation of local climate etc. influencing horticulture/ agriculture productivity of farmlands will be organized. Role of local communities in bringing down the forest fire incidences in Chir-pine zone is very important and need to be highlighted at various levels.

Cleaning of fire lines

Prescribed burning

Engagement of fire watchers

Procurement of firefighting equipment/ Elide fire extinguishing balls

Constructions of ponds/ water harvesting structures

Awareness campaign and Community awareness.

Table 5.26 - Cost Norms for RV/JK/NL/12 Fire Protection Model

Temperate to Sub-Tropical Areas									
Sr. No.	**Particulars of work to be done**	**Unit**	**Total Quantity**	**Unit Cost (Rs.)**	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**
					Amount (Rs.)	**Maint**	**Maint**	**Maint**	**Maint**
	Year-I								
1	Cleaning of Fire lines (10 m width) including the burning of slash debris, dry leafs, fallen branches and	km	0.2	14625	2925	2925	2925	2925	2925

	other inflammable material and labour charges								
3	Engagement of fire watchers per 1000 ha (3 months)	ha	1	25	25	25	25	25	25
4	Constructions of Ponds/ water harvesting structures and maintenance	ha	1	10000	10000	1000	1000	1000	1000
6	Procurement of fire fighting equipment's/ Elide fire extinguishing balls and maintenance	ha	1	10000	10000	4000	3000	2000	1000
7	Awareness campaign, Community awareness	ha	1	1500	1500	1500	1500	1500	1500
Total (Rs.) =					**24450**	**9450**	**8450**	**7450**	**6450**

Model No – RV/JK/NL/13	**Plantation by Eco-Task Force in Temperate Forest**
Zone	**Sub-Tropical to Lower Temperate Areas**

Some sites in the upper Ravi River Basin have rugged topography, harsh conditions, shallow soils with low moisture content, etc. Such areas are mostly located on the southern slopes. These sites require continued presence and close supervision by planting and maintenance teams. The Eco-Task Force (ETF) in the past has exhibited great success in regeneration of such harsh sites. It is proposed to utilize this unique ability of ETF in planting on such difficult sites under this DPR. The task of establishment and maintenance of proposed plantations will be carried out by the raising one more unit under this DPR to be established in Basohli area of J&K UT. The unit will work in close coordination with Jammu and Kashmir Forest Department. One or more of the proposed plantation models amongst suggested models (RV/JK/NL/01 to RV/JK/NL/10) will be selected for replication by the ETF under this model.

Table 5.27 - Nursery Rate in Jammu and Kashmir Rates After including inflation factor

Year	Rs. per Manday	Factor of 7% increase each year
I	225	1.000
II	241	1.070
III	258	1.145

IV	276	1.225
V	295	1.311
VI	316	1.403
VII	338	1.501
VIII	361	1.606

(C) Treatment Models for Natural Landscape in Punjab

The existing situation of forests in the entire Punjab area is heavily populated and most of the land is used for agriculture. In view of this, the following forestry interventions by way of different treatment models are proposed.

Model No. – RV/PB/NL/01	**Restoration of Degraded Forests Model**
Zone	**Tropical Areas**

This model is specifically proposed for restoration of degraded protected forests or plantation in village common lands or community lands. Proposed sites are mostly flat and covered either with shrubs/ herbs/ grasses or invasive and alien species. Often such areas are inhabited by Nilgai or wild pig and locally abundant populations of these two herbivore species could be a menace to proposed plantation activities. Moreover, such sites also face severe biotic pressure by way of livestock grazing, and collection of fodder and fuel wood. Hence, effective fencing of sites selected for proposed forestry interventions is a pre-requisite so as to ensure full protection to young plantations. Heavy monsoon rains cause severe siltation in Ravi River and resultant flooding in Punjab plains.

Suitable and effective forestry interventions in above sites can immensely help in improvement of vegetation cover, checking soil erosion, and enhancing groundwater recharge. Block plantations of native broadleaved species are proposed for such areas. Trees will be planted at the rate of 1,000 plants ha^{-1} at 3 m x 3 m spacing. Pit size of 50 cm x 50 cm x 40 cm will be used for proposed plantations under this model.

After land development, pit digging, etc. plants mainly of broadleaved species like *Acacia nilotica, Dalbergia sissoo, Senegalia catechu, Melia composita, Ailanthus excelsa, Toona ciliata, Morus alba, Alstonia scholasis, Terminalia arjuna, Tectona grandis, Azadirachta indica*, *Ficus racemose,* etc. will be planted. Conservation and other management practices as prescribed in the Forest Working Plan of the respective Forest Division would be applicable. Nursery of selected tree species will be established during first year and [planting will be done in the second year. Subsequently, the plantations will be managed during next three year of the project.

List of species for plantation

Trees: *Acacia nilotica, A. catechu, Dalbergia sissoo, Melia composita, Ailanthus excelsa, Toona ciliata, Tectona grandis, Azadirachta indica, Cordia myxa, Morus alba, Pongamia pinnata, Bombax ceiba, Aegle marmelos, Pterocarpus marsupium, Grewia elastica, Cassia fistula, Moringa oleifera, Butea monosperma, Santalum album, Tamarindus indica, Ziziphus mauritiana*, etc.

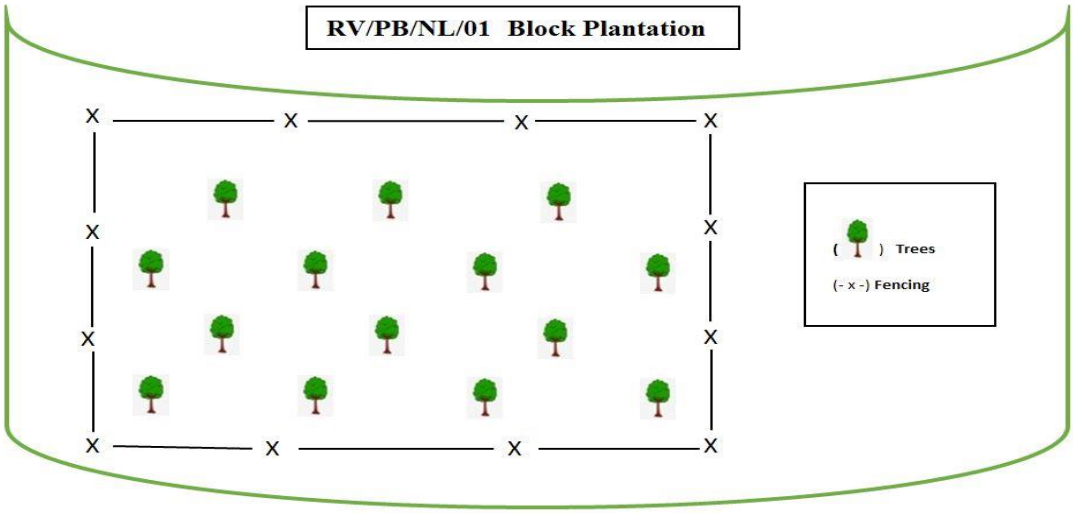


Fig. 5.21 - Schematic Diagram of Restoration of Degraded Forests Model

Trees:1,000 No., Spacing (m) – 3 x 3, Pit size (cm) – 50 x 50 x 40

Fencing: Cement pole/ local material-wood/ branches /brushwood fencing

Table 5.28 - Cost Norms for RV/PB/NL/01Restoration of Degraded Forests Model

Labour Rate Rs. 342/day in Ist year and Annual Increase @ 7% in Subsequent Years				
Year	**Item**	**Detail of work**	**Amount/ha (Rs)**	**Tentative Man days**
	Number of Plants (No.)	Plants- 1000 No.		
1st Year	Nursery Advance Work Labour Cost	Cost of seedlings including (a) Original planting =1000 per ha (b) Replacement 10%= 100 per ha Total 1100 No. in Bio-degradable polybag.	16,115	47

2nd year	Advance Work Labour Cost	Cutting of *Lantana*/Mallah etc., Kana stubbing, Survey and alignment Earth work i.e., digging of pit of size, a) 1000 no x .5m x0.5mx 0.40m, Refilling of pits and Fencing (5% of plantation cost).	25,100	70
3rd Year	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of plants, Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Preparation of inspection path, Watch and ward for every 10 ha of plantation, Cutting of *Lantana*/mallah IInd and IIIrd times, Spot Irrigation (8+1 times),Reopening of trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of planation cost) POL, OE and Miscellaneous.	1,10,424	305
Total Establishment Cost (Rs.) =			**1,51,639**	**422**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Cost of seedlings (25%), Cutting of *Lantana*/Mallah etc., Kana stubbing, Earth work i.e., re-digging of pit Refilling of pits, (25%) Fencing (5% of plantation cost), Carriage of plants, Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation, Spot Irrigation (8+1 times),Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE and Miscellaneous.	51,534	118
5thyear	Maintenance Cost - II Year	Earth work i.e., re-digging of pit Refilling of pits, (15%) Fencing (5% of plantation cost), Carriage of plants, Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation,	21,346	41

		Spot Irrigation (8+1 times),Reopening of trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE and Miscellaneous.		
6th year	Maintenance Cost - III Year	Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers (twice), Providing thorny protection to plants against Porcupine attack, Watch and ward for every 10 ha of plantation, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE and Miscellaneous.	7394	10
Total Maintenance Cost (Rs.) =			**80,274**	**169**
Total cost of Plantation (Rs.) =			**231,913**	**591**

Model No. – RV/PB/NL/02 **Road Side Plantation**

Zone **Tropical Areas**

This model is specifically proposed for the purpose of road side plantations. Hence, proposed plantations will be in narrow strips along the roads. Generally, proposed sites along the roads are either sparsely covered by native vegetation or select invasive alien species or often blank. Stray cattle as well as wild animals like Nilgai and wild pig could be a menace to proposed plantations. Hence, effective fencing of sites proposed for plantation is a pre-requisite. The proposed road side plantations would help in enhancing the forest cover in a State which is otherwise deficient in natural vegetative cover besides checking soil erosion and runoff.

Strip plantations on both sides of the road are proposed. The planting area will be cleaned and one row of shrubs is proposed at 1 m x 1 m spacing towards the road side. Fast growing ornamental shrubs are proposed. Two rows of native broadleaved trees are recommended under this roadside plantation model at 3 m x 2 m spacing. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging, etc. plants mainly of broadleaved species *viz*., *Dalbergia sissoo, Terminalia bellirica, Terminalia chebula, Terminalia arjuna, Melia azedarach, Acacia nilotica, Azadirachta indica, Anthocephalus cadamba, Ailanthus excelsa, Toona ciliata,* etc., will be planted. Nursery of selected tree species will be established during the first year and planting will be done in the second year. Subsequently the plantation will be managed during next three year of the project.

List of species for plantation

Trees: *Dalbergia sissoo, Terminalia* spp., *Melia composita, Acacia nilotica, Albizia* spp., *Butea monosperma, Azadirachta indica, Anthocephalus cadamba, Ailanthus excelsa, Toona ciliata, Jacaranda mimosifolia, Grevillea robusta, Salix* spp., etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., *Maesa indica, Woodfordia fruticosa*, etc.

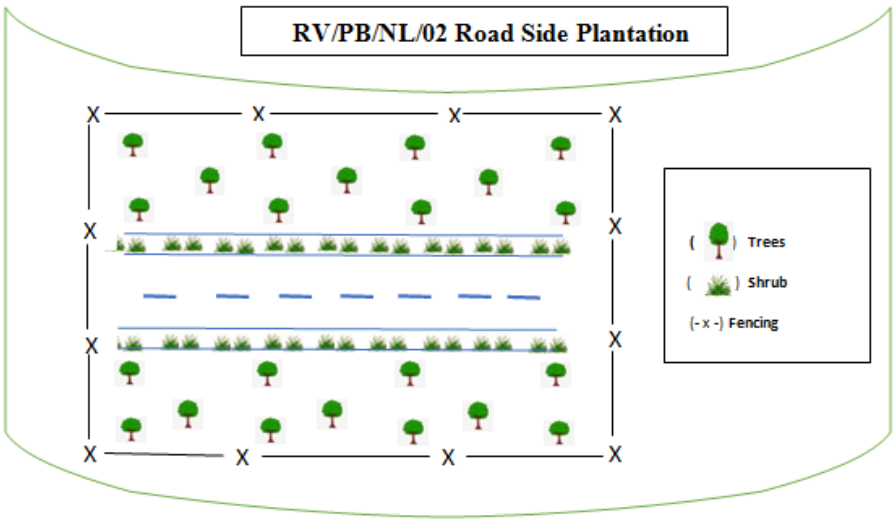


Fig. 5.22 - Schematic Diagram of Restoration of Road Side Plantation Model

Trees: 1,000 No., Spacing (m) - 3 x 3, Pit size (cm) – 50 x 50 x 40

Shrubs: 2,500 No, Spacing (m) - 2 x 2, Pit size (cm) – 30 x 30 x 30

Fencing: Cement pole/local material-wood/branches/brushwood fencing

Table 5.29 - Cost Norms for RV/PB/NL/02Road Side Plantation

Year	Item	Detail of works	Amount/Ha (Rs)	Tentative Man days
	Number of Plants (No.)	Plants- 1000 No., Herbs- 2500.		
1st Year	Nursery Advance Work Labour Cost	Cost of seedlings including (a) Original planting =3500 per ha (b) Replacement 10%= 350 per ha Total 1100 No. in Bio-degradable polybag Cost of Herbs - (a) Original planting =2500 per ha (b) Replacement 10%= 250 per ha	38115	111

		Total 2750 No. in Bio-degradable polybag. (Ist year)		
2nd year	Advance Work Labour Cost	Cutting of *Lantana*/Mallah etc., Kana stubbing, Survey and alignment Earth work i.e., Digging of pit of size a) 1000 no x .5m x0.5mx 0.40m, b) 2500 no. Spacing (m) - 2 x 2, Pit size (cm) – 30 x 30 x 30, Refilling of pits, Fencing (5% of plantation cost).	52361	119
3rd Year	Creation	Carriage of plants, Lay out of pits and patches, Pitting & Planting of plants, Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Preparation of inspection path, Watch and ward for every 10 ha. of plantation, Cutting of *Lantana*/mallah IInd and IIIrd times, Spot Irrigation (8+1 times),Reopening of trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of plantation cost) POL, OE and Miscellaneous.	180376	442
Total Establishment Cost (Rs.) =			**2,70,852**	**672**
MAINTENANCE				
4th year	Maintenance Cost - I Year i/c Material	Cost of seedlings (25%), Cutting of *Lantana*/Mallah, etc., Kana stubbing, Earth work i.e., re-digging of pit Refilling of pits, (25%) Fencing (5% of plantation cost), Carriage of plants, Weeding hoeing (twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha of plantation, Spot Irrigation (8+1 times),Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of plantation cost) POL, OE and Miscellaneous.	125712	311
5th year	Maintenance Cost - II Year	Earth work i.e., re-digging of pit Refilling of pits, (15%) Fencing (5% of plantation cost), Carriage of plants, Weeding hoeing	47220	114

		(twice),Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha of plantation, Spot Irrigation (8+1 times),Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of plantation cost) POL, OE and Miscellaneous.		
6th year	Maintenance Cost - III Year	Weeding hoeing (twice), Application of insecticides, Application of FYM/fertilizers (twice), Providing thorny protection to plants against Porcupine attack, Watch and ward for every 10 ha of plantation, Fertilizers i.e., urea, etc. including carriage, Overhead charges (10% of maintenance of plantation cost) POL, OE and Miscellaneous.	5863	10
Total Maintenance Cost (Rs.) =			**178795**	**435**
Total cost of Plantation (Rs.) =			**4,49,648**	**1107**

Table 5.30 - Rate after including inflation factor in Punjab

Year	Rs. per Manday	Factor of 7% increase each year
	342	
I	342	1.000
II	366	1.070
III	392	1.145
IV	419	1.225

(II) Agriculture Landscapes

The tree cover outside recorded forest area, particularly on farm lands is of vital importance from ecological functions of agro-ecosystems (i.e., pollinators, soil and moisture conservation regime, carbon sequestration (CS), environmental amelioration, etc.). As per the strategies given in the foregoing description, 'Agriculture Landscapes' have been recognized as one of the zones in the Ravi River / Ravi Riverscape. Comprehensive afforestation/ plantations on private farm lands in Agriculture Landscapes have been proposed in DPR.

Farmers/ villagers do recognize significance of trees on farm/private lands and they come forward for availing saplings of economic and fruit trees for plantations not only to augment their income, but they also do recognize ecological merits of such plantations. The current DPR, therefore, also proposes plantation activities in Agriculture Landscapes by adopting six models (RV/HP/AL/01, RV/HP/AL/02, RV/PB/AL/01, RV/PB/AL/02, RV/JK/AL/01 and RV/JK/AL/02). NYKS, *Mahila Mandals* and other NGOs/CBOs may play an important role in awareness campaigns about Forestry interventions which have also been included in the DPR. It is widely assumed and accepted that farmers usually do not indulge in cutting of such economic and fruits tress except those are solely planted as agro-forestry plantations of fast growing species as they do recognize multiple values obtained from such tree plantations on farmlands. Moreover, maintenance cost to be provided to the farmer which will motivate them to protect and retain these planted tree species on their private land. The monetary aid proposed for the plantation will ensure sustainability of proposed plantations (maximum 150 trees/ ha) in agriculture landscapes and thus adding ecological benefits. Further, though the ownership of the plantation raised under the agriculture landscapes is vested with farmers but the felling, removal, and transportation of such plantation material are regulated under the framework of various acts and procedures, (e.g., State Felling and Transit Regulations, Land Preservation Act, etc.) and other relevant regulations enforced from time to time by the concerned States/UT.

The proposed agricultural models will be implemented in private farmlands and community/Panchayat lands in rural areas. Availability of land will be ascertained by local officials of State Forest Department based upon proposals from local farmers and communities. Plants will be supplied to farmers and local communities who will carry out planting. Maintenance cost will be given to the land owners based upon plant survival at the end of first, second, third and fourth years. Nehru Yuva Kendra may play a pivotal role in facilitating coordination between State Forest Department and farmers/communities.

(A) Treatment Models for Agriculture Landscapes (AL) in Himachal Pradesh

Model No. – RV/HP/AL/01	**Boundary Plantation Model**
Zone	**Agriculture/Horticulture Land in Himachal Pradesh**

This model will be implemented in agricultural land in sub-tropical to temperate zones in Himachal Pradesh. The area is mostly hilly for most of this zone with moderate to steep slopes. The sites proposed for this model are agricultural or horticultural lands where off season vegetables and fruit crops are grown; hence, these sites possess better soil fertility and

managerial care with occasional subsistence irrigation mostly available as water is judiciously divided among local communities collectively distributed by themselves only.

The farmers/orchardists will decide the species and number of plants per unit area of economically important tree species (including hill bamboo) keeping in view their requirements; they may freely grow agricultural/horticultural crops of their own choice with the trees in any planting geometry. Mostly tree planting will be done on vacant areas around farms/ orchard and near settlements. Hill bamboo will be planted on boundaries, and will also act as live fencing for farm/ orchard in future. Quality planting material will be supplied to the local communities through HPSFD. Planting and maintenance of the plants will be done by farmers/ orchardists. Financial incentive to the growers will be provided keeping in view the performance of the plantation, especially survival. The local communities/ beneficiaries would be provided technical knowledge for the purpose through relevant institutes or universities, etc.

List of species for plantation

Tree: *Prunus armeniaca, Prunus cerasifera, Prunus domestica, Prunus persica, Myrica esculenta, Citrus limon, Diospyros lotus, Diospyros edulis, Diospyros kaki, Phyllanthus emblica, Terminalia chebula, Mangifera indica, Psidium guajava, Eriobotrya japonica, Terminalia bellirica, T.chebula,* etc.
Shrubs: *Drepanostachyum falcatum, Thamnocalamus spathiflorus, Berberis* spp., *Rubus* spp., *Zanthoxylum armatum, Justicia adhatoda, Vitex negundo*, etc.

Cost Sharing: The Government will share cost of planting material i.e., plant cost Rs. @ 70/- during the first year. In addition The Government would also provide Rs. @ 35/-, Rs. 35/-, Rs. 35/- for II to IV towards maintenance and maximum of 150 trees per ha. would be allowed. So cost comes out to be Rs.9,000 per hectare for Ist year while and for IInd, IIIrd and IVth year will be Rs.4,500 per ha.

Table 5.31 - Cost Norms and Pattern of financial Assistance for Peripheral and Boundary Plantation (PBP)

Sr. No.	Type of Interventions	Indicative Unit Cost Per Plant (Rs.)
1	Pre-Plant activities/Land clearing/Maintenance, etc.	20
2	Digging /Planting, etc.	12
3	Single Unit Planting Material, etc.	30
4	Transportation Charges	3
5	Critical Inputs *viz*., FYM, Fertilizer, Seed Treatment, Vesicular Arbuscular Mycorrhizae (VAM), etc.	20
6	Planting Cost	5

Sr. No.	Type of Interventions	Indicative Unit Cost Per Plant (Rs.)
7	Fencing	20
8	Maintenance (Weeding+ Watering, etc.)	40
Total =		**150**
Note: (i) The activity wise cost indicated above are tentative and States would have the flexibility to formulate their own estimates based on local requirements subject to a maximum of Rs. 150/- per plant. (ii) The assistance will be given on the basis of year-wise proportion in ratio of 40:20:20:20 during four-year of programme implementation.		

Table 5.32 - Cost Norms for RV/HP/AL/01per Hectare

Year	Amount (RS)/ha	Tentative Man days
Ist year Establishment.	9000	36
Maintenance Ist year	4815	18
Maintenance IInd year	5152	18
Maintenance IIIrd year	5513	18
Total	**24480**	**90**

Model No. – RV /HP/AL/02	**Planting of Economic Trees in Block Plantation**
Zone	**Agriculture/ Horticulture Land in Himachal Pradesh**

This model will be implemented in Agricultural/Horticultural land in sub-tropical to temperate zones in Himachal Pradesh. The area is hilly and the slope is moderate to gentle. The sites proposed for this model are agricultural/ horticultural/ grassland where grains, off season vegetables, stone fruit crops, grasses, etc. are grown. Hence, these sites possess better soil fertility and managerial care with occasional subsistence irrigation mostly available water judiciously divided among local communities collectively distributed by themselves only.

The zone experiences heavy rainfall during monsoon season and modest rainfall during winter months. Heavy rains during monsoon transport silt from these areas through number of seasonal water channels, *Nallahs*, rivulets, etc. to Ravi causing siltation and floods downstreams. Besides this, agriculture, construction and developmental activities are the main reasons behind soil erosion from these areas. A large part of rainwater flows down the streams within a few hours of rainfall as surface run-off causing lot of soil erosion. The pressure for grazing, fuel wood and tree fodder collection is considerable. Effective forestry interventions in this zone in agricultural/ horticultural/grassland areas can help significantly in improvement of the flow of Ravi River and its tributaries.

For these areas, planting of economic trees in hills has been proposed for this zone. The farmers/ orchardists will decide the species and number of plants of per unit area of economically important tree species i.e., Harad (*Terminalia chebula*), Bahera *(Terminalia bellirica)*, Amla (*Phyllanthus emblica*), Reetha (*Sapindus mukorossi*), Chandan (*Santalum album*), etc. Block plantation in vacant and fallow land can be taken up by the farmers for increasing their income as well as utilising the fallow lands and other grasslands also.

List of species for plantation

Trees: *Prunus armeniaca, Prunus cerasifera, Prunus domestica, Prunus persica, Myrica esculenta, Diospyros lotus, Diospyros edulis, Diospyros kaki, Phyllanthus emblica, Terminalia chebula, Terminalia bellirica, Sapindus mukorossi,* etc.

Table 5.33 - Cost Norms and Pattern of Assistance for High Density Block Plantation (HDBP)

Sr. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block (or in proportion to planting intensity)				Total
		1st Year	2nd year	3rd Year	4th Year	
1	1200	48,000	25,680	27,478	29,401	1,30,559
	Mandays	192	96	96	96	480

(B) Treatment Models for Agriculture Landscape (AL) in Jammu & Kashmir UT

Model No. -RV/JK/AL/01	**Planting of Economic Trees**
Zone	**Agriculture/Horticulture land in Jammu region**

The model will be applied in agriculture fields in the plains of Jammu region. These fields are intensively cultivated for wheat, rice, sugarcane, etc. and open to soil erosion especially during flood irrigation. Heavy monsoon rains in this zone transport huge quantities of silt to Ravi River causing siltation in dams downstream and floods in Jammu plains. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Ravi River and its tributaries.

The sites proposed for this model are agricultural lands where selected clones of Poplar (*Populus deltoides*), Dek (*Melia composita*), Neem (*Azadirachta indica*), Chandan (*Santalum album*), etc., will be planted at 4m x 4m spacing. Pit size of 50cm x 50cmx 40cm will be used for plantation. Selected plants will be distributed to farmers for planting on their agricultural land. Planting will be done by the farmers. The farmers will place requirement for plants to local forest officials who will supply the plants to the farmers at the start of the planting season.

List of species for plantation

Trees : *Populus deltoides, Melia composita, Phyllanthus emblica, Aegle marmelos, Albizia* spp., *Azadirachta indica, Syzygium venosum , Gmelina arborea, Holarrhena antidysenterica, Tamarindus indica, Terminalia arjuna, Terminalia bellirica, Terminalia chebula,* etc.

Cost Sharing: The Government will share cost of planting material i.e., plant cost Rs. @ 70/- during the first year of establishment while Rs. 35/-, Rs. 35/-, Rs. 35/- during II to IV year and maximum of 150 trees per ha. would be allowed. So cost comes out to be Rs. 10,500 per ha. for I year and for II to IV year will be Rs.5,250/ha.

Table 5.34 - Cost Norms for RV/JK/AL/01per Hectare

Year	Amount (Rs)/ha	Tentative Man days
Ist year Establishment	9000	40
Maintenance Ist year	4815	20
Maintenance IInd year	5513	20
Maintenance IIIrd year	5899	20
Total =	**25227**	**100**

Model No. -RV/JK/AL/02	**Planting of Economic Trees in Block plantation**
Zone	**Agriculture/Horticulture Land in Jammu Region**

This model will be applied in agriculture fields in the plains of Jammu region. These fields are intensively cultivated for wheat, rice, sugarcane, etc. and open to soil erosion especially during flood irrigation.

Heavy monsoon rains in this zone transport huge quantities of silt to Ravi River causing siltation and floods in Jammu plains. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Ravi River and its tributaries.

The sites proposed for this model are agricultural lands where selected tree species will be planted at 4m x 4m spacing – Pit size of 50 cm x 50 cm x 40 cm will be used for plantation. This is a practice of growing trees in rectangular or square planting pattern throughout the field as mostly adopted by farmers having large land holdings. Poplar (*Populus deltoides*), and Dek (*Melia composita*) are the important tree species for block planting. Wheat, potato, mustard, berseem, turmeric, sugarcane, etc., can be profitably raised intermixed with block plantation of trees. Planting will be done by the farmers. The farmers will place requisition for plants to local forest officials who will supply the quality nursery stock to the farmers at the start of the planting season.

List of species for plantation

Trees: *Populus deltoides, Melia composita, Aegle marmelos, Azadirachta indica, Syzygium venosum , Gmelina arborea, Holarrhena antidysenterica, Santalum album, Tamarindus indica, Terminalia arjuna, Terminalia bellirica, Terminalia chebula, Phyllanthus emblica, Sapindus mukorossi,* etc.

Table 5.35 - Cost Norms and Pattern of Financial Assistance for High Density Block Plantation (HDBP)

Sr. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block ((or in proportion to planting intensity)				Total
		1st Year	2nd year	3rd Year	4th Year	
1	1200	48,000	25,680	27,478	29,401	1,30,559
	Mandays	213	107	107	107	533

(C) Treatment Models for Agriculture Landscape (AL) in Punjab

Model No. – RV/PB/AL/01	**Boundary Plantation Model**
Zone	**Agriculture/ Horticulture Land in Punjab**

The model will be applied in agriculture fields in the plains of Punjab. These fields are intensively cultivated for wheat, rice, sugarcane, etc. and prone to soil erosion especially during flood irrigation. Heavy monsoon rains in this zone transport huge quantities of silt to Ravi River causing siltation and floods in dams downstream. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Ravi River and its tributaries.

The sites proposed for this model are agricultural lands where selected clones of Poplar (*Populus deltoides*), Dek (*Melia composita*), Neem (*Azadirachta indica*), Chandan (*Santalum album*), etc., will be planted at 4m x 4m spacing. Pit size of 50cm x 50cmx 40cm will be used for plantation. Selected plants will be distributed to farmers for planting on their agricultural lands. Planting will be done by the farmers. The farmers will place requirement for plants to local forest officials who will supply the plants to the farmers at the start of the planting season.

List of species for plantation

Trees: *Populus deltoides, Melia composita, Eucalyptus* spp., *Phyllanthus emblica, Aegle marmelos, Albizzia* spp., *Azadirachta indica, Syzygium venosum , Gmelina arborea, Holarrhena antidysenterica, Santalum album, Tamarindus indica, Terminalia arjuna, Terminalia bellirica, Terminalia chebula,* etc.

Cost Sharing: The Government will share cost of planting material i.e., plant cost Rs. @ 70/- during the first year of establishment while Rs. 35/-, Rs. 35/-, Rs. 35/- during II to IV year and maximum of 150 trees per ha.So cost comes out to be Rs.10,500/ha. for I year and for II and to IV year will be Rs.5,250/ha.

Table 5.36 - Cost Norms for RV/PB/AL/01 per Hectare

Year	Amount (Rs)/ha	Tentative Man days
Ist year Establishment	9000	26
Maintenance Ist year	4815	13
Maintenance IInd year	5513	14

Maintenance IIIrd year	5899	14
Total	**25227**	**67**

Model No. -RV/PB/AL/02	**Block Plantation Model**
Zone	**Agriculture/ Horticulture land in Punjab**

This model will be applied in agriculture fields in the plains of Punjab region. These fields are intensively cultivated for wheat, rice, sugarcane, etc. and prone to soil erosion especially during flood irrigation.

Heavy monsoon rains in this zone transport huge quantities of silt to Ravi River causing siltation and floods in Dams downstream and floods in Punjab plains. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Ravi River and its tributaries.

The sites proposed for this model are agricultural lands where selected tree species will be planted at 4m x 4m spacing – Pit size of 50 cm x 50 cm x 40 cm will be used for plantation. This is a practice of growing tree in rectangular or square planting pattern throughout the field as mostly adopted by farmers having large land holdings. Poplar (*Populus deltoides*), and Dek (*Melia composita*) are the important tree species for block planting. Wheat, potato, mustard, berseem, turmeric, sugarcane, etc. can be profitably raised intermixed with block plantation of trees. Planting will be done by the farmers. The farmers will place requisition for plants to local forest officials who will supply the quality nursery stock to the farmers at the start of the planting season.

List of species for plantation
Trees: *Populus deltoides, Melia composita, Phyllanthus emblica, Aegle marmelos, Albizia* spp., *Azadirachta indica, Syzygium venosum, Gmelina arborea, Holarrhena antidysenterica, Santalum album, Tamarindus indica, Terminalia arjuna, Terminalia bellirica, Terminalia chebula,* etc.

Table 5.37 - Cost Norms and Pattern of Assistance for High Density Block Plantation (HDBP)

Sr. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block ((or in proportion to planting intensity)				Total
		1st Year	2nd year	3rd Year	4th Year	
1	1200	48,000	25,680	27,478	29,401	1,30,559
	Mandays	140	70	70	70	351

(III)Treatment Models for Urban Landscapes (UL)

(A) Treatment Models for Urban Landscapes (UL)in Himachal Pradesh

(i) Riverfront Development

Many cities, towns and semi-urban areas are located along the Ravi River and its tributaries. Urban and peri-urban area along the Ravi River may be developed to attract residents and visitors and offer them a grand sight of the river along with fresh air, mental peace, solace and spiritual fulfillment that would connect them with the river.

Riverfront development envisages riverbank plantation to stabilize it by protecting it from soil erosion. This involves covering the entire ground by intercepting the sunlight at various heights of canopy through multiple layers of vegetation. At the ground surface, the grasses or surface growers are allowed to cover and to bind the surface soil and control the surface soil erosion like sheet erosion, splash erosion and rill erosion. It also promotes the rain water percolation and minimizes the surface runoff. At the second layer of vegetation, small to medium sized herbs and shrubs are accommodated to intercept some amount of sunlight and slow down the speed and reduce the erosive force of rain drops falling directly from sky and/or upper layers of canopy thereby reducing soil erosion (splash erosion). At the third layer of canopy above the ground surface, small to medium sized trees or larger shrubs are accommodated to provide a dense crown cover. This comprises light loving plants having good timber value and multipurpose benefits like fodder, fuel woods, etc. Scattered taller strong light demander trees may make one or two higher layers of canopy. Strong root binders are promoted on this type of site. Multi-tier planting methods are preferred. A basic support system may also be developed for the convenience of visitors.

The Riverfront of Ravi River and its tributaries have different owners: farmers, municipal corporations, irrigation department, institutions, forests department, etc. and substantial

proportion is under private ownership. Suitable steps will be taken to ensure smooth coordination of the activities among different agencies/owners.

One model for riverfront development has been proposed. Site-specific activities will be carried out at different places commensurate with the local site conditions available for riverfront development. Description of the model is given below:

Model No. –RV/HP/ UL/01	**Riverfront Development**
Zone	**Along the Ravi River Course or Tributaries**

The proposed model of Riverfront development would involve plantation of avenue shrubs and trees along the riverbank to stabilize the soil and protect the bank from erosion. It would also have beds of annual flowering plants and patches of grasses. The area is so developed that would provide a pleasing and relaxing environment to the visitors. It would be a typical landscaping area comprised of vegetation and non-vegetation components.

According to requirements following components need to be created for riverfront development:

i. **Vegetation Part:** Grove consisting of shade trees, ornamental trees and bamboos, small herbal garden, climbers, hedges, grasses for lawn, etc.
ii. **Non-vegetation Part:** Stairs, pathways, walking trails, stone pitching, benches, rain shelters, e-public utilities, parking area, information centre, refreshment area, etc. as per the site specific requirements.

The vegetation and non-vegetation components will be arranged in such a way to enhance the aesthetic beauty of Riverfront. Ornamental species will be planted according to their recommended spacing and site specific suitability.

For using the available space economically and efficiently multi-tier planting methods will be used. Soil binding and water loving ornamental tree and shrub species are ideal choice for riverbank planting. To bind the surface soil, grasses and surface growers will be allowed to cover the surface and protect soil from erosion especially during rainy season or river flooding. It will minimise soil loss through sheet erosion, splash erosion and rill erosion. It will also improve rain water per collation or absorption. Besides this, small to medium sized herbs and shrubs will be accommodated at the second layer of vegetation to intercept some amount of sunlight and stop the fast/ forceful falling of rain drops directly from sky in turn which stop soil erosion (splash erosion). Small to medium sized ornamental trees or larger shrubs i.e. mainly light demanding plants will be accommodated at the third layer of canopy to cover the crown area. This layer will provide small timber, fuel, fodder and intangible benefits. The top canopy will be occupied by the strong light demanding species which are ultimately the dominant species on riversides.

List of species for plantation
Trees: *Jacaranda mimosifolia, Grevillea robusta, Albizia* spp., *Butea monosperma*, *Dalbergia sissoo, Salix* spp., *Saraca asoca, Polyalthia longifolia, Callistemon viminalis, Thevetia peruviana,* etc.
Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., *Euonymus* spp., etc.

(ii) Institutional and Industrial Estate Plantations

Number of Educational institutes, hospitals, government and private sector offices, factories, religious places, historical places, hotels, Guest Houses, etc. are located in the entire stretch on the banks of Ravi River and its tributaries. Many of such institutions and industries may have possibility to accommodate number of trees of different sizes for beautifying the overall landscape. Tree/shrub/climber plantations will be encouraged on such lands within the Riverscape area. This would improve aesthetics; provide shade; produce non-wood and wood produces; reduce air, noise and dust pollution; harbour birds; reduce erosion; and create awareness about importance of trees. Some of the trees may serve religious purpose too and could be developed as small sacred grooves with the approval of management of such institutions.

One model has been proposed for Institutional and Industrial Estate Plantation. Site-specific activities will be carried out according to the site conditions. Description of the model is given below.

Model No. – RV /HP/ UL/02	**Institution and Industrial Estate Plantation**
Zone	**Institutions and Industrial Estate**

In this model, mainly ornamental, shade and fruit plants will be encouraged for planting. Evergreen plants especially Silver oak (*Grevillea robusta*) will be preferred so that the leaves do not shed during winter months when air pollution is usually high in plains. Plantation of forest species will be raised near the vicinity of various institutions and industries at 3m x 3m. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. Pit size of 45 cm x 45 cm x 45 will be used for plantation. After land development, pit digging, etc., plants mainly of broadleaved species such as *Syzygium venosum , Anthocephalus cadamba, Dalbergia sissoo, Melia* spp., *Pongamia pinnata, Holoptelea integrifolia, Azadirachta indica, Saraca asoca, Acacia nilotica,* etc. will be planted. The initiative will beautify the area, create awareness among people associated with institutions and industries and promote environmental services, besides providing economic returns from under-utilized land.

List of species for plantation

Trees: *Syzygium venosum, Anthocephalus cadamba, Dalbergia sissoo, Pongamia pinnata, Holoptelea integrifolia, Thuja orientalis, Cryptomeria japonica, Araucaria araucana, Acacia nilotica, Jacaranda mimosifolia, Grevillea robusta, Albizia chinensis, Albizia procera, Salix alba, Saraca asoca, Ficus rumphii, Polyalthia longifolia, Callistemon citrinus, Kigelia pinnata* and *Tamarindus indica.*

(iii) Eco-Park Development

Development of some sites of Urban Landscapes into Eco-Park is an important activity keeping in view the growing population and settlements in urban areas. Actually landscaping and beautification is proposed to be done for Urban and Peri-urban Landscapes of frequent public visitation so as to enhance aesthetics and entertainment coupled with nature awareness. The natural layout of the land will be maneuvered in such a way that the aesthetics will be enhanced without much investment by greening the blank areas. Landscape area will be designed to afford good soil, moisture and biodiversity conservation besides to improvement in aesthetic values.

One model has been proposed for Eco-Park development. Site-specific activities will be carried out at different places in harmony with the selected site conditions. Description of the model is given below.

Model No. – RV/HP/UL/03	**Eco-park Development**
Zone	**Proximity to Rivers and its Tributaries**

An Eco-Park will be better equipped than riverfront development to facilitate visitors. An Eco-Park will have both vegetation and non-vegetation components. Even in the Eco-Parks the proportion of ornamental plants will be relatively more than in the riverfront development model.

According to the requirement, the list of components to be created under this model are:

i. **Vegetation Part:** Miscellaneous ornamental plant species e.g., trees, shrubs, herbs, creepers, hanging plants, etc.
ii. **Non-vegetation Part:** Fencing, stairs, pathways, walking trails, stone pitching, rain shelter, e-public utilities, benches parking area, information centre, children playing area, pond beautification, landscaping, etc. as per site-specific requirements.

List of species for plantation

Tree: *Jacaranda mimosifolia, Grevillea robusta, Albizia chinensis, Albizia procera, Butea monosperma, Thuja orientalis, Cryptomeria japonica, Araucaria araucana, Kigelia pinnata, Dalbergia sissoo, Salix babylonica, Saraca asoca, Polyalthia longifolia, Callistemon citrinus, Syzygium venosum , Ficus rumphii,* etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., etc.

Table 5.38 - Cost Norms for Treatment Models for Urban Landscapes in Himachal Pradesh

Sr. No	Model No.	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Man days	Amount Rs/Ha	Tentative Man days
		Establishment		1st year Maintenance		2nd year Maintenance		3rd year Maintenance	
1	RV/HP/UL/01 Riverfront Development	1,50,00,000	18000	45,00,000	5400	30,00,000	3600	22,50,000	2700
2	RV/HP/UL/02 Institution Plantation	2,60,000	312	78,000	94	52,000	62	39,000	47
3	RV/HP/UL/03 Eco-Park Development	1,50,00,000	18000	45,00,000	5400	30,00,000	3600	22,50,000	2700

(B) Treatment Models for Urban Landscapes in Jammu & Kashmir UT

(i) River Front Development

Model No. – RV/JK/UL/01	**Riverfront Development**
Zone	**Along the River Course or Tributaries**

The proposed model of riverfront development would involve plantation of avenue shrubs and trees along the riverbank to stabilize the soil and protect the bank from erosion. It would also have beds of annual flowering plants and patches of grasses. The area is so developed that would provide a pleasing and relaxing environment to the visitors. It would be a typical landscaping area comprised of vegetation and non-vegetation components.

According to requirements following components need to be created for riverfront development:

i. **Vegetation Part:** Grove consisting of shade trees, ornamental trees and bamboos, small herbal garden, climbers, hedges, grasses for lawn, etc.

ii. **Non-vegetation Part:** Stairs, pathways, walking trails, stone pitching, benches, rain shelters, e-public utilities, parking area, information centre, refreshment area etc. as per the site specific requirements.

The vegetation and non-vegetation components will be arranged in such a way to enhance the aesthetic beauty of Riverfront. Ornamental species will be planted according to their recommended spacing and site specific suitability.

For using the available space economically and efficiently multi-tier planting methods will be used. Soil binding and water loving ornamental tree and shrub species are ideal choice for riverbank planting. To bind the surface soil, grasses and surface growers will be allowed to cover the surface and protect soil from erosion especially during rainy season or river flooding. It will minimise soil loss through sheet erosion, splash erosion and rill erosion. It will also improve rain water per collation or absorption. Besides this, small to medium sized herbs and shrubs will be accommodated at the second layer of vegetation to intercept some amount of sunlight and stop the fast/ forceful falling of rain drops directly from sky in turn which stop soil erosion (splash erosion). Small to medium sized ornamental trees or larger shrubs i.e., mainly light demanding plants will be accommodated at the third layer of canopy to cover the crown area. This layer will provide small timber, fuel, fodder and intangible benefits. The top canopy will be occupied by the strong light demanding species which are ultimately the dominant species on riversides.

List of species for plantation

Trees: *Jacaranda mimosifolia, Grevillea robusta, Albizia chinensis, Albizia procera, Butea monosperma, Kigelia pinnata, Dalbergia sissoo, Salix alba, Saraca assoca, Polyalthia longifolia, Callistemon viminalis, Syzygium venosum* , etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp.

(ii) Institution and Industrial Estate Plantation

Model – RV/JK/UL/02	**Institution and Industrial Estate Plantation**
Zone	**Institutions and Industrial Estate**

Under this model mainly ornamental, shade and fruit plants will be encouraged for planting. Evergreen plants especially Silver oak (*Grevillea robusta*) will be preferred so that the leaves do not shed during winter months when air pollution is usually high in plains. Plantation of forest species will be raised near the vicinity of various institutions and industries at 3m x 3m. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging, etc. plants mainly of broadleaved species *Syzygium venosum , Anthocephalus cadamba, Dalbergia sissoo, Melia composita, Pongamia pinnata, Holoptelea integrifolia, Acacia nilotica, Ficus rumphii,* etc. will be planted. The initiative will beautify the area, create awareness among people associated with institutions

and industries and promote environmental services, besides providing economic returns from under-utilized land.

List of species for plantation

Trees: *Syzygium venosum, Anthocephalus cadamba, Dalbergia sissoo, Melia composita, Pongamia pinnata, Thuja* orientalis, *Cryptomeria japonica, Araucaria araucana, Holoptelea integrifolia, Acacia nilotica, Jacaranda mimosifolia, Grevillea robusta, Albizzia chinensis, Albizzia procera, Salix babylonica, Saraca asoca, Polyalthia longifolia, Callistemon citrinus, Kigelia pinnata, Morus alba,* etc.

(iii) Eco-Park Development

Model No. – RV/JK/UL/03	**Eco-Park Development**
Zone	**Proximity to Rivers and its Tributaries**

An Eco-Park will be better equipped than riverfront development to facilitate visitors. An Eco-Park will have both vegetation and non-vegetation components. Even in the Eco-Parks the proportion of ornamental plants will be relatively more than in the Riverfront Development Model.

According to the requirement, the list of components to be created under this model are:

i. **Vegetation Part:** Miscellaneous ornamental plant species e.g., trees, shrubs, herbs, creepers, hanging plants etc.
ii. **Non-vegetation Part:** Fencing, stairs, pathways, walking trails, stone pitching, rain shelter, e-public utilities, benches parking area, information centre, children playing area, pond beautification, landscaping, etc. as per site-specific requirements.

List of species for plantation

Trees: *Jacaranda mimosifolia, Grevillea robusta, Albizzia chinensis, Albizzia procera, Butea monosperma, Thuja orientalis, Cryptomeria japonica, Araucaria araucana, Dalbergia sissoo, Eucalyptus tereticornis, Eucalyptus camaldulensis, Salix alba, Saraca asoca, Polyalthia longifolia, Callistemon citrinus, Syzygium venosum* , etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., *Euonymus* spp., etc.

Table 5.39 - Cost Norms for Treatment Models for Urban Landscapes in Jammu and Kashmir UT

Sr. No	Model No.	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days
		Establishment		1st year Maintenance		2nd year Maintenance		3rd year Maintenance	
1	RV/ JK/UL/01 Riverfront Development	1,50,00,000	20,000	45,00,000	6,000	30,00,000	4,000	22,50,000	3,000
3	RV/ JK/UL/02 Institution Plantation	2,60,000	347	78,000	104	52,000	69	39,000	52
4	RV/JK/UL /03 Eco-Park Development	1,50,00,000	20,000	45,00,000	6,000	30,00,000	4,000	22,50,000	3000

(C) Treatment Models for Urban Landscapes in Punjab

(i) Bio-remediation and Bio-filtration

Under the Urban Landscape models, Bio-remediation and Bio-filtration are among the important forestry intervention activity proposed for restoration of polluted stretches of rivers/tributaries. Varied anthropogenic activities and ever burgeoning population have resulted in deterioration of river ecosystems making them unfit for survival of indigenous biological forms. Rampant industrialization, improper agricultural methods, unchecked discharge of pollutants both organic and inorganic into water bodies, drains, *Nallahs*, hillsides, rivulets and streams ultimately leads to the contamination of the river systems. Heavy metal effluents from the processing units of industrial agglomerations situated in the towns are rebased in the river systems which degrade the quality of water, rendering of little or no use. Water bodies including rivers, lakes and streams have been heavily impacted due to the indiscriminate human activities and natural calamities and there is a great loss to their biodiversity or utility. In this dismal scenario, cleaning of water bodies and removal of toxic pollutants from the river ecosystems to restore freshwater bodies by making them free of contaminants is urgently required.

In comparison to the conventional methods like physical, chemical and thermal processes, bio-remediation techniques involving biological systems such as microorganisms or their products and plants are sustainable, cost effective options for abatement of pollution of the water bodies. In bio-remediation, biological systems are applied for reclamation of the contaminated water by transformation of toxic pollutants into less hazardous or completely non-hazardous forms. The

bio-remediation technology includes use of microorganisms or their enzymatic machineries, phyto-remediation (plants) and rhizo-remediation i.e., plant and microbe interactions techniques. Thus, bio-remediation is an effective and eco-friendly technique for removing toxic pollutants from aquatic environment. Water pollution from untreated municipal wastewater is an enormous problem in urban agglomerations. Low-cost, decentralized, wetland-based bio-filters have strong potential to dramatically improve the water quality. Well-designed bio-treatment systems with inclusion of appropriate native plant species are ideal for removing pollutants from municipal wastewater. They can be applied extensively in rural areas, small towns, peri-urban areas of large cities, industrial townships or institutional campuses, as well as for certain types of industries such as agro-food/beverage, etc. The biofilters are simple to construct, easy to operate, and cost effective. Major advantage of this method is that the pollutant is converted into bio-degradable waste which can decompose within a moderate time frame, thus, producing no secondary pollutants. Broadly, in this technique plants and microbes associated with plant root system are used to remove the pollutants in the form of inorganic and organic wastes. Selection criteria of plants for achieving high efficiency is always important. For example plants such as *Tecoma stans, Scirpus grossus, Spirodela polyrrhiza* (aquatic plant), etc. have been found good for dye degradation.

Organic and inorganic substances released from various sources into the existing natural water bodies cause their contamination. Among various water pollutants, nitrogen compounds form a significant role in wastewater contamination due to increase in anthropogenic sources like agriculture. Release of nitrate into freshwater poses severe problems including eutrophication. Biological denitrification is one of the more versatile and promising methods for the treatment of nitrate contaminated waters.

The plants in bio-filters played a great role in removing phosphates, nitrates, nitrites and ammonia. Many substances harmful to people and animals are conducive to plant growth. Plants require ammonia, phosphates and nitrates, and most synthetic fertilizers. Duckweed (*Lemna* spp.), nut grass (*Cyperus rotundus*) and water lilies (*Nelumbo* spp.) are known to absorb these substances.

(i) Bio-remediation and Bio-filtration

Model No. - RV/PB/UL/01	**Bio-remediation and Bio-filtration**
Zone	**Proximate Areas to Polluted Stretches of Rivers/Tributaries**

The State Forest Department, Municipal Bodies have to adopt the suitable approach for Bio-filter suiting to the specific requirements and site characteristics. The model will include the following activities.

i. Waste water treatment through mechanical measures as per the site requirement.

ii. Drainage line treatment by planting grasses, herbaceous vegetation and shrubs.

iii. Bio-filters: Bio-filters may be of different types: Free floating macrophyte bio-filter, emergent macrophyte biofilter, sub-merged macrophyte bio-filter, multispecies algal bio-filter.

List of species for plantation

Salix spp., *Eichhornia* spp., *Scirpus grossus, Spirodela polyrrhiza, Lemna* spp., *Cyperus rotundus*, *Nelumbo* spp., *Typha* spp., *Phragmites* spp., etc.

(ii) Riverfront Development

Model No. - RV/ PB/UL/02	**Riverfront Development**
Zone	**Along the River Course or Tributaries**

The proposed model of Riverfront development would involve plantation of avenue shrubs and trees along the riverbank to stabilize the soil and protect the bank from erosion. It would also have beds of annual flowering plants and patches of grasses. The area is so developed that would provide a pleasing and relaxing environment to the visitors. It would be a typical landscaping area comprised of vegetation and non-vegetation components.

According to requirements following components need to be created for riverfront development:

i. **Vegetation Part:** Grove consisting of shade trees, ornamental trees and bamboos, small herbal garden, climbers, hedges, grasses for lawn, etc.
ii. **Non-vegetation Part:** Stairs, pathways, walking trails, stone pitching, benches, rain shelters, e-public utilities, parking area, information centre, refreshment area, etc. as per the site specific requirements.

The vegetation and non-vegetation components will be arranged in such a way to enhance the aesthetic beauty of Riverfront. Ornamental species will be planted according to their recommended spacing and site specific suitability.

For using the available space economically and efficiently multi-tier planting methods will be used. Soil binding and water loving ornamental trees and shrubs are ideal choice for riverbank planting. To bind the surface soil, grasses and surface growers will be allowed to cover the surface and protect soil from erosion especially during rainy season or river flooding. It will minimise soil loss through sheet erosion, splash erosion and rill erosion. It will also improve rain water per collation or absorption. Besides this, small to medium sized herbs and shrubs will be accommodated at the second layer of vegetation to intercept some amount of sunlight and stop the fast/ forceful falling of rain drops directly from sky in turn which stop soil erosion (splash

erosion). Small to medium sized ornamental trees or larger shrubs i.e., mainly light demanding plants will be accommodated at the third layer of canopy to cover the crown area. This layer will provide small timber, fuel, fodder and intangible benefits. The top canopy will be occupied by the strong light demanding species which are ultimately the dominant species on riversides.

List of species for plantation

Trees: *Jacaranda mimosifolia, Grevillea robusta, Albizia chinensis, Albizia procera, Butea monosperma, Kigelia pinnata, Dalbergia sissoo, Salix* spp., *Saraca asoca, Polyalthia longifolia, Callistemon citrinus, Syzygium venosum ,* etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., *Euonymus* spp., *Casuarina*spp., etc.

(iii) Institutional and Industrial Estate Plantations

Model No. – RV/PB/UL/03	**Institution and Industrial Estate Plantation**
Zone	**Institutions and Industrial Estate**

In this model mainly ornamental, shade and fruit plants will be encouraged for planting. Evergreen plants *Ficus rumphii, Syzygium venosum* and Silver oak (*Grevillea robusta*) will be preferred so that the leaves do not shed during winter months when air pollution is usually high in plains. Plantation of forest species will be raised near the vicinity of various institutions and industries at 3m x 3m. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging, etc. plants mainly of broadleaved species *Syzygium venosum, Anthocephalus cadamba, Dalbergia sissoo, Melia composita, Azadirachta indica, Pongamia pinnata, Holoptelea integrifolia, Acacia nilotica,* etc. will be planted. The initiative will beautify the area, create awareness among people associated with institutions and industries and promote environmental services, besides providing economic returns from under-utilized land.

List of species for plantation
Trees: *Syzygium venosum, Anthocephalus cadamba, Dalbergia sissoo, Melia composita, Pongamia pinnata, Azadirachta indica, Thujaorientalis,Cryptomeria japonica, Araucaria araucana, Holoptelea integrifolia, Acacia nilotica, Jacaranda mimosifolia, Grevillea robusta, Albizzia chinensis, Albizzia procera, Salix babylonica, Saraca asoca, Polyalthia longifolia, Callistemon citrinus, Kigelia pinnata, Ficus* spp., etc.

(iv) Eco-Park Development

Model No. – RV/PB/UL/04	**Eco-Park Development**
Zone	**Proximity to Rivers and its Tributaries**

An Eco-Park will be better equipped than riverfront development to facilitate visitors. An Eco-Park will have both vegetation and non-vegetation components. Even in the Eco-Park the proportion of ornamental plants will be relatively more than in the riverfront development model.

According to the requirement, the list of components to be created under this model are as follows.

i. **Vegetation Part:** Miscellaneous ornamental plant species i.e., trees, shrubs, herbs, creepers, hanging plants, etc.
ii. **Non-vegetation Part:** Fencing, stairs, pathways, walking trails, stone pitching, rain shelter, e-public utilities, benches, parking area, information centre, children playing area, pond beautification, landscaping, etc. as per site-specific requirements.

List of species for plantation

Tree: *Jacaranda mimosifolia, Grevillea robusta, Albizia chinensis, Albizia procera, Butea monosperma, Thujaorientalis, Cryptomeria japonica, Araucaria araucana, Kigelia pinnata, Dalbergia sissoo, Salix* spp., *Saraca assoca, Polyalthia longifolia, Callistemon viminalis, Syzygium venosum*, etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium indicum, Nyctanthes arbor-tristis, Spiraea* spp., *Euonymus* spp., etc.

Table 5.40 - Cost Norms for Treatment Models for Urban Landscapes in Punjab

Sr. No	Model No.	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days	Amount Rs/Ha	Tentative Man days
		Establishment		1st year Maintenance		2nd year Maintenance		3rd year Maintenance	
1	RV/PB/UL/01 Bio-remediation and Bio-filtration	15,00,000	1316	4,50,000	395	3,00,000	263	2,25,000	197
2	RV/PB/UL/02 Riverfront Development	1,50,00,000	13,158	45,00,000	3,947	30,00,000	2,632	22,50,000	1,974

3	**RV/PB/UL/03 Institution Plantation**	2,60,000	228	78,000	68	52,000	46	39,000	34
4	**RV/PB/UL /04 Eco-Park Development**	1,50,00,000	13,158	45,00,000	3,947	30,00,000	2,632	22,50,000	1,974

5.5.3 Projected Targets – Model-wise Extent and Cost

The foregoing description has provided details on the potential treatment models under different landscapes within the riverscape. It is evident that the for Natural Landscapes of Himachal Pradesh, Jammu and Kashmir UT and Punjab model-wise cost ranged from Rs. 1 Crore to 15 Crores, Rs.0.31 Crore to Rs. 4.7 Crores and Rs. 10 Crores to 13 Crores, respectively. The proposed extent under different landscapes during the Phase I and Phase II i.e., during the 5-year Project Implementation and 5-year Maintenance Phase would range from 104 ha to 3265 ha. The projected targets of proposed forestry interventions under three types of landscapes are summarized in Table 5.41

Table 5.41 - Projected Physical Targets of Proposed Plantations in Different Landscapes within the Ravi Riverscape

Sr. No.	Landscape	Plantation Extent (ha)			Total Number of Plants to be Planted
		Himachal Pradesh	Jammu and Kashmir UT	Punjab	
1	**Natural**	3265.00	750.00	795.35	2005554.00
2	**Agriculture**	204.00	245.00	818.00	384300.00
3	**Urban**	113.20	126.59	104.40	--
Total		**3582.20**	**1121.59**	**1717.75**	**2389854.00**

5.5.4 Theme Plans

'Conservation Interventions' and 'Supporting Activities', those common to two or more lower order sub-zones or three types of landscapes described above, are referred as 'Theme Plans'. Details of proposed Conservation Interventions and Supporting Activities are provided below.

(A) Conservation Interventions

Three types of conservation interventions *viz*., (a) Soil and water conservation, (b) Riparian wildlife management, and (c) Wetland management are proposed for implementation by the

concerned States, and Union Territory level IAs. Proposed conservation interventions will be implemented at the States and UT and local field levels. Details of three types of conservation interventions proposed are presented below.

(a) Soil and Water Conservation Measures

The catchments of the Ravi River and its catchments, particularly in the mountainous tract of Himachal Pradesh and Jammu & Kashmir UT suffer on account of landslides, bank erosion, habitat loss, construction activities and other unsustainable human activities resulting into severe problem of soil erosion and sedimentation. Accordingly, bio-engineering and mechanical measures are envisaged for the purpose of soil and water conservation. Various models have been proposed for soil and water conservation in concerned States and UT which are given in Tables 5.42, 5.43, 5.44 and 5.45.

Table 5.42 - List of Models for Soil Conservation Intervention

Soil Conservation Intervention			
Sr. No.	**Himachal Pradesh**	**Jammu and Kashmir UT**	**Punjab**
1.	RV/HP/CI/01- Brushwood Check Dam	RV / JK/CI/01- Brushwood Check Dam	RV / PB/CI/01- Brushwood Check Dam
2.	RV /HP/ CI/02- Dry Stone Check Dam	RV / JK/CI/02- Dry Stone Check Dam	RV / PB /CI/02- Dry Stone Check Dam
3.	RV /HP/ CI/03- Crate Wire Structure	RV / JK/CI/03- Crate Wire Structure	RV / PB /CI/03- Crate Wire Structure
4.	RV /HP/CI/04- Pond	RV /JK/CI/04- Pond	RV / PB /CI/04- Pond
5.	RV /HP/ CI/05- Silt Detention Structure	RV /JK/CI/05- Silt Detention Structure	RV / PB /CI/05- Silt Detention Structure

Table 5.43 - Cost Norms of Treatment Models for Soil and Water Conservation Interventions in Himachal Pradesh

Sr. No.	Model No.	Amount Rs/m^3	Tentative Mandays
1	RV/HP/CI/01 Brushwood Interventions	300	2
2	RV/HP /CI /02 Dry stone activities	1800	8
3	RV/HP /CI /03 Crate wire activities	4500	15

4	RV/HP /CI/04 Water Ponds	350	22
5	RV/HP /CI /05 Silt Detention Dam Type Activities	6000	14

Table 5.44 - Cost Norms of Treatment Models for Soil and Water Conservation Interventions in Jammu region (J&K UT)

Sr. No.	Model No.	Amount Rs/ m^3	Tentative Mandays
1	RV/JK/CI/01 Brushwood Interventions	300	1
2	RV/ JK /CI /02 Dry Stone Activities	1800	8
3	RV/ JK /CI /03 Crate Wire Activities	4500	20
4	RV/JK /CI/04 Water Ponds	350	2
5	RV/JK /CI /05 Silt Detention Dam Type Activities	6000	14

Table 5.45 - Cost Norms of Treatment Models for Soil and Water Conservation Interventions in Punjab

Sr. No.	Model No.	Amount Rs/ m^3	Tentative Mandays
1	RV/PB/CI/01 Brushwood Interventions	300	1
2	RV/PB/CI /02 Dry Stone Activities	1800	5
3	RV/PB/CI /03 Crate Wire Activities	4500	13
4	RV/PB/CI/04 Water Ponds	350	2
5	RV/PB/CI /05 Silt Detention Dam Type Activities	6000	4

(b) Riverine and Riparian Management

The term 'Riparian' refers to the biotic communities and the environment on the shores of streams, rivers, ponds, lakes and some other wetlands. The riverine wetlands are an important component of a river system and they play a critical role in improving flood protection, recharging ground water and increasing the biodiversity, thus providing several ecological services. The riparian zone is the interface between the terrestrial and aquatic ecosystems and encompasses sharp gradients in environment and community processes. As mentioned in the

Project Goal i.e., Aiming a holistic Riverine Landscape (Riverscape) approach for sustainable management of Ravi River, its banks, or its riparian areas, within its fluvial system. Riparian buffer zones are exceptionally rich in biodiversity and they perform a wide range of functions along with economic and social values to people. These functions include: (a) trapping/removing sediment from runoff, (b) stabilizing stream banks and reducing channel erosion, (c) trapping/removing phosphorus, nitrogen and other nutrients that can lead to eutrophication of aquatic ecosystems, (d) trapping/removing other contaminants, such as pesticides, (e) storing flood waters, thereby decreasing damage to property, (f) maintaining habitat for fish and other aquatic organisms by moderating water temperatures and providing woody debris, (g) providing habitat for terrestrial organism, (h) improving the aesthetics of stream corridors, and (i) offering recreational and educational opportunities.

The principal objective of a riparian buffer may appear simple enough so as to protect the aquatic zone from disturbance by forest operations or any other land use on the adjacent land, it is important to understand the deeper logic and science behind the planning for such vegetation cover and plantations. In several instances, developing a riparian corridor may actually not be a natural aspect of the ecological system at all, and it must be clearly seen as a management initiative which is planned for the protection and restoration of river water flow and quality.

The river team consulted the list of riverine riparian area and wildlife areas and made list of prominent or high prioritized area in consultation with stakeholders which can be taken under this component. The part of area the Riverine and Riparian area also can be taken up as this is package for the whole Protected Area concerned. The area taken for management can be taken up with the concerned stakeholder (Department as well as NGO or any other secondary sources).

The activities included in the proposed Models along with nomenclature for Himachal Pradesh and Punjab is as follows.

In Himachal Pradesh: RV/HP/CI /06

In Jammu region (J&K UT): RV/JK/CI /06

In Punjab: RV/PB/CI /06

Table 5.46 - Details of Activities under Riverine and Riparian Management

Sr. No.	Components	Activities	Years				
			1	2	3	4	5
1	Protection	General Protection from illicit felling, illegal grazing, mining, poaching, etc.	√	√	√	√	√
		Survey and demarcation of boundaries and establishment and maintenance of permanent boundaries	√		√		√

Sr. No.	Components	Activities	Years				
		Physical Infrastructure (Watch Tower Patrolling Path); Electric Vehicle; etc.	√	√	√		
		Field Equipment - Tranquillization Gun, Night Vision with Binoculars, GPS, Surveillance equipment, Camera trap, etc.	√	√	√		
		Communications equipment including laptops, Wi-Fi system, etc.	√	√	√		
2	Habitat Management	Water ponds in every 2x2 km grid	√	√	√	√	
		Habitat enrichment plantations 1. Slopy area, 2. Riverine area (receded area broadcasting of lintels in strips), 3. Riparian area, and 4. Grass land development	√	√	√	√	√
		Soil and Water Conservations Measures	√	√	√	√	√
		Control of Invasive and Alien Species	√	√	√	√	√
3	Wild Faunal Species Management	Conservative Breeding; Re-introduction of Species, etc.	√	√	√	√	√
4	Research and Development	Short Term Projects up to 1 year; and Long Term Projects (5-Year)	√	√	√	√	√
		Essential Equipment and Field Infrastructure for facilitation of Research and Development and Monitoring					
5	Eco-development	Basic Infrastructure; Training to Tourist Guides of Peripheral Villages; Interpretation Centre for Nature Education	√	√	√	√	
6	Community Awareness and Participation	Creation of Self-help Groups (SHG), Provision of Revolving Fund for SHG; Alternate Income Generation Activities; Federation for Developing Entrepreneurship and Supply Management, etc.	√	√	√	√	√
7	Ecotourism	Provision of Essential Facilities; Regulation of Tourism Activities, with respect to carrying capacity of the area etc.	√	√	√	√	

(c) Wetland management (Natural and Artificial)

Wetlands provide water for human consumption and agriculture and numerous benefits for people, wildlife and aquatic species. Important functions of wetlands include protecting and improving water quality, providing fish and wildlife habitats, storing flood water, maintaining surface water flow, and protect shores. Wetlands are ecologically sensitive and adaptive systems. The Convention on Wetlands or the Ramsar Convention defined wetlands as 'Areas of marsh, fen, peatland or water, whether natural, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceeds 6 meters' (Ramsar Convention, 1971). These include estuaries, deltas, bogs, streams, ponds, reservoirs, etc. Like most wetlands in India and elsewhere, wetlands in above two States and one UT within the Ravi Riverscape are facing enormous human pressure as they are surrounded by densely populated townships or other urban areas. Most high altitude wetlands in Himachal Pradesh are fragile and threatened by geological processes, climate change and ever increasing tourism pressure. The man-made wetlands created due to reservoirs/barrages face challenges owing to high rate of sedimentation, pollutants from surroundings agricultural lands and waste from towns and cities besides issues of excessive fishing, livestock grazing in draw down areas, unchecked increase in tourism activities. There are many wetlands, therefore only more degraded or prominent have been considered in consultation with stakeholders i.e., Departments/NGOs/secondary services.

The activities included in the proposed Model along with nomenclature for the Himachal Pradesh and Punjab are as follows.

In Himachal Pradesh: RV/HP/CI /07

In Jammu region (J&K UT): RV/JK/CI /07

In Punjab: RV/PB/CI /07

Table 5.47 - Component-wise Details of Activities under Wetland Management (Natural and Artificial)

Sr. No.	Components	Activities	Year				
			1	2	3	4	5
1	Protection	General Protection from illicit felling, illegal grazing, mining, poaching, etc.	√	√	√	√	√
		Survey and demarcation of boundaries and establishment and maintenance of permanent boundaries	√		√		√
		Physical Infrastructure i.e., Watch Tower, Patrolling Path; Electric Vehicle; Field Equipment - Tranquillization Gun, Night Vision	√	√	√		

Sr. No.	Components	Activities	Year				
		with Binoculars, GPS, etc.					
		Communications	√	√	√		
2	Habitat Management	Habitat enrichment plantations 1. Sloppy area, 2. Riverine area (receded area broadcasting of lintels in strips), 3. Riparian area and 4. Grass land development	√	√	√	√	√
		Soil and Water Conservation Measures	√	√	√	√	√
		Control of Invasive and Alien Species	√	√	√	√	√
		Creations of Mounds/ Highlands	√	√	√	√	√
3	Wild Faunal Species Management	Conservative Breeding; Re-introduction of species, etc.	√	√	√	√	√
4	Research and Development	Short Term Projects up to 1 year; Long Term Projects (5-Year)	√	√	√	√	√
		Essential Equipment and Field Infrastructure for facilitation of Research and Development and Monitoring					
5	Eco-development	Basic Infrastructure; Training to Tourist Guides of Peripheral Villages; and Interpretation Centre for Nature Education	√	√	√	√	
6	Community Awareness and Participation	Creation of Self-help Groups (SHG), Provision of Revolving Fund for SHG; Alternate Income Generation Activities; Federation for Developing Entrepreneurship, Supply Management, etc.	√	√	√	√	√
7	Eco-tourism	Provision of Essential Facilities; Regulation of Tourism Activities, etc.	√	√	√	√	

Table 5.48 – Cost Norms of Treatment Models for Other Conservation Interventions in Himachal Pradesh

Sr. No.	Year	RV/HP/CI/06 Riverine and Riparian Management		RV/HP/CI/07 Wetland Management	
		Amount Rs/ha	Tentative Mandays	Amount Rs/ha	Tentative Mandays
	1st year	3,20,000	512	2,80,000	448
	2nd year	2,80,000	448	2,50,000	400
	3rd year	1,90,000	304	1,60,000	256
	4th year	1,20,000	192	1,20,000	192
	5th year	90,000	144	90,000	144

Table 5.49 – Cost Norms of Treatment Models for other Conservation Interventions in Jammu region (J&K UT)

Sr. No	Year	RV/JK/CI /06 Riverine and Riparian Management		RV/JK/CI /07 Wetland Management	
		Amount Rs/ha	Tentative Mandays	Amount Rs/ha	Tentative Mandays
	1st year	3,20,000	569	2,80,000	498
	2nd year	2,80,000	465	2,50,000	415
	3rd year	1,90,000	295	1,60,000	248
	4th year	1,20,000	174	1,20,000	174
	5th year	90,000	122	90,000	122

Table 5.50 – Cost Norms of Treatment Models for other Conservation Interventions in Punjab

Sr. No	Year	RV/PB/CI/06 Riverine and Riparian Management		RV/PB/CI/07 Wetland Management	
		Amount Rs/ha	Tentative Mandays	Amount Rs/ha	Tentative Mandays
	1st year	3,20,000	374	2,80,000	327
	2nd year	2,80,000	306	2,50,000	273
	3rd year	1,90,000	194	1,60,000	163
	4th year	1,20,000	115	1,20,000	115
	5th year	90,000	80	90,000	80

(B) Forestry Interventions

The denuded forest areas need to be restocked with enrichment planting and plantation blocks at bare areas. As the area under planting is gulled and cut up with natural drainage channels, the planting has to be supplemented with soil conservation works both mechanical and vegetative to make the plantations a success. The planting area should be closed to grazing, lopping and quarrying, etc. through a proper legal notification. For effective protection, it is necessary that the area is fenced and fence is maintained properly. It has generally been seen that after a couple of years of fencing, these plants get grazed and damaged leading to failures. Plants must be protected till these attain a height which is above the grazing/browsing level. Prior to planting, bush cuttings should be done and area cleared of all obnoxious vegetation. On steep slopes, it is preferable to clear strips where planting is to be done so that entire area is not bared of all vegetation.

Pits to be dug should be of 30 cm x 30 cmx 30 cm or 45 cm x 45cm x 45cm size depending upon the species and type of land for planting. In case of afforestation and compensatory plantations, there should be 1,100 plants per ha and in case of enrichment plantations, it should be 800 plants per hectare. Hoeing, weeding and mulching should be attended regularly. Preference should be given to fuel wood and fodder species like *Quercus oblongata*, *Alnus nitida*, *Robinia pseudoacacia*, *Ulmus wallichiana*, *Juglans regia* (Walnut), *Aesculus indica* (Khanor), *Morus serrata*, etc. Maintenance of plantations will be needed for at least 7 years in the refractory areas and where grazing pressure is very heavy.

(i) Stabilization of Unstable Slopes

Such slopes will be in land slips, slides and along roadsides caused by cutting of roads and disturbance of strata during construction. In stabilizing these slopes, there is generally the choice between vegetative measures and solid structures of stone and concrete or a combination of both. Vegetative measures are widely applicable and adaptable, economical, effective, easy to repair and in harmony with natural environment. However, purely biological measures have their limitation on unstable slopes where only solid structures may provide the desired protection and stability. In fragile Ravi River, hill slopes, where soil is shallow, blasting and earth cutting on steep slopes for ever expanding road construction programs are in progress aided by overgrazing, it is generally the combination of both vegetative and engineering works that are likely to succeed in stabilization of slopes especially in case of landslips and landslides.

Methods of slope stabilization have their limitations on slopes over 50%. In steeper, bouldery slopes with very shallow and stony soil formations, solid retaining walls are needed. However, because of their high costs, these should be limited to places where their construction is justified by their function. In many situations, masonry check walls and gabions structure is necessary. Thereafter, a series of loose stone check walls, depending upon the length, width and slope needs to be constructed and vegetation introduced in the intervening spaces through planting. Where the size of slope is small, soil is hospitable and slopes have formed the angle of repose, purely

vegetative measures can be successful. Where one has to cope with high quantities of run-off due to size, length of slope and quantity of rainfall, diversion channel at the head of the slope has to be provided to prevent surface run-off from entering the area to be stabilized and to divert it into stable waterways without creating new gullies/slips. The foundation must be deep enough to avoid sinking.

(a) Gabions

These are rectangular wire crates that are filled with stones and employed in erosion control. These have some significant advantage over solid structure.

- **Flexibility:** Gabions bend without breaking and in contrast to concrete or masonry with mortar they do not crack. This can be an important aspect with regard to unevenly sinking foundation and the pressure in slopes.
- **Permeability:** Gabions structures are permeable and do not need an extra drainage system. They retain the soil and allow extra water to spill over.
- **Economics**: Usually they are cheaper to construct than other solid engineering structures. They may become expensive only where stones are not available in sufficient quantity.

Gabions can be used in flowing water and for land reclamation along banks, for retaining walls and gully stabilization. The toe wall/retaining wall are the base of the slope using gabions can be very satisfactory. It is possible to stabilize the base of a slope with only one row of gabion or to arrange them in terrace formation. Especially the first type of structure should always have a slight inclination towards the slope.

(b) Wattlings

Wattling consists of interwoven fences of brushwood in shallow trenches about 30cm deep. The pegs are driven 90 – 120 cm apart, between which stems of sprouting species like *Salix tetrasperma, Alnus nitida, Populus deltoides,* etc. are planted. The stems must be interwoven in a way that the butt ends are bent down into the soil and their upper potion exposed. It is also possible to insert cuttings in the wattling structure. Finally, the trenches are refilled with the excavated soil leaving the upper part of the wattling structure exposed. Wattling can be constructed in continuous lines or intermittently along the contour. The distance between wattling depends upon the slope and stability of the soil. The intervening space between successive wattling structures can be planted with seedlings or cuttings of suitable species like *Alnus nitida*, *Robinia pseudo-acacia* and *Populus deltoides*. Where slope has an angle of repose and the soil is not shallow and stony, it may be desirable to stabilize the slip entirely through wattling only without any recourse to engineering (masonry) structures. Wattling is very useful on uphill side slopes of roadsides.

(ii) Stabilization of Gullies and *Nallahs*

Due to irregularities of the soil surface, the water is often forced to concentrate small and shallow channels where rill erosion starts. The flowing water loosens the soil particles, lifts them up and transports them away. Gully is similar to rill and can be considered as its advanced stage. Gullies are formed when many rills join, which will increase the volume and the erosive power of the water flow. Gullies can have different shapes 'U'- shaped gullies are formed where the sub soil erodes as easily as the top soil. 'V'-shaped gullies are formed in soils with a very resistant layer below the surface. Typical measures for reclamation of small gullies include brushwood plugs and loose stones. Their function is to reduce the velocity of the flood and comb out the sediments so that gulley is gradually silted up.

(a) Brushwood Plugs

At first, trenches following the contour are dug 40-60 cm deep across the gulley bed and the banks. The brushwood which must be of sprouting species is placed upright and tightly together on the downstream side of the trench. Afterwards the trench is refilled and tamped.

(b) Loose Stone Plugs

Smaller gullies of less than one meter in depth can often be stabilized by plugging them with loose stone check dams, which may be simply heaped in the gully. It can be in combination with bushy brushwood which may not even be of sprouting species.

(c) Dry Stone Check Dam

These are generally constructed in upper reaches of eroding *Nallahs* to reduce the bed slope, stabilize the grade and check the bed scouring and retain silt sand and pebbles. Depending upon the size of the dam, depth of foundations may vary from 30 – 60 cm. Foundation should be dug across the *Nallah* width extending well into the banks. The soil is pulled up-stream to be used later for the refill. The largest stones are placed on the bottom layers. Larger check dams with steps in front are stronger, sager and more useful. In every layer of stones a step of 15 – 20 cm is left on the downstream side, so that width is reduced from base to top. The advantage is that the flow is gradually conducted down to the apron. Two wing walls with appropriate foundation are often constructed at the upper side to force the flow into the water spill or notch and to prevent it from damaging the banks. The wing walls should form an angle of about 30° with the banks. In the center of the 'Crown' a notch of concave shape is to be provided which must be wide enough to cope with the peak run-off generally a length of half the span of the dam and depth of 20 – 30 cm are considered appropriate. Below the dam an apron has to be constructed with stones. On the up-stream side the dam, has to get an earth fill for greater strength. Finally, the structure is supplemented by planting seedlings and cutting of suitable species along the banks on the upstream side. *Alnus nitida, Salix* spp. (Willows), *Ulmus wallichiana* and *Celtlis australis* are good species for this purpose.

(d) Solid Check Dams

In bouldery *Nallahs*, with or without some water flow, check dams may be constructed of gabions, masonry with mortar or concrete. Each situation will have to be looked into for the type of dam that needs to be constructed.

(e) Brushwood Check Dams

These are only temporary and should be preferred where stones are not available and water discharge is not substantial. At first a foundation extending well into the banks is dug. The brushwood preferably sprouting type is placed between two tows of pegs driven in 40 cm apart across the gulley bed. The distance between the rows should be 0.80 - 1m for gullies/*Nallahs* up to 5 m in width. The brushwood is packed firmly and two rows of pegs are tied together. On the top, a notch of about half the span of the dam is kept for stream flow.

(iii) Stream Bank Training

Perennial or seasonal streams crossing through the steep slopes, bring lot of debris in them during rains and spread the same over even cultivated lands besides washing away the land on the bank. In all these situations, the remedy lies in construction of spurs and embankments of stone, masonry, gabion or vegetative or a combination of both depending upon the local situations.

Spurs

These are required to protect the structures and agricultural lands on the banks by diverting the stream flow away. Generally a single spur may serve the purpose in view. However, in certain situations, a series of spurs may be needed. In some rare cases, construction of spurs on both the banks may become necessary. A large spacing can be adopted for convex bank and smaller one for concave bank. A spacing of 2 to 2.5 times the length of the spur is the general practice. Generally attractive type spurs i.e., pointing sown wards are used in the presently described situations. These are around 30° inclination with the bank facing downstream flow. These can be of dressed masonry or gabbiness. Construction of spurs should be supplemented with vegetation enforcement. Species like *Alnus nitida, Robinia pseudoacacia*, *Populus deltoides, Ulmus wallichiana* and *Salix* spp. could be planted, depending upon locality factors in space between the spurs.

(iv) Scope of Drainage Line Treatment

The Ravi River originates at an elevation of 4229 m and there are 34,293 streams of different orders found in this basin in Himachal Pradesh. The drainage lines from Chamera-I upwards can be conveniently divided into those located on southern aspect and those located on northern part.

(v) Retaining Walls

These are strong walls along the banks for bank protection. These can be of stones, gabions, or vegetation. If soils along the bank are hospitable, vegetative embankments supported by strip

planting along the bank can be cheaper and more lasting. In case of bouldery terrain, use of gabion is more appropriate.

(vi) Landslide Control

The Chamba to Bharmour Road Corridor of National Highway (NH-154A) is highly prone to landslides. The field visit to this tract revealed that the landslides are the major cause of concern and need immediate attention. Such landslides cause traffic problems and also make silt loads of the Ravi River beyond permissible limits. There are about 60 landslides between Chamba and Bharmour making the roads dusty and bumpy. All communication is through roads situated along the banks of rivers and distributaries and landslides has become a major cause of concern. They, hamper the communication network and huge money is spent on maintaining roads at landslide pockets. JCBs keep on standing to clear the debris whenever it falls. Vehicles are seen damaged by falling boulders and debris.

Main Causes of Land Slides

a) **Geological Formation** – In between hard rock strata, there are rock stones, earth materials which slide easily with seismic, moisture.
b) **Under Cutting of Roads Disregarding Angle of Response-** Where there was hard rock, it has stayed as seen narrow stretch to Bharmour over hanging the road, but where wide formation it continues to slide – PWD provided crate wire/retaining walls of 2 to 3 m height, but debris over flows and reach the road – cleared frequently – make the road dusty and bumpy.
c) **Oversaturation of Slope –** At the top higher snow fed moisture, or moisture from upward cultivated lands saturated the soil mass which gets overweight during rains and slides down. Once the mouth opens, then it continues to slide down.
d) It was also noted that in the reservoir areas of hydro-electric projects (HEPs) the peripheral areas or run area gets saturated and when level of water rises.
e) Landslides due to rural road construction.



Plate 5.1 -- View of Landslide

The general landscape along the slopes of the Ravi River from Chamba to Bharmour indicated that some of the southern slopes are covered with rock out crops and there are not many signs of landslides because of the rocky hard strata. But at some of the locations the parent material is composed of pulverized rocks which collapse under the pressure of rainwater during the monsoons. The seismic activities also contribute to the collapse of such slopes. The PWD Department has constructed large number of retaining walls at the base of these landslides to maintain the traffic flow. A comprehensive treatment package is required for sustainable management of the landslide prone areas having weak geological formation. Some of the typical sites having landslides due to weak geological formation are given for reference (Plate 5.1).

Landslides Due to Road Cutting: It is most unfortunate that there is no coordination between the PWD and the Forest Department with respect to the restoration of ecological degradation in the catchment areas of the Ravi River. While the PWD Department makes all out efforts to make road communication network functional at all cost because of public demand and loss to the traffic. In so doing the PWD Department many a times makes vertical cuts on the hill slopes disregarding the angle of repose concept. Because of the vertical cut, the valuable forest trees at the top of the cut portion become vulnerable to the damage. The forest department has already taken up this issue with the PWD Department, but no viable solution is coming forth. Some of the sites having such problems are shown in the photographs below (Plate 5.2). A vertical cut made by PWD which endangered the forest plantation Landslide prone area, 6 km below Bharmour.



Plate 5.2 - Road cutting and landslide

PWD has made vertical cut on the road and there is vulnerable plantation above the road cut. The most unfortunate part is that no cross drainage works along the road have been done by the PWD causing lot of soil erosion problems. The forest plantation is in danger because of landslide along the road. Landslide rehabilitation by bio-engineering measures is needed with a strong retaining wall at the base along the roads.

Landslides Due to Rural Road Construction: The State Government has an ambitious program to provide connectivity to different villages even located at remote locations because of the demand of the communities to take their produce to the markets. In this endeavor, large numbers of rural roads are being constructed not following the rules and norms of road construction in vulnerable areas. The funds are limited and the debris thus generated is put on the lower sides of the hill slopes which ultimately reaches the main river and add to the sediment load. As no cross drainage works are provided along such roads, the runoff water creates gullies which form the

shape of landslides. The possible solutions include the cross drainage works, cutting of the road keeping in view the angle of repose and disposal of the material at muck disposal sites rehabilitated in due course by bio-engineering measures. Dugh village is such an example where there is road cutting and landslide for the construction of road (Plate 5.3).



Plate 5. 3 - Landslides due to Rural Road Construction

Landslides Due to Over Saturation of Hill Slopes

The topography of the catchment area of Ravi River is such that there are snow bound peaks at the top and forest lands are situated below such peaks. As the snow melts, the slopes get saturated with the snow melting runoff water and as a result of oversaturation, the lands where geology is weak and there is no support down below in the form of retaining walls, such slopes tend to slip down and becomes landslide when the mouth gets open near the road (Plate 5.4).

It is recommended that all such micro-watersheds having the above stated problem should be marked by a proper survey and a comprehensive treatment plan should be worked for each and every landslide of this type. This is important because the areas having valuable tree species are being damaged by the landslides of this nature. The retaining wall at the base, drainage of the slopes by various means and promotion of vegetative barriers on the slopes would be part of the technological package.



Plate 5.4 - Landslides due to saturation along Ravi River

Landslides Due to Saturation Along Reservoirs of HEPs

The entire length of Ravi River has series of reservoirs of hydro-electric projects (HEPs). For example in the Chamera-I Hydro-Electric Project (HEP), the reservoir area extends by 18 km towards Chamba Township and 11 km towards Baira-Siul Project site extending up to Koti village. In the submergence area, there are forest plantations in most of the area. The river level rises when the reservoirs are filled up to the full capacity and gradually lowers down as the water is used for electricity generation. During the rising period, the hill slope becomes saturated and as the reservoir level drops down, the slope collapses because of the overload generated by the saturated mass. This causes landslides in the peripheral area of the reservoirs.

Plantation Along the Reservoir

Unfortunately, such areas are inaccessible and there is no viable solution to this problem as the reservoir levels will keep on rising and falling every year.

(vii) Scope of Bio-engineering Measures

It was noted that along the highway from Chamba and Bharmour particularly on northern aspect, there is a 10 to 20 m strip between the road ends to the forest land above the slope all along at large number of strips. This strip is critical as it is acting as buffer between road and forest and is generally not well stocked. This strip should be covered with bio-engineering species meticulously by wattlings which would reduce slipping of forest slopes. The above indicate that the scope of mechanical measures for stream bank erosion control is very limited and wherever

there are possibilities of providing support to the banks, it would be possible only through the bio-engineering measures.

Along the Ravi River, there are only few locations where the course of the river is slightly wider and the velocity is relatively low where the bio-engineering species have come up which have protected the banks. These are native species which have come up under degraded soil conditions but fortunately have come up under relatively better moisture regime along the river (Plate 5.5 to 5.8)



Plate 5.5 - Bio-engineering Species on Southern Aspect



Plate 5.6 - Bio-engineering Species on the Right Bank on Southern Aspect



Plate 5.7 - A Bio-engineering species protecting river bank on right side on southern aspect



Plate 5.8 - Valuable Plantation Along the Ravi River Bank on Northern Aspect

(A) Bio-engineering Measures - A Homeopathy of Environmental Restoration

Bio-engineering is the process of designing grasses, shrubs and trees to improve and protect the land. The aqueous and mechanical effects of the plant community are used to accomplish an engineering function. Plants can be used alone or in combination with engineering structures, called bio-technical engineering. Bio-engineering techniques have been developed to prevent soil erosion and to help plants regenerate in deteriorated areas such as mountain slopes and streams. Living plant materials are used to create live structures with low cost engineering structures that not only stabilize the slope of the mountain, but also stimulate growth and provide a permanent solution to the unstable mountain slope. Plant protection technology includes a set of biological activities that are often planned and designed in conjunction with engineering/mechanical methods to conserve soil and water resources for sustainable bio-production (Clark and Howell, 1992).

(i) Special Characteristics for the Conservation of Flora

The plant species providing dense ground cover during rainy season like Bhabbar grass (*Eulaliopsis binata*), *Saccharum munja* and *Phragmitis* spp. are considered as erosion resistant crops. There are some plant species which are preferred because of their special characteristics as summarized below.

- The selected plant species should be generally evergreen.
- The species should be adapted to local climate, soil and site conditions.
- They must have a dense, fibrous and strong root system for soil binding.
- They should have a genetic ability to thrive on poor/impoverished/marginal lands.
- They must be fast growing and of primary colonizing nature.
- Such plants may not be attacked by termites/insects/pests and damaged by frost.
- Such plant species should multiply very fast by profuse tillering or through suckers.
- Such plants should have social and some economic value to local population.
- Such plants should profusely grow during monsoon when soil erosion is highest.
- Their architecture should be such that plants bend with currents of water and erect again when flow stops.

(ii) Vegetative Measures for Soil and Water Conservation

The vegetative measures are cost effective and play important role in conserving soil and water and are included in any watershed management plan. These bio-engineering measures are different for arable and non-arable lands and generally divided into five categories *viz*., (a) Land

slope management, (b) Drainage line treatment, (c) Stream bank protection, (d) Landslide stabilization, and (e) Land-fill, mine spoiled and other problem areas.

(iii) Bio-engineering Measures for Land Slope Management

- Barriers of suitable and compatible grasses, shrubs and trees are established against over land slope on contour to intercept soil and water.
- The species vary according to agro-climatic conditions.
- There is considerable variation in soil working, planting techniques and planting material.
- In general, the soil excavated from contour trenches/V-ditches/contour furrows is deposited on the down-slope side leaving a 15 cm berm to form a parallel contour bund along the contour trench having breaks at regular interval.
- Rooted slips of grasses are planted at a spacing of 10-15 cm on bunds and fodder trees are planted in/ along the trenches.
- On the lower side of the bunds, a row of grasses are raised to form complete barrier.
- The vertical interval between the rows varies usually with slope and tree rows spacing which may vary from 3 - 6 m.
- The contour trenches get partly filled with eroded soil and store rainwater which in turn provide sufficient moisture to the vegetative strips.
- Once established, the closely growing hedges along with dense roots reduce soil erosion by breaking the slope length, reduce velocity of water and increase infiltration to the soil, induce deposition of the eroded soil and help in establishing trees raised on trenches by improving moisture regime.

The grass barriers are established during rainy season and when planted during drizzling establish very quickly. *Vetiveria zizanioides* grass performs well only on wet/moist areas in non-arable lands, but suffers high mortality and then termite attack on drier slopes. Bhabar grass (*Eulaliopsis binata*) performs well when planted properly during light showers and particularly in association with trees having light/ thin canopy like khair (*Senegalia catechu*). Napier grass (*Pennisetum purpureum*) is most liked by the farmers and provides forage for livestock. These hedges take 2 to 3 years to establish and over a period of time eroded soil accumulate above the hedges and this would tend to form terraces by breaking the slope into series of terraces.

(iv) Bio-engineering Measures for Drainage Line Treatment

A wide range of measures are available for the drainage line treatment. These are described below.

Live Check Dams

Live check dams are the barriers created by planting available grasses and shrubs across the first order gullies to check soil erosion, retain fine soil and moisture. These are also raised to check extension of gully heads to upper slopes. To prolong the life of water storage structures, live

check dams in drainage lines above the water storage structures and in between the silt detention dams assumes significance.

Construction of Live Check Dams: Live check dams are constructed using locally available plant species such as *Vitex negundo*, *Arundo donax*, *Ipomea carnea, Agave sisalana, A. cantala,* etc. Two rows of grasses like *Vetiveria zizanioides*, *Panicum maximum* and *Pennisetum purpureum*, etc. are planted at 10 cm interval from plant to plant and 20 cm row to row spacing. On the down side of grass row, two rows of shrubs like *Vitex negundo, Arundo donax* and *Ipomoea carnea* are planted at close spacing of 30 cm from plant to plant and 50 cm from row to row across the *Nallah* bed. In case sand/debris load is large then series of live check dams are constructed above and below the crate/dry stone check dams.

Brush Wood Check Dams

Brush wood check dams are constructed using locally available brush wood material and wooden poles from the forest. They are feasible where such material is available. They are constructed in small gullies not deeper than one meter depth. They are of two types *viz*., (a) Single row post brush wood dams, and (b) Double row post brush wood dams.

Single Row Post Brush Wood Dam

These are made of wooden stakes to which long branches of trees and shrubs are tied in a zigzag manner across the small gully. The site is first eased to slope of 1:1 and bottom of the gully excavated by about 25 cm. Then, the wooden stakes of about 10 cm in diameter are driven about 0.75-0.90 m deep and 0.60-0.90 m apart along the dam axis. Their tops are kept in such a way that a depression is formed in the centre for disposal of excess water. In order to control termite attack, the wooden stakes are treated with coal tar. The height may vary from 30-60 cm. On the lower side, the brush wood is laid in such a way that cut end side half is placed inside the structure and remaining half extended downward as a mat to act as apron which may protect the base against erosion.

Double Row Post Brush Wood Dam

When the size of gully increases from 1-2.5 m depth and 5-6 m wide, then double row post brush wood dams are more appropriate. The construction is same as that of single row dam except that the brush wood is laid across the gully in between of two rows of poles spaced about 0.9 m apart. At the base, some branches are laid along the slope of gully with cut ends laid upside and branches extending to lower side to form an apron of branches. A row of live hedge is planted both on the upstream and downstream side of brush wood check dam which may become functional when brush wood decay after some time (Fig. 5.23).

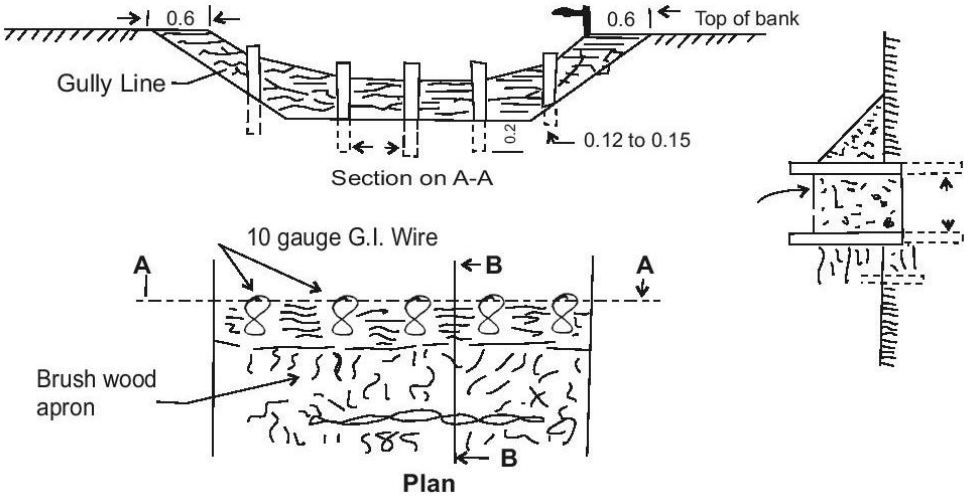
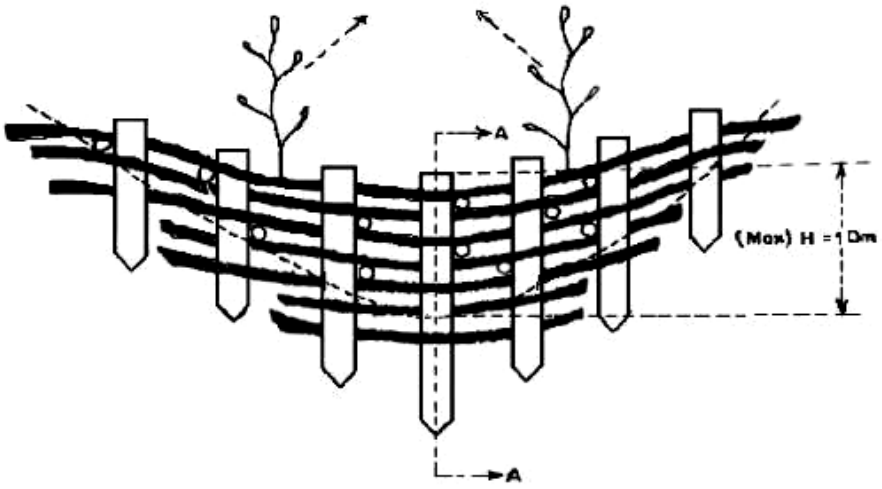


Fig. 5.23 - Design of Double Row Post Brush Wood Dam

Another method is to lay branches of trees horizontally between the wooden poles and tie those with wire to wooden poles and fill the central portion with some brush wood at the base and place heavy stones to press the brush wood. Because of serious termite problem, brushwood is decomposed very quickly and hence live hedge are preferred (Fig. 5.24).



a: Front view

A. Seedlings

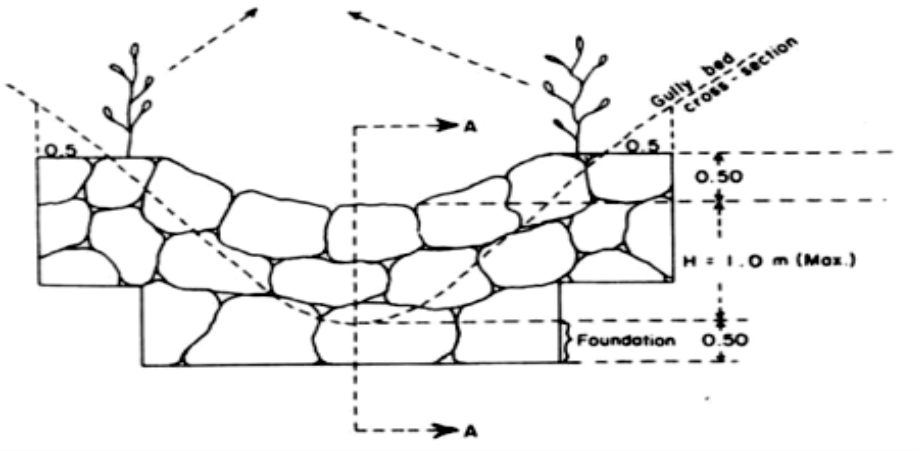


Fig. 5.24 - Alternative Construction Design of Double Row Post Brush Wood Dam

Contour Wattling

The wattling should be preferred on fragile slopes where soil working is difficult and mulching material should be locally available. The live contour wattles obstruct the movement of debris and allow the run off to pass through. Contour wattling is a method of breaking the length of slope into shorter portions by providing contour wattles at 3-5 m interval. It is normally used on portions of the side which is easily accessible. The advantage is that it holds the downward movement of earth and reduces the raindrop impact. Wattles are laid out at a vertical interval of 3 m up to 66% slope and 5-7 m up to 33% slope. Trenches of 0.3 m wide and 0.3-0.5m deep are dug up on contour and filled with brushwood bundles of 5-6 cm diameter branches laid horizontally. The poles of 8-12 cm diameter and around 1.5 m length of plant species which sprout on planting are embedded about half the length at about one meter interval on the lower side of the trenches. Some self-sprouting species are *Ficus racemosa, Lannea coromandelica, Erythrina suberosa, Vitex negundo, Salix tetrasperma* (Willow), *Hamiltonia suaveolens, Cassia fistula,* etc. The inter-space between the wattles is protected by mulching with a thick layer of locally available grass and tied with a thin wire or rope to avoid its displacement by water or wind. The inter-space area should be planted by soil binding grasses/shrubs.

Contour Live Hedges

Contour live hedges serve the purpose of vegetative barriers and created by planting suitable erosion resistant grass/herb species on lower side of contour trenches which form a dense hedge to intercept soil and water (Fig. 5.25).

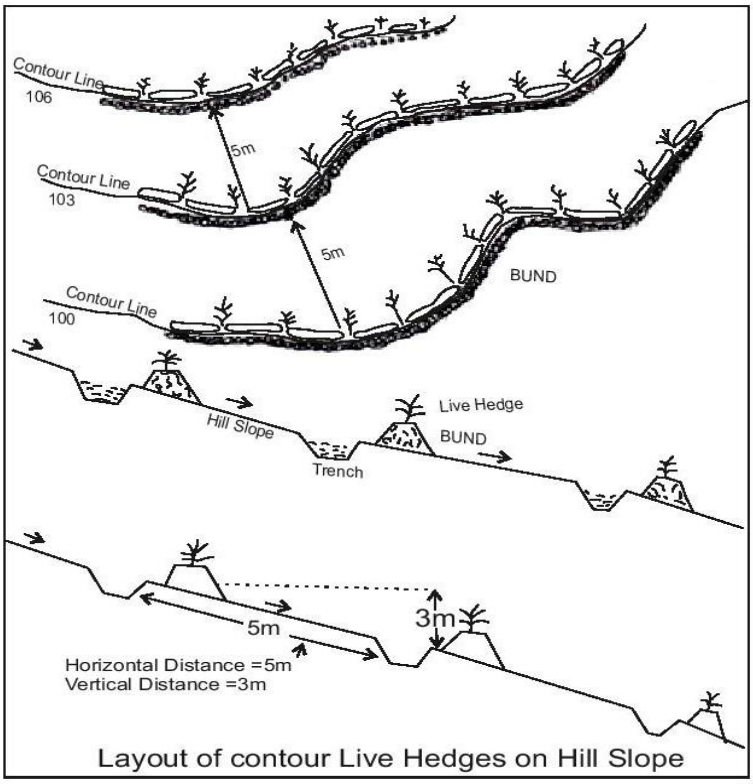


Fig. 5.25 - Design of Contour Live Hedge

(v) Bio-engineering Vegetative Measures For Stream Bank Protection

When drainage lines meander like a snake on relatively steep slopes the problem of stream bank erosion becomes quite serious. Generally, the *Khad* cut the bank on the outer side on a curve because of higher velocity and deposit the eroded debris on the inner side of the curve. The protection of the banks is necessary particularly when infrastructure and costly farm lands are at risk of bank cutting. With the retards and revetments, vegetative reinforcement is always considered essential. When flow discharges are low, the *khad* do not meander much, the vegetation alone can serve the purpose of bank protection.

Two lines of *Ipomoea carnea*, *Arundo donax*, *Phragmites* spp, etc. are planted along the eroded bank at one meter apart. Along with this, on cutting side, repelling type spurs are raised in double rows at 15-20 m apart and extending only up to 1/4th length of active flow. In between the spurs, seeding of fast growing plant species is carried out. In these vegetative spurs, mixing of *Ipomoea carnea* and *Arundo donax* provides better results. If possible, brush wood of *Ber (Ziziphus mauritiana)*, *Karonda (Carissa opaca)*, or any thorny shrub may be imbedded which not only protect the vegetation from under cutting by reducing the velocity of water, but also induce sediment deposition. In the subsequent year, bamboo may be planted on sand deposited moist bank sides to provide the additional strength to the spurs.

Such live hedges are used extensively for stream bank protection both alone and in conjunction with mechanical spurs and retaining walls. It is recommended that suitable shrub species like *Ipomoea carnea* should be planted in between the spurs along the gully banks and also along the spurs and particularly at its nose. These hedges break the velocity of water and induce deposition along the banks and near the structures. Once the land reclamation process starts, a row of bamboo is planted along the gully banks behind the live hedges. Bamboo as such is the most suitable plant for stream bank protection. On the reclaimed beds of the gullies, tree species like Khair (*Senegalia catechu*), *Cassia fistula* and Shisham (*Dalbergia sissoo*) are planted during second and third rainy season.

Where live spurs and hedge rows of *Ipomoea carnea* were planted for stream bank protection, the silt deposition along the bank takes place. In case, *Arundo donax* and *Ipomoea carnea* are mixed together, the stability is further enhanced. The best time for planting these vegetative structures is mid July to mid August when there is sufficient moisture in the soil. Most plants are vegetatively propagated.

(vi) Bio-engineering Measures for Landslide Control

The Himalaya is vulnerable to landslides where debris flow and other forms of mass wasting are common. The problem is pronounced in the Himalaya with high energy environment due to active tectonics, rugged topography with very high relief and highly concentrated monsoon precipitation. Moreover, high densities of both human and livestock populations and consequent changes in land use and land cover have caused further intensification of the processes of landslide and debris flow. The loss of life and properties from landslides, debris flow and flood has been increasing and the livelihood options of mountain people have been threatening.

Measures for Control of Landslides

As stated above, the cause for landslide could be multiple. Depending upon the reason for landslide, different treatments would be applicable. These are described below.

(vii) Landslides Caused by Excessive Wetness/Over Saturation of Slip Zone

In order to treat landslides caused by excessive wetness/ over saturation of slip zone, the proposed mitigation measure involves the following five steps.

(a) **Step 1:** The foremost requirement is to locate the source of water entering from upper areas. In case water is entering from some leaking irrigation channel, the control of such a leak by suitable technique would be necessary. The channel may have to be lined or water is allowed to pass through a pipeline in that particular stretch. In case of runoff water, the construction of a diversion channel would be necessary to divert the runoff and dispose it off at non-erosive velocity to a side drainage way. The diversion channel on gentle gradient may be protected by stone laid bed and sides supported by vegetation.

(b) **Step 2:** As a second step, drainage of excess water in the soil mass would require cross drainage works which may be carried out by installing perforated pipes, filter drains of stones/rubble (wire bolsters) and /or simple open drains converging to main pipe drain as shown in Fig. 5.26

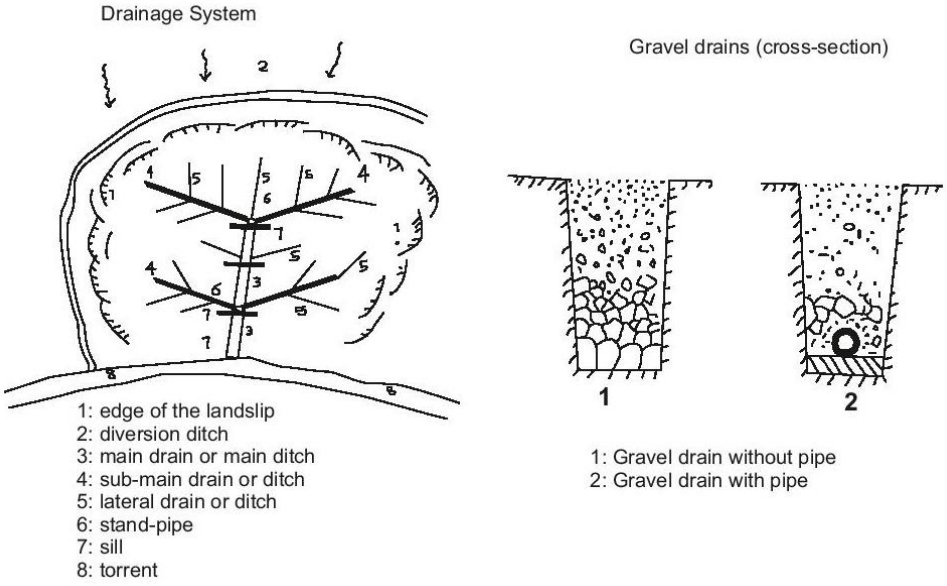


Fig. 5.26 - Drainage System of a Typical Landslip Site

In Fig 5.26 (a-h), (a) The landslide area is shown by outer hachuring; (b) A diversion ditch is provided to carry away the water from top for safe disposal; (c) A main drain of perforated pipes or gravel filter is provided in the centre along the slope; (d) Four sub-drains are provided as laterals to carry seepage/surface water to the main drain; (e) In each sub-drain, few lateral drains are provided to drain water from the wet/moist land; (f) At each junction, vertical stand pipes are provided in which sub-pipes discharge water; (g) The main pipe at the end is placed over a wall of check dam or retaining wall for support and water fall over this wall/structure without causing scouring at the base; and (h) All the drained water is ultimately drained into the main torrent or drainage system.

(c) **Step 3:** The next most important part is the construction of gabion/masonry/dry stone retaining walls. One major retaining wall at the base of the landslide/slip zone to hold back the entire soil mass is necessary. The site should be selected carefully where maximum load can be retained with minimum length. The height of the retaining wall may vary from 1.5-4 m depending upon the height of the soil mass at site. The base width of 2 m and top width of 1 m is often suggested. The retaining wall is constructed either straight with steps or slanting at an angle of 75° to 80° from the base. Weep holes of 7.5 cm must be made at regular interval and one hole for every 6 m^2 area. Back of the wall is filled with boulders for ensuring quick drainage. A toe drain in the foot of the wall may be required to carry the overflow to the nearby *Khad*.

(d) **Step 4:** The fourth step is the construction of series of staggered retaining walls on the slope. In addition to the main retaining wall at the base, series of staggered dry stone retaining walls are often required over the slipped land mass to retain the debris *in situ*. The local slate type stones are preferred for better stability. The number should not be too large as it would increase the weight of soil mass. More reliance has to be placed on vegetative measures.

(e) **Step 5:** The final step relates to the live hedges as part of bio-engineering measures**.** The live hedges of selected tree and shrub species are planted almost on contour and soil binding grasses are planted between the rows of hedges. Close growing plant types forming mat and showing spreading and creeping habit hold promise. Hardy and xerophytic plants are ideal for dry areas. *Woodfordia fruticosa* shrub has great potential because of deep root system and *Mimosa himalayana* a shrub is also a good colonizer. *Alnus nitida* (tree), *Debregeasia hypoleuca, Populus ciliata,* etc. are considered as potential soil conserving tree species. *Alnus nitida, Populus ciliata, Crataegus crenulata* and *Pennisetum clandestinum* (grass) on forest slopes damaged by landslides are also recommended. The tree species recommended for bioengineering application in the State of Himachal Pradesh are given in Table 5.51.
Species for the bio-engineering have been recommended along the altitudinal gradients of Ravi River Basin according to their occurrence. Three tiers plantation of species i.e., (i) Herbs, grasses and sedges; (ii) Shrubs; and (iii) Trees have been suggested as happens in natural succession. The altitudinal zone wise recommended species are given below, which can be considered as per the site conditions.

Table 5.51 - Plant Species Recommended for Bio-engineering in Ravi River Basin (Himachal Pradesh, Punjab and Jammu & Kashmir UT)

Altitudinal Zone	**Trees**
<1000m	*Senegalia catechu, Haldinia cordifolia, Aegle marmelos, Dalbergia sissoo, Terminalia* spp., *Mallotus philippinensis, Oroxylum indicum, Sapindus mukorossi, Dendrocalamus strictus, D. hamiltonii, Bambusa bambos, B. arundinacea, Holoptelea integrifolia, Albizzia* spp., *Celtis australis, Litsea chinensis, Alstonia scholaris, Phyllanthus emblica, Diospyros montana, Bauhinia variegata, Grewia optiva, Cassia fistula, C. javanica, Cinnamomum tamala, Anogeissus* spp., *Bixa orellana, Bombax ceiba, Casearia tomentosa, Delonix regia, Elaeodendron glaucum, Eucalyptus tereticornis, Ficus benghalensis, F. hispida, F. semicordata, F. rumphii, F. racemosa, Flacourtia indica, Holarrhena pubescens, Lagerstroemia parviflora, L. speciosa, Limonia acidissima, Magnolia grandiflora, Michelia champaca, Mimusops elengi, Peltophorum pterocarpum, Populus deltoides, Prosopis cineraria, Salix tetrasperma, Azadirachta indica, Tamarindus indica, Sysygiumvenosum, Butea monosperma, Boehmeria rugulosa* and *Morus alba.*

	Shrubs *Rosa* spp., *Debregeasia hypoleuca, Zanthoxylum armatum, Ziziphus* spp., *Carissa opaca, Desmodium gangeticum, Tephrosia hamiltonii, Justicia adhatoda, Tinospora cordifolia, Woodfordia fruticosa, Maesa indica, Nyctanthes arbor-tristis, Vitex negundo, Bambusa bambos, Berberis asiatica, Celastrus paniculatus, Rhus parviflora, Duranta repens, Flemingia semialata, Clerodendron* spp., *Murraya koenigii, M. paniculata, Meizotropis buteiformis, Senna tora, Thysanolaena maxima, Corchorus aestuans, C. olitorius, Coriaria nepalensis,* etc. **Grasses and Forbs** *Heteropogon contortus, Chrysopogon fulvus, C. serrulatus, Boerhavia diffusa, Festuca pratensis, Festuca arundinacea, Erianthus rufipilus, Phleum pratense, Themeda anathera, Arundo donax, Cymbopogon martinii, C. citrullus, C. microtheca, Eulaliopsis binata, Calamagrostis spp., Eragrostis nigra, Panicum maximum, Dichanthium annulatum, Sporobolus diander, Hierochloe laxa, Carthamus oxyacantha, Centella asiatica, Chamaecrista pumila, Cichorium intybus, Citrullus colocynthis, Desmodium triflorum, Eclipta prostrata, Malva parviflora, Malvastrum coromandelianum, Medicago polymorpha, Vetiveria zizanioides, Saccharum munja, Polygonum* spp., *Heteropogon contortus, Chrysopogon serrulatus, Fimbristylis* spp., *Polypogon fugax, Bothriochloa* spp., *Carex* spp., *Cyperus* spp., *Neyraudia reynaudiana,* etc.
Altitudinal Zone 2001-3000m	**Trees** *Alnus nitida, Albizia julibrissin, Abies pindrow, Alangium chinense, Acer caesium, A. pictum, A. acuminatum, Aesculus indica, Betula alnoides, Celtis australis, Carpinus viminea, Cupressus torulosa, Cedrus deodara, Corylus jacquemontii, Cornus macrophylla, Cornus capitata, Debregeasia saeneb, Euonymus tingens, E. lucidus, Fraxinus micrantha, Ilex dipyrena, Juglans regia, Lyonia ovalifolia, Myrica esculenta, Morus serrata, Neolitsea pallens, Pinus roxburghii, Populus ciliata, Pyrus pashia, Salix babylonica, Symplocos paniculata, Toona sinesis, Quercus oblongata, Q. glauca, Q. floribunda, Wendlandia heynei, Prunus cerasoides, Pinus wallichiana, Picea smithiana, P. cornuta, Quercus oblongata, Rhododendron arboreum, Salix tetrasperma, S. daphnoides, Toona sinensis, Taxus wallichiana, Ulmus wallichiana,* etc. **Shrubs** *Asparagus* spp., *Berberis lycium, Berberis aristata, Cotoneaster bacillaris, Clematis buchananiana, C. montana, Elaeagnus conferta, Cornus oblonga, Colquhounia coccinea, Deutzia staminea, D. corymbosa, Daphne papyracea, Desmodium elegans, Debregeasia hypoleuca, Myrsine africana, Drepanostachyum falcatum, Rubus* spp., *Hypericum oblongifolium, Inula cuspidata, Indigofera heterantha, Lonicera* spp., *Rosa moschata, R. sericea, R. macrophylla, Sorbaria tomentosa, Salix denticulata, Sinarundinaria falcata, Syringa emodi, Skimmia laureola, Thamnocalamus spathiflorus,*

	*Sarcococca saligna, Pyracantha crenulata, Prinsepia utilis,Viburnum cotinifolium, V. grandiflorum,*etc. **Grasses, Sedges and Forbs** *Arundinella nepalensis, A. pumila, Apluda mutica, Agrostis gigantea, A. pilosula, A. munroana, Anemone rivularis, Arundinella pumila, Ainsliaea aptera, Angelica glauca, Agropyron* spp., *Alopecurus aequalis, Bothriochloa pertusa, B. parviflora, Bergenia ciliata, Chrysopogon gryllus, Carex* spp., *Cyperus* spp., *Cymbopogon distans, Chrysopogon gryllus, Calamagrostis* spp., *Dactylorhiza hatagirea, Dactylis glomerata, Festuca pratensis, F. valesiaca, F. arundinacea***,** *Geranium wallichianum, Koeleria* spp., *Poa pratensis, Erianthus filifolius, E. rufipilus, Phleum pratense***,** *Cymbopogon distans, Saccharum spontaneum, Rumex hastatus, Melilotus officinalis, Mentha arvensis, Trifolium repens, T. pratense, Valeriana jatamansi, Themeda anathera, Fimbristylis,* spp., *Polygonum* spp., *Polypogon fugax, Poa pratensis, P. annua, Sinopodophyllum hexandrum, Polygonatum verticillatum, P. cirrhifolium, Phytolacca acinosa, Setaria glauca, Trifolium pratense, Trillium govanianum, Viola biflora, Valeriana jatamansi, Verbascum thapsus,*etc.
Altitudinal Zone >3000m	**Trees** *Abies spectabilis, A. pindrow, Acer acuminatum, Betula utilis, Pinus wallichiana, Populus ciliata, Prunus cornuta, Quercus ilex, Q. semecarpifolia, Salix daphnoides, Cedrus deodara, Picea smithiana, Taxus wallichiana, Cupressus torulosa*, etc. **Shrubs** *Colutea nepalensis, Cotoneaster bacillaris, C. acuminatus, Daphne oleoides, Juniperus communis, J. indica, J. squamata, Rhododendron campanulatum, R. Anthopogon, Rosa sericea, Rosa macrophylla, Salix* spp., *Syringa emodi, Thamnocalamus spathiflorus, Skimmia laureola, Lonicera* spp., *Ribes* spp., *Spiraea* spp., *Rubus foliolosum, Berberis* spp., etc. **Herbs, Grasses and Sedges** *Aconitum heterophyllum, Anemone polyanthes, A. tetrasepala, Arnebia benthamii, Artemisia*spp., *Dactylorhiza hatagirea, Danthonia cachemyriana, Heracleum candicans, H. wallichii, Polygonatum verticillatum, , P. multiflorum, P. cirrhifolium, Selinum tenuifolium, S. vaginatum, Allium humile, Geranium wallichianum, Bergenia stracheyi, Angelica glauca, Picrorhiza kurroa, Sinopodophyllum hexandrum, Rheum* spp., *Carex* spp., *Potentilla* spp., *Bromus* spp., *Bistorta* spp., *Festuca pratensis, F. valesiaca, Trifolium pratense, Poa pratensis, P. alpina, Dactylis glomerata, Agrostis gigantea, A. pilosula, A. munroana, Agropyron* spp., *Brachypodium sylvaticum, Bromus himalaicus, B. ramosus, Danthonia cachemyriana, D. cuminsii, Stipa roylei, Valeriana jatamansi, V. hardwickii, Fritillaria roylei, Ainsliaea aptera*, etc.

(Source: HFRI, Shimla)

The plant species suitable for bio-engineering in Himalaya as reported by Agrawal (2006) are given in Table 5.52

Table 5.52 - Plant Species Suitable for Bio-engineering Practices in Indian Himalayan Region

Species	Elevation (m)	Site Condition	Functions	Method of Propagation
Species Suitable for Entire Indian Himalayan Region				
Alnus nepalensis	900 m - 2,700 m	Moist to Wet	Anchor, catch, armour, reinforce, support, drainage	Seed
Amomum subulatum	Upto 1,700 m	Swamp	-do-	Rhizome
Camellia sinensis	Upto 2,000 m	Varied and moist	Armour, catch, reinforce	Seed/cuttings
Crotalaria tetragona	Upto 1,600 m	Dry	-do-	Seed
Dalbergia sissoo	Upto 150 m	Dry	-do-	Seed
Dendrocalamus hamiltonii	Upto 1,300 m	Moist to Wet	Armour, catch, reinforce, support	Nodal segment
Ficus semicordata	Upto 2,000 m	Hot and dry, varied	Armour, catch, reinforce	Seeds/polypots
Flemingia macrophylla	300 m - 2,000 m	Varied	-do-	Seeds
Lagerstroemia parviflora	Upto 1,200 m	Varied to dry	Anchor, catch, armour, support	Seeds/polypots
Musa paradisiaca	Upto 1,300 m	Varied to dry	-do-	Root suckers
Thysanolaena maxima	Upto 2,000 m	Moist	-do-	Rhizome
Toona ciliata	Upto 1,700 m	Moist, good soil	-do-	
Species Suitable for Western Himalaya				
Justicia adhatoda	Upto 1,000 m	Varied	Support, catch, reinforce	Hard wood cuttings
Drepanostachyum falcatum	Above 1,600m	Moist	Catch, armour,	Rhizome

Species	Elevation (m)	Site Condition	Functions	Method of Propagation
			reinforce, support	
Bauhinia variegate	Upto 1,200 m	Moist	-do-	Seed
Boehmeria rugulosa	300 m - 1,200 m	Varied	-do-	Seed/cuttings
Buddleja asiatica	600 m - 1,800 m	Dry, harsh	Catch, armour, reinforce	Seeds/hard wood cutting
Dodonaea viscosa	Upto 1,700 m	Varied, dry	-do-	Seeds
Duranta repens	Upto 1,500 m	Varied, dry	-do-	Seeds/cuttings
Erythrina suberosa	900 m - 3,000 m	Varied	-do-	Seeds/cuttings
Eulaliopsis binate	Upto 1,500 m	Dry	Armour, catch, reinforcement	Slips
Grewia oppositifolia	Upto 2,100 m	Dry to moist	Anchor, catch, armour, drainage	Seed
Heteropogon contortus	Upto 2,100 m	Dry	-do-	Slips/seeds
Juglans regia	1,000 m - 3,300 m	Dry to moist	-do-	Seed
Melia azedarach	Upto 1,800 m	-do-	-do-	Seed
Morus alba	Upto 3,300 m	-do-	-do-	Cutting, seed
Pennisetum purpureum	Upto 1,700 m	Dry	-do-	Rhizome/ cutting
Pyrus pashia	1,500 m-2,500m	Varied	-do-	Seeds
Quercus glauca	600 m-2,000 m	Moist	-do-	Seed
Saccharum spontaneum	Upto 2,000 m	Hot, dry and moist	Armour, catch, reinforce	Slip/cutting/ seeds
Salix tetrasperma	Upto 1,800 m	Moist	Support, catch, reinforce	Cutting
Sapium insigne	Upto 1,800 m	Dry	-do-	Cutting
Vitex negundo	Upto 1,500 m	Moist to dry	Support, catch, reinforce	Cutting

Species	Elevation (m)	Site Condition	Functions	Method of Propagation
Woodfordia fruticosa	Upto 1,500 m	Dry	-do-	Seed

(Source: Agrawal, 2006)

Geo Jute:

In a fast developing country like India due to the remarkable development in road infrastructure, soil stabilization has become the major issue in construction activity. Stabilization is an unavoidable for the purpose of highways and runway construction, stabilization denotes improvement in both strength and durability which are related to performance. Geo-Jute can play a vital role as they improve the bearing capacity. Jute plants are grown mostly in the Gangetic delta in the eastern part of the Indian sub-continent. People used to consume its leaves as a vegetable and also as a household herbal remedy (Farooq and Goyal, 2017). Geo-textile is a knitted structure made up of natural material or synthetic polymers. Use of natural geo-textiles (geo-jute) is preferred as they are less expensive, available from local resources and are environmental friendly due to their biodegradability. Geo-textile has been used in bank protection, establishment of steep hill slope, checking run-off etc. Geo-jute was used for erosion control in mine spoil on different slopes, ranging from 30°-70°. The geo-jute should be of the grade 500 g/m^2 with strand thickness of 5 mm and open area 65 %. In recent times, natural geo-textile product called geo-jute have entered the market and becoming popular for eco-restoration of disturbed sites. This is basically a mat made of jute with mesh size of 2-5 mm having aperture of 10 mm. This bio-degradable material was found highly effective when used to stabilize mine-spoiled sites, landslide/slip areas and specific slopes stabilizing of which is essential to maintain road/ railway network. The area to be treated is carefully measured and the length and width of sheet required is calculated. The surface to be covered is smoothened. The mat sheet is spread over the area and is secured by driving wooden stakes to a reasonable depth of 50-100 cm. The sides of strips can be buried in a 30 cm deep trench. The sheets are overlapped with the adjoining sheet. The seeds/rooted slips/cuttings of the selected plants are planted during rainy season through the openings at quite close spacing to have good cover in a short time. The jute mat does not allow the movement of eroded mass and allow undisturbed germination and establishment of plants. Geo-jute was found successful for initial establishment of vegetation on degraded slopes up to 60°- 70°. The total estimated cost of jute and planting is around Rs. 25/-per m^2 (Plate 5.9).



Plate 5.9 – Use of Geo-Jute on Steep Degraded Slopes

Log Crib Structures

The log wood structures are generally constructed where stone check dams are not feasible because of steep slope. The log check dams are constructed as steps by nailing each of the horizontal cross poles of long lasting wood with 3-4 longitudinal poles. These poles are of 3-4 m length and 8-12 cm diameter. These are driven to a depth of 50-60 cm depth and erected in two parallel lines about a meter apart from pole to pole and one meter from line to line. The height may be kept about 1.5 m above the ground. The log wood crib structures are filled with stone/brush wood which can be used to stabilize slopes above 40°. The inter-space between paired lines is vegetated with suitable fast growing plant species. These are stable because horizontal poles can withstand the load of the earth above it and consequently hold the soil more effectively and provide the vegetation an opportunity to establish.

Gunny Bag Structures

The practice of using cement gunny bags for temporary protection is quite common by the PWD Department as they have plenty of bags available. These bags are filled with inert material like sand and gravel and used for bank protection, slope stabilization and temporary diversions. Soil is not used as it hastens decomposition of gunny bags. For more stability and durability, the cement and sand mixed in the ratio of 1:20 may be used. The filled gunny bags are laid in row over one another to gain the desired height. The back side is filled with earth and compacted.

(viii) Mechanical Measures for Soil and Water Conservation

Various mechanical measures are used for soil and water conservation. These include various engineering techniques and structures aim at the following objectives.

a) To divide a long slope of land into a series of shorter ones in order to reduce the velocity of runoff water.
b) To retain the water in the land for long period so as to allow maximum water to be absorbed and held in the soil and less water flows down the slope of the land at non-erosive velocity.
c) To protect the soil against erosion by water.

The important mechanical soil conservation measures are described below.

(i) Engineering Measures for Landslide Control

In case of landslides when the overburden is pushed down slope and is compacted, it may cause a problem of mass movement of the overburden. In such cases, engineering measures like constructing a toe wall of stone at a bottom of the overburden checks the sliding of the overburden. To avoid erosion and land slide through over flowing water from uphill side, a diversion channel of 1/2 m x 1/2 m is constructed. This not only avoids erosion, but also prevents accumulation of water at the active mine site below it. Some have used gabion structure as mechanical measures in mined area to check soil erosion. They were of the view that concrete and brick masonry fails easily in areas which settle down. However, in such areas, gabion structures, owing to their inherent flexibility, ability to bend without breaking, permeability to water, but not to soil and their reusable nature prove their success. Gabion structure is a box type structure. For the construction of gabion, 12 gauge galvanized iron (GI) wires are used while 14 gauge GI wire is used for binding purpose.

Other soil and water conservation measures for erosion control are described below.

Dry Stone Check Dams

Dry stone check dams are porous checks constructed across the *Nallah* using loose boulders to check water velocity and arrest silt (Fig. 5.27 and Fig. 5.28). This is usable in all areas irrespective of soil and rainfall. They are effective for reducing run-off velocity in upper parts of the drainage lines having steep slopes. These are planned in shallow/first order gullies having stones of suitable quality and required quantity locally available in and around the drainage ways. When properly constructed by the trained masons and suitable sites are selected, such structures help in stabilizing bed gradient and establishment of vegetation in the silted up portions of the gullies. This is a semi-permanent mechanical measure. Slab type dressed stones are arranged with proper spillway in the center. At least half a meter anchorage to sides and half meter foundations are enough for a one meter high structure.



Plate 5.10 – Typical Dry Stone Structure Made of Slate Type Stones for stabilitv

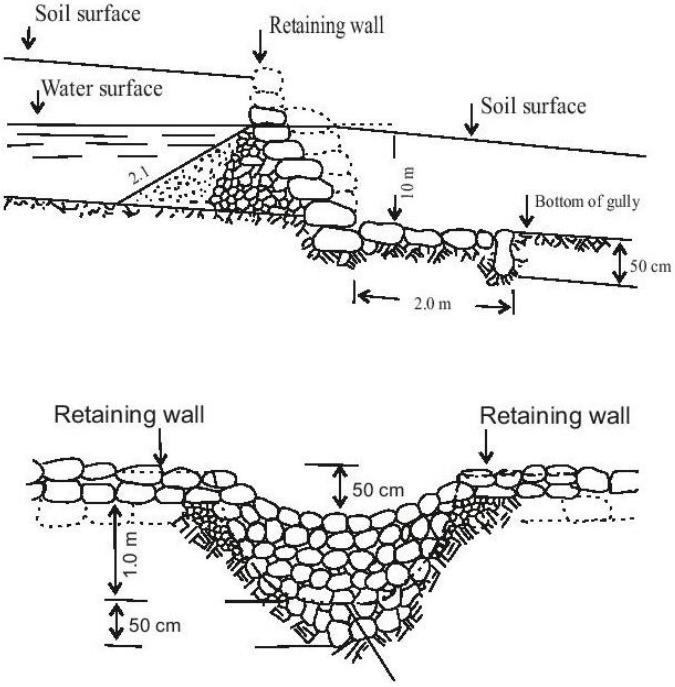


Fig. 5.27 - Design of Dry Stone Check Dams

Proper site selection is very important for all types of erosion control structures. These structures are constructed in series one after the other usually keeping head and toe relationship excluding the permissible stable bed gradient. The following safeguards may be considered in site selection.

a) The gully should have narrower section at the dam axis.
b) It should have bowl type wider section above the site for storage of water and silt.
c) Preferably, the bed gradient in *Nallah* should be as low as possible above the site. This would ensure more storage of water/debris.
d) Slab type/flat stones should be available near the sites. No stones should be excavated from the actual *Nallah* bed.
e) Construction with stones transported from longer distances be avoided in view of high cost involved.
f) In case *Nallah* bed is well covered with vegetation and no scouring is visible, then dry stone check dams may not be required.

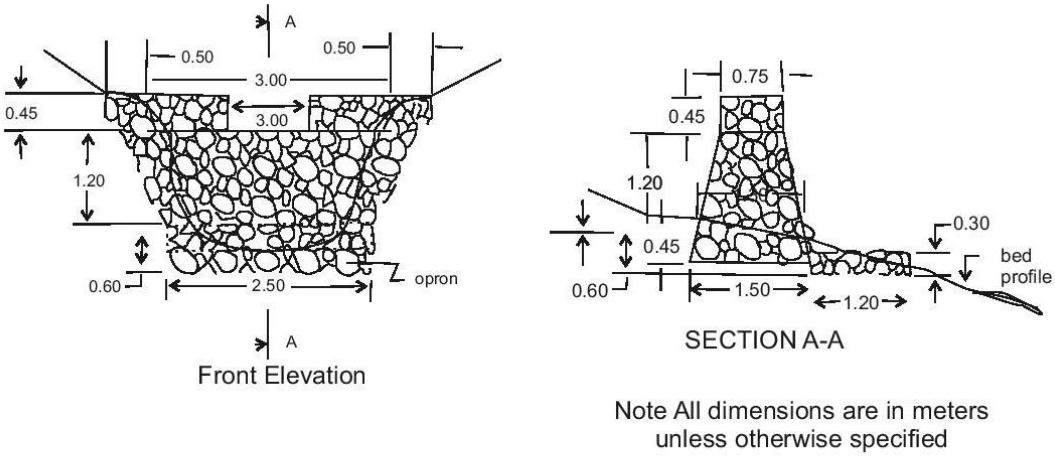


Fig. 5.28 - Design of Dry Stone Check Dam

Gabion Check Dams

The gabion check dams may be constructed in main gullies/channels for retention of debris and soil accumulation without pondage. Check dams encourage good plant cover not only along the bank but also in the bed of the stream due to increased moisture regime. Gabion structures are made with stones/boulders packed closely in wire mesh cages made with GI wire of 10 gauge thickness. Gabion structures are preferred in soil conservation works as they are: (a) flexible i.e., bend without breaking, (b) porous i.e., water can seep through them, (c) stable, and (d) economical as compared to cement concrete structures.

GI wire of 8-10 gauge thickness is used in the fabrication of wire nets and the mesh is generally kept 10-15 cm. Gabion structures have a long life (20-25 years) almost similar to cement masonry permanent structures (Fig. 5.29)

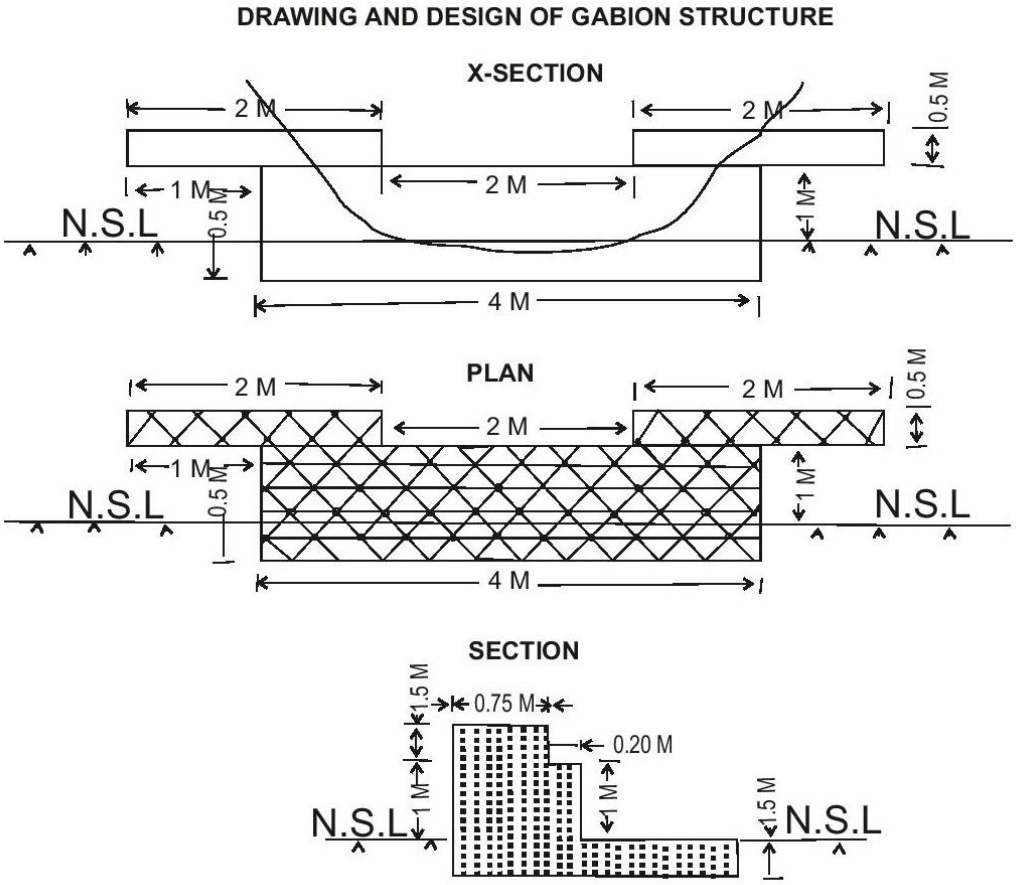


Fig. 5.29 - Drawing and Design of Gabion Structure

Permanent Structures for Gully Stabilization

Permanent soil conservation structures are often used for runoff and sediment control as well as storage of water for irrigation in arable and non-arable lands. These can be constructed of cement masonry or gabion. Their use becomes necessary when the runoff from the catchments is too large to be handled with vegetative measures/temporary structures or where high degree of safety is warranted against the loss of life and property. However, it should be ensured that the benefits from such structures are justifiable against the cost. Permanent structures in soil conservation are normally designed for a Recurrence Interval (RI) or frequency of 10 to 50 years which means that they are supposed to discharge maximally during the design period. The structure should be strong enough to withstand the forces exerted by water/earth.

Silt Detention Structure

These check dams are constructed in *Khads* to check the flow of silt. A cement concrete wall is constructed across the flow of water. On the downstream side the buttresses can be constructed, if the length of the check dam is more than 3.0 m. Such types of check dams need proper foundation, as well as sufficient embedment in the sides. A spillway is constructed on the top of the check dam. A cistern is constructed on the downstream side of the check dam. Apron of the proper length is constructed depending on site conditions and drop (Fig. 5.30).

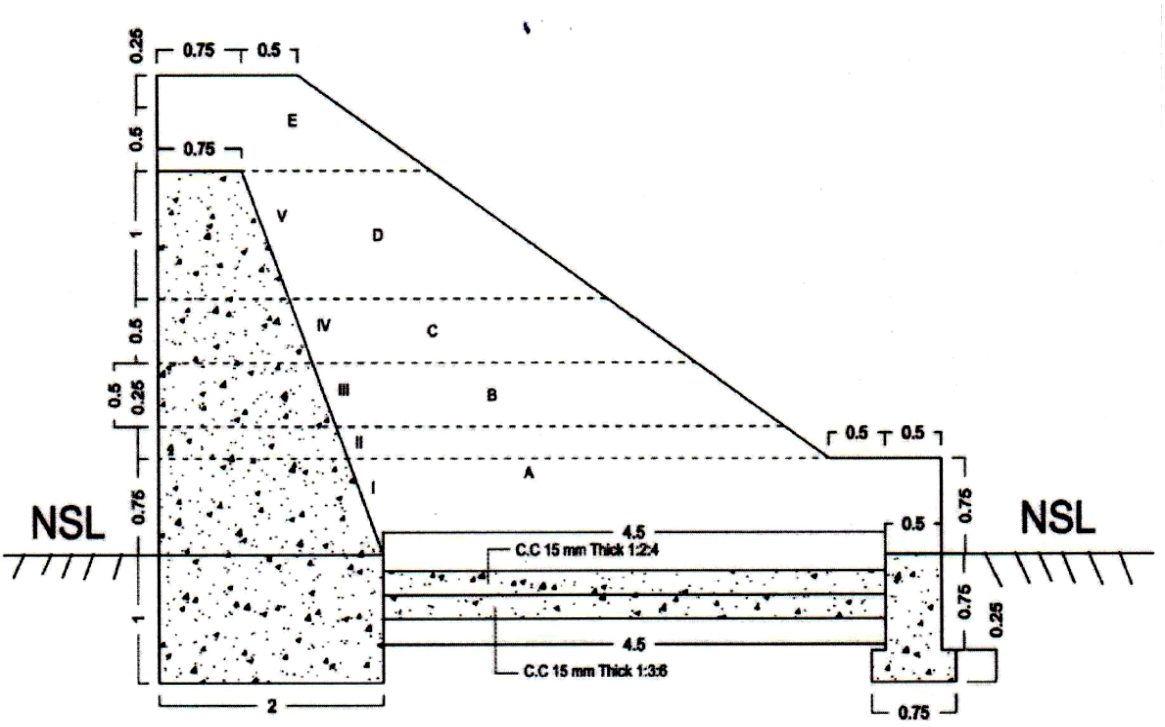


Fig. 5.30 - Silt Detention Structure

Stream Bank Erosion Control

Several mechanical measures can be used for the control of soil bank erosion. These are described below.

(a) Mechanical Spurs: Spurs are structures constructed transverse to river flow extending from one of the banks at an angle to the flow. These structures are known by different names, such as spur-dikes, groynes, transverse dikes, jetties, etc. Their main functions are to serve as a protection to the stream bank from erosion and to train the main stream along a desired alignment. A well designed series of spurs built along an eroding bank will, firstly, check the erosion, and secondly induce siltation in the quite water between the spurs. As the silt beds so formed rise above normal low water level, vegetation may be planted on them to bind the silt and to catch more (Fig. 5.31

Types of Spurs: The spurs may be classified according to: (a) Method and material of construction – permeable and solid/impermeable type, (b) Function served – attracting, deflecting and repelling type, (c) Height of spur with respect to high water – submerged or un-submerged type, and (d) Special type – T headed, hockey type, etc. Depending on the purpose, spurs can be used singly or in series. River conditions affecting the choice of type and design of spurs may be:

a) Grade and velocity of river
b) Character of bed and material carried – shingle, sand mud, etc.
c) Width of waterways and area of flood way.
d) Depth of waterway, and height of flood rise.
e) Availability of material and financial resources.

Spur Types According to Material of Construction: Wire created (gabion) and vegetative spurs are the commonly used permeable spurs in torrent control works. They have a dampening action on the velocity of approaching flow. Gabion spurs are ideally suited as they are flexible, porous, stable and economical. They are fabricated using 8-10 gauge G.I wire. Spurs constructed with vegetative materials i.e., trees, brushwood, etc. are also in vogue since olden times. Cement masonry or concrete structures come under the impermeable types.

Spur Types According to Function Served: According to the function served, spurs may be of the following types.

(a) Repelling type: The repelling type of spur projects towards upstream direction of the flow current. The spur angle is recommended to be 95^0 - 110^0 from the downstream (i.e., 5^0-20^0 with normal flow towards upstream). It has the property of repelling flow away from it.

(b) Attracting type: Attracting type of spur projects towards the downstream of flow direction, normally an angle of 30^0-60^0 from downstream. It attracts the river flow towards it, hence named so.

(c) Deflecting type: Deflecting type of spur is made projecting at right angle with the bank. It is usually of short length and gives local protection.

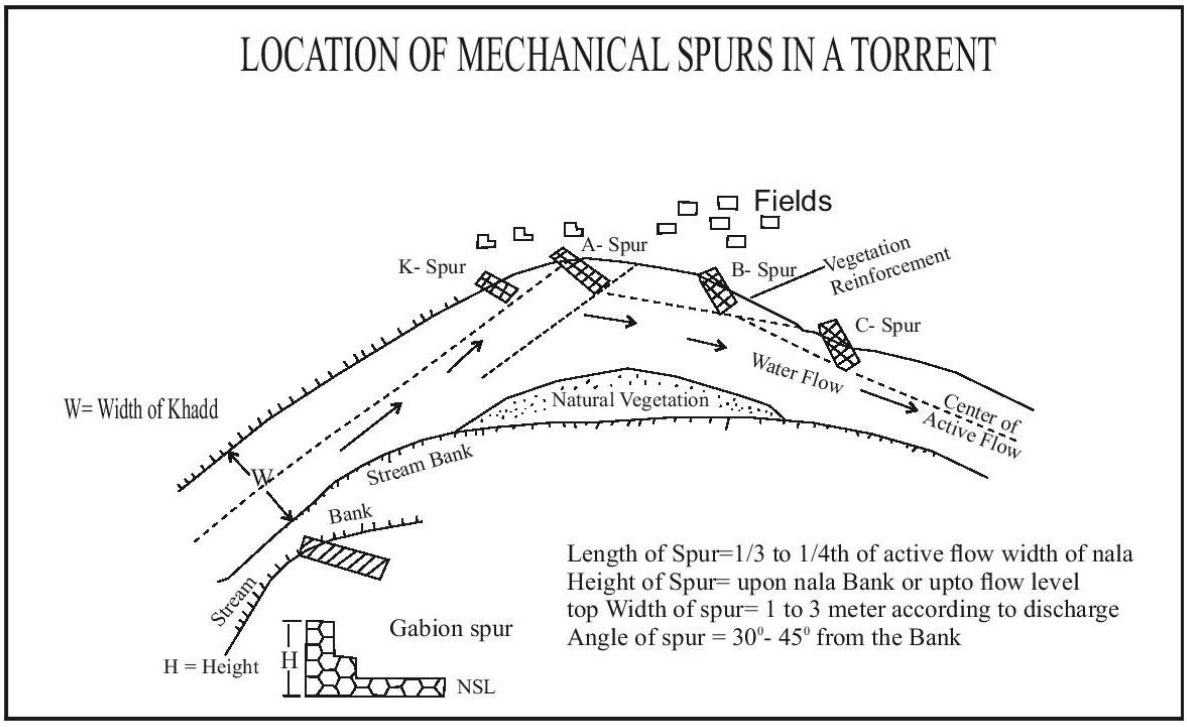


Fig. 5.31 - Location of Mechanical Spurs in a Torrent

Crate Wire Spurs - Cement masonry structures are impermeable, but they are not generally used in soil conservation works. Semi-permeable gabion structures are being used extensively for stream bank protection because they are flexible and economical. Gabion spurs are made of boulders packed closely in wire crates made of 10 gauge GI wires (Fig. 5.32)

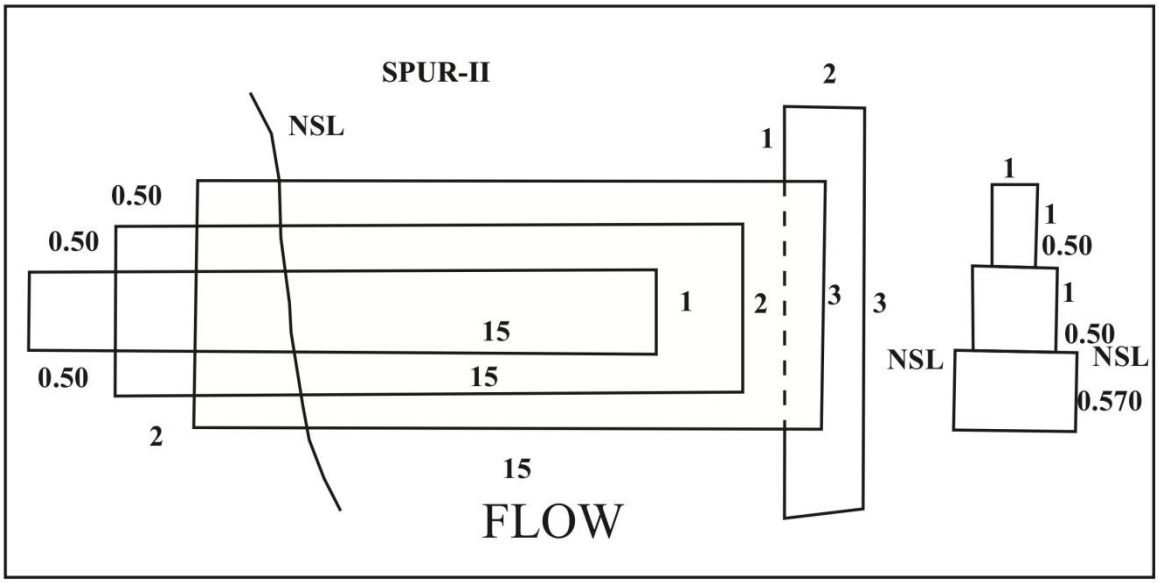


Fig. 5.32 - Crate Wire Spur

Retaining Walls - Masonry or gabion retaining walls are constructed to retain the sliding debris from the hill sides. The retaining walls are also constructed to provide support to buildings made on steep but unstable slopes. The retaining walls are constructed to stabilize steep hill slopes and to provide stability to stream banks. In case *Nallah*/gullies are cutting the banks and there is costly land, buildings or road near the top of the banks, then retaining walls are constructed to provide stability to the banks. In case slope length is small, then only one retaining wall may be sufficient. But, if slope length is more then a series of retaining walls, one over the other are made to provide necessary protection (Fig 5.33).

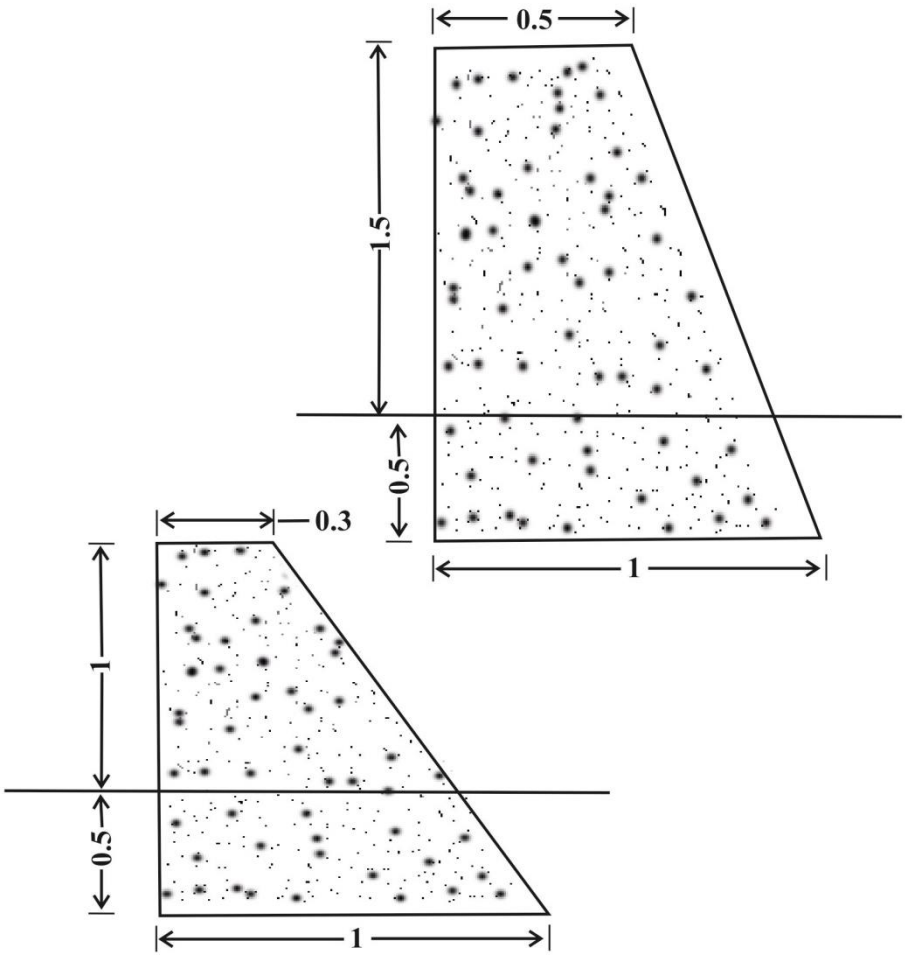


Fig. 5.33 - Masonry Retaining Walls

(C) Riparian and Riverine Wildlife Management

Riparian areas are the zones along water bodies that serve as interfaces between terrestrial and aquatic ecosystems. Riparian ecosystems generally compose a minor proportion of the landscape. Typically, however, they are more structurally diverse and more productive in plant

and animal biomass than adjacent upland areas. Riparian areas supply food, cover, and water for a large diversity of animals, and serve as migration routes and connectors between habitats for a variety of wildlife (Manci, 1989). A healthy riparian zone contains diverse plant species, aquatic and terrestrial wildlife. Riparian zones are an unusually diverse mosaic of landforms, communities and environments within the larger landscape. The riparian area or corridor interacts with adjacent water body through reciprocal exchanges of materials and energy (NRC, 2002; Verry *et al*., 2004; Naiman *et al*., 2005; Stoffyn-Egli and Willison, 2011). As such, riparian areas strongly influence the ecological integrity of freshwater ecosystem.

According to Dudgeon *et al*. (2006), riparian areas support high level of biodiversity on relatively small areas of the landscape. Riparian vegetation is important to aquatic ecosystems because it regulates the energy base by shading and supplying plant detritus to the stream. Narrow headwater streams are influenced most by riparian vegetation, both through shading and as the source of organic matter inputs. These low-light, high-gradient, constant-temperature streams receive an abundant supply of coarse particulate matter in the form of plant detritus. A group of macro-invertebrates known as shredders reduce detrital material to smaller particulate organic matter which becomes the food for another group of invertebrates, collectors. The abundance of life further supports both macro invertebrate and fish predators (Vannote *et al*. 1980).

The functioning of aquatic ecosystems depends on the exchange of subsidies but various human activities act as stressors and easily disrupt reciprocal flows. The clear felling of trees can increase the input of silt, nutrients, and pollutants to streams and influence assemblages of aquatic insects (Gundersen *et al*., 2010). Changes in forest composition caused by forestry also influence terrestrial input to rivers. Planted coniferous forests, for instance, will produce fewer subsidies for fish growth than broad leaved forests will (Inoue *et al*., 2013). There is ample evidence that the use of exotic tree species in forestry, particularly *Eucalyptus* can reduce decomposition and nutrients levels, which in turn affect macro invertebrates as leaves of *Eucalyptus* are poor quality food for invertebrates owing to their oil and polyphenolic content, ultimately can also affect fish growth and survival (Richardson and Rejmanaek, 2011; Larranaga *et al*., 2014; Morrongiello *et al*., 2013; Hjälteń *et al*., 2016). The presence of exotic tree and shrub species is likely to have a significant influence on forest-stream links. Flow regulation and stream channelization have profound impacts on aquatic and adjacent habitats.

The wildlife community within riparian zones is composed of obligate and generalist riparian species as well as introduced species. Riparian obligates are species considered so highly dependent on riparian and aquatic resources that they would disappear with the loss of this habitat from the drainage basin. Amphibian species dominate the list of riparian obligates when the proportion of obligates is compared to the total number of species present in a given situation. Species that utilize both riparian and upland forests are considered riparian generalists. Obligate riparian bird species require aquatic or riparian habitat for either breeding, nesting, roosting, or feeding, although several species do not require aquatic or riparian habitat at all

times. Fishing eagle and some raptors are best examples of obligate species as they depend for roosting/nesting on large trees in the riparian zones while they depend exclusively on the aquatic/riverine environment for feeding on fishes. Undisturbed riparian ecosystems normally provide abundant food, cover, and water. Often they contain some special ecological features or combinations of features that are not found in upland areas. Consequently, riparian ecosystems are extremely productive and have diverse habitat values for wildlife (Brinson *et al*., 1981).

The enhanced extraction of forests and water resources has led to habitat degradation, biodiversity loss and decline in ecosystem services. As a consequence, ecological restoration has become a conservation priority. Restoration efforts to offset this trend, however, are not always effective owing to the fact that several restoration projects target single ecosystem and fail to acknowledge functional links between ecosystems. Despite the clear evidence of strong linkages between aquatic (riverine) and terrestrial (riparian) ecosystems, there are still few scientific studies evaluating and highlighting combined efforts jointly restore streams and forests (Hjälteń *et al*., 2016).

In the context of Ravi Riverscape, the riparian forests as well as riverine ecosystem have been severely impacted in the mountainous tract of Himachal Pradesh and Jammu & Kashmir UT and in the alluvial plains of Punjab due to enhanced human activities. It is very well established fact that riverscape and its environment, wild flora and fauna in the riparian zone as well as the aquatic environment have been adversely impacted due to various anthropogenic stressors. In the aquatic environment, fish fauna, particularly migratory species have been impacted while a wide range of other species using the riparian zone as well as the lotic system have also been impacted. Thus, there is an urgency to protect, conserve, and rehabilitate species of concern. Several protected areas i.e., Kalatop-Khajjiar WLS, Tundah WLS, Kugti WLS, Dhauladhar WLS, Gamgul-Siahbehi WLS, Jasrota WLS, Dhauladhar WLS and Kathlaur Kushlian WLS) are some of the prominent PAs along the main channel of Ravi River and its tributaries.

In view of the above enormous significance of riparian zones and riverine ecosystem, protected areas, and associated threatened biodiversity, it is vital to have appropriate conservation interventions to protect the wildlife habitat and associated wildlife. The following forestry interventions are proposed in the present DPR.

a) Collection of baseline information – status, distribution and population dynamics
b) Ecological research on select threatened taxa
c) Protection and improved management of protected areas
d) Protection and conservation measures for riparian and riverine wildlife
e) Habitat enrichment and improvement including control of invasive and alien species in the terrestrial and aquatic environment
f) Conservation breeding and reintroduction of gharial, turtle, otter, etc.
g) Awareness creation
h) Capacity development
i) Long term ecological monitoring

In view of the above proposed forestry interventions and allied activities, necessary budget provisions for IAs in two concerned States and one Union Territory within the riverscape have been made towards site specific activities for the protection, management, restoration and conservation of wildlife relevant to riparian zones and riverine (aquatic) ecosystem.

(D) Wetland Management

Wetland sustains all life and performs some useful functions in the maintenance of overall balance of nature. Wetlands are fragile ecosystems and are susceptible to changes even with little change in its composition of biotic and abiotic factors. Wetlands are most productive and biologically rich ecosystems on earth and are also among the most endangered. In recent years, there has been increasing concern over the continuing degradation of wetlands and in particular, rivers and lakes. They interface between land and water systems. 'Wetlands' is the collective term for marshes, swamps, bogs, and similar areas. They filter sediments and nutrients from surface water and support all life forms through extensive food webs and biodiversity. Natural and manmade wetlands those occur in two concerned States i.e., Himachal Pradesh, Punjab and one Union Territory i.e., Jammu & Kashmir help in maintaining the ecological balance, serving the various needs of the society by recycling nutrients, purifying water, attenuating floods, maintaining stream flow, recharging groundwater, etc. Wetlands are not only one of the most productive ecosystems, but are also repository of rich and unique biodiversity. In addition, majority of wetlands in Himachal Pradesh (HP), Jammu & Kashmir UT (J&K UT) and Punjab offer enormous opportunity of livelihood for local communities, and are major attraction centers for recreation and tourism activities. In the context of Ravi Riverscape, the Manimahesh Lake, Khajjiar Wetland, Ranjit Sagar Dam, Keshopur Lake, Jastarwala Lake are some of the prominent wetlands of greater ecological, cultural and recreational importance. Majority of these wetlands on account of small size, large interface with urban/ rural environments, traditional resource dependence, and enhanced biotic activities are either deteriorated or in the process of degradation. In view of this, as a part of the proposed forestry interventions in HP, Punjab and J&K UT as one of the strategies on conservation interventions, the present DPR focuses on wetland conservation and restoration efforts. The proposed strategy for conservation and restoration of wetlands is broadly two pronged. Firstly, the proposed strategy aims to protect, manage and restore priority wetlands within the Ravi Riverscape. Secondly, the strategy also focuses on restoration and conservation of featured species and species of concern those are relevant to various wetlands. The strategy towards wetland conservation and restoration has been described below.

(a) Protection, Management and Restoration of Wetlands along the Ravi River

In most cases, the necessity is to guarantee protection of different wetlands and encourage their scientific management. The Space Application Center, Ahmedabad has provided the baseline information on various natural and manmade wetlands in HP, Punjab and J&K UT by way of preparing the inventories and mapping. However, such information is more than 10 years old and there are large scale land use and land cover changes besides rapid development and enhanced

biotic activities in HP, Punjab and J&K UT. Subsequently, it is utmost significance that exercise is repeated on a shorter interval of five year in order to keep track on the present status of threatened wetlands. Being intricate, delicate and dynamic ecosystems, majority wetlands require a lot of desired protection and scientific management. This essentially requires the preparation of comprehensive management plans adopting the landscape approach incorporating insights from research and monitoring activities. Majority wetlands sites require creation of awareness, decrease in biotic pressure and creating awareness so as to seek support for conservation of wetlands through the execution of site specific eco-development strategy. The conservation of wetlands and restoration of degraded wetlands require multidisciplinary understanding and proper methodologies. The officials and frontline staff involved in the protection and management of various wetlands require opportunities for capacity development and support of modern technologies and tools so as to implement prominent activities related to protection, habitat enrichment/improvement, species management, and control of invasive and alien species, eco-development, tourism and visitor management, nature interpretation and monitoring.

(b) Restoration and Conservation of Aquatic and Riparian Wildlife

The available published literature has revealed the declining state of several prominent and featured species (e.g., fishes–snow trout and mahseer; amphibians; water birds and aquatic mammals) and narrated recent efforts to restore/conserve such species. The recent rediscovery of the Indus River Dolphin after a considerable gap and efforts to create Beas River Conservation Reserve in the Punjab efforts are needed to explore potential habitat/stretches in Ravi River or its tributaries where the Indus River Dolphin can be reintroduced and conserved. The community led participatory approaches are thus, visualized so as to augment and strengthen populations of Rare, Endemic and Threatened (RET) species. The foregoing review also revealed that there is conspicuous devoid of much desired scientific insight on most of the RET species with respect to their distribution and status, population dynamics, ecology, habitat preference, reproductive behavior, and their likely response to climate change.

In view of the above, the following site specific activities are being proposed towards wetland management and conservation as a part of the present DPR and proposed forestry interventions.

- **a)** Protection of wetlands and associated floral and faunal species including survey and demarcation.
- **b)** Habitat enrichment and improvement works – de-siltation, control/ removal of invasive alien species, protection of embankments, soil and moisture conservation works, and afforestation.
- **c)** Conservation of RET species.
- **d)** Ecological and management oriented research.
- **e)** Eco-development measures namely awareness, mitigation of people-PA/human-wildlife conflict, sustainable livelihoods, and participatory management.
- **f)** Nature interpretation and ecotourism.
- **g)** Long term ecological monitoring.

Accordingly, necessary budget provisions for concerned Implementing Agencies i.e., State Forest Departments in HP, Punjab and J&K UT have been made towards proposed activities for wetland management and conservation.

5.5.5 Supporting Activities

In addition to the above stated proposed forestry interventions in three types of landscapes i.e., Natural, Agriculture, and Urban and three types of conservation interventions, execution of priority supporting activities is considered vital for the successful implementation of the present DPR and envisaged wide range of specific activities in the priority sites identified within the Riverscape on the basis of geospatial analysis and inputs from the field. A list of supporting activities is given in Table 5.53.

Table 5.53 - List of Supporting Activities

Supporting Activities			
Sr. No.	**Himachal Pradesh**	**Jammu and Kashmir UT**	**Punjab**
1.	RV/HP/SA/01- Policy Level Intervention	RV/JK/SA/01- Policy Level Intervention	RV/PB/SA/01- Policy Level Intervention
2.	RV/HP/SA/02- Strategic Adaptive Research and Development	RV/JK /SA/02- Strategic Adaptive Research and Development	RV/PB/SA/02- Strategic Adaptive Research and Development
3.	RV/HP/SA/03- Participatory Monitoring	RV/JK /SA/03- Participatory Monitoring	RV/PB/SA/03- Participatory Monitoring
4.	RV/HP/SA/04- Capacity Development	RV/JK/SA/04- Capacity Development	RV/PB/SA/04- Capacity Development
5.	RV/HP/SA/05- Awareness	RV/JK/SA/05- Awareness	RV/PB/SA/05- Awareness
6.	RV/HP/SA/06- Evaluation	RV/JK/SA/06- Evaluation	RV/PB/SA/06- Evaluation
7.	RV/HP/SA/07- Project Management	RV/JK/SA/07- Project Management	RV/PB/SA/07- Project Management

(A) Policy Level Interventions

It is apparent from the review that the complex and developing subject of river conservation and restoration in nation like India is supported up by various acts and policies. There is a growing concern about the predicament of rivers in India at all levels. Nonetheless, simultaneously, there have been a few legislative and governmental activities towards stream/river protection including countless decisions and explicit orders by the different Hon'ble Courts including NGT to safeguard the interests of rivers. However, despite considerable progress in recent decades, there are gaps and several issues those continue to affect the river and associated biodiversity, production sectors, and even the human communities all along the main river channel and its tributaries. Undoubtedly, a wide range of stakeholders including numerous government agencies are involved in efforts towards river conservation and there are competing demands and conflicts. By and large, isolationist approaches are still being applied. In the absence of single agency overseen river conservation, there are serious issues of coordination and monitoring. In absence of appropriate alternatives, most concerned government agencies find difficult to effectively implement/enforce various legislative acts and even the directives of the Hon'ble Courts. In general, the desired institutional framework and infrastructure is inadequate to tackle the complex nature of river ecosystem spread over large extent. Hence, expansion and strengthening of existing policies and lawful systems are alluring and much should be done as such as to recover the past glory of the Ravi River and its tributaries. In view of this, appropriate interventions related to improvement in the policy, law and institutional context are proposed as a part of the present DPR and to be implemented in the plan period. Necessary budget provision for envisaged policy level interventions by way of reviews, seminars, workshops, visits, field level assessments and monitoring has been made. A total amount of Rs.20 Lakh has been provisioned for this purpose for concerned States/UT while a provision of Rs.8 Lakh for Himachal Pradesh, Rs.6 Lakh for Jammu and Kashmir and Rs.6 Lakh for Punjab has also been envisaged.

(B) Strategic Adaptive Research and Development

Certainly, the discipline of river environment, management, restoration and preservation is generally newer in the nation and very little work has been finished. Additionally, the methodology has been to a great extent piecemeal, fragmentary and confined in nature. A significant part of the data on different parts of rivers originate from various government offices and agencies those are responsible for cryosphere, surface water, groundwater, contamination control, water system, hydropower, and so on. The majority of the researches by different agencies and individual endeavors have concentrated so far on the extent of glaciers and wetlands, glacier retreat/snowmelt, surface water, groundwater revive and improvement, water quality and effect of different developmental and biotic activities. Often, such initiatives are just one time efforts or in a project mode. In several instances, information is obsolete or specific to a particular tributary or stretch of a larger river. Only recently, first time effort has been made to carry out comprehensive study on cumulative impact of HEPs and carrying capacity. Ecological

insight on threatened taxa in the riparian and riverine environments is generally poor. There have been hardly studies on the various aspects of socio-economics and human impacts on the river ecosystems. The subject of restoration of rivers in India is certainly new. Consequently, neither desired information nor basically required tools and procedures are accessible those can be conveyed in the financial milieu of the nation. Thus, the present DPR seeks adoption of a holistic, integrated, multidisciplinary and multi-scale approach to forestry interventions by executing plantation activities, soil and water conservation measures, riparian and riverine wildlife management, and wetland management. As a part of the supporting activities, priority research as the concurrent activity is proposed by the national partner organization, SFDs and other concerned agencies. Research findings would immensely help the agencies in effective implementation of the present DPR and in similar efforts on other rivers. Concurrent research is proposed to be taken up on the following priority thrust areas.

(a) Forest Hydrology Studies

It is well established fact that forests not only influence the hydrological cycle but they also have a profound effect on water resources both quantitatively and qualitatively. The study of water in forests is termed forest hydrology and it includes the distribution, storage, movement, and quality of water; hydrological processes within forested areas; and the delivery of water from forested areas (NRC, 2008). Forest hydrological science is regarded as the foundation of modern integrated watershed management. Hence, the subject of forest hydrology has been of great interest for long to natural resource professionals and policy makers. As such, forest hydrology is an interdisciplinary science that evolved from the specialization of traditional hydrological science and forest ecosystem science during the past century and enormous literature exists on the subject, primarily from the western world. However, in spite of nearly 125-years old elaborate country-wide infrastructure exists on forestry research in India, the discipline of forest hydrology has been poorly addressed. All major rivers in the country and other freshwater resources are on decline. There is growing concern about the poor state of rivers and other freshwater resources. Hence, there is an urgency to initiate priority research in the field of forest hydrology in diverse forests of the country so as to understand how different forests are helping in distribution, storage, movement, supply and quality of water. Likewise, to answer the pertinent question that how forestry interventions, particularly plantations in different bio-geographic/ agro-climatic zones.

(b) Screening of Suitable Species and Pilot Trials on Bio-remediation and Bio-filtration

Most rivers in the country suffer on account of multitude of pollutants, waste and sewage originating from agricultural lands, industries and the urban environment. Both organic and inorganic contaminants find their way into rivers and other freshwater resources. Heavy metals are likely to be more in both municipal waste waters and industrial effluents. Approaches like phyto-remediation, bio-remediation and bio-filters have been developed to treat pollutants in such waters. Removal of metals through phyto-remediation techniques and the subsequent

recovery of the metals or their safe disposal are attracting research and commercial interests. Bio-remediation is being used as a method to treat waste water wherein biological organisms are used to convert the hazardous waste into non-toxic or less toxic substances. Usually, micro-organisms are being used for bio-remediation of sewage. Much work has been done in these emerging technologies, mainly in developed nations. However, in India these technologies are relatively emerging and thus, in infancy. Only handful sporadic efforts have been made so far in this direction and the success stories have been inadequately documented and disseminated. Nevertheless, these technologies have enormous potential to treat contaminated water prior to their release in the river or other wetlands. There is an urgency to initiate and support pilot trials in these priority fields in collaboration with potential scientific institutions and also to undertake researches on screening of suitable species for such purposes. The results obtained can be applied not only to Ravi River, but also on its tributaries, other major river systems and water bodies of the country.

(c) Evaluation of Ecosystem Services Especially in Provisioning of Water Supplies

There has been a growing public interest in the role and value of natural ecosystem and their contributions to the quality of human life and human well-being. Ecosystems services and their continued provision underpin human existence, health and prosperity. Different forest ecosystems and forestry plantations provide a wide range of goods and services, both tangible and intangible in nature. Tangible benefits like timber, non-timber forest products (NTFPs) including medicinal plants, fuel wood, and fodder have been adequately quantified arising from various provisioning services. However, water supply under provisioning services, soil conservation under supporting services, and environmental amelioration under regulatory services are yet to be quantified. Likewise, river ecosystems also provide a wide array of ecosystem services. In general, researches in the context of ecosystem services provided by forests as well as river ecosystems in the country are wanting. Hence, it is proposed to support priority researches in this field.

(d) Bio-engineering Methods for Soil Conservation and Stream/River Bank Stabilization

The review on the riverscape and its environment highlighted that the Himalayan Rivers like Ravi River and its tributaries are severely impacted by soil erosion and eroding stream/river banks owing to landslides, steep slopes, higher rates of runoff, and enhanced developmental/biotic activities. Thus, soil and moisture conservation, and stabilization of stream/river banks are amongst the priority activities towards river restoration. The use of biological and engineering measures in combination or biological interventions alone to control soil erosion and improve moisture conservation is referred as bio-engineering measures. Appropriate bio-engineering measures involving suitable cultural practices and plant species in addition to engineering structures have proven to be the cost effective methods to check soil erosion and efficient soil moisture conservation strategy. Newer eco-friendly materials (e.g., geo-jute) are being extensively used in stabilizing steep slopes and checking soil erosion. However,

researches in this emerging field need augmentation and strengthening, particularly in identification of newer eco-friendly materials, appropriate use of solid waste, screening of suitable plant species, and designing new bio-engineering models. Hence, proposed research activities in this emerging field with a focus on innovative and low cost bio-engineering methods for riverbank stabilization and soil and moisture conservation are envisaged by the National Level Partner Organization in collaboration with SFDs and the Indian Institute of Soil and Water Conservation, Dehra Dun and its regional centers.

(e) Biodiversity, Forestry and Livelihoods

The world over, humanity is strongly intertwined with forests as they offer wide range of ecosystem services. Forests also provide habitat for wildlife, and are repository of biodiversity. Forests play a vital role in the rural economy. In India, it has been observed wherever there is a large concentration of forests, there is also high concentration of tribal people in particular and of the rural population in general. Rural people are dependent on forest resources for their livelihood. Forests not only provide resources for economic subsistence, but they are also a way of life socially and culturally. Sustainable livelihood is increasingly linked to the maintenance of 'Natural Capital' and environmental conservation at large. The Sustainable Forest Management (SFM) has been recognized as the pillar of biodiversity conservation and ensuring livelihood security of the local people. The United Nations adopted the Agenda 2030 with its core element, the 17 Sustainable Development Goals (SDGs) in September, 2015. Further, it has been realized that forests not only have a special role to just contribute to the Goal 15 (Life on Land), but forests have greater role to play in achieving several interconnected SDGs. Like most other natural ecosystems, the world over forests has also suffered due to enhanced human activities and face enormous challenges. In past five decades or so, country has made concerted efforts to protect and conserve diverse forests in different States and UTs through appropriate innovations, policy and legal interventions, setting aside significant proportion of forest lands as protected areas, wildlife management and conservation of biodiversity, wetland management, integrated watershed management, adoption of participatory community led approaches, implementation of afforestation programmes, actions for recovery and conservation of RET floral and faunal species, research and monitoring, capacity development, etc. However, much needs to be done. A comprehensive research agenda on priority themes relevant to SFM, biodiversity conservation, management of NTFPs, fire management, eco-development and sustainable livelihoods needs to be planned and implemented. It is proposed that the National Level Partner Organization be made responsible for research, monitoring and capacity development will carry out researches on the above stated thrust areas in collaboration with SFDs and other National/State Level Scientific Organization.

(f) Climate Change Mitigation and Adaptation

The Ravi River originates in the Himalayan State of Himachal Pradesh, traverses through the steep mountains in Himachal and Jammu & Kashmir UT and finally flows through the alluvial

plains of Punjab before entering into Pakistan. The fragile mountain environment of the riverscape in Himachal Pradesh is extremely sensitive to the changes in the global climate system, with widespread glacial retreat being one of the major signals of warming temperatures over the past century. The glacial retreat coupled with enhanced human activities by way of expansion of agriculture, infrastructural development, urban growth, and other environmental pressures are considered as significant climate related threats to the river ecosystem, snow cover and high altitude wetlands, forests and biodiversity including aquatic biota, human lives, and livelihoods. The review on the riverscape and its environment has highlighted that one of the prominent glacier (Bhadal Glacier) within the Ravi Riverscape has shown signs of retreat in the past two decades or so. Likely implications of climate change are expected to alter the structure and composition of forests and the distributional range of some of the featured floral and faunal species. Uncertain climatic events i.e., avalanche, cloud burst, floods, droughts, etc. are expected to impact the river, surrounding lands, and environmental flows besides local communities and their livelihoods. The State of Punjab is considered as the granary of the country due to its contribution towards the green revolution and production of food crops. The semi-arid State is over-developed in terms of its groundwater and prone to droughts and floods. Climatic perturbations arising due to global warming are recognised as serious threats to this economically important agriculture-horticulture belt and food security in the region. Thus, the slightest changes in the climate patterns can have large implications on the Ravi River and its tributaries, not only for their own ecological values but also for larger humanity in HP, Punjab and J&K UT. As of now, there is poor insight on the nature of impending impacts and the ways and mean to adapt and mitigate. Hence, it is proposed that the national level partner organization undertakes the priority researches relevant to this important theme involving other State/ National Level Scientific Organizations.

(g) Support of Modern Technology in Natural Resource Management (NRM)

Degradation of natural resources is a growing concern that threatens the livelihoods of millions of people. Innovations by research and development organization, and local communities themselves have produced several promising technologies and practices for making natural resource management more productive and sustainable. The advent of modern technologies in the fields *viz*., remote sensing and GIS, IT, bio-technology and genetics, waste management, forestry and agricultural operations, wildlife conservation, nano-technology, water use and efficiency, etc. have opened several avenues for effective planning and managing of vital natural and manmade resources including cryosphere, forests, wetlands, wildlife, agriculture. However, the potential of advanced technological interventions in NRM is yet to be fully explored. Hence, collaborative researches with the aim to augment and strengthen advanced technological support in NRM are envisaged and proposed as part of the present DPR. The National Level Partner Organization is expected to play a lead role in this endeavor so as to encourage active involvement and partnership of related organizations. In addition to national level endeavours, the site specific researches in the aforementioned technology fields are proposed to be encouraged, supported, and facilitated by the state level organizations. As the subject of river

conservation and restoration is relatively new for the country and very little experience exists at this juncture, it is proposed that the national level partner organization would organize a research need analysis workshop involving all the probable research organizations so as to plan the research agenda for this priority field and to facilitate the cooperative research.

(C) Participatory Monitoring

The adverse impacts of past river use and developments have been widely recognized in recent decades (Malmqvist and Rundle, 2002; Tockner and Stanford, 2002; Woolsey *et al*., 2007). Thus, elaborate restoration attempts are underway worldwide to return human impacted rivers to more natural states and to restore lost ecosystem services (Palmer *et al*., 2004; Speed *et al*., 2016, Johanson *et al*., 2019). Off late, the Government of India has also decided to restore major rivers of the country and new initiatives have been launched. Assessing the outcome of river restoration projects is vital for adaptive management, evaluating project efficiency, optimizing future programmes and gaining public acceptance. Participation of the various stakeholders and the public in river restoration is increasingly prompted because it is expected to improve resource management and enable participants to engage freely and equally in management. The present DPR has earlier provided an overview on the diverse stakeholders associated with the river, its use, management, restoration, and those are impacted by the river. As a part of the preparation of this DPR, one of the key components was on the involvement of various stakeholders and following the process of extensive consultation at all levels. Concurrent, participatory, results based monitoring is envisaged while implementing the present DPR on forestry interventions.

(a) Monitoring: Monitoring, evaluation and adaptive management play vital roles in supporting effective river restoration. Monitoring against defined and measurable objectives is critical for assessing the effectiveness of river restoration measures and for guiding adaptive management. Monitoring describes the process of gathering qualitative or quantitative data at periodic intervals, using pre-determined indicators of progress towards project or programme objectives. The following regions dictate that the process of monitoring be made an integral part of the programme implementation on proposed forestry interventions in the Ravi River.

a) **Seasonal Activities and Timely Implementation:** Most proposed forestry interventions i.e., soil and moisture conservation, planting and allied activities are seasonal in nature. Moreover, the Himalayan mountainous tract in the upper part of the riverscape allows limited time for field activities owing to harsh climatic conditions and the larger extent of the riverscape is inaccessible during winter when areas are covered by snow. Timely implementation of proposed seasonal activities is vital for the success of the programme. Thus, regular monitoring of progress is essential so as to minimize any risk of failure.

b) **Involvement of Multiple Agencies and Stakeholders:** Proposed forestry interventions so as to rejuvenate the Ravi River would be spread across HP, Punjab and J&K UT and it would involve multiple agencies and stakeholders in its implementation. Forestry interventions have

been planned in natural, agriculture and urban landscapes. Obviously, it would include a wide range of stakeholders and implementing partners. Hence, periodic monitoring of the progress of various works through appropriate mechanisms is considered essential.

c) **Adaptive Management:** River conservation and restoration are complex activities and prone to several uncertainties. Moreover, river restoration programmes such as forestry interventions in the context of a river are relatively new and very little experience exists within the country. Thus, the adaptive management as an inbuilt programme is vital. Adaptive management is often used in generic sense to reflect the need for flexibility in project and programme management in the light of evidence gathered through monitoring and evaluation programme. Adaptive management is a tool that can be used not only to change a system but also to learn about the system. Since adaptive management is based on practice and learning through monitoring, therefore, it improves long run management outcomes and builds adaptive capacity (Speed *et al*., 2016).

d) **Transparency and Accountability:** Increasingly, there is greater emphasis on transparency and accountability in the prevailing system of governance, particularly when the tax payer's money is involved. Regular and periodical monitoring ensures much desired transparency and accountability in the programme implementation at various levels.

(b) Monitoring Needs: Thorough review on the existing situation of the river and its environment, the present DPR has provided much desired insight about the varied monitoring activities (i.e., glaciers and snow cover; climate–rainfall, snowfall, temperature, wind, etc.; surface water and runoff, groundwater and aquifers, sedimentation, forest cover, growing stock, carbon sequestration and fire incidences, e-flow and water quality, wetlands and water birds; fish production; population monitoring of RET floral and faunal species; visitors to tourism sites; and demography), undertaken by different Central/State Level Departments and agencies. Some of these monitoring activities are well designed, planned, executed and supported by appropriate institutional mechanisms and carried out either on regular basis or for longer stretches. Definitely, to a great extent baseline information for several important themes, components and variables is available. Nevertheless, there is ample scope to strengthen and augment the current monitoring activities. The logical framework analysis provides a broad based insight on verifiable indicators. However, it is proposed to firm up the verifiable indicators, methods and periodicity besides monitoring sites, etc. so as to ensure a meaningful and diagnostic monitoring on regular basis for vital aspects of the river ecosystem. It is also proposed to plan for collection of baseline data wherever required during the first year itself. This can be facilitated by the national partner organization responsible for research, monitoring and capacity development.

(c) Concurrent Monitoring Mechanisms for Proposed Forestry Interventions: Considering the complex and dynamic nature of river ecosystem, and the fact that the vast area is covered within the riverscape and much of the area is in difficult terrain and inaccessible, it is essential to adopt various concurrent monitoring mechanisms and relevant tools for carrying out envisaged

monitoring activities. Thus, concurrent monitoring mechanisms include: (a) IT enabled monitoring, (b) RS and GIS based monitoring, (c) Online monitoring through web portal, (d) On ground monitoring, and (e) Participatory monitoring. In recent times, increasingly mobile app based monitoring on real time basis in a much more transparent manner is possible. Thus, it is proposed to incorporate IT/mobile app based monitoring. Since large, difficult and inaccessible areas form the major part of the river basin/riverscape, optimal use of RS and GIS technologies, particularly for monitoring glaciers; sedimentation in reservoirs; and changes in channel morphology, land use and land cover, snow cover, forest cover, wetlands, cropping pattern, etc. The SFDs and other governmental agencies have established their own state-of-Art RS and GIS facilities which can be used effectively for the monitoring purpose. A grant of total Rs. 1.44 Crores has been provisioned for Participatory Monitoring in concerned States and UT in phase I and phase II. The Forest Survey of India, Dehra Dun or its Regional Centers would play an important role in carrying out RS based monitoring of forest cover. Online monitoring of the proposed interventions is being planned through Web Portal developed by the HFRI, Shimla during the process of preparation of DPR. The Portal would be able to incorporate and process all vital information like area and extent, geo-references and locations of each of the activity, financial expenditure, plantation survival status, maintenance works, and actual pictures of field sites at various stages of programme implementation and progress. This online web based monitoring shall not only facilitate the compilation of desired information for each of the type of Landscapes/Forest Division/State and even the entire riverscape on yearly basis, but would also facilitate instant query and report generation. In addition, on-ground monitoring by way of participatory monitoring at division level and third party monitoring are envisaged. The proposed monitoring would include physical as well as financial progress aspects at the local level and shall be monitored jointly by the field level staff of Forest Department and select Community Based Organizations. The monitoring reports shall be submitted by the Divisional Forest Officers (DFOs) to the Principal Chief Conservator of Forests. The scope of monitoring would include the extent treated, expenditure details, survival of plantations, performance of other activities, flow of tangible benefits to the community and adherence to time schedules. The SFDs may design proforma for participatory monitoring based on local needs. Local level Monitoring is proposed to be carried out annually while incorporating vital physical parameters such as e-flow/discharge rate of streams and silt load at randomly selected field sites in each of the forest divisions. In addition, it is proposed to select at least ten points each on different streams/ tributaries contributing to the main channel and shall be randomly selected in different micro-watershed areas in each division. Monitoring of e-flow and siltation shall be carried out seasonally. Further, the DFOs will submit a quarterly progress report of physical and financial achievements. The quarterly reports so obtained from the divisions/FDAs shall be compiled for analysis by the PMU under SFDA at the State Level and submitted further to the PMU of the Central Nodal Ministry and the National Partner Organizations for consolidated monitoring purpose. The proposed multi-tiered monitoring mechanism for proposed forestry interventions in Ravi Riverscape is depicted in Fig. 5.34.

In short, the implementation plan envisaged multi-tiered monitoring mechanism for monitoring progress of the project as well as achievements of objectives. The National Level Partner Organization most likely HFRI, Shimla selected by the Central Nodal Ministry implementing the project will be responsible for comprehensive monitoring besides State/local site specific monitoring would be undertaken by the concerned SFD. The monitoring and evaluation of the program will be carried out as per the existing State norms. However, a budgetary provision for developing a comprehensive monitoring programme as well as its implementation has been made which accounts for about 2-2.5% of the total cost of the project.

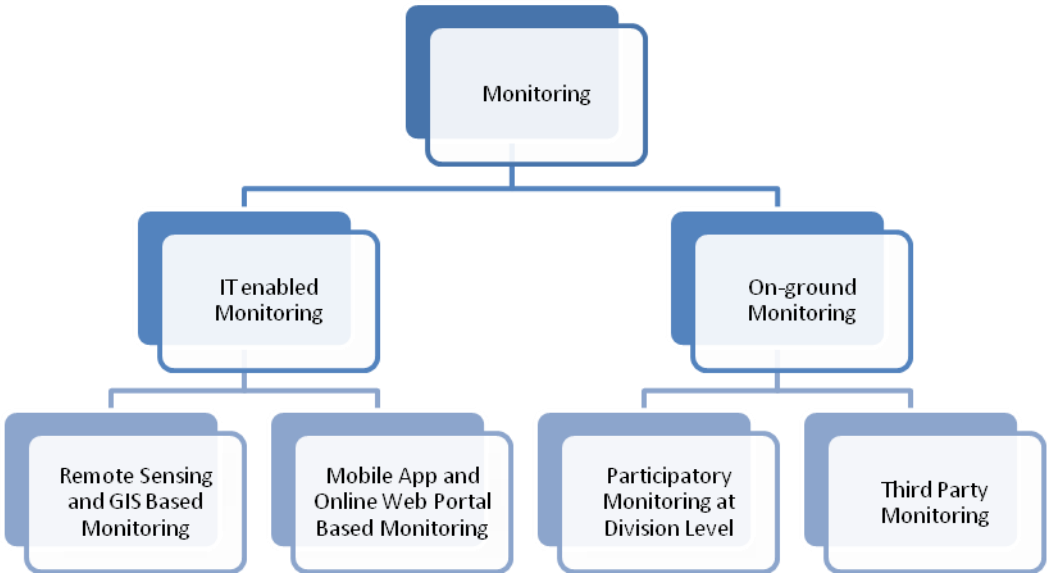


Fig. 5.34 – Multi-Tiered Monitoring Mechanism for Proposed Forestry Interventions in Ravi Riverscape

(D) Capacity Development

The world over, the development agenda is being implemented for past several decades by various International/National/State/Local Governments with mixed success. Often, developmental projects are not yielding desired results and a reasonably high number of projects even fail. One of the primary reasons of failures of major developmental projects in spite of elaborate planning and huge investments is the inadequate capacity.

Capacity is Development: *Capacity* has been defined as the ability of people, organizations and society as a whole to manage their affairs successfully; whereas the *capacity development* has been defined as the process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time (UNDG, 2008). Further, National and International Agencies engage in addressing global challenges (e.g., land degradation; water crisis; food insecurity; depleting 'Natural Capital' and loss of biodiversity; poverty; hunger; malnutrition; social issues– gender, equity and peace; and climate change) or contributing towards specific sector or the agenda of development increasingly emphasize on decentralized,

bottom up, participatory, science-based, integrated approaches, essentially seeking building alliances, inter-agency cooperation and sectoral convergence. There is now emerging agreement in the community development that capacity development at all levels is of utmost importance and is the engine of human development. Capacity development starts from the principle that are best empowered to realize their full potential when the means of development are sustainable – home-grown, long-term, generated, and managed collectively by those who stand to benefit. According to UNDP (2009), the 'Capacity is Development' and the capacity development is about transformations that empower individuals, leaders, organizations and societies. Capacity development is aimed at effective and informed participation in decision making for implementation of any programme towards sustainable development. Capacity development initiatives go much beyond raising awareness of stakeholders and aim at developing the capacity of diverse stakeholder groups to appreciate the multifaceted issues, and their own role within a complex set of actors and dynamic environment. Capacity development is central for ensuring ownership of any development plan for effective resource management, empowering communities and civil society, scaling up, sustaining progress overtime.

Objectives of Capacity Development: The Logical Framework Analysis has summarized the vision, goals, and objectives of river conservation and restoration along with envisioned outputs and outcomes. Accordingly, objectives of capacity development lay emphasize on participatory planning involving various line agencies and engaging communities at the grass roots level. Development of soft skills relevant to communication, advocacy, negotiation, conflict resolution, etc. is a prerequisite for varied stakeholders, particularly in case of professionals representing different Line Agencies, and local communities. Considering the intricate nature of river and associated measures for river restoration, it is proposed to build professional competence and develop skills for science and technology based backstopping. The agenda of capacity development would need to focus on sustainable livelihoods alongside effectively managing and maintaining natural resources as the natural capital. Enhanced capacity for monitoring and evaluation is also proposed. A wide range of stakeholders are expected to be involved in proposed plantation activities in three type of landscapes besides implementation of different conservation interventions. Hence, one of the objectives of capacity development would be to enhance capacity in the field of forestry interventions. The holistic approach to river conservation essentially requires sectoral integration, convergence and sustainability. Thus, developing appropriate capacity in these specialized fields is envisaged as one of the objectives. Various objectives for capacity development are presented in Fig. 5.35



Fig. 5.35 - Objectives of Capacity Development

Core Modules: The newer generation approaches towards river conservation and restoration emphasize on the river basin or riverscape approach wherein the linkages between the upstream and downstream, riverine *lotic* system and the adjacent riparian zone, surface water and groundwater, and environmental flow and aquatic biota matter. The river ecosystem management efforts are regardless of administrative and legal boundaries and require application of different scales.

In view of the above, the capacity development efforts for river conservation and restoration envisage various core modules on: (a) River ecology and ecosystem management, (b) Organizations and project management, (c) Participatory approaches and sustainable livelihoods, (d) Science and technology based backstopping, (e) Cross-cutting issues, convergence and synergies, (f) Climate change mitigation and adaptation, (g) Forestry interventions, (h) Monitoring, evaluation and learning documentation, and (i) Sustainability (Fig. 5.36).

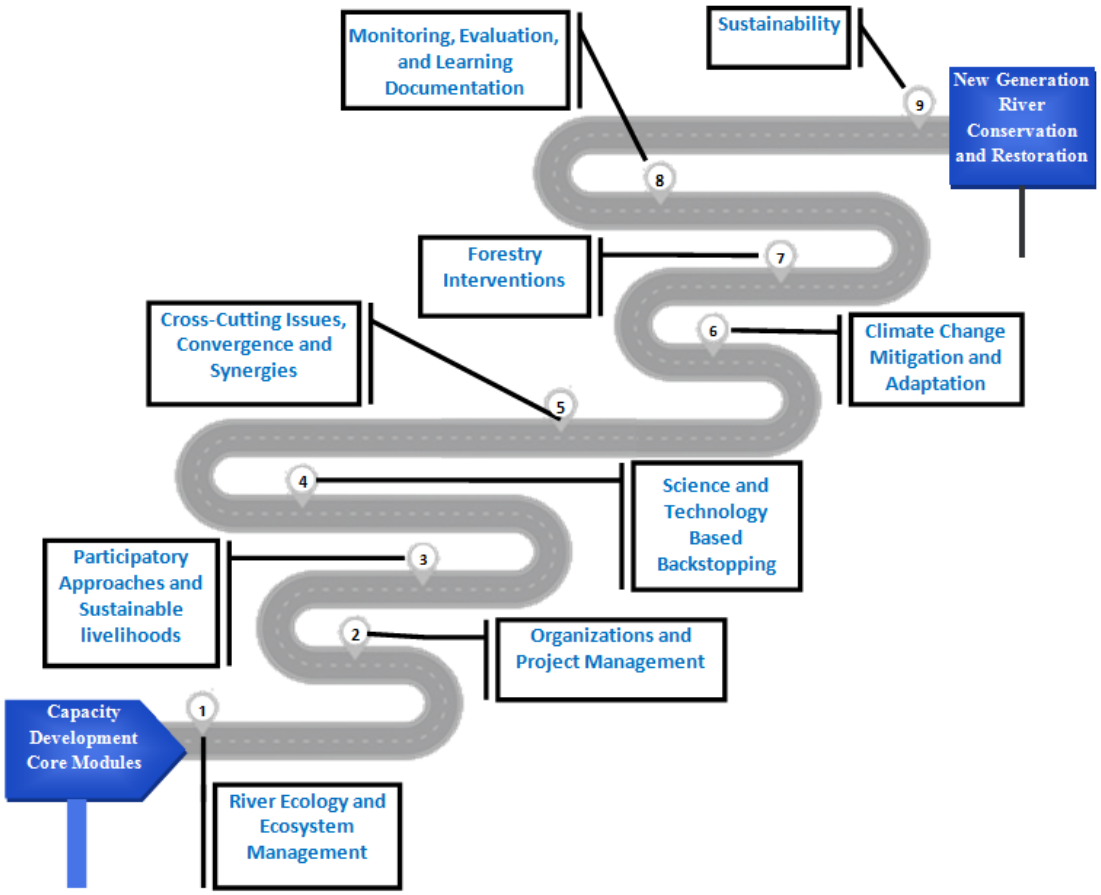


Fig. 5.36 - Capacity Development – Core Modules for River Conservation and Restoration

Target Groups: Broadly, the Target Groups for capacity development can be grouped at four hierarchical levels *viz*., National, State, Division and Community (Fig. 5.37). It is essential to target the right people for specific inputs towards capacity development. Potential target audience at different hierarchical levels includes:

a) **National Level –** Policy and decision makers and professionals of partner organizations
b) **State Level** - Forest officials and professionals of various line agencies, partner Institutions
c) **District/Division Level -** Forest frontline staff and NGOs
d) **Community Level** – CBOs, local communities, farmers, grazers, fishermen, etc.

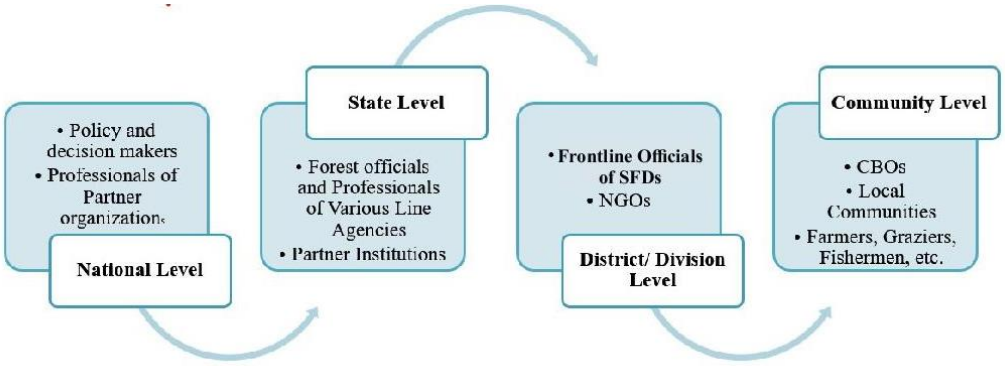


Fig. 5.37 - Capacity Development at Various Hierarchical Levels and Target Groups

Proposed capacity development is expected to improve the knowledge and skills of the professionals, partners, frontline staff of SFDs, local communities and specialized occupational groups.

Trainings, Workshops, Scientific Exchange and Engagement of National/ International Experts

The Knowledge and Skill Development of various target groups can be enhanced through trainings, seminars, workshops, scientific exchange, exposure visits, demonstrations and resource inputs by National and International Experts. Theme based short duration trainings (2-3 days) have been planned. Seminar/Workshops have also been planned. Exposure visits for professionals, frontline staff, local communities and other occupational groups have also been provisioned. The National Level Partner Organization responsible for capacity development would plan and organize for the National Level Capacity Enhancement by organizing trainings and orientation seminar/meetings, scientific exchange, field tours and overseas visits for professionals and decision makers. Considering the fact that the discipline of river restoration is relatively new for the country, the National Level Partner Organization also plans to involve select reputed National and International Experts, especially in the fields of river conservation and ecological restoration, bio-remediation and bio-engineering methods, climate change mitigation and adaptation, conservation breeding, policy interventions, and advanced technologies relevant to riverscape management so as to avail their resource inputs in endeavors towards knowledge management and National Level Capacity Development. Necessary budget provisions for such activities have been made in the budget outlay meant for the purpose of capacity development, scientific exchange and management of National and International Experts. The proposed expenditure norms include costs towards payment of honorarium to Resource Persons, training and learning material, travel and transportation, lodging and board, venue charges, and other contingent expenses. The trainings, workshops, meetings, exposure visits, etc. at the State/Division/Community Levels will be either conducted in house by the SFDs or outsourced to other relevant specialized organizations or technical agencies having

expertise in the relevant field. The cost details towards various activities of capacity development by the National Partner Organization have been provided.

The Training and Workshops at different levels to be organized by concerned States and UT, IAs at the State Level are also proposed to be conducted as per details given in Tables 5.54, 5.55 and 5.56.

Table 5.54 - Cost of Capacity Building (Training, Workshops, Seminars and Exposure Trips) in Himachal Pradesh

Sr. No.	Activity	Norms Rs. in lakh	Phase I					Grand Total
			Year					(Cost Rs. in lakh)
			(Cost Rs. in lakh)					
			I	II	III	IV	V	
1	Local Level Training for Communities (Trainings; 2-3 days) 25	2	8	8.40	8.82	9.26	9.72	44.21
2	Division Level Trainings for SFD Personnel, Line Departments and Other Partner Agencies (1 Training/ Division/ 2-3 days) 25	2	8	8.40	8.82	9.26	9.72	44.21
3	State Level Inception Workshop (2-3 days) 1	10	10				0	10.00
4	State Level Seminar – Mid Term (2-3 days) 1	10	0	0	10	0	0	10
5	Exposure Trip Within State (30 participants; 2 per year)	10	20	21.00	22.05	23.15	24.31	110.51
6	Exposure Trip Outside State (15 participants; 1 per year)	15	15	15.75	16.54	17.36	18.23	82.88
Grand Total			**61.00**	**53.55**	**66.23**	**59.04**	**61.99**	**301.81**

Table 5.55 - Cost of Capacity Building (Training, Workshops, Seminars and Exposure Trips) of Jammu & Kashmir UT

Sr. No.	Activity	Norms Rs. in lakh	Phase I					Grand Total
			Year					(Cost Rs. in lakh)
			(Cost Rs. in lakh)					
			I	II	III	IV	V	
1	Local Level Training for Communities (Trainings; 2-3 days) 25	2	10	10.50	11.03	11.58	0.00	43.10
2	Division Level Trainings for SFD Personnel, Line Departments and Other Partner Agencies (1 Training/ Division/ 2-3 days) 25	2	10	10.50	11.03	11.58	0.00	43.10
3	State Level Inception Workshop (2-3 days) 1	5	5	5.25	5.51	5.79	0.00	21.55
4	State Level Seminar – Mid Term (2-3 days) 1 and Final year (1)	5	0	0.00	5.00		5.51	10.51
5	Exposure Trip Within State (30 participants; 2 per year)	5	10	10.50	11.03	11.58	12.16	55.26
6	Exposure Trip Outside State (15 participants; 1 per year)	10	15	15.75	16.54	17.36	18.23	82.88
Grand Total			**50.00**	**52.50**	**60.13**	**57.88**	**35.90**	**256.41**

Table 5.56 - Cost of Capacity Building (Training, Workshops, Seminars and Exposure Trips) in Punjab

Sr. No.	Activity	Norms Rs. in lakh	Phase I					Grand Total
			Year					(Cost Rs. in lakh)
			(Cost Rs. in lakh)					
			I	II	III	IV	V	
1	Local Level Training for Communities (Trainings; 2-3 days) 25	2	3	3.15	3.31	3.47	0.00	12.93
2	Division Level Trainings for SFD Personnel, Line Departments and Other Partner Agencies (1 Training/ Division/ 2-3 days) 25	2	3	3.15	3.31	3.47	0.00	12.93
3	State Level Inception Workshop (2-3 days) 1	5	5	5.25	5.51	5.79	0.00	21.55
4	State Level Seminar – Mid Term (2-3 days) 1 and Final year (1)	5	0	0.00	5.00		5.51	10.51
5	Exposure Trip Within State (30 participants; 2 per year)	5	10	10.50	11.03	11.58	12.16	55.26
6	Exposure Trip Outside State (15 participants; 1 per year)	10	15	15.75	16.54	17.36	18.23	82.88
Grand Total =			**36.00**	**37.80**	**44.69**	**41.67**	**35.90**	**196.06**

Capacity Enhancement through Technology Adoption: It is essential to incorporate appropriate modern technologies and innovations in an endeavor towards river restoration. Thus, capacity enhancement at the National Level, National Level Partner Organizations, and capabilities of field personnel of concerned States and UT Forest Department is proposed by adopting innovations and modern technologies so as to facilitate efficient implementation of activities envisaged in the DPR. For facilitation of smooth field level operations, the concerned SFDs will require support of physical infrastructure. Accordingly, necessary budget provision has been made to augment and strengthen physical infrastructure including office, computer, RS and GIS, IT and communication, and field equipment. The field staff of SFDs will be provided

proper training in the use of GPS, mobile app, and other modern field tools relevant to analysis of water quality, sedimentation and runoff, animal monitoring, etc.

(E) Awareness

All prominent rivers in the country and their tributaries are in the state of degradation due to the fact that the rural and urban populations living along the river course continue to exploit its resources, contaminate and neglect the ecological concerns of the river and contribute in some form of the disturbance or pollution. Thus, it has been lately realized that the public awareness campaign is a prerequisite for any planned efforts towards river restoration. In absence of such efforts, any amount of investments and diversity of interventions would not help in the restoration process of degraded rivers.

A public awareness campaign is an effort to build public recognition of a problem through media, messaging, and an organized set of communication tactics. These campaigns target masses and specific groups of people over a period of time so as to try and generate explicit outcomes or achieve predetermined goals. Public awareness campaigns are important as they can help to facilitate policy change and encourage the community to take action. Campaigns also help to inform the community about the declining condition of the river, factors responsible for the current state, and how they affect the overall environment, economy, livelihoods, ecological integrity of the river, and even the human health. Awareness campaigns can also help in drawing attention of the community in such a way that the information and education provided can elicit their support for river restoration and solicit actions to make changes in current use patterns of river resources, lifestyle and behavior those have been adversely impacting the river and its ecological functioning.

In view of the above, creating awareness and sensitizing the masses on the importance of restoration of river and the role public has to play in such efforts are the priority agenda envisaged as a part of the proposed forestry interventions. Awareness campaigns are proposed to be directed primarily towards two broad groups i.e., the general public, and the educational institutions, particularly targeting the youth. The SFDs as IAs in concerned States and UT can adopt different approaches and tools for awareness campaigns and sensitizing the masses. These are: use of multimedia, awareness camps and rallies, posters, brochures, pamphlets, booklets, hoardings, mobile vans, audio visual shows, and celebration of important days (i.e., Water Day, Wetlands Day, Wildlife Week, World Environment Day, World Forestry Day, etc.). It is proposed that concerned States and UT Forest Department can organize awareness campaigns in educational institutions i.e., Schools, Colleges, and Universities through the NYKS, Eco-clubs, NSS, NCC, Scout and Guide and other appropriate mechanisms approved by the educational authorities both in government and private institutions. The Civil Society Organizations (CSOs), NGOs and religious organizations are expected to play pivotal role in this priority endeavor. SFDs can prepare video documentaries highlighting ecosystem services offered by the river; declining state and its reasons; and how public can meaningfully contribute towards river restoration by way of planting trees, reducing biotic pressure and various contaminants and widely use them for awareness campaigns. Necessary budget provisions for carrying out various

activities by SFDs for awareness have been made. Likewise, budgetary provisions have also been made for various envisaged activities relevant to this priority agenda by the National Level Partner Organization. The activities to be carried out by the concerned States and UT Implementing Agencies for effective awareness creation over five years as per the details in given in tables 5.57, 5.58 and 5.59.

Table 5.57 - Projected Cost of Awareness Programmes for Himachal Pradesh

Sr. No.	Activity	Phase I					Grand Total
		Year					(Cost Rs. in lakh)
		(Cost Rs. in lakh)					
		I	II	III	IV	V	
1	Awareness Campaigns@1	4	4.2	4.41	4.63	4.86	22.10
2	Awareness Activities for General Public@2	8	8.4	8.82	9.26	9.72	44.20
3	Awareness Material – Pamphlets, Brochures, Booklets, Signages, Boards and Hoardings @2	8	8.4	8.82	9.26	9.72	44.20
4	Publicity Through Mass Media@3	12	12.6	13.23	13.89	14.59	66.31
Grand Total		**32**	**33.6**	**35.28**	**37.04**	**38.89**	**176.81**

Table 5.58 - Projected Cost of Awareness Programmes for Jammu & Kashmir UT

Sr. No.	Activity	Phase I					Grand Total
		Year					(Cost Rs. in lakh)
		(Cost Rs. in lakh)					
		I	II	III	IV	V	
1	Awareness Campaigns@1	5	5.25	5.51	5.79	6.08	**27.63**
2	Awareness Activities for General Public@2	10	10.50	11.03	11.58	12.16	**55.26**
3	Awareness Material – Pamphlets, Brochures, Booklets, Signages, Boards and Hoardings @2	10	10.50	11.03	11.58	12.16	**55.26**
4	Publicity Through Mass Media@3	15	15.75	16.54	17.36	18.23	**82.88**
Grand Total		**40.00**	**42.00**	**44.10**	**46.31**	**48.62**	**221.03**

Table 5.59 - Projected Cost of Awareness Programmes for Punjab

Sr. No.	Activity	Phase I					Grand Total
		Year					(Cost Rs. in lakh)
		(Cost Rs. in lakh)					
		I	II	III	IV	V	
1	Awareness Campaigns@1	1.5	1.58	1.65	1.74	1.82	**8.29**
2	Awareness Activities for General Public@2	3	3.15	3.31	3.47	3.65	**16.58**
3	Awareness Material – Pamphlets, Brochures, Booklets, Signages, Boards and Hoardings @2	3	3.15	3.31	3.47	3.65	**16.58**
4	Publicity Through Mass Media@3	4.5	4.73	4.96	5.21	5.47	**24.87**
Grand Total		**12.00**	**12.60**	**13.23**	**13.89**	**14.59**	**66.31**

(F) Evaluation

A strong evaluation mechanism is a core element of a major, multifaceted project like the present one on proposed forestry interventions for restoration of a river so as to assess the project performance, collect evidence that indicates the extent to which the envisaged outcomes have been achieved, and document what has been the impact of the project to bring desired change. The Logical Framework Matrix has earlier provided details on the range of activities, expected outputs and outcomes, performance and impact indicators along with their means of verification. This information forms the basis to assess the project's impact. The project envisages project evaluation, particularly appraisal of annual progress, Mid Term Review (MTR), and the Terminal Evaluation (TE).

Third Party External Evaluation: Third party or external evaluation is essential so as to get an independent view of the project activities, performance and impact. The MTR and TE are proposed as independent evaluation involving External Experts other than those who have been neither the part of the project design and development nor of implementation. The independent evaluations would rely on the criteria developed by the third party involved in the process. However, they would also review the monitoring efforts made by the Implementing Agencies at the State and Division Levels, the National Partner Organization, and the Central Nodal Ministry at different stages of the project implementation. The MTR would specifically focus on mid-course corrections so as to accomplish the project goals while the TE is expected not only to focus on documentation of project performance, accomplished outcomes and impact, but also provide recommendations for future projects based on learnings. The aim of evaluation is also to share the knowledge gained in project implementation. The National Level Partner Organization is expected to facilitate project evaluation and would require an amount of Rs. 1.42 Crores, while

Rs. 2.75 Crores has been provisioned for carrying out various activities related to field evaluation by concerned SFDs and UT.

(G) Project Management

Proficient administration of project activities is of most extreme significance in accomplishing desired objectives and goals. This requires suitable institutional plans at different progressive levels and a very much structured system for viable usage of the task, especially smooth progression of expected assets to state level execution offices, particularly taking into account the occasional and time bound nature of majority proposed works. Appropriately, Project Steering Committees (PSCs) at two hierarchical levels (National and State) have been imagined. The details on institutional courses of action and system for program usage are given in the DPR. In view of the much desired transparency and efficiency, the optimum use of IT-based mobile app is envisaged.

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6.1 Project Implementation – The Components and Partnership Arrangements

The Government of India recognizing the problem of river pollution, established National River Conservation Authority, and Prime Minister is the Chairman of the Authority. The river conservation programmes will be effective only if the ecological, economic, technological and social dimensions of the problem are seen in a comprehensive manner. What ultimately flows down the river is the result of a lot that happens outside the river. Accordingly, the country's 'Strategy for New India @75' envisaged that by 2022–23, India's strategy on management of water resources should facilitate and ensure water security by way of adequate availability of water for life, agriculture, economic development, ecology and environment (NITI Aayog, 2018). The broader vision is aimed to be achieved by attaining the various sectoral goals including a focus on *Aviral* and *Nirmal Dhara* of the National River as well as other major rivers along with their tributaries. Further, the commitment of the Government of India to realize its vision is amply evident from the D.O. Letter No. 11(1)/ 2017 – WR Vol.- I, dated 06 June, 2018 issued by the CEO, NITI Aayog, New Delhi to all the Chief Secretaries/Administrators of all States/UTs conveying the GoI's decision to launch of a major mission which details how the revitalization of India's River Programme will be implemented on the ground utilizing the existing schemes and programmes of the government with community led efforts. The said letter also stated that this very programme would be led by the Department of Rural Development (DoRD) under the guidance of NITI (National Institution for Transforming India) Aayog and would target convergence of Mahatma Gandhi National Rural Employment Guarantee Act Scheme (MGNREGA) with other programmes of Central Ministries like Ministry of Environment, Forest and Climate Change (MoEF&CC), Department of Agriculture, Cooperation & Farmers Welfare DoAC&FW, Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR RD&GR) now Ministry of Jal Shakti (MoJS), Ministry of Panchayat Raj (MoPR), Department of Land Resources (DoLR) and the State Governments.

Considering the significance of revitalization of major Indian rivers and their tributaries, in line with the instructions and directives by the NITI Aayog, the National Afforestation and Eco-Development Board (NAEB) under the MoEF&CC has entrusted the major task of preparation of DPR of 13 major rivers of India to Indian Council of Forestry Research and Education (ICFRE) and its institutes. Himalayan Forest Research Institute (HFRI) being a regional research Institute of ICFRE prepared the DPR of five major rivers of Indus River Basin. MoEF&CC not only provided full financial support for the project formulation but also advised ICFRE to follow the pathway earlier adopted in case of DPR preparation of rejuvenation of Ganga River. In the case of Ganga, the *Namami Gange* Programme of the National Mission for Clean Ganga (NMCG) has provided the financial support for implementation of the programme. However, the MoEF&CC has been envisioned as Nodal Ministry. It may either decide to implement the DPR

at its own or may request the MoJS to provide required funds to execute or implement as a joint venture in collaboration with any other Central Ministry/National or International Agency. The Project envisages the following four components of programme implementation (Fig. 6.1).

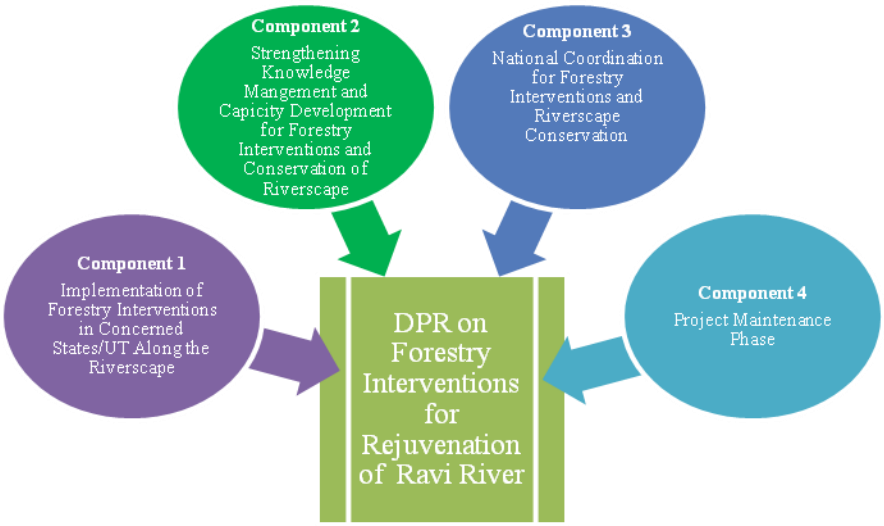


Fig. 6.1 - Four Components of the Project

Component 1: Implementation of Forestry Interventions in concerned States/UT of Riverscape

This component deals with the implementation of proposed forestry interventions in concerned States and UT along the course of Ravi River. The component 1 includes three sub-components: (i) the proposed 'Forestry Interventions in Natural Landscape (NL), Agriculture Landscape (AL) and Urban Landscape (UL) adopting appropriate plantation treatment models'; (ii) 'Conservation Interventions'; and (iii) 'Supporting Activities'. Besides proposed extensive plantation in three types of landscapes within the riverscape, the significant inputs under the sub-components on 'Conservation Interventions' by way of soil and water conservation, riparian and riverine wildlife management, and wetland management have been envisaged.

To ensure overall success of project on forestry interventions, it is important that concerned participating States/UT will carry out 'Supporting Activities' referred as 'Themes' at the State and local levels. These activities include: (a) policy level interventions; (b) concurrent research and development; (c) participatory monitoring; (d) capacity development; (e) awareness; and (f) evaluation.

Further, in order to ensure effective implementation, coordination and monitoring of the State-wide project activities, support for the establishment and smooth running of the State level Project Management Units (SPMUs) in two concerned States and one UT is also provisioned as a part of this component. The sub-components and various envisaged activities are summarized in Fig. 6.2.

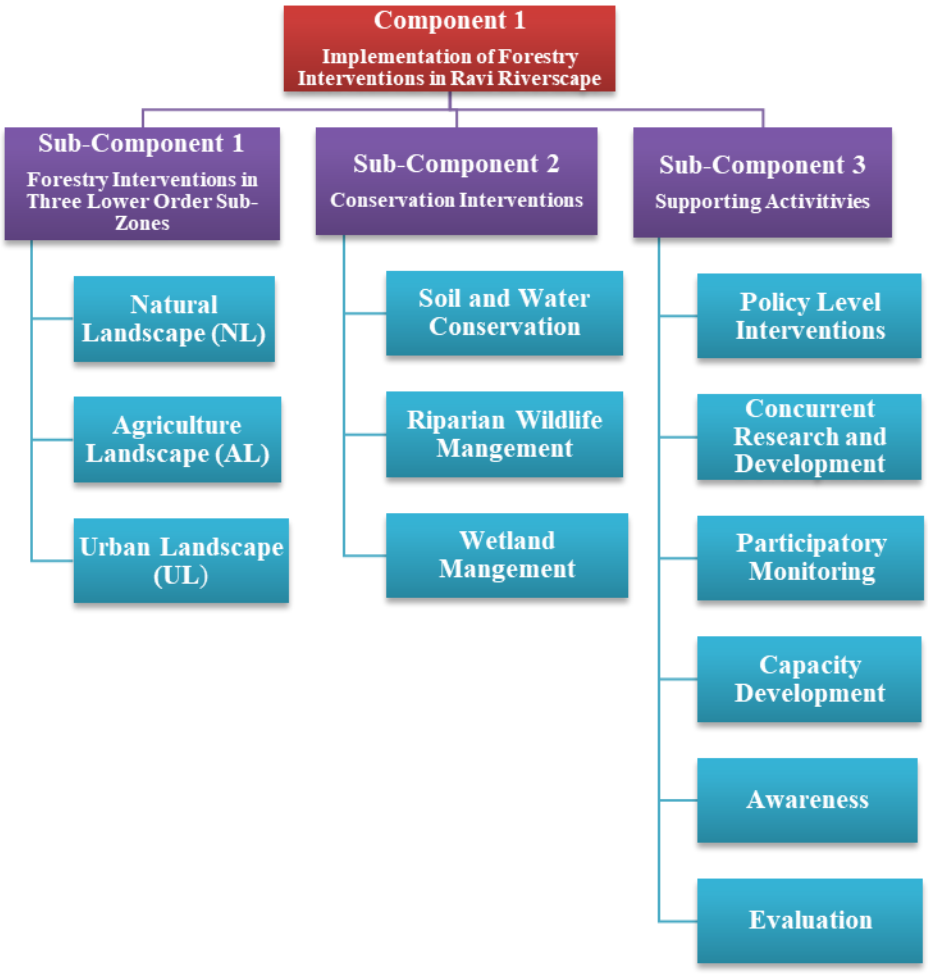


Fig. 6.2 – Project Component on Forestry Interventions and Proposed Activities

The State Forest Departments (SFDs) of concerned States and UT i.e., Himachal Pradesh, Punjab and Jammu & Kashmir UT will provide a most congenial institutional framework for implementation of this project and will act as primary Implementing Agencies (IAs) for forestry interventions mainly plantation activities in three types of landscapes. The Chapter-4 has already provided an insight on the organizational structure, mandate, functions and activities, schemes, past experiences of SFDs in afforestation, forest management, protected area management, biodiversity conservation and improvement of rural livelihoods. The organizational structure of SFDs, administrative units and management units existing in the SFDs provide most suitable and greater options of scientific interventions. Role and responsibility of each level of hierarchy, well laid physical infrastructure, procedures for programme execution, communication, expenditure, accounting, auditing, monitoring and a perfect synergy between various disciplines of science and knowledge exist which is required for implementation of forestry intervention of Ravi River.

The management units in SFDs have been carved out on the basis of natural micro-watershed boundaries and such mechanism makes it easier for planning, implementation, monitoring, and evaluation of such activities at micro-watershed levels.

Besides concerned States/UT level lAs (SFDs), the project also envisages that the SFDs may like to involve the Eco Task Force Battalion(s) of the Territorial Army and Civil Society Organizations (i.e., Nehru Yuva Kendra Sangathan (NYKS), National Service Scheme (NSS), Youth and Eco Clubs, *Mahila Mandals*, Non-Governmental Organization (NGOs), etc.) as important partners in execution of proposed activities as planned in the DPR and also to replicate the reputed community led initiatives. Further, SFDs may like to involve the Agriculture Department, Pollution Control Board and Municipal Corporation/Municipal Board for specific activities related to agriculture landscape and urban landscape, respectively.

Component 2: Strengthening Knowledge Management and Capacity Development for Forestry Interventions and Conservation of Riverscape

Chapter-1 have highlighted the river's complex and dynamic nature, river ecosystem-human use and disturbances, four types of connectivity, strong linkage between forests and water, significance of rivers for human well-being, environmental stability and prosperity and also provided much desired clue that how enhanced anthropogenic activities in a river basin have degraded the river ecosystem. Rivers serve as the chief source of renewable freshwater for humans worldwide. Water quality is affected by a large range of natural and human influences. The most important natural influences are geography, water and climate as they affect the quantity and quality of water available (Bartran and Balance, 1996). With the increase of human populations, their demands are increasing day by day for water and water resources are dwindling, water quality is deteriorating. The situation of rivers in developing countries like India is more complex and severe where all major rivers are facing enormous challenges for their sustainable management and competing demands of various production sectors. These natural renewable freshwater ecosystems now not only offer much reduced ecosystem services but are also a major concern for poor health of human as well as his livestock.

Streams and rivers are among the most endangered ecosystems and there is an urgent need for comprehensive approaches to evaluate the past and present state of these rivers, causative factors responsible for their deterioration and to monitor their rate of change.

In the management of river ecosystem, there is an evident paradigm shift from river development to river conservation and then river restoration. Obviously, India lacks desired experience in restoration of rivers as relatively it is a new discipline for the country. However, efforts are on in this direction. For successful river conservation and restoration, holistic strategies should be adopted in policy and planning for better understanding of forest-river linkages and their intricacies, and successful river conservation needs. Moreover, in the emerging scenario of transparency in public policy, and essential requirements of comprehensive environmental

impact assessment, and integrated planning for conservation of water resources, there are several expectations from multidisciplinary sciences. These expectations can vary based on the political climate, objectives of different (and often competing) government agencies, spatial and temporal scales of river resources and resultant complexity of the issues. The best available science in river management and restoration should be based on six broad criteria of: (a) relevance, (b) inclusiveness, (c) objectivity, (d) transparency and openness, (e) timeliness, and (f) peer review. In view of the above stated facts, the component 2 of the project aims to incorporate science into policy, planning and management for informed decision making that can facilitate positive outcomes of concerted efforts towards sustainable management of rivers and river restoration in particular in India.

HFRI, Shimla has taken a lead in the preparation of present DPR adopting a multistep holistic approach based on exhaustive consultations and stakeholder participation while following a scientific planning process using Remote Sensing (RS) and Geographic Information System (GIS) based geospatial analysis for the riverscape, multidisciplinary review on the riverscape environment, and extensive field data collection filled by the concerned SFDs in the data formats prescribed by the Institute. The HFRI is a reputed and well known established learning centre in the fields of natural resource management, forestry research and education, particularly relevant to the Himalayan environment, those have direct relevance to the river ecosystems. Thus, it is of utmost importance that HFRI is not only involved as a National Level Partner Organization for facilitating monitoring, evaluation and capacity development as proposed in the present DPR, but also be entrusted the responsibility of major task to serve as the Knowledge Management/Learning Center and to undertake concurrent research related activities essential for conservation and restoration of the Himalayan Rivers. The HFRI will also play a pivotal role in building desired national capacity for demonstrating the strong linkages between diverse forests in the Himalaya and river ecosystems.

This component will seek to support improved knowledge by strengthening the Knowledge Management Center and capacity building on learning and experience required for conservation of Himalayan riverscapes within the country by offering best practices for forestry interventions and various activities like conservation measures as envisaged in the DPR.

In addition, the Knowledge Management Center (HFRI) is expected to contribute towards envisaged intervention and activities relevant to policy, training, coordination, extension, capacity development and monitoring and evaluation. In order to accomplish this, the national level organization for knowledge management and capacity development would need to establish a Project Facilitation Unit (PFU) for effective coordination with participating States and the Central Nodal Ministry supporting the implementation of the programme.

Wide range of strategies and practices are required in the knowledge Management Center to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insight and experiences comprise knowledge, either embodied in individuals or embedded in organizational processes or practices. An organization seeking to become a Knowledge

Management Center would primarily require: people, processes, innovations and technologies (Fig. 6.3). In an organization, People are the key to the success of a Knowledge Management Programme. In an organization, multidisciplinary knowledge exist which play an important role in dealing with the complexities of Himalayan Rivers. It is essential that a culture of active experimentation through involvement of all concerned is encouraged, and trust and relationships among the members is build. The 'institution building' is complex and continuum process. It has to be holistic–have to go beyond organization management and development, and involves the process of developing people, and streamlining various systems, improving style of functioning, developing a positive climate, and promote organizational culture of professional and non-hierarchical relationships. Innovations and technologies are enabler in a knowledge management programme. Remote Sensing and GIS tools, information technology (i.e., mobile apps, and web portals), automatic meteorological and hydrological equipment for measurement of river flow and rate of sedimentation, and applications of Unmanned Aerial Vehicles (UAVs), camera traps, satellite telemetry, etc. are some of the emerging technologies. These can be used for various purposes *viz*., planning, management and monitoring. The internet and World Wide Web would not only connect people, but also connect them to various databases being maintained across the globe.

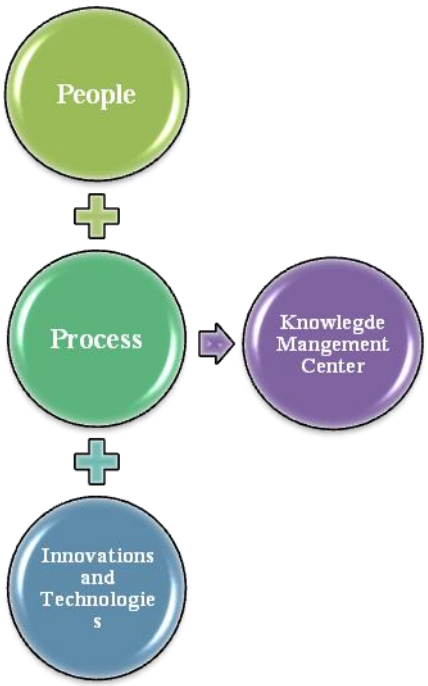


Fig. 6.3 – Three Essential Elements for the Knowledge Management Center

Component 3: Scaling Up, Replication of Successful Models in Additional Sites and Maintenance Phase

The present implementation plan of DPR focuses on implementation in whole catchment area in concerned hilly state (Himachal Pradesh) and UT (J&K) and on the selected tributaries, particularly once the river descends in the plains in the State of Punjab. The component 3 plans to support the scaling up and replication of planned efforts in additional sites/tributaries of Ravi River besides primarily, supporting the maintenance phase of various types of plantations raised in later years (3rd, 4th and 5th years) of the Phase I i.e., Implementation Phase.

Component 4: National Coordination for Forestry Interventions and Riverscape Conservations

River management and restoration programmes require national level coordination for proposed forestry interventions and various conservation efforts among the participating States located along the course of main channel and its tributaries because basin of major Indian rivers and its tributaries are spread over multiple States. MoJS is the Central Nodal Ministry for all aspects of management of water resources including river development and restoration of rivers but several other ministries are also involved for specific components/needs.

Thus, for National level coordination, an appropriate mechanism is vital for forestry interventions and and river restoration at the level of Central Nodal Ministry. The component 4, therefore, visualizes activities for: (a) establishment of the River Decision Support and Management Information System (RDS & MIS); (b) facilitating activities relevant to policy and legal interventions, riverscape level coordination, monitoring and impact evaluation; and (c) administering the implementation of major project on forestry interventions. In order to accomplish this, the component 4 specifically envisages the establishment of a Project Management Unit (PMU) at the Nodal Ministry Level. The PMU at the Nodal Ministry would handle the programme implementation, coordination among participatory States, partner organizations at the National and State level besides extending support for the finances required for the project execution.

6.2 Institutional and Implementation Arrangements

Basically, the execution of project is based on implementation and monitoring at multiple hierarchical levels *viz*., the National, State, Division, and Local levels. Implementation of planned project activities; financial management and procurement functions; and project monitoring, learning and reporting through enhanced transparency is based on the arrangement at all hierarchical levels. At the apex level, the identified Central Nodal Ministry will provide the overall policy guidance and the supervision of the project at the National or the riverscape level. The PMU established at the Central Nodal Ministry will not only responsible for overseeing and coordinating the efforts at the national or riverscape level but also ensure timely release of funds.

The concerned SFDs of involved States/UT within the riverscape will be the primary Implementing Agencies (IAs) at the State, division, and local levels. However, SFDs would be able to involve other partners (i.e., the Agriculture/Urban Development Departments, Eco Task Force, NYKs, NSS, select NGOs, etc.) for programme implementation in different landscapes. Each Concerned states/UT at the State level will establish the PMU for effective implementation of the project across the State/Divisions/Ranges and even at the Panchayat/Community levels.

In addition, the National Level Partner Organization (HFRI, Shimla) responsible for facilitation, concurrent research, monitoring, evaluation, and capacity development would also be functioning and will have the support of Project Facilitation Unit (PFU). Details of institutional arrangements at different hierarchical levels are provided below:

6.2.1 Project Management Unit (PMU) at the Central Nodal Ministry

The MoEF&CC is expected to be the Central Nodal Ministry for implementation of project. However, other related Ministries (i.e., MoJS & MoRD) may also join and collaborate with the Central Nodal Ministry depending upon the decision of GoI for the purpose and provide/arrange required financial resources. Once the GoI decides about the Central Nodal Ministry and entrusts the task for implementation of the project planned in the present DPR, then designated Central Nodal Ministry would require to establish the PMU, specifically for performing various functions relevant to project overseeing, advice, steering, coordination, programme approval, policy level interventions, budget allocations, fund flow, monitoring and evaluation.

The PMU at the Central Nodal Ministry will be headed by an Addl. Secretary/Joint Secretary level officer who will be designated as the Project Director (PD). The PD will be supported by a small project management team of existing and project staff on contract to support various activities related to coordination, technical supervision, communication, project administration, procurement, financial control and management, report preparation, monitoring and evaluation. The PD will be supported by one Senior Project Scientist (for Policy Intervention/Riverscape Conservation/Communication), one Junior Project Scientist (for Forestry/Riverscape Conservation/Monitoring and Evaluation), one Project Manager (for RDS & MIS/Administration /Procurement/Finance and Audit), two Project Assistants, two Office Assistants, and two Multi-Tasking Staff (MTS) (Fig. 6.4).

The PMU will carry out the following tasks relevant to the financial control and management.

a) Annual budgetary provision for the project and monitoring of project expenditure against allocated budget.
b) Approval of Annual Plan of Operations (APOs)/Work Plan and budgets.
c) Coordination and ensuring sufficient and timely fund flow to concerned State/UT IAs and national partner organization for activities at the riverscape level and for national capacity development activities, respectively.

d) Regular financial reporting of the project at all levels and compilation of quarterly financial reports and annual financial statements of the project.
e) Ensuring internal audits and annual external audit of the project by the Comptroller and Auditor General (CAG).

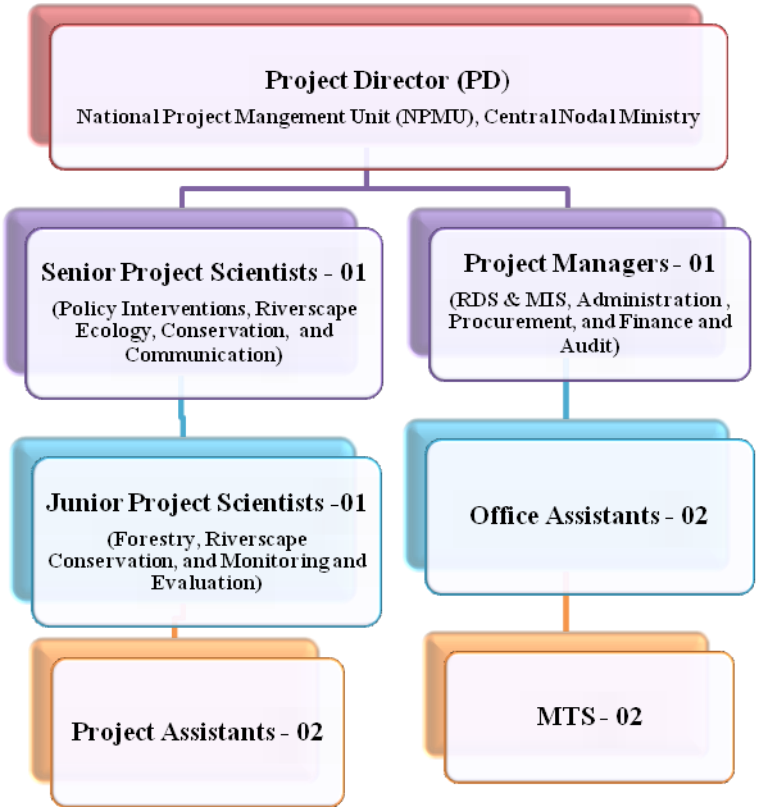


Fig. 6.4 – Proposed Organization Structure of the Project Management Unit at the Central Nodal Ministry

For the establishment of PMU and to make the PMU fully functional, necessary budgetary provisions for office equipment beside recurring costs on salary and wages, office expenses, travel, workshops/seminars meetings, publications, dissemination and miscellaneous expenditures and contingency have been made. In addition to these, adequate budget provisions for capacity development, planning and conduct of national level seminars/workshops, and coordination, review meetings, etc. have also been made so as to make the working of PMU effective in its mandate.

6.2.2 Project Facilitation Unit at the National Level Partner Organization (HFRI, Shimla) for Knowledge Management and Enhancement of National Capacity for Forestry Interventions and Riverscape Conservation

Himalayan Forest Research Institute (HFRI), Shimla is one of the nine regional institutes under the umbrella of ICFRE. HFRI has successfully been providing services based on sound scientific and technological basis, with a multidisciplinary approach to various forestry sectors through its scientists and distinguished practicing forests. The institute has a team of multidisciplinary scientists working in five divisions and supported by technical staff. Over the years, HFRI has developed as a knowledge management centre in the field of high altitude ecology (Himalayan and Trans-Himalayan regions) and conservation of diverse temperate forest ecosystems and privilege to have essential integral: (a) professionals and expertise, (b) state of the art laboratories and other physical infrastructure, and (c) processes and innovative technologies. Since its establishment, HFRI has made significant contributions towards the development of suitable nursery techniques, propagation of native plant species, eco-restoration of mined areas and cold desert. HFRI have long experience in dealing with cumulative environmental impact assessments of Himalayan Rivers. To undertake the major responsibility as the National Level Partner Organization for effective implementation of this priority project on river restoration through forestry intervention, liaisoning with Central Nodal Ministry and Implementing Agencies at the State level, concurrent research and development, science and technology based back-stopping, capacity development, monitoring, and evaluation a well-laid infrastructure has been proposed.

For this purpose, the HFRI would need to establish a Project Facilitation Unit (PFU), headed by the Nodal Officer (NO) of the project at a senior level (Scientist–G or CCF level officer). He/ she will be supported by River Coordinator (RC)/SPS (Senior Project Scientist), one Junior Project Scientist (for Forest Biodiversity/Bio-remediation and Bio-filtration/Aquatic Ecology/Remote Sensing and GIS/Agroforestry/SMC and Bio-engineering), two Project Associate (for Forestry Research/Communication and Conservation Education/Ecosystem Monitoring/Forestry Training), one Project Manager (for IT and National River Database/Administration/ Procurement/Finance and Audit), one Office Assistant, and one MTS (Fig. 6.5). For making the PFU effective and fully functional, provision for its establishment, office equipment besides recurring costs on salaries and wages, office expenses, travel, publications and dissemination, and contingent and miscellaneous have been made. Further, adequate provisions for engagement of International/National consultants, capacity building, planning and conduct of National Level seminars/workshops and coordination meetings, awareness, ecological and socio-economic monitoring, International exposure visits/exchange, project and impact evaluation, etc. have been included to make the PFU and the National partner organization functional and effective in its diverse mandate relevant to knowledge management and national capacity building.

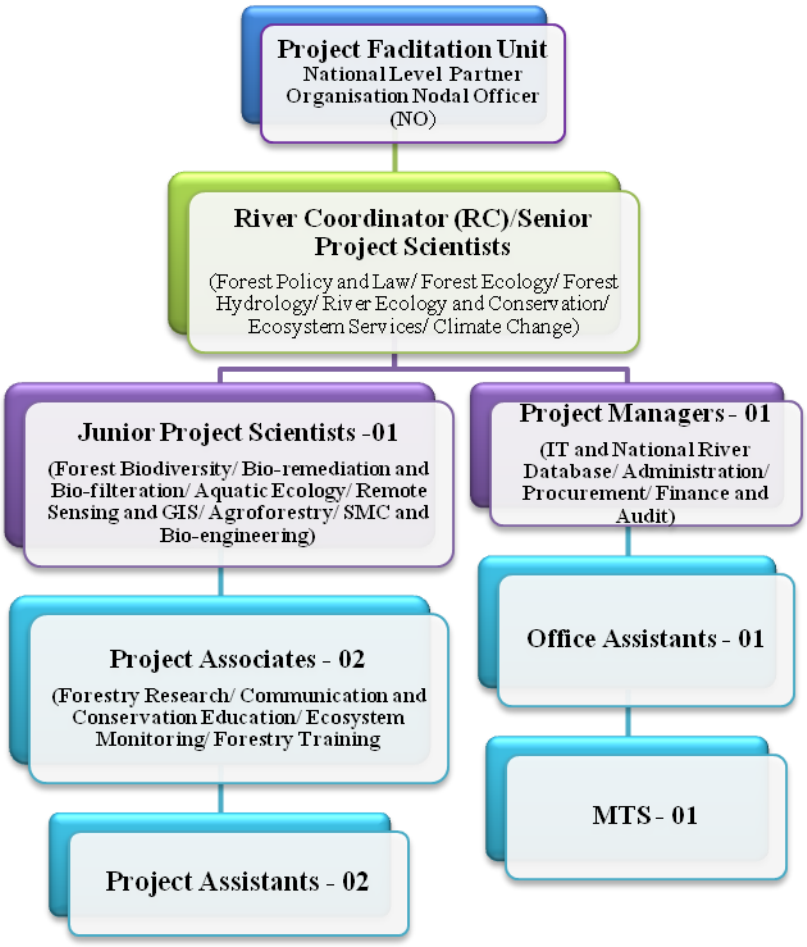


Fig. 6.5 – The Proposed Organizational Structure of the Project Facilitation Unit (PFU) at the National Level Partner Organization on Knowledge Management and Capacity Development

6.2.3 Project Management Unit(s) at the Concerned States/UT Forest Departments

The SFDs in concerned states/UT are primary IAs for proposed forestry interventions in the Riverscape. Thus, they are expected to carry out large extents of natural, agriculture and urban landscapes forestry activities, soil and water conservation works, riverfront development, eco-parks, riparian wetland management, and bio-remediation and bio-filtering besides implementation of various allied/supporting activities at three hierarchical levels *viz*., State, Division, and Local Communities in these concerned two States (Himachal Pradesh and Punjab) and one UT (Jammu & Kashmir). Thus, a provision of Project Management Unit (PMU) at each SFD has been made so as to facilitate, coordinate, and manage envisaged project activities through 12 Territorial Forest Divisions and 4 Wildlife Divisions within the States and UT Riverscape. The PMU in each of the participating State will be headed by the Addl. PCCF/CCF level officer and designated as the Project Executive Director (PED)/PEO. The DFOs/DCFs of

16 Divisions will be responsible for actual implementation of proposed forestry interventions and other allied activities envisaged in the DPR. The existing Forest Development Agencies (FDAs) operating at Divisions/District level or any other appropriate suitable State specific mechanism could be utilized for implementation of the project at the field level while Joint Forest Management Committees (JFMCs)/Eco-development Committees (ECs)/Biodiversity Management Committees (BMCs)/Gram Panchayats or other relevant bodies need to be involved in field level execution at the local/community level. Each State specific PMU will avail the existing Government Officers/ staff besides select contractual employees for the project tenure. The contractual staff will include one Project Assistant (Forest Management/RS and GIS/IT/Communication and Database), and one Office Assistant, two MTS and one Data entry operator for each divisions of concerned state/UT would be engaged for the project duration (Fig. 6.6).

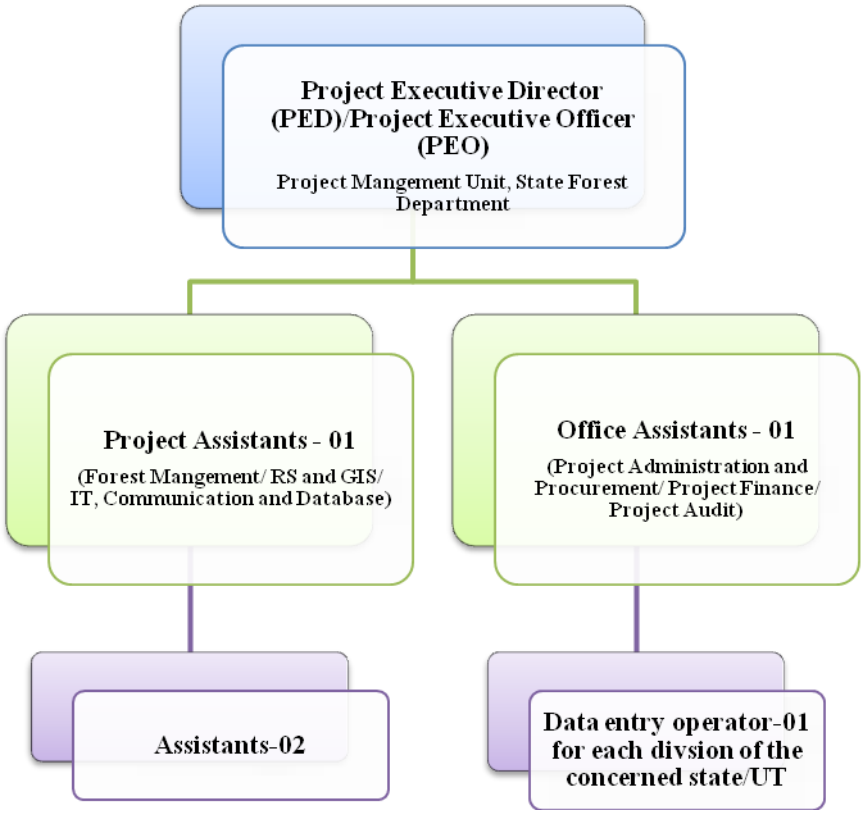


Fig. 6.6 - Proposed Organizational Structure of Project Management Unit at the State Forest Department in the Concerned States/UT

6.3 Implementation and Fund Flow Mechanism

In order to ensure effective execution of the project involving multiple agencies across the concerned two States and one UT of riverscape, an efficient implementation mechanism is desirable. Thus the project visualizes setting of two Project Steering Committees (PSCs), one at the National Level in the Central Nodal Ministry i.e., National Programme Steering Committee (NPSC), while other at the State Level in each of concerned states and UT i.e., State Programme Steering Committee (SPSC).

(i) National Level Programme Steering Committee (NPSC)

The National Level NPSC will be chaired by the Secretary of the concerned Central Nodal Ministry and the Member Secretary would be the National Project Director (NPD). The NPSC is expected to have multiple members represented by senior officials of the MoEF&CC; Ministries of Jal Shakti, Agriculture, AYUSH (Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy), Youth Affairs and Sports, Tribal Development, Rural Development, Urban Development, Panchayati Raj, and Tourism; Principal Chief Conservator of Forests (PCCFs) and Head of Forest Forces (HoFFs) of concerned States/UT or their representatives; Director/Nodal Officer of the National Partner Organization (HFRI); and one representative each from Indo-Tibetian Border Police Force (ITBP) and Eco Task Force. Thus, the NPSC is expected to have about 20 members or so. The NPSC shall meet twice in a year at appropriate time for considering and approving the APOs submitted by the concerned SFDs. The funds against the approved APOs of the States shall be transferred by the NPMU to respective SFDs. The national level PFU will follow its own mechanism of governance and if required will have its Monitoring and Steering Committee for overseeing the project. Details on proposed institutional arrangements, implementation mechanism at the State and field levels, and constitution of SPSC in concerned States are presented in Fig. 6.7.

(ii) State Level Programme Steering Committee (SPSC)

As similar to National Level NPSC, each concerned SFD will also have the State Level SPSC. The existing framework of the State Forest Development Agency (SFDA) at the State Level or any other similar/equivalent agency will be used for transferring of funds at the State Level and funds will be released on the approval of the SPSCs. Only after approval of SPSC, the matching funds will be transferred to SPMU for further allocation to concerned divisions as per the respective APOs, duly approved by the SPSC. At the Circle/District Level, a Circle Project Implementation Committee (CPIC) will be constituted under the Chairpersonship of the Conservator of Forests (CF) with concerned Divisional Forest Officer (DFO) as the Member Secretary so as to ensure a transparent and accountable mechanism for implementation of activities as proposed in present DPR. Various works related to proposed forestry interventions

in the riverscape could be implemented in close association and involvement of the Village *Panchayat*/JFMC level setup. SPMU is proposed to perform in each of the implementing States. The SPMUs shall be responsible for all the directions, operations and control of forestry interventions at the State level through SPSC. The SPSC shall be chaired the Principal Secretary Forest/ PCCF and HoFF while at the State level Project Executive Director (PED) shall be the Member Secretary. The SPSC shall have equal level representative of various Line Agencies/ Departments, Civil Society, NGOs, Eco Task Force, ITBP, etc. The SPSC shall meet atleast twice a year at appropriate times for approving the APOs submitted by divisions and steering the project implementation activities across the State/UT.

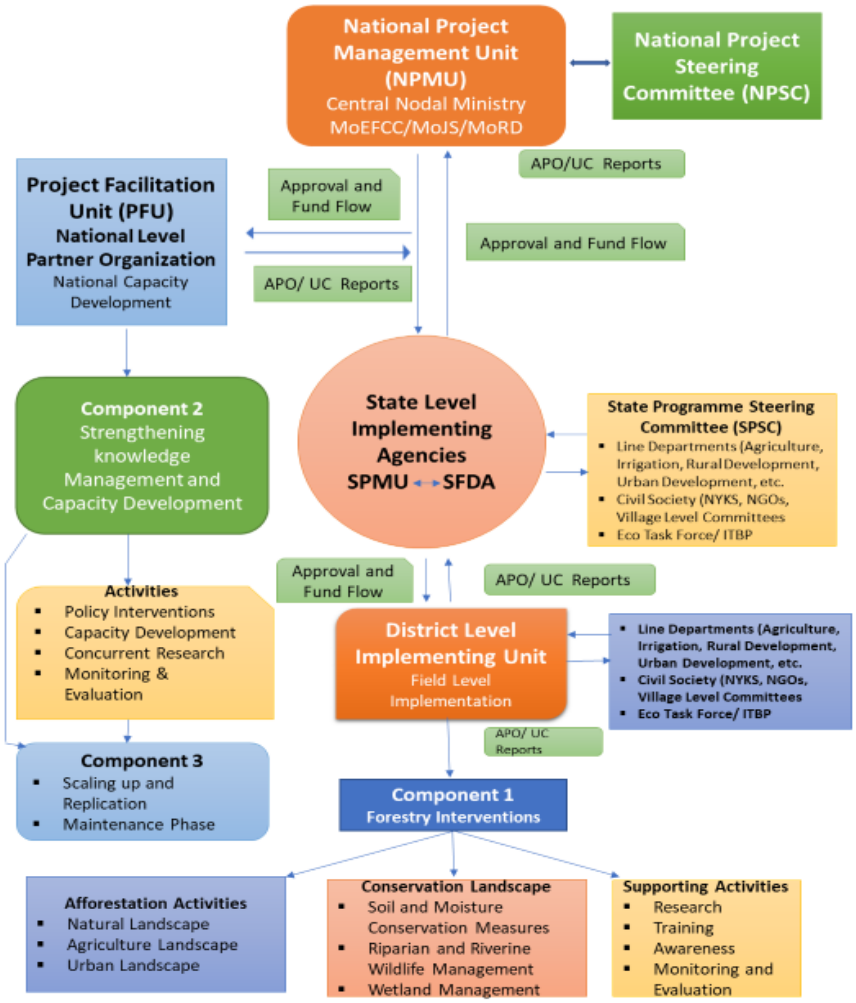


Fig. 6.7 – Proposed Hierarchical Institutional Arrangement and Mechanism for Project Implementation

(iii) Implementation at District/ Division Level

The District Level Implementing Committee (DIC) shall be constituted for programme execution having the CF as the Chairperson and the concerned DCF/DFO as the Member Secretary along with the representation of District Level Line Agencies/Departments as well as the Civil Society. A Civil Society Organization at the Division/District Level shall be involved for programme execution at the field level. The concerned DFO as the Member Secretary who is also the Chief Executive Officer of this FDA wherever in existence and functional shall submit APOs for forestry interventions as envisaged in the project in consultations with the representatives of Line Departments, NGOs, Eco Task Force, and other Civil Societies who shall be invited by DFO and involve every time in the consultation process. The SPMU will scrutinize the APOs received from concerned DFOs and ensure timely approval by the SPSC, with or without necessary changes, for further submission to the NPSC at the Central Nodal Ministry. Upon approval of the APO by the NPSC, the funds shall be transferred against the APO to an account separately maintained by the respective SFDs for implementation of the project envisaged in the present DPR. Likewise, separate accounts shall be opened by each of the DFOs at the Division Level so as to exclusively operate planned forestry interventions as proposed/envisaged in the DPR. DFOs will ensure that there is no mixing up of expenses/accounts of any other nature with the account specifically opened for the purpose of present project. The SPSC shall authorize SFDA to transfer funds against approved APOs to accounts opened by divisions specifically for the purpose. Financial expenses, creation and management of assets, incurring overhead expenditures, etc. shall be as per the provisions of GFR-2017 and/or any rules/guidelines framed by the Central and State Governments in this regard from time to time. The SFD or any other Implementing Partner Department/Agency as well as the Civil Societies shall be responsible for achieving the objectives/targets while maintaining proper documents and accounts, besides accountability and transparency. The Himalayan States will ensure active involvement of the Eco Task Force/ITBP in plantation and other related soil and water conservation measures, control of forest fires and protection of Rare Endangered and Threatened (RET) faunal species in the terrestrial as well as the riverine environments and other relevant project activities. It is proposed that at least 10% plantation activities in the Himalayan States will be entrusted to the Eco Task Force and/or ITBP. The PMUs of concerned SFDs will allocate funds to these agencies for actual implementation in areas under their command or arrange to allocate new areas. Further, setup under the Ministry of AYUSH will be involved for works related to afforestation/plantation, conservation and sustainable harvest of Medicinal and Aromatic Plants (MAPs). The State/District and Field Level formations under the NYKS of the Ministry of Youth Affairs and Sports, such as Youth Clubs/Eco-Clubs/*Mahila Mandals* and other leading Civil Society Organizations (CSOs) (e.g., Seechewal initiative, etc.) will also be actively involved not only in plantation works, but also in awareness campaign and other activities relevant to this project. The concerned SFD/SPMU will work out the detailed mechanism as per the specific requirements and prevailing conditions and duly signed MoUs on record. A budget of Rs. 25.64 Crores is provisioned for supporting activities in the project for all the concerned State/UT and will be utilised through above stated State level and local level organizations/formations. The SPMUs

will invite proposal and APOs from AYUSH, NYKS, ITBP, Eco Task Force, and other CSOs for consideration by the concerned SPSC. On approval, signing of MoU and timely funds will be released to the concerned agency for the specific/set of activities.

To summarize, the District/ Divisional Level arrangement will cover the following functions:

a) To prepare the APO in respect of activities covered under DPR as per approved document.
b) Capacity building and awareness of field functionaries through short term training courses.
c) To ensure smooth flow/ expenditure of funds and maintain proper accounts.
d) To check and monitor the ongoing activities of the project and ensure proper documentation.
e) To ensure timely physical, financial and social auditing of the activities undertaken.
f) To ensure suitable arrangement for post maintenance of assets created.
g) To ensure timely submission of reports to the CCF concerned for onward transmission to SPSC.

(iv) Execution at Field Level:

Once the APO submitted by the Division/District approved and works alotted, the respective work shall be executed with active involvement of JFMCs and/or other CSOs in the area. In case, the works are entrusted to JFMCs/CSOs for execution, the cashbook and account so maintained by them in turn shall be submitted to the concerned DFO who will ensure that the works have been done in accordance with the physical and financial parameters prescribed. The accounts as well as the bank account for the purpose of execution of work project as per the present DPR shall be maintained separately. The Measurement Books (MBs) for such activities recorded through JFMCs or CSOs of the SFDs shall be maintained by the concerned officials of the SFDs while the JFMCs shall submit Utilization Certificate (UC) dully verified by RFOs and Completion Certificates (CCs) to the concerned DFO. The concerned Range Officers will be responsible for the implementation of the project activities as per the approved document/APO pertaining to their ranges with the assistance of field staff, namely Block Forest Officers and Forest Guards.

For the works to be executed by the other Line Departments, Eco Task Force, ITBP, NGOs, and other Community Based Organizations (CBOs), the DFOs shall convey the approved APOs to concerned officials of the respective Department/Agency, and also release corresponding funds to them. The responsibility of execution shall completely rest with the Line Department/Agency and they shall be maintaining MBs at their own level and submit account for the same to the DFO. These works shall be inspected jointly by the concerned field staff of SFDs with the executing Department/Agency and inspection report submitted to DFO. DFO who is the Member

Secretary of District/Division Level Implementing Agency (DIC) specifically constituted for implementation of the present project, shall make electronic fund transfer to the executing agency to facilitate timely implementation of envisaged works. SFDs will maintain records for individual site with all the activities logged in immediately as and when carried out along with the expenditure incurred on the standard forms being used by respective SFD. The UCs and CCs compiled at State Level PMU shall be submitted to the NPMU at the Central Nodal Ministry for monitoring.

New JFMCs for programme implementation shall be formed by the SFDs, if required and deemed fit. Concerned SPSCs, SPMUs and DFOs will ensure adequate involvement and participation of other recognized CSOs like, NYKS, NSS, NCC, NGOs, *Mahila Mandals*, Self Help Groups, etc. In areas where none of these CSOs exists or are not feasible for any justifiable reason, the DFO may opt for executing the works departmentally with the help of any other active civil society in the area.

The expenditure incurred is auditable as per the Government of India Rules/Procedures and/ or as per the specifications provided by the Central Nodal Ministry or even the prominent financial agency supporting the project.

(v) Budget: The SFDs are mandatorily required to organize and undertake in-house/internal monitoring and necessary budget provisions have been made in this regard. Twenty five per cent of the actual works carried out will have to be essentially monitored. The mechanism of such monitoring shall be finalized by the concerned SPSC which will also lay down the procedure for submission of UCs to the Central Nodal Ministry along with the approved APO for various works during the next year. Based on APO as well as UC for the amount released during the previous year, the Central Nodal Ministry/NPMU shall release the funds after obtaining the approval of the NPSC.

6.4 Risk Assessment

Conservation of forest biodiversity is vital for mankind as it provides enormous benefits such as biological resources and ecosystem services. Of late, the forests are facing risk and threats such as fragmentation, degradation and forest fires which are responsible for the deteriorating condition. Risk is defined as the expected loss due to a particular hazard for a given area and reference period. An expected loss may be calculated as the product of the damage and its probability uncertainty and multiple risks are typical aspects of forest management.

Forestry activities and river conservation are likely to be influenced by a wide range of driving forces i.e., solar radiation, precipitation, temperature, humidity, wind, etc., biotic (human disturbances–deforestation, fragmentation and habitat loss, livestock grazing, forest fires, invasive and alien species, pests, agriculture expansion, developmental activities, etc.) and abiotic factors (i.e., soil erosion, landslides, etc.). While some of these factors (biotic and abiotic) can be managed to an extent, others (driving variables) are beyond the scope of human

interventions. Hence, a certain degree of risks is involved in the implementation of planned activities of forestry interventions. Potential risks broadly grouped into biotic and abiotic categories based on the likely causes of such risks are summarized below in Table 6.1.

Table 6.1 - Potential Risk Factors Relevant to Forestry Interventions and River Conservation

Sr. No.	Risk Factors	Risk Reduction Measures
A.	**Biotic Risks**	
1.	Grazing of plantations by domestic livestock and wild herbivores can adversely impact plantation efforts at any stage.	Proper fencing of plantation areas, watch and ward, social fencing and awareness.
2	Illicit cutting of plantations or any other type of damage by human activities like road construction, unscientific muck dumping during road construction, hydropower projects construction activities, etc.	Effective fencing and protection measures (watch and ward and social fencing) so as to prevent any illegal activities and damage to plantations. Authorised muck dumping sites and regular monitoring of construction companies for proper muck dumping during the developmental activities, if they don't follow the environment protection rules, take action against them by the concerned DFO's.
3.	Encroachment of forest lands by local inhabitants	Proper fencing of forest land
4.	Overdependency of locals on forests for fuel, fodder, Timber, medicinal plants, etc. in tribal areas and unscientific extraction of forest products	Regular monitoring of over harvesting of forest resources.
5.	Forest fires – recurrent manmade annual forest fires are widespread and Forest fires is hampering the regeneration processes of different tree species	Adoption of comprehensive strategy towards prevention of forest fires. This would include awareness campaign, creation and maintenance of fire lines, watch and ward and efforts to control the fire in case it outbreaks.
6.	Pest and disease attacks	Use of chemical pesticides is discouraged due to toxic effect on water sources. Bio pesticides should uses at the place of chemical pesticides
B.	**Abiotic Risks**	
1.	Erratic rainfall, flash floods, – delayed rainfall, long dry	Timing of planting activities in consonance with rainfall is important for survival. Success of plantations depends on timely

	spells and excessive rains can adversely impact planting activities	and optimum rainfall. Hence, prepare exigency plan – select hardy species those can withstand erratic rainfall pattern, ensure alternate methods for watering in the event of dry spells, select plant species those can also withstand impact of excessive rains/ flooding.
2.	Climatic factors – Temperature: High temperature may lead to drying up of seedlings and root stock; Low temperatures and frost in the alluvial plains are likely to cause mortality among plantations due to frost injury and desiccation.	• The risk factor can be minimized by adopting planned adaptation in forest management practices. At the community level, planned adaptation may include diversification of forest based and non-forest based income sources, better local governance of forest resources and capacity development for monitoring. Industrial forest sector may involve the inclusion of bioenergy. • At the stands level, planned adaptation may mean planting a larger diversity of species or provenances, or trees bread for resistance to accepted stresses. • At the landscape level, planed adaptation may include measures to minimize the potential impact of fire, pests and diseases, increased afforestation and reforestation, and creation of biodiversity corridors. • Science is essential to support planned adaptation. The development of planting stock with desirable genetic traits may be a promising avenue to counter changes in the local climate. Intensive forest monitoring is key component of planned adaptation. • The impetus for change in the forest sector and society primarily comes from socio-economic situation, not ecological crisis. Planned adaptation needs to link to local adaptation policies focusing on the importance of the social and behavioral sciences in the forest management. Awareness of actual and potential impacts from climate change is crucial.
3.	Edaphic factors – soil erosion and landslides: the Himalayan mountainous tract is prone to soil erosion and landslide due to fragility, steep slopes and enhanced human disturbances.	Adopt appropriate soil and water conservation measures (bioengineering and mechanical); species selection and use of quality nursery material is important to reduce the risk factor.
4.	Drought	Small water recharge ponds

Any one or a combination of above stated potential risk factors can influence establishment, survival and desired growth of various proposed plantations as well as impact different conservation activities envisaged in the DPR. Hence, field officers of the Forest Departments of concerned States and UT and other involved implementing agencies shall consider the following possible mechanisms to reduce above risks:

a) The quality of planting stock, particularly age and size is an important aspect. In order to reduce above stated risks, IAs must ensure to use the quality planting stock. Tall nursery plants have proven to minimize several risk factors to a great extent.
b) Time is essence for successful operation of plantation activities. Thus, timely establishment of nursery and supply of high quality planting materials well before the planting season are essential to minimize risk factors. Damage to planting materials in transit also needs to be prevented.
c) Timely completion of planned advance works (fencing, cleaning of site, pit digging, etc.) and execution of actual plantation activities supplemented by use of bio-fertilizers, organic manure and composed, mulching, etc. can reduce risk levels drastically.
d) Establishment of required fencing and protection of plantations from livestock and wild herbivores will ensure from the risk of grazing and browsing. Thus, awareness, sensitization and involvement of local communities are essential so as to reduce the above stated biotic risks.

In spite of all possible attempts to minimize the risk involved, much of the progress, growth and success of the plantations are left to nature. Vagaries of nature in the form of climatic and edaphic extremities pose the greatest threat to proposed forestry interventions.

6.5 Mid-Course Learning and Adaptation

Proposed forestry interventions for restoration of a river by way of enhanced e-flow and water quality are definitely an innovative and integrated approach. The preceding section has highlighted the potential risks and vulnerability. Erratic climatic conditions and unpredictable external forces of nature tend to impact the field level activities as envisaged in the DPR. In view of the local conditions, activities and treatment models proposed in the DPR might need certain modifications to make them adaptable to micro-level conditions. The periodic monitoring, particularly the midterm review would allow the midcourse corrections and adaptation of new ideas and design. Such adaptive modifications in the design, criteria, specifications, timing of a particular activity, selection of sites and species, if any will have to be specifically mentioned in the APOs and executed by the DFOs/Partner Organizations only after obtaining approval from the SPMU. If need be, special approval may be accorded by the State Level Project Executive Director in order to ensure timely execution keeping in view the seasonal nature of envisaged works.

6.6 Monitoring and Evaluation of Outcomes/Results

The preceding Chapter 5 has described details on various aspects of participatory monitoring as well as evaluation. Broadly, two types of monitoring have been envisaged during the project execution phase: (a) monitoring of project performance in terms of project goals/objectives, activities, targets, outputs, outcomes and impact; and (b) and socio-economic monitoring in terrestrial as well as aquatic ecosystems. The set of measurable indicators elucidated will be

monitored on a given timeline (Table 6.2). In addition, the Chapter-8 provides a greater insight on the potential benefit on successful implementation of this project.

Table 6.2 – Measurable Indicators for Monitoring and Review Mechanism

Sr. No.	**Indicator based on Outputs**
1	Area covered under plantations in different landscapes
2	Survival of plants on the forestry intervention site
3	Growth performance of plants (Height, Collar diameter etc.)
4	Plants planted according to the concerned model
5	Maintenance of the forestry intervention site and condition of the fencing
6	Biomass Production in Natural, Agriculture and Urban Landscape (t/ha/year)
7	Extent of soil and moisture conservation works
8	Monitoring of quality of water at some locations, BOD & COD measurements
9	Siltation and sedimentation measurements od Ravi river, tributaries and reservoir as per CWC methods
10	Carbon sequestration measurements
11	Contribution to Carbon Stock of three landscapes after 10/20 years
11	Estimated Carbon reduction from forestry interventions in three landscapes after 10/20 years
12	Potential to generate Carbon Credit from plantation in three landscapes over a span of 20 years
13	Water Quality: Estimated sediment reduction through forestry intervention after 10/20 years
14	Water Quantity: Conservation of water through forestry interventions after 10/20 years
	Socio-Economic Indicators
1	Extent of employment generation (Number of mandays generated)
2	Number of awareness campaigns, development of publicity material i.e., pamphlets, brochures,books, booklets, etc.
3	Enhanced crop productivity improved livelihood
4	Quantity of NTFP produced
5	Estimated benefit from NTFPs

Plantation activities make the core activity of the proposed forestry interventions by adopting varied plantation/treatment models in Natural, Agriculture and Urban Landscapes within the riverscape and concerned States and UT. Accordingly, a bulk amount of the total budget outlay has been provisioned for this important activity. Considering the significance of plantation activities for the overall success of the project, in house monitoring has been envisaged and to be carried out by the IAs i.e., the concerned SFDs. Thus, only 25% of the actual works carried out will have to be mandatorily monitored. The DPR has made adequate provisions for the required budget for monitoring of plantations as well as other interventions has envisaged in the project. Further, in order to ensure optimal success of the plantations, necessary budgetary provisions have also been made for replacement of failed plants in the establishment year and gap filling (15% cost for first year, and 10% cost for second year) in subsequent years of maintenance. The DPR also envisions actual field level, and annual monitoring at three hierarchical levels of SFDs/ IAs by way of monitoring of 40-50% plantation sites by the concerned ACFs, 20-25% sites by

DFOs, and 10-12% CFs. The SPMU in consultation with the SPSC shall finalize the mechanism for proposed 25% in house monitoring. The SPSC will also lay down the procedure for submission of UCs to the NPMU based at the Central Nodal Ministry along with the approved APO for the proposed works in the next year and the budget estimates. The NPMU would release the funds for the next year after the NPSC has considered the UCs and APO and approved release of funds.

States and UT Forest Departments have provided preliminary information of proposed sites for plantations in field data formats submitted to HFRI, Shimla along with GPS locations for the preparation of present DPR. Site details have been incorporated in GIS/Google Earth maps. As per the well-established traditional practice of documentation, concerned Forest Departments are required to maintain 'Nursery Journal', 'Plantation Journals' and 'Journals for Other Interventions' meticulously. As per the existing system and laid procedures, these journals contain all requisite information on plantations, selected sites, geographical coordinates, site sketch and map, details of activities carried out and expenditure on plantations, weeding, tending, gap filling, and maintenance as well as the chronology of natural i.e., flood, drought, etc. and man-made i.e., fire events, if any impacting plantations adversely. As already stated, the DPR envisages actual monitoring of plantations at three hierarchical levels and proper recording of site Level observations in the Plantation Journals. As a first step, SFDs are required to place a sign board at the plantation site indicating the name of the scheme, area covered, and other details on planted species and their numbers. Necessary budget provisions for this purpose have been made in the cost norms under the head of contingency of various proposed forestry interventions.

The Logical Framework Analysis earlier presented incorporates important aspects of project monitoring and provides an insight on monitoring of project performance at various hierarchical levels (National/State/Local Levels). The logical framework has also provided details of verifiable indicators and appropriate means. The envisaged project outcomes i.e., biological, socio-economic and institutional will assess the impact of project interventions against the baseline developed during the Year-1 of implementation. The National Level Partner Organization (HFRI) will facilitate project monitoring and evaluation of outcomes/results through consultative process with leading scientific organizations and effective coordination with the Central Nodal Ministry, State level IAs and CSOs.

Outcome indicators include: (a) creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management; (b) enhanced levels for multi-sector convergence, alliances, integration, favorable national and state level policies.

The National Level Partner Organization in collaboration with concerned SFDs would involve concerned experts and organizations to develop an integrated, long-term ecological and socio-economic monitoring programme during the first year of project implementation and generate the base line information for evaluation of project impact in future. The ecological and socio-economic monitoring programme, thus, developed will be executed periodically as per the plan

developed for the purpose. Additional priority researches and theme based studies would be supported for each of the landscape category, river and its tributaries so as to supplement the participatory impact monitoring programme. Local Universities, Expert Scientific Organizations, and CSOs will be involved in monitoring programme envisaged for the project.

In addition to the above stated project as well as ecological and socio-economic monitoring, HFRI (National Partner Organization) will undertake and facilitate supervision missions in consultation and coordination with the NPMU based at the Central Nodal Ministry so as to review the progress made in execution of the project besides the well-structured and designed Mid Term Review (in third year) and the Terminal Evaluation (last quarter of fifth year of project implementation) by the Third Party/External Experts selected by the PMU of the Nodal Ministry.

6.7 Sustainability, Replication and Cost Effectiveness

For a multifaceted project on forestry interventions for restoration of river, three aspects *viz*., sustainability, replication and cost effectiveness are of immense significance. These aspects are elaborated below:

6.7.1 Sustainability

The geospatial analysis of the riverscape was an important step towards the preparation of present DPR and that provided a valuable insight on priority sites (high, moderate and low) for proposed forestry interventions and execution of other conservation interventions etc. Availing this insight, forestry interventions have been proposed mainly in high and moderately priority sites identified on the basis of geospatial analysis. Hence, majority targeted sites are of great significance for protection, conservation and restoration. Proposed interventions in such sites are likely to generate global biodiversity benefits i.e., enhanced forest cover and tree cover and diversity of species, carbon sequestration, and improved ecosystem services besides improved rural livelihoods. The project relies on the ecosystem based approach to river conservation and targets towards forest–river linkages, conservation and development interventions at the riverscape level so as to contribute in a meaningful way towards three important goals (*Aviral Dhara*, *Nirmal Dhara* and ecological integrity). Hence, project itself aims to achieve the ecological sustainability of Ravi River ecosystem. The project also lays emphasis on social sustainability as the project approach focuses on community driven strategy for forestry interventions and ecosystem management while ensures active involvement of CBOs/CSOs, line departments and various agencies. Project seeks to achieve objectives of empowerment of local communities, livelihood support and plans to distill disseminate best practices for optimal use at elsewhere. The project is of utmost importance for the concerned States/UT and the country, as the river contributes significantly towards water availability, agricultural sustainability particularly in the plains, economic development, biodiversity conservation, and the overall prosperity in the region.

6.7.2 Replication

The present project is yet another pilot effort after the first project of similar nature in the context of Ganga River which is being presently implemented in five States. Hence, the country has very little experience in implementing a major project in the entire riverscape on river restoration while specifically focusing on the theme of forestry intervention. Thus, the success of this yet another pilot project will help in developing capacity for replication of such efforts within the country and elsewhere. The project has an integral component to enhance the national capacity on river conservation and restoration. The project fits into the national priorities and is expected to contribute towards the wider goals of sustainable development. Since, it is the beginning of implementation of project of this nature in a vast country like India having nine major river systems, experiences and learnings in execution shall have enormous scope for their replication.

6.7.3 Cost Effectiveness

The project adopts newer, holistic and participatory approaches towards river conservation and restoration and aims to develop best practices. The project promotes to enhance ecological integrity of the complex and dynamic river ecosystem. The cost norms for various proposed interventions have been computed on the basis of acceptable cost on the establishment of plantations in Natural, Agriculture and Urban Landscapes and the reasonable maintenance costs in the subsequent years. The project has also considered the norms of success rates of plantation in different States as well as the country as a whole. The project is expected to contribute a wide array of tangible and intangible values besides helping in the restoration of an important river ecosystem for the country. In general, cost effective norms and scientific basis to planning, management and conservation have been adopted. The project will be highly cost effective since it is not only expected to meaningfully contribute towards river conservation and restoration but also would help in development of national capacity in such endeavors and enhanced ecosystem services. In addition, the Chapter-8 provides a greater insight on the potential benefit on successful implementation of this project of immense national importance.

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Chapter 7

Project Budget and Schedule

7.1 Project Budget

The DPR envisages two phases: (a) Phase 1- Project Implementation, and (b) Phase II Maintenance Phase. Each phase is of 5-year duration. Thus the project activities planned and incorporated in the DPR spread over a period of 10-years. The total financial outlay for phase I and phase II for detailed project report of Ravi River through forestry intervention is Rs. **498.77**

Crore. The projected financial outlay of the Phase 1 on Project Implementation of five-year duration is Rs. **395.95** Crore. The projected budget outlay of Phase II (Maintenance Phase) of five-year duration is Rs. **102.819** Crore. As mentioned above, the project includes four broad based components. Accordingly, financial cost of each of these four components is summarized below:

7.2 Project Outlay: Component and Activity Wise

The Principal Component-A: Implementation of Forestry Interventions in Ravi Riverscape

An amount of Rs 359.33 Crore, which is 72.04 % of the overall project budget, is provisioned for principal component A. This includes total Rs. 333.69 Crores for forestry interventions in three landscapes (Sub-component A.1) and Conservation intervention (Sub-component A.2) and Rs. 25.64 crore provisioned for supporting activities (Sub-component A.3).

Component -A: The Component - A on plantations and various treatment models in three types of landscapes within the riverscape is the largest in terms of its spread, extent and quantum of funds provisioned. The component A, being the predominant component of the overall project have envisaged three sub-compenents.

Sub-Component–A.1 the predominant sub-component (A.1) emphasizes on extensive plantation in three types of Landscape (Natural, Agriculture, Urban and Plantations under Eco-Task Force (ETF) within the riverscape (Table 7.2). Among three landscapes, the highest predominance of proposed activity is in Natural Landscapes within the riverscape i.e., Rs. 105.47 Crores. Two Battalions of Eco-Task Force with also carry out plantation (2,000 ha) activities in the Natural Landscape in Hiamchal Pradesh and Jammu & Kashmir UT at projected cost of Rs. 45.34 Crores. Plantations and other appropriate treatment models have also been planned for Agriculture Landscape and Urban Landscape within the riverscape and budget provision to the tune of Rs. 4.81 Crores and Rs.67.22 Crores respectively of the sub-component (A.1) have been made.

The second Sub-component on 'Conservation Interventions' (**A.2**) includes three major types of interventions/activities. These are: (a) soil and moisture conservation measures, (b) riverine and riparian wildlife management, and (c) wetland management. Rs. 110.85 Crores are provisioned for this subcomponent, which is 22.22 % of total budget outlay. Out of this, the budget outlay for SMC is Rs. 73.21 Crore, which is 20.37 % allocation of the funds provisioned for Component A. Budget outlay provisioned for Riverine, Riparian Wildlife Management and Wetland Management is Rs. 37.64 Crore, which is 10.48 % of total budget of component A (Table 7.1 and Table 7.3).

The third Sub-component (**A.3**) pertaining to 'Supporting Activities' is to be executed by concerned States/UT level IAs. This Sub-component includes seven broad based activities viz., (a) policy and legal interventions, (b) participatory monitoring, (c) adaptive research, (d)

capacity development, (e) awareness, (f) project management, and (g) evaluation. A budget of 25.64 Crore or 5.14% of total budget proposed to the concerned States/UT has been provisioned for carrying out various supporting activities for five-year period (**Table 7.1 and Table 7.4**). The break-up of proposed budget allocation under the Sub-component (A.3) on supporting activities of Ravi riverscape is given in Table 7.4.

The Component-B: The component B specifically pertains to the National Partner Orgnization (NPO) responsible for carrying out priority activities relevant to the strengthening of knowledge management, enhacement of capacity for forestry interventions and river conservation. Strengthening Knowledge Management and enhancement of national capacity for forest hydrology, forestry interventions, and conservation and restoration of rivers would require a sum of Rs. 18.53 Crore or 3.72% of the overall project outlay (Table 7.1 and 7.5). The year-wise breakup of proposed budget for Strengthening Knowledge Management and capacity enhancement by National Level Partner Organization- ICFRE/HFRI is given in Table 7.5. The highest budget amounting Rs. 4.89 Crore has been provisioned for cost of PFU, while budget of Rs. 3.93 Crore has been provisioned for Research and Development, while Rs. 1.12 Crores, Rs. 1.69 Crore, Rs. 2.25 Crore, Rs. 0.92 Crore, Rs. 0.42 Crore and Rs. 0.29 have been envisaged for policy level interventions, capacity development, Scientific exchange, awareness, Monitoring and Evaluation respectively.

The Component – C on the Phase II of the project of five-year duration for maintenance of plantations raised during Phase I of the project has also been planned. The Phase II would also include limited activities related to replication of efforts in additional tributaries/areas and scaling up of the planned effort. A sum of Rs. 102.81 Crore or 20.61 % of the total project financial outlay has been envisaged specifically for the Component – C on 'Maintenance Phase'.

The Component – D pertains to project management at the national level which would include the establishment of National Project Management Unit (NPMU) at the Central Nodal Ministry with the responsibility to oversee, steer and manage this priority project. A sum of Rs. 18.09 Crore, representing 3.63 % of the overall budget over a period of five-year during the Phase I has been provisioned (Table 7.1 and Table 7.6). Year-wise proposed budget for Project Management Unit at Central Nodal Ministry for Ravi River is presented in Table 7.6. Thus, it is clear that the major portion of project budget outlay is meant for field level activities incorporating proposed forestry interventions, conservation interventions and supporting activities to be implemented in concerned States/UT.

A total of 12 Territorial Forest Divisions and 4 Wildlife Divisions in Ravi Riverscape, will carry out proposed activities relevant to forestry interventions within the Riverscape. A total of 6401.54 ha area of three landscapes (Table 7.2), 421 ha area of Riverine and Riparian wildlife management and wetland management and 452920.5 m^3 extent of soil and moisture conservation in Ravi Riverscape is envisioned to be treated under the various forestry interventions (Table 7.3).

Cost Indexing: The project costs have been worked out on the basis of rate prevalent during year 2019-20 in the respective State/UTs and 7% escalation in the project cost during the subsequent years has been incorporated in anticipation of the cost escalation in future. However, actual project cost at the time of implementation on yearly basis shall need revision as per the change in Wholesale Price Index (WPI) on year to year basis. The Conservator of Forest may be empowered to revise the project cost accordingly for the quality desired output of the project.

The consent letters regarding availability of land in different landscapes within the concerned States (Himachal Pradesh and Punjab) and UT (Jammu & Kashmir) has been enclosed as Annexure 7, 8 and 9 in Vol. 1.

The proposed budget allocation for Ravi River for three State/UT Level Implementing Agencies under Three Landscapes, Conservation Interventions and Supporting Activities is given Table 7.7 and model/activity wise area and cost of Forestry Interventions in Ravi Riverscape is given Table 7.8.

Table 7.1 – Project Budget Outlay - Component/ Activity Wise Budget Allocation for Ravi Riverscape

Sr. No.	Component/ Activity	Amount (Rs. in Crore)	Allocation Total (%)	Allocation Phase I (%)
	Implementation of Forestry Interventions in Two States and one UT of Riverscape (A.1+A.2+C1+C3)	**410.34**	82.27	84.27
A.1	**Plantations and Treatment Models in Three Categories of Landscape**	**222.84**	44.68	56.28
A.1.1	Natural Landscapes	105.47		
A.1.2	Eco Task Force	45.34		
A.1.3	Agriculture Landscapes	4.81		
A.1.4	Urban Landscapes	67.22		
A.2	**Conservation Interventions**	**110.85**	22.22	27.99
A.2.1	Soil and Moisture Conservation	73.21		
A.2.2	Riverine and Riparian Wildlife Management and Wetland Management (Natural and Artificial)	37.64		
A.3	**Supporting Activities**	**25.64**	5.14	6.48
A.3.1	Policy Level Interventions	0.19		
A.3.2	Research Activities	2.44		
A.3.3	Capacity Development	7.54		
A.3.4	Awareness	4.64		
A.3.5	Participatory Monitoring	0.90		
A.3.6	Cost of PMUs of Two State Level Implementing Agencies	9.33		

A.3.7	Evaluation	0.56		
A.3.8	Contingency and Miscellaneous Activities	0.05		
Total Budget of Component A (A1+A2+A3)		**359.33**		
B.	**Strengthening Knowledge Management and National Capacity for Forestry Interventions and Conservation of Riverscapes**	**18.53**	3.72	4.68
C.	**DPR – Phase II (Maintenance phase) Including Scaling Up and Replication of Successful Models of Forestry Interventions**	**102.819**	20.61	
C.1	Maintenance Cost of A.1 and A.2 (Cost of Phase II)+ Est. of Phase II ETF	59.97		
C.2	Maintenance Cost of A.3, B and D	26.169	5.24	
C.3	Scaling Up and Replication of Successful Models of Forestry Interventions (5% of A.1 & A.2)	16.68		
D.	**National Coordination for Forestry Interventions and Riverscape Conservation**	**18.09**	3.63	4.57
	Total Phase I (A+B+D)	**395.95**		100.00
	Total Project Cost (Phase I+II) (A+B+C+D)	498.769 or say **498.77**	**100.00**	

C.1 Maintenance Cost in Crore [(NL)16.04+(ETF)36.48+(Est. of Phase II ETF)1.80 + (AL) 0.33 + (UL)1.95 = 56.6]+[(SMC) 0+ (Riparian & Wetland)3.37]= 59.97

Note: In the proposed budget of Ravi River for HP, Punjab and J & K UT Implementing Agencies, 5% of total budget of phase I will be added in phase II for Scaling Up and Replication of Successful Models.

Table 7.2 – Proposed Budget Allocation for Various Plantations and Treatment Models in Three Types of Landscapes in Ravi Riverscape

A. Natural Landscapes*						
State	**No. of Sites**	**Area (ha)**	**Phase I (Project Implementation)**		**Phase II (Maintenance Phase)**	**Total Cost**
			Establishment Cost (Rs. in Crore)	**Maintenance Cost (Rs. in Crore)**	**Maintenance Cost (Rs. in Crore)**	**(Rs. in Crore)**
Himachal Pradesh	250	3265	61.49	12.51	11.97	85.97

Jammu & Kashmir	31	730	8.14	2.41	1.45	12.00
Punjab	102	795.35	14.85	6.07	2.62	23.54
Total	**383**	**4790.35**	**84.48**	**20.99**	**16.04**	**121.51**

B. Agriculture Landscape

State	**No. of Sites**	**Area (ha)**	**Phase I (Project Implementation)**		**Phase II (Maintenance Phase)**	**Total Cost**
			Establishment Cost (Rs. in Crore)	**Maintenance Cost (Rs. in Crore)**	**Maintenance Cost (Rs. in Crore)**	**(Rs. in Crore)**
Himachal Pradesh	24	204	0.30	0.46	0.05	0.81
Jammu & Kashmir	30	245	0.37	0.57	0.08	1.02
Punjab	18	818	1.20	1.91	0.20	3.31
Total	**72**	**1267**	**1.87**	**2.94**	**0.33**	**5.14**

C. Urban Landscape

State	**No. of Sites**	**Area (ha)**	**Phase I (Project Implementation)**		**Phase II (Maintenance Phase)**	**Total Cost**
			Establishment Cost (Rs. in Crore)	**Maintenance Cost (Rs. in Crore)**	**Maintenance Cost (Rs. in Crore)**	**(Rs. in Crore)**
Himachal Pradesh	28	113.2	16.504	9.53	1.20	27.23
Jammu & Kashmir	24	126.59	10.808	6.76	0.27	17.84
Punjab	32	104.4	14.603	9.01	0.48	24.09
Total	**84**	**344.19**	**41.915**	**25.30**	**1.95**	**69.16**

D. Eco-Task Force

State	**No. of Sites**	**Area (ha)**	**Phase I (Project Implementation)**		**Phase II Establishment and (Maintenance Phase)**	**Total Cost**
			Establishment Cost (Rs. in Crore)	**Maintenance Cost (Rs. in Crore)**	**Maintenance Cost (Rs. in Crore)**	**(Rs. in Crore)**
Himachal Pradesh	1 No.	1000	9.78	12.65	18.84	41.27
Jammu & Kashmir	1 No.	1000	9.78	13.13	19.44	42.35

Total	**2 No.**	**2000**	**19.56**	**25.78**	**38.28**	**83.62**
Grand Total (A + B + C+D)	**541**	**8401.54**	**147.83**	**75.01**	**56.6**	**279.43**

**Natural landscape also includes area and cost of fire protection and natural regeneration models of natural landscape*

Table 7.3 – Budget Allocation for Proposed Activities under the Sub-Component (A.2) on Conservation Interventions in Ravi Riverscape

Activity	Himachal Pradesh			Jammu & Kashmir			Punjab			Total of Two States and one UT		
	No. of Sites	Extent	Total Cost (Rs. in Crore)	No. of Sites	Extent	Total Cost (Rs. in Crore)	No. of Sites	Extent	Total Cost (Rs. in Crore)	No. of Sites	Extent	Total Cost (Rs. in Crore)
Soil and Moisture Conservation (Extent in m^3)	416	247830.5	53.21	43	19590	5.90	147	185500	14.10	606	452920.5	73.21
Riverine and Riparian Wildlife Management (Extent in ha)*	5	235	23.50	1	20	2.00	2	57	5.70	8	312	31.20
Wetland Management (Extent in ha)*	2	53	4.77	-	-	-	2	56	5.04	4	109	9.81
Total Cost on Proposed Conservation Interventions in Ravi Riverscape =												**114.2**

**Area is virtual considered for calculation of budgetary provisions*

Table 7.4 – Proposed Budget Allocation under the Sub-Component (A.3) on Supporting Activities in Ravi Riverscape

		Phase I				Phase II				
Sr. No.	**Activity**	**States**			**Total**	**States**			**Total**	**Grand Total**
					(Rs. in Crore)				**(Rs. in Crore)**	**(Rs. in Crore)**
		Himachal Pradesh	**Punjab**	**J&K**	**Phase I**	**Himachal Pradesh**	**Punjab**	**J&K**	**Phase II**	**Phase I+II**
		(Rs. in Crore)	**(Rs. in Crore)**			**(Rs. in Crore)**	**(Rs. in Crore)**			
1	**Policy Level Interventions**	0.07	0.06	0.06	**0.19**	0.01	0.004	0.004	**0.01**	**0.20**

2	**Research**	0.84	0.75	0.84	**2.44**	0.54	0.479	0.538	**1.56**	**3.99**
3	**Capacity Development**	3.02	1.96	2.56	**7.54**	0.00	0.000	0.000	**0.00**	**7.54**
4	**Awareness**	1.77	0.66	2.21	**4.64**	0.00	0.000	0.000	**0.00**	**4.64**
5	**Participatory Monitoring**	0.31	0.28	0.31	**0.90**	0.18	0.164	0.184	**0.53**	**1.44**
6	**Project Management**	3.33	2.83	3.17	**9.33**	1.60	0.757	0.849	**3.21**	**12.53**
7	**Evaluation**	0.20	0.17	0.19	**0.56**	0.83	0.641	0.718	**2.19**	**2.75**
8	**Contingency and other Expenses**	0.02	0.01	0.02	**0.05**	0.01	0.004	0.004	**0.02**	**0.06**
Total Cost – Supporting Activities		9.56	6.72	9.36	**25.64**	3.16	2.049	2.298	**7.51**	**33.15**

Table 7.5 – Proposed Budget for Strengthening Knowledge Management and Capacity Enhancement by the National Level Partner Organization – ICFRE/HFRI Shimla

Sr. No.	**Item**	**Year**											**Total**	**Cost**
		Phase I					**Total**	**Phase II**					**(Rs. in Crore)**	**(Rs. in Crore)**
		I	**II**	**III**	**IV**	**V**	**Phase I**	**VI**	**VII**	**VIII**	**IX**	**X**	**Phase II**	**Phase I+II**
A.	**Recurring Cost**													
A.1	Cost of PFU - Salary and Wages, Equipment, Office Expenses and Management, Travel, Vehicle and POL, Audits, etc.	1.02	0.91	0.95	0.99	1.03	**4.89**	0.34	0.33	0.31	0.29	0.27	**1.54**	**6.43**
A.2	Inputs for Policy Level Interventions	0.20	0.21	0.22	0.24	0.25	**1.12**	0.26	0.00	0.00	0.00	0.30	**0.56**	**1.68**
A.3	Strategic Adaptive Research and Development	0.71	0.75	0.78	0.82	0.87	**3.93**	0.43	0.45	0.48	0.50	0.53	**2.39**	**6.32**
A.4	Knowledge Management and Capacity Development	0.31	0.32	0.34	0.35	0.37	**1.69**	0.19	0.19	0.20	0.21	0.23	**1.02**	**2.71**
A. 5	Scientific Exchange, Exposure Visits, and	0.41	0.43	0.45	0.47	0.49	**2.25**	0.25	0.26	0.27	0.29	0.30	**1.37**	**3.61**

	Engagement of International and National Consultants													
A. 6	Inputs for Awareness													
A.7	Monitoring - Project, and Ecological and Socio-economic	0.31	0.15	0.15	0.15	0.15	**0.92**	0.04	0.00	0.01	0.00	0.00	**0.05**	**0.97**
A. 8	Project Evaluation	0.10	0.09	0.08	0.07	0.07	**0.42**	0.06	0.05	0.05	0.04	0.04	**0.25**	**0.66**
	Sub Total Recurring Cost (A)	**3.05**	**2.86**	**3.26**	**3.10**	**3.23**	**15.50**	**2.06**	**1.29**	**1.32**	**1.33**	**2.31**	**8.31**	**23.81**
B.	**Non-Recurring Cost**													
B.1	Incorporation of Advance Technology	0.10	0.09	0.08	0.07	0.07	0.42	0.03	0.00	0.00	0.00	0.00	**0.03**	**0.45**
B.2	Permanent Equipment and Maint.	0.10	0.05	0.03	0.01	0.01	0.20	0.01	0.01	0.01	0.01	0.01	**0.03**	**0.23**
	Sub Total Non-Recurring Cost (B)	**0.20**	**0.14**	**0.11**	**0.09**	**0.07**	**0.61**	**0.04**	**0.01**	**0.01**	**0.01**	**0.01**	**0.07**	**0.68**
C.	**Total (Recurring and Non-Recurring Costs) A+B**	**3.25**	**3.00**	**3.37**	**3.19**	**3.30**	**16.12**	**2.10**	**1.29**	**1.33**	**1.34**	**2.31**	**8.37**	**24.49**
D.	**Institutional Charge @ 15%**	0.49	0.45	0.51	0.48	0.50	2.42	0.31	0.19	0.20	0.20	0.35	**1.26**	**3.67**
E.	**Grand Total (C+D)**	**3.74**	**3.45**	**3.88**	**3.66**	**3.80**	**18.53**	**2.41**	**1.49**	**1.52**	**1.54**	**2.66**	**9.63**	**28.16**

Table 7.6 – Proposed Budget for Project Management Unit at the Central Nodal Ministry for Ravi River

Sr. No.	**Item**	**Year**											**Grand Total Cost**
		Phase I					**Total**	**Phase II**				**Total**	**(Rs. in Crore)**
		I	**II**	**III**	**IV**	**V**	**Phase I**	**VI**	**VII**	**VIII**	**IX**	**X**	**Phase II**	**Phase I+II**
A. Recurring Cost														

A.1	Cost of PMU - Salary and Wages, Equipment, Office Expenses and Management, Travel, Vehicle and POL, Audits, etc.,	1.23	0.95	0.99	1.04	1.09	**5.31**	0.34	0.32	0.31	0.29	0.27	**1.54**	**6.84**
A.2	Inputs for Policy Level Interventions	0.37	0.39	0.41	0.43	0.45	**2.05**	0.45	0.00	0.00	0.00	0.52	**0.97**	**3.02**
A.3	National Decision Support and Management Information System	0.49	0.52	0.54	0.57	0.60	**2.73**	0.32	0.28	0.26	0.23	0.21	**1.29**	**4.02**
A.4	Scientific Exchange, Exposure Visits, and Engagement of International and National Consultants	0.62	0.65	0.68	0.71	0.75	**3.41**	0.68	0.31	0.31	0.31	0.31	**1.91**	**5.32**
A.5	Inputs for National Level Awareness	0.37	0.39	0.41	0.43	0.45	**2.05**	0.41	0.38	0.36	0.34	0.32	**1.82**	**3.86**
A.6	Project Monitoring and Evaluation			0.32			**0.32**	0.53				0.68	**1.21**	**1.53**
Sub Total Recurring Cost (A)		3.09	2.90	3.35	3.18	3.34	**15.86**	2.72	1.30	1.23	1.17	2.32	**8.74**	**24.60**
B. Non-Recurring Cost														
B.1	Incorporation of Advance Technology	0.37	0.33	0.30	0.27	0.24	**1.52**	0.24	0.00	0.00	0.00	0.00	**0.24**	**1.76**
B.2	Permanent Equipment	0.37	0.19	0.09	0.05	0.02	**0.72**	0.01	0.01	0.01	0.01	0.01	**0.03**	**0.75**
Sub Total Non-Recurring Cost (B)		0.74	0.52	0.39	0.32	0.27	**2.23**	0.25	0.01	0.01	0.01	0.01	**0.28**	**2.51**
C.	**Grand Total (Recurring and Non-Recurring**	**3.83**	**3.42**	**3.74**	**3.50**	**3.61**	**18.09**	**2.97**	**1.31**	**1.24**	**1.18**	**2.32**	**9.02**	**27.11**

	Costs) A+B													

Table 7.7 – Proposed Budget Allocation for Ravi River for three State/UT Level Implementing Agencies under Three Landscapes, Conservation Interventions and Supporting Activities

Sr. No.	**Activity**	**Phase I**				**Phase II**				**Grand Total (Rs. in Crores)**
		States				**States**				
		Himachal Pradesh (Rs. in Crores)	**Jammu & Kashmir ((Rs. in Crores))**	**Punjab (Rs. in Crores)**	**Total (Rs. in Crores)**	**Himachal Pradesh (Rs. in Crores)**	**Jammu & Kashmir ((Rs. in Crores))**	**Punjab (Rs. in Crores)**	**Total (Rs. in Crores)**	
1	Natural Landscape	74.00	10.55	20.92	**105.47**	11.97	1.45	2.62	**16.04**	121.51
2	Eco Task Force	22.43	22.91	-	**45.34**	18.84	19.44	-	**38.28**	83.62
3	Agriculture Landscape	0.76	0.94	3.11	**4.81**	0.05	0.08	0.20	**0.33**	5.14
4	Urban Landscape	26.04	17.56	23.62	**67.22**	1.20	0.27	0.48	**1.95**	69.17
5	Soil and Moisture Conservation Measures	53.21	5.90	14.10	**73.21**	-	-	-	-	73.21
6	Other Intervention	26.04	1.82	9.78	**37.64**	2.23	0.18	0.96	**3.37**	41.01
7	Supporting Activities	**9.56**	9.36	**6.72**	**25.64**	**3.16**	2.30	**2.05**	**7.51**	33.15
Total Cost		212.04	69.04	78.23	**359.33**	37.45	23.72	6.31	**67.48**	**426.81**

Table 7.8 – Model/ Activity Wise Area and Cost for Forestry Interventionsin Ravi Riverscape

State	**Landscape**	**Model/Activity**	**Area (ha)**	**Cost (Rs. in Crore)**
Himachal Pradesh	Natural	RV/HP/NL/01- Sub-Alpine Conservation	**-**	**-**
		RV/HP/NL/02- Sub Alpine Enrichment	**-**	**-**
		RV/HP/NL/03- Temperate Conifer Forest	513	15.5943
		RV/HP/NL/04- Temperate Mixed Forest	1283	39.0985

		RV/HP/NL/05- Pasture and Grazing Land Development	100	2.2755
		RV/HP/NL/06- Himalayan Chir Pine Forest	351	10.6513
		RV/HP/NL/07- Himalayan Mixed Forest	54	1.4739
		RV/HP/NL/08- Sub Tropical Dry Deciduous Forest	59	1.5831
		RV/HP/NL/09- Eradication of Lantana (> 50%)	-	-
		RV/HP/NL/10- Control/ Removal of Invasive Species or <50% Lantana	-	-
		RV/HP/NL/11- Protection Model for Natural Regeneration	720	12.9042
		RV/HP/NL/12- Fire Protection Model	185	2.3851
		RV/HP/NL/13- Eco-Task Force Model	1000	41.27
	Agriculture	RV/HP/AL/01 - Boundary Plantation Model	175	0.4282
		RV/HP/AL/02 –Planting of Economic Trees in Block Plantation	29	0.3782
	Urban	RV/HP/ UL/01 - Riverfront Development	2	4.95
		RV/HP/ UL/02 -Institutional and Industrial Plantation	104	4.4616
		RV /HP/UL /03 -Eco-park Development	7.2	17.82
	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/HP/CI/01-Broushwood Intervention	14830	0.4449
		RV/HP/CI/02-Dry Stone Activities	132933	23.92
		RV/HP/CI/03-Create wire Activities	58817.5	26.46
		RV/HP/CI/04-Water Pond	39620	1.38
		RV/HP/CI/05- Silt Detention Dam Type Activities	1630	0.978
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/HP/CI/06-Riparian Wildlife Management	235	23.50
		RV/HP/CI/07-Wetland Management (Natural and Artificial)	53	4.77
		Sub Total =	**4870.20 ha. + 247830.5**	**236.72**
J&K UT	Natural	RV/JK/NL/01- Sub-Alpine Conservation	-	-
		RV/JK/NL/02- Sub Alpine Enrichment	-	-

		RV/JK/NL/03- Temperate Conifer Forest	11	0.3196
		RV/JK/NL/04- Temperate Mixed Forest	-	-
		RV/JK/NL/05- Pasture and Grazing Land Development	-	-
		RV/JK/NL/06- Himalayan Chir Pine Forest	38	0.9786
		RV/JK/NL/07- Himalayan Mixed Forest	-	-
		RV/JK/NL/08- Sub Tropical Dry Deciduous Forest	120	3.2359
		RV/JK/NL/09- Eradication of Lantana (> 50%)	46	1.0211
		RV/JK/NL/10-Control/ Removal of Invasive Species or <50% Lantana	15	0.3603
		RV/JK/NL/11- Protection Model for Natural Regeneration	310	4.7198
		RV/JK/NL/12-Fire Protection Model	190	1.1748
		RV/JK/NL/13- Eco-Task Force Model	1000	42.35
	Agriculture	RV/JK/AL/01 -Planting of Economic Trees	207	0.5217
		RV/JK/AL/02 –Planting of Economic Trees in Block Plantation	38	0.4955
	Urban	RV/JK/ UL/01 - Riverfront Development	-	-
		RV/JK/ UL/02 -Institutional and Industrial Estate Plantation	121	5.1909
		RV /JK/UL /03 -Eco-park Development	5.59	12.6225
	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/JK/CI/01-Broushwood Intervention	-	-
		RV/JK/CI/02-Dry Stone Activities	10810	1.9458
		RV/JK/CI/03-Create wire Activities	8780	3.951
		RV/JK/CI/04-Water Pond	-	-
		RV/JK/CI/05- Silt Detention Dam Type Activities	-	-
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/JK/CI/06-Riparian Wildlife Management	20	2.00
		RV/JK/CI/07-Wetland Management (Natural and Artificial)	-	-
		Sub Total =	**2121.59 ha. + 19590.00m^3**	**80.908**
Punjab	Natural	RV/PB/NL/01- Restoration of Degraded Forests Model	561.35	13.0185
		RV/PB/NL/02- Road Side Plantation	234	10.5217

	Agriculture	RV/PB/AL/01 -Boundary Plantation Model	700	1.766
		RV/PB/AL/02 – Block Plantation Model	118	1.5408
	Urban	RV/PB/ UL/01–Bioremediation and Biofiltration	9.1	2.2524
		RV/PB/ UL/02 - Riverfront Development	2.7	6.6825
		RV/PB/ UL/03 - Institutional and Industrial Estate Plantation	88	3.9897
		RV /PB/UL /04 -Eco-park Development	4.6	11.385
	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/PB/CI/01-Broushwood Intervention	24120	0.7236
		RV/PB/CI/02-Dry Stone Activities	43580	7.8444
		RV/PB/CI/03-Create wire Activities	3400	1.53
		RV/PB/CI/04-Water Pond	114400	4.004
		RV/PB/CI/05- Silt Detention Dam Type Activities	-	-
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/PB/CI/06- Riparian Wildlife Management	57	5.70
		RV/PB/CI/07- Wetland Management (Natural and Artificial)	56	5.04
			1830.75 ha+185500m^3	**75.9987**
Grand Total =			**8822.54 ha +452920.5m^3**	**393.6267**

7.3 Budget Outlay- Forest Divisions

A total of 16 Forest Divisions falling in Ravi Riverscape, will participate and carry out activities relating to forestry interventions including plantations, conservation interventions and supporting activities. Of these, twelve are territorial forest divisions and four are wildlife divisions. Overall budget outlay for 16 Forest Divisions of Ravi Riverscape has been given in State/UT summary of Himachal Pradesh, Punjab and J&K UT i.e., Vol. II of the Ravi River DPR. The range of budget allocation among 12 Forest Territorial Divisions varies from Rs. 2.34 Crore to Rs. 77.87 Crore over a period of five years of Establishment (Phase –I) and next five years of maintenance (Phase –II.) Whereas, the budget range for 4 wildlife divisions range from Rs. 2.00 Crores to Rs. 18.27 Crores over a period of 10 years (i.e., Phase I and II).

7.4 Project Schedule

The execution period of five years in Phase I and five years of Phase II of the project has been designed and incorporated in the present DPR. Thus, the total duration for programme implementation including the maintenance phase is of 10-years. At this point of time, it is not

clear when the project would start and which will be the first year of programme implementation during Phase I. The Government of India may take its own time to decide the Central Nodal Ministry responsible for the implementation of the project and to allocate required funds for the execution of plan. Various proposed activities have been proposed over five years of the Phase I. The experience illustrates that once the Government of India will accorded its approval for the project and will earmarked required funds, the first year by Implementing Agency (IA) would be largely devoted for project initiation, preparatory works, particularly the establishment of nurseries and commencement of various activities related to conservation interventions and supporting activities. The planting material meant for high altitude Himalayan part of the Ravi Riverscape would be ready in nurseries and earliest available by the end of second year of project implementation. Thus, the earliest effective establishment year of plantations would be the third year of Phase I in Ravi Riverscape. Establishment of plantations is proposed in third, fourth and fifth year of Phase I. The Phase II of five-year duration is specifically designed and incorporated for the purpose of maintenance of plantations and other activities. Considering the fact that most proposed activities are time bound and seasonal in nature, ideally the project initiation after all approvals, budget allocation, etc. should commence in month of April–May so as to allow adequate time for preparatory works, establishment of nurseries, development of planting material for afforestation/ reforestation in lower reaches of the Riverscape before the onset of monsoon season in month of July or so in the next year. Thus, careful scheduling of project commencement would be vital for the overall success and effective implementation of envisaged activities. The quantum of activities is expected to be at its peak in third or fourth year of Phase I. The Mid-Term Review (MTR) is proposed in the last quarter of third financial year of the project execution while the Terminal Evaluation (TE) is being envisaged in the third year of the Phase II.

Table 7.9 – Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Ravi Riverscape

Year	Period	Plantation and Treatment Models				Conservation Intervention	
		Natural Landscape (ha) *	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m^3)	Riverine and Riparian Wildlife Management (ha) and Wetland Conservation (ha)
A. Phase I (Implementation Phase)							

Year	Period	Plantation and Treatment Models				Conservation Intervention	
		Natural Landscape (ha) *	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m^3)	Riverine and Riparian Wildlife Management (ha) and Wetland Conservation (ha)
I	**Est.**	1105	-	495	104.2	79965	46
II	**Est.**	290	400	448	129.39	131935.5	375
	Maint.	1105	-	495	104.2	-	46
III	**Est.**	1082	400	324	110.6	114383.5	-
	Maint.	1395	400	943	233.59	-	421
IV	**Est.**	1186	400	-	-	84811	-
	Maint.	2477	800	1267	344.19	-	421
V	**Est.**	1127	400	-	-	41825.5	-
	Maint.	3663.35	1200	772	239.99	-	421
Total Phase I	**Est.**	4790.35	1600	1267	344.19	452920.5	421
	Maint.	3663.35	1200	1267	344.19	-	66
B. Phase II (Maintenance Phase)							
VI	**Est.**	-	400	-	-	-	-
	Maint.	3685.35	1600	324	110.6	-	375
VII	**Est.**	-	-	-	-	-	-
	Maint.	3031.35	1200	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-
	Maint.	2002	1200	-	-	-	-
IX	**Est.**	-	-	-	-	-	-
	Maint.	1007	800	-	-	-	-
X	**Est.**	-	-	-	-	-	-
	Maint.	-	400	-	-	-	-
Total Phase II	**Est.**	-	400	-	-	-	-
	Maint.	3685.35	1600	324	110.6	-	375
Grand Total Phase I and Phase II	**Est.**	4790.35	2000	1267	344.19	452920.5	421
	Maint.	4790.35	2000	1267	344.19	-	421

**Natural landscape also includes area of fire protection and natural regeneration models of natural landscape; 1st& 2nd year area of NL is virtual.,considered for calculation of budgetary provisions.*

Table 7.10 – Year-Wise Breakup of Cost for Proposed Forestry Interventions in Ravi Riverscape

Year	Period	Plantation and Treatment Models				Conservation Intervention	
		Natural Landscape (Rs. In Lakhs)*	Eco Task Force (Rs. In Lakhs)	Agriculture Landscape (Rs. In Lakhs)	Urban Landscape (Rs. In Lakhs)	Soil and Moisture Conservation Measures (Rs. In Lakhs)	Riverine and Riparian Wildlife Management (Rs. In Lakhs) and Wetland Conservation (Rs. In Lakhs)
B. Phase I (Implementation Phase)							
I	**Est.**	1289.03	1400.00	65.22	312.8	1277.43	132.8
II	**Est.**	1639.69	120.00	68.79	2582.27	1962.44	1170.8
	Maint.	164.85	612.00	34.87	93.84	-	118
III	**Est.**	2422.14	132.00	52.17	1296.5	1874.34	-
	Maint.	203.11	642.00	75.45	837.24	-	1104.7
IV	**Est.**	2300.5	144.00	-	-	1101.72	-
	Maint.	671.01	652.00	109.73	952.32	-	745.8
V	**Est.**	796.38	160.00	-	-	1104.53	-
	Maint.	1059.98	672.00	74	646.64	-	491.4
Total Phase I	**Est.**	8447.74	1956.00	186.18	4191.57	7320.46	1303.6
	Maint.	2098.95	2578.00	294.05	2530.04	-	2459.9
B. Phase II (Maintenance Phase)							
VI	**Est.**	-	180.00	-	-	-	-
	Maint.	927.38	692.00	32.81	194.49	-	337.5
VII	**Est.**	-	-	-	-	-	-
	Maint.	445.44	760.00	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-
	Maint.	203.06	748.00	-	-	-	-
IX	**Est.**	-	-	-	-	-	-
	Maint.	27.08	728.00	-	-	-	-
X	**Est.**	-	-	-	-	-	-
	Maint.	-	720.00	-	-	-	-
Total Phase II	**Est.**	-	180.00	-	-	-	-
	Maint.	1602.96	3648.00	32.81	194.49	-	337.5
Grand Total Phase I and Phase II	**Est.**	8447.74	2136.00	186.18	4191.57	7320.46	1303.6
	Maint.	3701.91	6226.00	326.86	2724.53	-	2797.4

**Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape.*

Table 7.11 – Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Himachal Pradesh

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (ha) *	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m^3)	Riverine and Riparian Wildlife Management (ha)	Wetland Conservation (ha)
C. Phase I (Implementation Phase)								
I	**Est.**	*645*	-	76	35	54985	10	30
II	**Est.**	*260*	200	79	43.4	69245.5	225	23
	Maint.	645	-	76	35	-	10	30
III	**Est.**	672	200	49	34.8	57873.5	-	-
	Maint.	905	200	155	78.4	-	235	53
IV	**Est.**	809	200	-	-	38731	-	-
	Maint.	1577	400	204	113.2	-	235	53
V	**Est.**	879	200	-	-	26995.5	-	-
	Maint.	2386	600	128	78.2	-	235	53
Total Phase I	**Est.**	3265	800	204	113.2	247830.5	235	53
	Maint.	2386	600	204	113.2		110	30
B. Phase II (Maintenance Phase)								
VI	**Est.**	-	200	-	-	-	-	-
	Maint.	2620	800	49	34.8	-	225	23
VII	**Est.**	-	-	-	-		-	-
	Maint.	2360	600	-	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-	-
	Maint.	1688	600	-	-	-	-	-
IX	**Est.**	-	-	-	-	-	-	-
	Maint.	879	400	-	-	-		
X	**Est.**	-	-	-	-	-	-	-
	Maint.	-	200	-	-	-	-	-
Total Phase II	**Est.**	-	200	-	-	-	-	-
	Maint.	2620	800	49	34.8	-	225	23
Grand Total Phase I and Phase II	**Est.**	3265	1000	204	113.2	247830.5	235	53
	Maint.	3265	1000	204	113.2	-	235	53

***Natural landscape also includes area of fire protection and natural regeneration models of natural landscape; 1st& 2nd year area of NL is virtual.,considered for calculation of budgetary provisions.*

Table 7.12 - Year-Wise Breakup of Cost for Proposed Forestry Interventions in Himachal Pradesh

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (Rs. in Lakhs)*	Eco Task Force (Rs. In Lakhs)	Agriculture Landscape (Rs. in Lakhs)	Urban Landscape (Rs. in Lakhs)	Soil and Moisture Conservation Measures (Rs. in Lakhs)	Riverine and Riparian Wildlife Management (Rs. in Lakhs)	Wetland Conservation (Rs. in Lakhs)
A. Phase I (Implementation Phase)								
I	**Est.**	*862.54*	700.00	11.13	91	883.98	32	84
II	**Est.**	*1349.86*	60.00	10.62	761.4	1250.32	720	64.4
	Maint.	116.05	300.00	5.94	27.3	-	28	75
III	**Est.**	1722.34	66.00	7.92	798	1459.63	-	-
	Maint.	150.3	315.00	12.03	246.62	-	649	105.5
IV	**Est.**	1594.3	72.00	-	-	891.74	-	-
	Maint.	398.9	320.00	17.1	405.33	-	439.5	72.8
V	**Est.**	620.04	80.00	-	-	834.89	-	-
	Maint.	585.71	330.00	11.04	273.81	-	279	54.6
Total Phase I	**Est.**	6149.08	978.00	29.67	1650.4	5320.56	752	148.4
	Maint.	1250.96	1265.00	46.11	953.06	-	1395.5	307.9
B. Phase II (Maintenance Phase)								
VI	**Est.**		90.00	-	-	-	-	-
	Maint.	664.78	340.00	4.86	119.7	-	202.5	20.7
VII	**Est.**		-	-	-	-	-	-
	Maint.	356.32	374.00	-	-	-	-	-
VIII	**Est.**		-	-	-	-	-	-
	Maint.	163.94	368.00	-	-	-	-	-
IX	**Est.**		-	-	-	-	-	-
	Maint.	11.52	358.00	-	-	-	-	-
X	**Est.**	-	-	-	-	-	-	-
	Maint.	-	354.00	-	-	-	-	-
Total Phase II	**Est.**		90.00	-	-		-	-
	Maint.	1196.56	1794.00	4.86	119.7	-	202.5	20.7
Grand Total Phase I and Phase II	**Est.**	6149.08	1068	29.67	1650.4	5320.56	752	148.4
	Maint.	2447.52	3059.00	50.97	1072.76	-	1598	328.6

**Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape*

Table 7.13 – Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in J&K

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (ha) *	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m^3)	Riverine and Riparian Wildlife Management (ha)	Wetland Conservation (ha)
B. Phase I (Implementation Phase)								
I	**Est.**	*460*	-	80	33	8730	-	-
II	**Est.**	*30*	200	77	47.19	6110	20	-
	Maint.	460	-	80	33	-	-	-
III	**Est.**	46	200	88	46.4	3210	-	-
	Maint.	490	200	157	80.19	-	20	-
IV	**Est.**	66	200	-	-	1260	-	-
	Maint.	536	400	245	126.59	-	20	-
V	**Est.**	128	200	-	-	280	-	-
	Maint.	602	600	165	93.59	-	20	-
Total Phase I	**Est.**	730	800	245	126.59	19590	20	-
	Maint.	602	600	245	126.59	-	20	-
B. Phase II (Maintenance Phase)								
VI	**Est.**	-	200	-	-	-	-	-
	Maint.	270	800	88	46.4	-	20	-
VII	**Est.**	-	-	-	-	-	-	-
	Maint.	240	600	-	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-	-
	Maint.	194	600	-	-	-	-	-
IX	**Est.**	-	-	-	-	-	-	-
	Maint.	128	400	-	-	-	-	-
X	**Est.**	-	-	-	-	-	-	-
	Maint.	-	200	-	-	-	-	-
Total Phase II	**Est.**	-	200	-	-	-	-	-
	Maint.	270	800	88	46.4	-	20	-
Grand Total Phase I and Phase II	**Est.**	730	1000	245	126.59	19590	20	-
	Maint.	730	1000	245	126.59	-	20	-

**Natural landscape also includes area of fire protection and natural regeneration models of natural landscape; 1st& 2nd year area of NL is virtual.,considered for calculation of budgetary provisions.*

Table 7.14 - Year-Wise Breakup of Cost for Proposed Forestry Interventions in J&K

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (Rs. in Lakhs)*	Eco Task Force (Rs. In Lakhs)	Agriculture Landscape (Rs. in Lakhs)	Urban Landscape (Rs. in Lakhs)	Soil and Moisture Conservation Measures (Rs. in Lakhs)	Riverine and Riparian Wildlife Management (Rs. in Lakhs)	Wetland Conservation (Rs. in Lakhs)
C. Phase I (Implementation Phase)								
I	**Est.**	361.23	700.00	12.27	85.8	251.1	-	-
II	**Est.**	95.24	60.00	11.61	815.47	172.08	64	-
	Maint.	48.8	312.00	6.55	25.74	-	-	-
III	**Est.**	123.77	66.00	12.99	179.6	104.76	-	-
	Maint.	52.81	327.00	13.44	261.8	-	56	-
IV	**Est.**	189.57	72.00	-	-	56.7	-	-
	Maint.	62.27	332.00	21.57	229.84	-	38	-
V	**Est.**	43.83	80.00	-	-	5.04	-	-
	Maint.	77.03	342.00	15.07	158.24	-	24	-
Total Phase I	**Est.**	813.64	978.00	36.87	1080.87	589.68	64	-
	Maint.	240.91	1313.00	56.63	675.62	-	118	-
B. Phase II (Maintenance Phase)								
VI	**Est.**	-	90.00	-	-	-	-	-
	Maint.	55.06	352.00	8.22	26.94	-	18	-
VII	**Est.**	-	-	-	-	-	-	-
	Maint.	43.6	386.00	-	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-	-
	Maint.	30.25	380.00	-	-	-		-
IX	**Est.**	-	-	-	-	-	-	-
	Maint.	15.56	370.00	-	-	-	-	-
X	**Est.**	-	-	-	-	-	-	-
	Maint.	-	366.00	-	-	-	-	-
Total Phase II	**Est.**	-	90.00	-	-	-	-	-
	Maint.	144.47	1854.00	8.22	26.94	-	18	-
Grand Total Phase I and Phase II	**Est.**	813.64	1068.00	36.87	1080.87	589.68	64	-
	Maint.	385.38	3167.00	64.85	702.56	-	136	-

**Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape.*

Table 7.15 – Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Punjab

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscape (ha)*	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m^3)	Riverine and Riparian Wildlife Management (ha)	Wetland Conservation (ha)
D. Phase I (Implementation Phase)							
I	**Est.**	-	339	36.2	16250	-	6
II	**Est.**	-	292	38.8	56580	57	50
	Maint.	-	339	36.2	-	-	6
III	**Est.**	364	187	29.4	53300	-	0
	Maint.	-	631	75	-	57	56
IV	**Est.**	311	-	-	44820	-	-
	Maint.	364	818	104.4	-	57	56
V	**Est.**	120	-	-	14550	-	-
	Maint.	675.354	479	68.2	-	57	56
Total Phase I	**Est.**	795.35	818	104.4	185500	57	56
	Maint.	675.35	818	104.4	-	57	56
B. Phase II (Maintenance Phase)							
VI	**Est.**	-	-	-	-	-	-
	Maint.	795.354	187	29.4	-	57	50
VII	**Est.**	-	-	-	-	-	-
	Maint.	431.354	-	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-
	Maint.	120	-	-	-	-	-
IX	**Est.**	-	-	-	-	-	-
	Maint.	-	-	-	-	-	-
X	**Est.**	-	-	-	-	-	-
	Maint.	-	-	-	-	-	-
Total Phase II	**Est.**	-	-	-	-	-	-
	Maint.	795.354	187	29.4	-	57	50
Grand Total Phase I and Phase II	**Est.**	795.35	818	104.4	185500	57	56
	Maint.	795.35	818	104.4	-	57	56

**Natural landscape also includes area of fire protection and natural regeneration models of natural landscape; 1st& 2nd year area of NL is virtual.,considered for calculation of budgetary provisions.*

Table 7.16 - Year-Wise Breakup of Cost for Proposed Forestry Interventions in Punjab

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscape (Rs. in Lakhs)*	Agriculture Landscape (Rs. in Lakhs)	Urban Landscape (Rs. in Lakhs)	Soil and Moisture Conservation Measures (Rs. in Lakhs)	Riverine and Riparian Wildlife Management (Rs. in Lakhs)	Wetland Conservation (Rs. in Lakhs)
E. Phase I (Implementation Phase)							
I	**Est.**	65.26	41.82	136	142.35	0	17
II	**Est.**	194.6	46.56	1005.4	540.04	182.4	140
	Maint.	-	22.38	40.8	-	0	15
III	**Est.**	576.03	31.26	318.9	309.95	0	0
	Maint.	-	49.98	328.82	-	159.6	134.6
IV	**Est.**	516.63	-	-	153.28	0	0
	Maint.	209.84	71.06	317.15	-	108.3	87.2
V	**Est.**	132.51	-	-	264.60	0	0
	Maint.	397.24	47.89	214.59	-	68.4	65.4
Total Phase I	**Est.**	1485.03	119.64	1460.3	1410.22	182.4	156.8
	Maint.	607.08	191.31	901.36	-	336.3	302.2
B. Phase II (Maintenance Phase)							
VI	**Est.**	-	-	-	-	-	-
	Maint.	207.54	19.73	47.85	-	51.3	45
VII	**Est.**	-	-	-	-	-	-
	Maint.	45.51	-	-	-	-	-
VIII	**Est.**	-	-	-	-	-	-
	Maint.	8.87	-	-	-	-	-
IX	**Est.**	-	-	-	-	-	-
	Maint.	-	-	-	-	-	-
X	**Est.**	-	-	-	-	-	-
	Maint.	-	-	-	-	-	-
Total Phase II	**Est.**	-	-	-	-	-	-
	Maint.	26 1.92	19.73	47.85	-	51.3	45
Grand Total Phase I and Phase II	**Est.**	1485.03	119.64	1460.3	1410.22	182.4	156.8
	Maint.	869	211.04	949.21	-	387.6	347.2

**Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape*

Table 7.17 – Year-Wise Breakup of Projected Cost on Supporting Activities in Ravi Riverscape Phase I

Sr. No.	Activity	(Rs. in lakh)					
		Phase I					Total
		I	II	III	IV	V	Phase I
1	Policy Level Interventions	4.41	3.31	3.47	3.64	3.82	18.65
2	Research Activities	44.11	46.32	48.63	51.07	53.62	243.75
3	Capacity Development	147.00	143.85	171.04	158.59	133.79	754.28
4	Awareness	84.00	88.20	92.61	97.24	102.10	464.15
5	Participatory Monitoring	22.06	19.85	17.87	16.08	14.47	90.32
6	Cost of PMUs of Three States/UT Level Implementing Agencies	220.56	165.41	173.52	182.04	190.99	932.53
7	Evaluation	0.00	0.00	55.95	0.00	0.00	55.95
8	Contingency and Miscellaneous Activities	1.10	0.83	0.87	0.91	0.95	4.66
Grand Total of Riverscape		**523.24**	**467.76**	**563.96**	**509.57**	**499.75**	**2564.29**

Table 7.18 – Year-Wise Breakup of Projected Cost on Supporting Activities in Ravi Riverscape Phase II

Sr. No.	Activity	(Rs. in lakh)						Grand Total
		Phase II						(Rs. in lakh)
		I	II	III	IV	V	Phase II	Phase I+II
1	Policy Level Interventions	1.47	0.00	0.00	0.00	0.00	1.47	**20.12**
2	Research Activities	28.15	29.56	31.04	32.59	34.22	155.54	**399.29**
3	Capacity Development	0.00	0.00	0.00	0.00	0.00	0.00	**754.28**
4	Awareness	0.00	0.00	0.00	0.00	0.00	0.00	**464.15**
5	Participatory Monitoring	13.02	11.72	10.55	9.49	8.54	53.33	**143.66**
6	Cost of PMUs of Three States/UT Level Implementing Agencies	73.65	67.66	63.54	59.68	56.05	320.58	**1253.10**
7	Evaluation	93.25	0.00	0.00	0.00	125.31	218.56	**274.51**
8	Contingency and Miscellaneous Activities	0.37	0.34	0.32	0.30	0.28	1.60	**6.27**
Grand Total of Riverscape		**209.91**	**109.28**	**105.45**	**102.06**	**224.40**	**751.10**	**3315.38**

Table 7.19 – Year-Wise Breakup of Projected Cost on Supporting Activities in Himachal Pradesh

Sr. No.	Activity	Year												Grand Total
		(Rs. in lakh)											Total	(Cost Rs. in lakh)
		Phase I					Total	Phase II					Phase II	Phase I+II
		I	II	III	IV	V	Phase I	I	II	III	IV	V		
1	Policy Level Interventions	1.53	1.19	1.25	1.31	1.38	**6.67**	0.72	0.00	0.00	0.00	0.00	0.72	**7.38**
2	Research Activities	15.28	16.05	16.85	17.69	18.58	**84.45**	9.75	10.24	10.75	11.29	11.85	53.89	**138.34**
3	Capacity Development	61.00	53.55	66.23	59.04	61.99	**301.81**	0.00	0.00	0.00	0.00	0.00	0.00	**301.81**
4	Awareness	32.00	33.60	35.28	37.04	38.90	**176.82**	0.00	0.00	0.00	0.00	0.00	0.00	**176.82**
5	Participatory Monitoring	7.64	6.88	6.19	5.57	5.01	**31.29**	4.51	4.06	3.65	3.29	2.96	18.48	**49.77**
6	Cost of PMUs of State Level Implementing Agencies	76.42	59.70	62.63	65.71	68.95	**333.41**	35.78	33.79	31.88	30.08	28.39	159.92	**493.33**
7	Evaluation	0.00	0.00	19.87	0.00	0.00	**19.87**	33.34	0.00	0.00	0.00	49.33	82.67	**102.55**
8	Contingency and Miscellaneous Activities	0.38	0.30	0.31	0.33	0.34	**1.67**	0.18	0.17	0.16	0.15	0.14	0.80	**2.47**
Grand Total		**194.25**	**171.27**	**208.62**	**186.70**	**195.15**	**955.99**	**84.28**	**48.26**	**46.45**	**44.81**	**92.68**	**316.48**	**1272.47**

Table 7.20 – Year-Wise Breakup of Projected Cost on Supporting Activities in Punjab

Sr. No.	Activity	Year												
		(Rs. in lakh)											Total	(Cost Rs. in lakh)
		Phase I					Total	Phase II					Phase II	Phase I+II
		I	II	III	IV	V	Phase I	I	II	III	IV	V	0.00	**0.00**
1	Policy Level Interventions	1.36	1.00	1.05	1.10	1.15	**5.65**	0.36	0.00	0.00	0.00	0.00	0.36	**6.01**
2	Research Activities	13.58	14.26	14.98	15.72	16.51	**75.05**	8.67	9.10	9.56	10.03	10.54	47.89	**122.95**

3	Capacity Development	36.00	37.80	44.69	41.67	35.90	**196.06**	0.00	0.00	0.00	0.00	0.00	0.00	**196.06**
4	Awareness	12.00	12.60	13.23	13.89	14.59	**66.31**	0.00	0.00	0.00	0.00	0.00	0.00	**66.31**
5	Participatory Monitoring	6.79	6.11	5.50	4.95	4.46	**27.81**	4.01	3.61	3.25	2.92	2.63	16.42	**44.23**
6	Cost of PMUs of State Level Implementing Agencies	67.91	49.86	52.30	54.87	57.56	**282.51**	17.85	15.97	14.92	13.95	13.04	75.73	**358.24**
7	Evaluation	0.00	0.00	17.01	0.00	0.00	**17.01**	28.25	0.00	0.00	0.00	35.82	64.08	**81.08**
8	Contingency and Miscellaneous Activities	0.34	0.25	0.26	0.27	0.29	**1.41**	0.09	0.08	0.07	0.07	0.07	0.38	**1.79**
Grand Total		**137.99**	**121.88**	**149.02**	**132.48**	**130.45**	**671.82**	**59.22**	**28.76**	**27.80**	**26.98**	**62.10**	**204.86**	**876.68**

Table 7.21 – Year-Wise Breakup of Projected Cost on Supporting Activities in Jammu and Kashmir, UT

Sr. No.	**Activity**	**Year**												
		(Rs. in lakh)											**0.00**	**Grand Total**
		Phase I					**Total**	**Phase II**					**0.00**	**(Cost Rs. in lakh)**
		I	**II**	**III**	**IV**	**V**	**Phase I**	**I**	**II**	**III**	**IV**	**V**	**Total**	**0.00**
1	Policy Level Interventions	1.52	1.12	1.17	1.23	1.29	6.33	0.40	0.00	0.00	0.00	0.00	0.40	**6.73**
2	Research Activities	15.25	16.01	16.81	17.65	18.53	84.24	9.73	10.22	10.73	11.26	11.83	53.76	**138.00**
3	Capacity Development	50.00	52.50	60.13	57.88	35.90	256.41	0.00	0.00	0.00	0.00	0.00	0.00	**256.41**
4	Awareness	40.00	42.00	44.10	46.31	48.62	221.03	0.00	0.00	0.00	0.00	0.00	0.00	**221.03**
5	Participatory Monitoring	7.62	6.86	6.17	5.56	5.00	31.22	4.50	4.05	3.65	3.28	2.95	18.43	**49.65**
6	Cost of PMUs of State Level Implementing Agencies	76.23	55.84	58.58	61.46	64.48	316.60	20.02	17.91	16.74	15.64	14.62	84.93	**401.53**
7	Evaluation	0.00	0.00	19.07	0.00	0.00	19.07	31.66	0.00	0.00	0.00	40.15	71.81	**90.88**
8	Contingency and Miscellaneous Activities	0.38	0.28	0.29	0.31	0.32	1.58	0.10	0.09	0.08	0.08	0.07	0.42	**2.01**
Grand Total		**191.00**	**174.61**	**206.32**	**190.39**	**174.15**	**936.48**	**66.41**	**32.26**	**31.19**	**30.27**	**69.63**	**229.76**	**1166.24**

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Chapter 8

Potential Benefits of Proposed Forestry Interventions

8.1 Benefits of River Restoration

Human development has resulted in a significant decline in the health of rivers globally. This is in turn impacting the many benefits that rivers provide to society, i.e., 'ecosystem services'. Population growth, urbanization and climate change are among other factors are expected to place further pressure on river ecosystem over coming decades (Speed *et al*., 2016). Healthy rivers offer a wide range of social and economic benefits besides performing various ecological functions. Social and economic benefits derived from healthy rivers can be expressed in terms of provisioning, regulatory, cultural or supporting ecosystem services (MEA, 2005). River restoration has become essential where river systems have degraded to the point that can no longer provide the services required of them. Increasingly, river restoration is now a common response to declining river health and its importance can only be expected to grow. Restoration is often triggered on account of ecological concerns, social and cultural factors, economic drivers, the need to protect infrastructure and assets from water related risks, and increasing water security concerns (Speed *et al*., 2016). Restoration includes any action aimed at improving the health of the river, including improving ecosystem functions and related ecosystem services. River restoration is an important part of the water resources management system. It can assist with balancing the needs of people for freshwater ecosystem services with anthropogenic pressures on river ecosystems (Speed *et al*., 2016). The benefits of well-designed River Restoration Projects will mainly be felt from the return of at least some services as a result of improvements in river health.

8.2 Need for River Restoration in the Context of Ravi River

Due to cumulative effect of forest degradation and deforestation in past, enhanced resource dependence on forests, expansion of agriculture and horticulture, increased developmental activities (i.e., Road network, HEPs, Urbanization and Industrialization along the course of Ravi River and its tributaries), over-extraction, diversion of water, pollution and climate change leads to Ravi River ecosystem degradation which is further indicated by decreased water availability; decline of water quality; loss of biodiversity; reduced aesthetics; recreational and tourism values; increased floods and the emerging risks. Therefore, the need for river restoration in the context of Ravi River has arisen.

Based on the exhaustive review on the river and its environment, it can be safely stated that the current degraded state of the Ravi River is a cumulative reflection of a number of anthropogenic activities occurred gradually in past one and a half centuries or so (Fig. 8.1). Resultant major environmental concerns or evident broad based symptoms of river deterioration are: (i) Degraded

land and river ecosystem; (ii) Excessive soil erosion, landslides and sedimentation; (iii) Non-availability of water and reduced e-flow; and (iv) Poor quality of water.

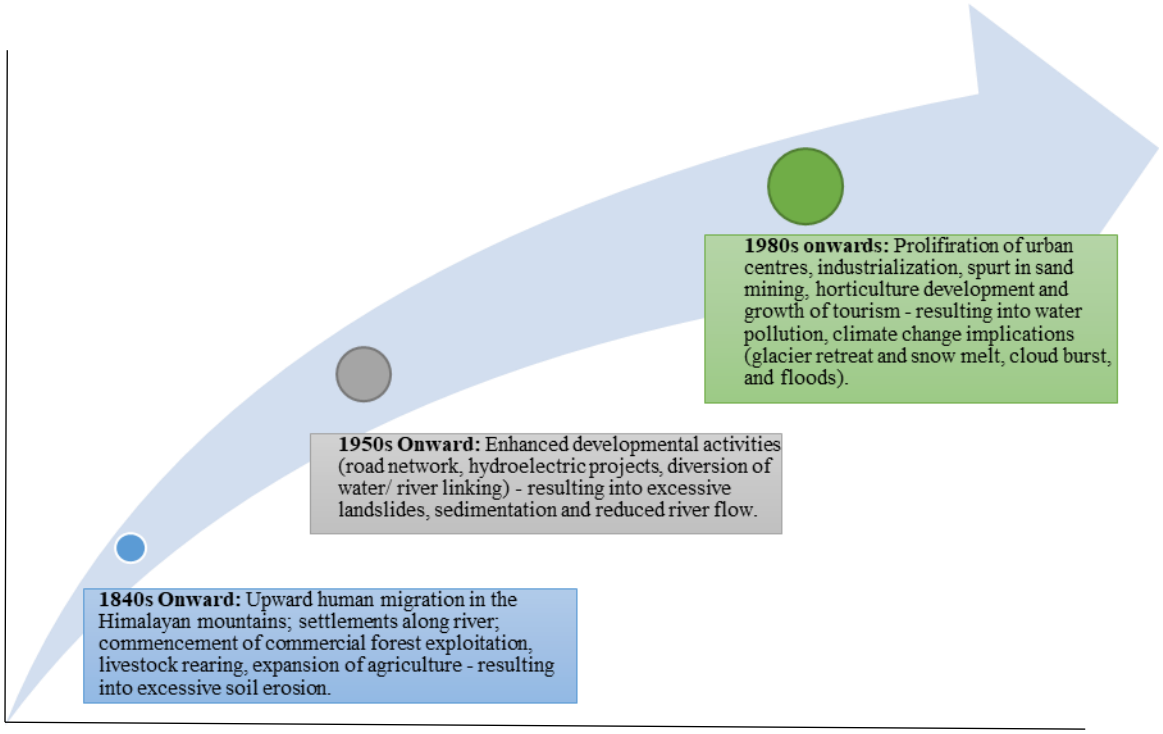


Fig. 8.1 – Gradual Process of Degradation and Cumulative Impact on the River Ecosystem

8.3 Strategy and Measures for River Restoration

River ecosystem requires a more strategic system based approach recognizing physical, socio-economic, political and cultural aspects of the river and human systems (Speed *et al*., 2016). Several potential measures have been planned for concurrent implementation. The proposed restoration strategy includes extensive plantation activities in natural, agriculture and urban landscapes within the riverscape along with appropriate bio-engineering and mechanical measures for soil and water conservation besides riparian and riverine wildlife management and wetland conservation. Several supporting activities *viz*., policy level interventions, concurrent research and development, awareness, capacity development, participatory monitoring and evaluation vital for effective and successful execution of the implementation plan have also been envisaged.

8.4 Potential Benefits of Proposed Forestry Interventions

The proposed efforts towards river restoration are confined exclusively to forestry interventions aiming for enhancement of forest cover, grassland and wetland management, reduction in soil erosion, riparian management, and in stream/aquatic habitat and species management. Certainly, several other measures of engineering, hydrological, mechanical, agricultural, bio-technological nature aiming channel and flow modification, dam removal or retrofitting, bank stabilization, storm water management and flood control, spring/aquifer management, floodplain reconnection and channelization, channel reconfiguration, management of industrial effluents and urban waste and sewage, climate smart agriculture, management of toxins, etc. are out of purview of the present DPR.

In view of the above, various potential socio-economic benefits and improved ecological functions expected as a result of proposed wide-ranging forestry interventions are summarized in Table 8.1.

Table 8.1 – Potential Socio-economic Benefits and Improved Ecological Functions as a Result of Proposed Forestry Interventions

Element	**Approach to Restoration**	**Ecosystem Services**			
		Provisioning	**Regulating**	**Cultural**	**Supporting**
Catchment	Protection and conservation of natural forests; forest plantations in natural landscape, agroforestry models in agriculture landscape, and development of Eco parks/ avenue plantations in urban landscape;	Wood, NTFPs – fuel wood, fiber, fruits, medicinal plants for human consumption; grass, fodder, and grazing for livestock; increased population and enhanced abundance of native flora and fauna including RET species	Carbon sequestration by forest/plantation and other vegetation and carbon storage in soils; water storage by forests/ plantations - function of 'sponge' and water purification; control water temperature; lessens soil erosion, sediment and nutrient run-off; control of	Aesthetic value of natural forests and riparian zones; benefit to tourism, employment generation, and areas for public recreation	Increased and improved habitat for biodiversity on land and in stream/rivers; checking soil erosion, water conservation; and sediment changes

Element	Approach to Restoration	Ecosystem Services			
		Provisioning	**Regulating**	**Cultural**	**Supporting**
	and riparian management		invasive and alien species; enhanced fluvial processes, lateral connectivity; and environmental amelioration		
Flow regime	Water availability and e-flow	Increased availability of water and enhanced e-flow; affect fish diversity and population and other services that rely on presence and abundance of migratory fishes	Alter the timing and delivery of water; and improvement in water quality; enhanced longitudinal and vertical connectivity	Increased ecotourism and recreation	Important fish spawning habitat and benthic invertebrates
Habitat	Instream habitat improvement and bank stability	Increase in availability of key fish and other featured aquatic fauna; improved fisheries, and conserve native species	Increased oxygenation and sediment flushing of water; reduced diffuse and point source pollution	Improved aesthetics and environment for recreation	Physical habitat heterogeneity; enhanced biodiversity; Improves and stabilizes physical habitats for breeding; increased richness and abundance of macro-invertebrates; enhanced

Element	Approach to Restoration	Ecosystem Services			
		Provisioning	**Regulating**	**Cultural**	**Supporting**
					spawning, feeding and refugia habitats for native fishes
Water Quality	Improvement in water quality	Supports aquatic fauna and enhancement in native fish diversity	Improvement in instream water quality and reduces competition of native fishes species for resources	Enhances the economic and social amenity value; improves the quality of life	Reduces habitat inhabitance by invasive species and increase in population and abundance of RET species
Biodiversity	Species management	Increase in availability of native fish and other aquatic fauna	Improves water quality and resource competition among native fish species	Improves river health and recreational activities	Alter aquatic native species distribution and abundance

(Source: Adopted and Modified from Speed *et al*., 2016)

8.5 Forests - River Flow and Water Conservation

The availability and especially the quality of water are strongly influenced by forests (Ekhuemelo *et al*., 2016). According to Carina (2008), forested catchments served as guarantors of high value surface and drinking water. The importance of forests and trees to rainfall and water supply include: improvement of water cycle, reduction of runoff, improving the replenishment of the water table, filtration of water pollutants, control of floods and regulation of storm water (Ekhuemelo *et al*., 2016).

Vertessy *et al*. (2002) also stated that the phasing of afforestation is an important factor that would mitigate against the maximal hydrologic impacts being realized. Plantings within a

catchment are usually made over a period of years, leading to a mixture of stand ages. In most situations, the full hydrologic effect of plantations is not attained until the stand has reached about 8-15 years of age. Thus, in their opinion, any catchment containing a significant portion of young stands will not exhibit the maximum hydrologic effects of afforestation. Further, they documented that there is also some evidence to indicate that evapo-transpiration rates in mature forests stands are lower than in vigorously growing ones with decreases starting to become apparent after 30-35 years. UNESCO (2017) stated that it has now been well documented that on local scale of a few thousand hectares, replacement of shallow root vegetation with forest often reduces stream flow, but may improve water quality. Various relative studies conducted in South Africa and Australia have suitably demonstrated that different plant species react variously to water use. Some utilize higher water than others. The choice of species is very important. It is well documented that *Eucalyptus* utilize higher water (Scott *et al*., 2005).

The overall effect on yield of water depends largely on the plantations done in catchment area in spatial configuration of the trees. It is difficult to reliably determine the impact of run off because hydrological effect and rainfall vary from site to site in the catchment area (Keenan and Van Dijk, 2010). Vertessy *et al.* (2002) suggested that planting trees on higher slopes could have a much smaller impact on stream flow than planting the same area on lower slopes, at least in areas with less water. Afforestation in catchment area decreases nutrient flow, soil erosion and amount of sediments in the stream. The surface run off is the main cause of soil erosion in river pollution. Afforestation/reforestation can decrease the amount of soil erosion and run off (Bruijnzeel, 2004; Sidle *et al*., 2006). The litter layers, understory growth and roughness of the surface provided by tree roots are helpful in reducing the soil erosion. The plantation of trees act as a 'Filter Strips', interrupt the runoff and nutrients flow to streams (Ellis *et al*., 2006). The accuracy of model on impact of water yield by plantation has many constrains because it depends upon the availability of data required for it especially soil property (Scott *et al*., 2005).

Despite growing literature on the above stated theme of plantations and water, there is evident acute deficiency of relevant literature from a vast country like India. Much of the available insight comes from different parts of the world and may not be relevant considering the complex and violent nature of Himalayan Rivers and the fact that the mountainous tract of the Himalaya was once well covered by diverse and dense forests, except the Trans-Himalayan region. It is only in the past 150 years or so that the forested tract was severely influenced by enhanced anthropogenic activities.

8.6 Forests for Climate Change Mitigation

The impact of climate change has alarmed the global communities and attracted the interest of scientific communities towards various mitigation and adaptation measures. Forest ecosystem plays a significant role in reducing the impact of climate change. Intrinsically forests and climate change are directly linked to each other's. Forests are known as the sink as well as the

source of carbon dioxide. Forest ecosystem during the process of photosynthesis, absorbs the carbon dioxide from the atmosphere and releases oxygen into the atmosphere. Role of forests have been increasingly recognized as most cost-effective option for climate change mitigation through carbon captured in biomass and soils. Forests are considered to provide a large climate change mitigation opportunity at relatively lower costs along with other significant co-benefits. Global forests cover around 30% of earth's surface, spread over about 4 billion hectares of land mass. Forestry mitigation options including reduced deforestation, forest management, afforestation, and agro-forestry are estimated to contribute 0.2-13.8 $GtCO_2$/yr of economically viable abatement in 2030 (IPCC, 2014). Thus managing our forest for carbon storage will help to absorb atmospheric carbon dioxide. Expansion of land under vegetative cover through afforestation and reforestation programs is another important component of forestry activities that could store more and more atmospheric carbon. Forestation implies increasing the amount of carbon stored in vegetation both above and below ground, dead organic matter and medium and long-term wood products (Watson, 1996).

In the forest ecosystem, carbon is stored in the growing stock (i.e., standing trees, shrubs, herbs etc.) and in the soil. The cutting down of trees and removal of vegetation from the forest ecosystem for fuel wood, timber, fodder, etc. releases the stored carbon in the form of CO_2. Various anthropogenic activities like burning of fossil fuels, industrial as well as urban growth, deforestation and forest degradation are mainly responsible for increasing the concentration of CO_2 and other greenhouse gases into the atmosphere. The overall contribution from Agriculture, Forestry and Other Land Use (AFOLU) sector is around one quarter of the global anthropogenic greenhouse gas emissions.

8.6.1 Market Potential of Forestry Interventions for Climate Change Mitigation

Role of forest plantations has been increasingly recognized as most cost effective option for climate change mitigation through carbon captured in biomass and soils. Carbon offset opportunities include reforestation, afforestation, farm forestry and improved soil management practices. Fulfilling their emission-limitation commitments under the Kyoto Protocol of UNFCCC, industrialized countries can claim credit for carbon captured in developing countries by executing Afforestation and Reforestation (AR) projects under Clean Development Mechanism (CDM) projects. Further, Government of India in its Nationally Determined Contributions (NDC) to UNFCCC also committed to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

Among the various carbon standards, the CDM was the only one to see a decline in volume in recent years. The CDM was initially created as a compliance standard under the Kyoto Protocol, but the program faces an uncertain future that will be decided by upcoming negotiations of the Paris Agreement. Many CDM project developers have turned to the voluntary markets to try and find buyers (Forest Trends, 2019).

Among the leading voluntary carbon markets, Verra develops and manages standards that help the private sector, countries, and civil society achieve ambitious sustainable development and climate action goals. One of Verra's standard programs, the Verified Carbon Standard (VCS) program allows certified projects to turn their Green House Gas (GHG) emission reductions and removals into tradable carbon credits. Since its launch in 2006, the VCS Program has grown into the world's largest voluntary GHG program. Outside of the Kyoto, The Land Use Land Use Change and Forestry (LULUCF) credits have been traded in voluntary market and voluntary carbon standard (VCS) is by far the largest standard in voluntary market.

Presently, The World Bank is among the few buyers of CDM forestry credits. With expiry of Kyoto Protocol and its replacement by new market mechanism under Paris Climate Agreement there is still large uncertainty about the forest carbon market. The CDM is likely to be replaced under new Mechanism called Sustainable Development Mechanism with new set of rules and regulations.

8.7 Carbon Services of India's Forests

India is a vast country with a rich biological diversity. Forest is the second largest land use in India after agriculture. Roughly, 275 million rural people in India depend on forests for at least part of their subsistence and livelihood (World Bank, 2006). As per the India State of Forest Report (FSI, 2019), the forest cover of the country stood at 712,249 km^2, while it was 708,273 km^2 in 2015 (FSI, 2017), recording an increase of 3976 km^2 within two years. The total forest and tree cover of the country is 24.56% of its geographical area. The National Forest Policy of India envisages 33% of its geographical area under forest and tree cover.

(LULUCF) sector was source of CO_2 in the year 1994 accounting for 1.16% of CO_2 eq emissions when India submitted its first National Communication (NATCOM) to UNFCCC in 2000 (MoEF&CC, 2004). With its focus on sustainable management of forests, afforestation and regulating diversion of forest lands for non-forest purposes, India has been successful in improving carbon stock in its forests. In 2017, estimated carbon stock in forest was 7,124.676 million tonnes (FSI, 2019) while in 2015 it was 7082 million tonnes (FSI, 2017) which is a net increase of 42 million tonnes in country's carbon stocks within two years. Various National Programmes and Policies have converted India's forests into net sink of CO_2. In its second National Communication, LULUCF sector was a net sink of 17% of total National Emissions (MoEF&CC, 2012). India's first biennial update report to UNFCCC has reported that the LULUCF sector was a net carbon sink offsetting 252.5 million tonnes of CO_2 which is 12% of India's total GHG emission (MoEF&CC, 2015). LULUCF sector was a net sink of 301,193 million CO_2 during 2014, registering an increase in the sink activity of the sector. Cropland dominates the CO_2 emissions/removal estimates for India for the year 2014. Forest lands were net sinks and about 12% of India's GHG emissions were offset by the LULUCF sector (MoEF&CC, 2018 a). Thus, forestry sector in India is making positive contribution for Climate Change Mitigation.

8.7.1 Forest Productivity in India

The potential yield of natural forests in India is 6 m^3/ha/year. Some of the plantation crops like *Eucalyptus*/poplars are fast growing species, and are planted for maximum volume production. They are expected to yield much higher than the potential yield of natural forests. This has been exemplified in the case of Brazil and South Africa, where actual yields are two and three times, respectively to the potential yields (Brazil: 11m^3/ha/yr and Republic of South Africa: 7m^3/ha/yr). The comparison between actual Permanent Sample Plot (PSP) data and actual yield for some of the plantation species has been obtained almost in the range of potential yield (Pande, 1995). However, well managed plantations are expected to gain much higher than potential yield of natural forests. Newly planted or regenerating forests, in the absence of major disturbances are likely to continue to uptake carbon for 20 to 50 years or more after establishment, depending on species, site conditions and objective of plantations.

8.7.2 Potential of Production Forestry for Carbon Sequestration in India

The National Forest Policy, 1988 envisages bringing one-third of the geographic area of the country under forest tree cover for maintaining ecological balance and environmental stability. India has been witnessing continuing improvement in existing policies and formulation of new policies and thus trying to keep pace with the activities and programmes to strive towards achievement of the country's National Goal of 33% forest/tree cover as enunciated in National Forest Policy. To realize this goal, India has to bring about 109 Mha (33% of its total geographic area) of 328 Mha of land under forest /tree cover. An extent of 4.6 Mha (1.41%) of scrub forests is also available in addition to the forest cover of 69.2 Mha. The difference in existing forest cover and the target area suggests that an additional 30 Mha has to be brought under the tree cover to achieve 33% tree cover as envisaged in National Forest Policy. This can be achieved by establishing plantations on non-forest land and through agro-ecosystems in existing agricultural lands. Forestry Interventions in the Riverscapes of Satluj, Jhelum, Beas, Chenab and Ravi Rivers will further contribute to achieving National Goal of 33% forest and tree cover.

8.7.3 Potential of Plant Biomass for Carbon Abatement

The current productivity of the forests is very poor and ranges between 0.7-1.5 m^3/ha/yr as against the world average of 2.1 m^3/ha/yr. The MAI in India can vary between 3t/ha/yr under degraded land conditions to 12 t/ha/yr with genetic improvement and addition of fertilizers (Rawat, 1996). Increase in forest productivity directly indicates an increase in forest biomass and higher carbon sequestration. Despite commendable efforts made in the country towards improvement of planting stock material productivity of plantation is still much low (5-10 m^3/ha/yr). This is attributed to use of unimproved seed/clonal planting material, not matching species with site and poor management practices. The productivity of fast growing tree species

of *Acacia, Casuarina, Eucalyptus* and *Populus* has increased from 10 m^3/ha/yr to > 40 m^3/ha/yr by the use of improved clones, adoption of clonal technology site matching with clones and proper management practices (Kumar *et al.*, 2016). Kant (2005) has reported tree productivity of *Cryptomeria japonica* upto 39m^3/ha/yr from Himalayan biogeographic zone and up to 35m^3/ha/yr for *Gmelina arborea* North-eastern bio-geographic zone. Kant (2005) applied Paterson Productivity Index to the 10 bio-geographic zones in the country and developed scenarios of productivity (Table 8.2 and Table 8.4). Forest Carbon Stock in Himachal Pradesh, Jammu and Kashmir UT and Punjab along with different carbon pools in Million tones is given in Table 8.3.

Table 8.2 - Potential Productivity of Different Bio-geographic Zones of India

Sr. No.	Bio-geographic zone	Description	Potential Ecosystem Productivity
1	**Trans-Himalayan**	Ladakh and high altitude zones abutting Tibet, very cold and arid, sparse alpine vegetation	Unproductive
2	**Indian Desert**	Thar and Kutch in Western India, sandy deserts, seasonal marshes, sparse thorn forests	1-3 m^3/ha/yr
3	**Semi-arid zone**	Plains of Punjab, Haryana, Gujarat, Eastern Rajasthan, west-central UP, Western MP. Most lands under agriculture, limited forested area	3-6 m^3/ha/yr
4	**Himalayan bio-geographic zone**	Four distinct biotic provinces of north, west, central and eastern Himalaya. Sharp altitudinal differences. Well forested and also degraded in places, rich biodiversity. Tea cultivation in eastern part.	6 m^3/ha/yr except on very high elevations.
5	**Deccan Peninsula**	Raised land covering 40% of India; bound by Satpura, Western Ghats and Eastern Ghats; elevation ranges from 300 to 1000 meters in east; covered by tropical dry and moist forests	6-9 m^3/ha/yr
6	**Gangetic Plains**	Plains of UP, Bihar, West Bengal; most fertile alluvial soils, mostly under crop; very little forest cover	6-9 m^3/ha/yr
7	**Northeastern bio-geographic zone**	Brahmaputra and Barak River Valleys and North eastern hills; evergreen and moist deciduous forests, heavily subjected to shifting cultivation	9-12m^3/ha/yr
8	**Coastal region**	Coastal belts of west and east coasts, higher rainfall in west, exposure to cyclones in east, extensive casuarinas plantations on Eastern coast	>12m^3/ha/yr on west coast, 9-12 m^3/ha/yr on east coast
9	**Western Ghats**	Moderately high hill range along west coast, eastern side under rain shadow, very rich in bio-diversity and forest cover; large extent under Tea, Rubber, Coffee, Cardamom, Tapioca; significant area under protected areas for wild life	>12m^3/ha/yr on west side, 9-12 m^3/ha/yr on east
10	**Indian Islands**	Group of 325 islands in Andaman sea and also Lakshadweep along West Coast; heavy rainfall, warm and humid climate, extensive forest cover	>12m^3/ha/yr

Source: Champion & Seth (1968), Kant (2004), Lal (1992), WII (2000)

Table 8.3 - Forest Carbon Stock in the state of Himachal Pradesh, Jammu and Kashmir UT and Punjab along with different carbon pools in Million tones

Carbon Pool	National	Himachal Pradesh	Jammu and Kashmir	Punjab
Above ground biomass	2256.533	1,10.045	1,70.222	3.529
Below ground biomass	700.824	30.745	47.806	1.367
Litter	127.902	2.711	3.706	0.125
Dead Wood	35.842	2.559	3.813	0.025
Soil Organic carbon	4003.575	1,06.300	1,64.648	8.298
Total	**7,124.676**	**2,52.360**	**3,90.195**	**13.344**

Table 8.4 - Per ha stock (tonnes/ha) in different carbon pools of Himachal Pradesh, Jammu and Kashmir UT and Punjab

Carbon Pool	National		Himachal Pradesh		Jammu and Kashmir UT		Punjab	
	IFSR 2017	**IFSR 2019**	**IFSR 2017**	**IFSR 2019**	**IFSR 2017**	**IFSR 2019**	**IFSR 2017**	**IFSR 2019**
Above ground biomass	31.59	31.68	46.79	71.30	48.59	72.09	27.74	19.09
Below ground biomass	9.86	9.84	12.38	19.92	12.94	20.25	10.25	7.40
Litter	0.43	0.50	1.66	1.76	1.52	1.57	87.31	71.18

Dead Wood	1.92	1.80	0.49	1.66	0.43	1.62	0.14	0.14
Soil Organic carbon	56.19	56.21	55.09	68.87	55.09	69.73	48.84	44.89
Total	**99.99**	**100.03**	**116.41**	**161.51**	**118.72**	**165.51**	**87.31**	**72.18**

8.7.4 Carbon Sequestration from Carbon Forestry Projects

India is the leading country in carbon forestry in so far as carbon trading under Clean Development Mechanism (CDM) of UNFCCC is concerned. A total of 19 CDM Forestry Projects are registered from India under CDM. Average Reduction (metric tonnes CO_2/year/ha) by the plantation activities under CDM project in India is in the region of 16 Metric tonnes of CO_2/ha/year. However, the estimated CO_2 mitigation the CDM project registered in Himachal Pradesh is expected to capture 10.34 tonnes of CO_2/ha/annum. The low carbon mitigation from the project (10.34 tonnes of CO_2/ha/annum) as compared to National average (16 Metric Tonnes of CO_2/ha/year is attributed to the nature of landscape where this project was implemented.

8.7.5 Carbon Sequestration in Agroforestry System

Agro-forestry is a form of agriculture that involves planting trees in crop and livestock farming systems. Removing atmospheric carbon (C) and storing it in the terrestrial biosphere is one of the options, which have been proposed to compensate Green House Gas (GHG) emissions. Agricultural lands are believed to be a major potential sink and could absorb large quantities of carbon if trees are reintroduced to these systems and judiciously managed together with crops and/or animals. Thus, the importance of agroforestry as a land use system is receiving wider recognition not only in terms of agricultural sustainability, but also in issues related to climate change. The inclusion of trees in the agricultural landscapes often improves the productivity of systems while providing opportunities to create C-sinks. The amount of carbon sequestered largely depends on the agroforestry put in places, the structure and function, which are determined by environmental and socio-economic factors to a great extent. The Carbon sequestration potential of afforestation/reforestation is specific to the species, rate and management involved and it is, therefore, variable.

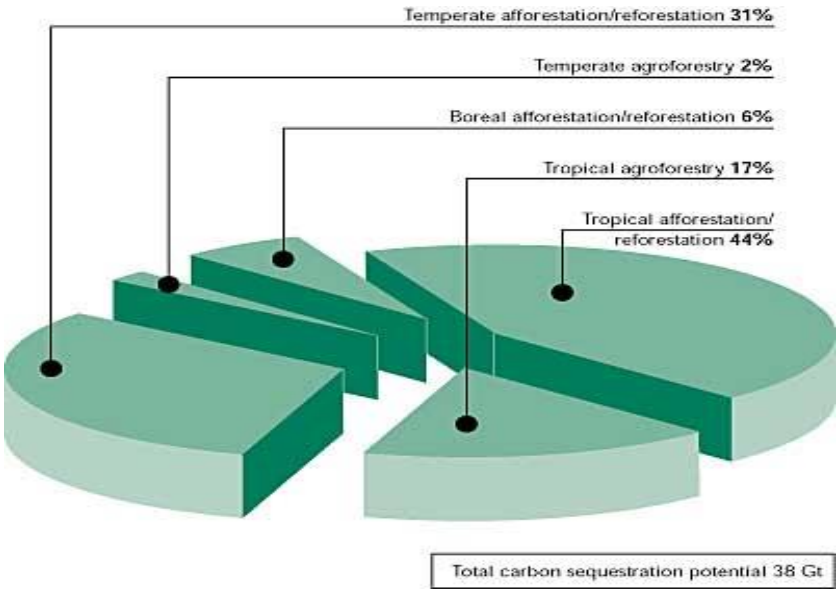


Fig. 8.2 - Potential contribution of Afforestation/Reforestation and Agro-forestry activities to global carbon sequestration, 1995-2015 (Source: Brown *et al*., 1996)

The sequestration potential for agro forestry practices is even more variable, depending on the planting density and production objectives of the system. Assuming a global land availability of 345 m/ha for afforestation/reforestation and agroforestry activities, Brown *et al.* (1996) estimate that approximately 38 Gt of carbon could be sequestered over the next 50 years i.e., 30.6 Gt by afforestation/reforestation and 7 Gt through the increased adoption of agroforestry practices (Fig 8.2). Studies of tropical regions indicate that an additional 11.5 to 28.7 Gt of carbon may be sequestered through the assisted regeneration of about 217 million ha of degraded land.

8.8 Fulfilling International Commitments on Climate Change

Fulfilling emission reduction commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement on Climate Change, Government of India, launched India's National Action Plan on Climate Change (NAPCC) in 2008. In 2015, Government of India, Nationally Determined Contributions (NDC) under Paris Agreement is committed to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.

8.8.1 National Mission for a Green India (GIM)

India's National Action Plan on Climate Change (NAPCC) launched in June 2008 identifies several measures that simultaneously advance the country's development and climate change related objectives of adaptation and mitigation. The implementation of the NAPCC is designed to take place through eight National Missions, which form the core of the National Action Plan on Climate Change and incorporate multi-pronged, long-term and integrated strategies for

achieving India's key goals in the context of climate change. National Mission for a Green India also known as Green India Mission (GIM), is one of the key missions under NAPCC dealing with mitigation and adaptation of Climate Change in the forestry sector (MoEF&CC, 2014).

The Green India Mission has the main aim to improve the ecosystem services example; storage of carbon and carbon sequestration and other ecosystem services like hydrological services and biodiversity in relation to climate change adaptation and mitigation. It also deals with other benefits like non-timber forests products (MoEF&CC, 2010).

The GIM aims to respond to climate change with a combination of adaptation and mitigation measures, which can be helpful in; (i) the increasing carbon sinks in managed forests and other ecosystems; (ii) adaptation of vulnerable species of plants /ecosystems to climatic variability and; (iii) adaptation of local communities dependent on forests in the era of climate change scenario. In view of negotiation related to recent global climate change scenario and India NDC's commitment under the Paris Climatic Agreement, the Government of India is in the process of improving the Goals and targets under the Green India Mission (MoEF&CC, 2010).

8.8.2 India's Nationally Determined Contribution (NDC) for Forestry Sector

Under Paris Climate Agreement India has committed to meet its Nationally Determined Contribution (NDC). The Forestry sector goal of NDC beside other goals commits to create an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. To achieve this, India is determined to continue with its on-going interventions, enhance the existing policies and launch new initiatives in the priority areas *inter alia* full implementation of Green India Mission and other programmes of afforestation. Planned afforestation has been seen as a major mitigation strategy in forestry sector. India is one of the few countries where forest and tree cover has increased in recent years transforming country's forests into a net sink owing to national policies aimed at conservation and sustainable management of forests.

India's efforts to increase the forest and tree cover have been further augmented by policies like National REDD-plus Strategy (2018a), National Agroforestry Policy (2014), Joint Forest Management Guidelines 1990; National Afforestation Programme, *Namami Gange* Programme and, Green Highways Mission and Afforestation under Compensatory Afforestation Fund Management and Planning Authority Act (UNFCCC, 2015). The aforesaid actions are major drivers listed by India in its INDC submitted to UNFCCC to achieve the target of capturing 2.5 to 3 billion tonnes of additional CO_2 equivalent. The recent initiatives of afforestation along the major River Basins of the country through Forestry Interventions will further contributor to additional carbon sequestration through afforestation activities.

8.9 Projected Reduction of CO_2 by Forestry Intervention in the Ravi Riverscape

Rejuvenation efforts of the Ravi Rivers through forestry Interventions in the concerned States/UT i.e., Himachal Pradesh, Jammu and Kashmir and Punjab will attempt to plant trees on 7995.84 ha of identified diverse landscapes on Ravi River scope area. The expected CO_2 mitigation benefits from the proposed forestry interventions have been estimated following the IPCC (2003) Good Practice Guidance by using following formula:

$$C = [V \times D \times BEF] \times (1+R) \times CF]$$

Where:

C=Carbon stock in Biomass (tonnes C)

V=Stand volume (m^3 ha^{-1})

D= Basic wood density (tonnes d.m m^{-3}). These values has been taken from Kaul *et al.* (2009)

BEF= Biomass expansion factor (Default). These values has been taken from Kaul *et al*. (2009)

R=Root shoot ratio (Default). These values has been taken from Kaul *et al*. (2009)

CF=Carbon Fraction (Default value of 0.47 (IPCC, 2006) has been considered

Carbon in the biomass has been converted into CO_2 eq by multiplying with 44/12

The estimated Carbon dioxide capture by the plantations raised under forestry interventions in the Ravi Riverscape are presented in Table 8.5.

Table 8.5 - Estimated Carbon dioxide capture by the plantations raised under forestry interventions in the Ravi Riverscape

Sr. No.	River basin	State and Landscape NL= Natural Landscape, AL= Agriculture landscape	Proposed area under Plantations (ha.)	Mean Wood density (Mg/cu.m) *	Estimated Biomass assuming productivity of 5 m^3/ha/yr	BEF*	Ratio of below ground biomass to above ground biomass *	Estimated CO_2Reduction (metric tonnes CO_2 Eq/ha/yr)	Estimated CO_2Reduction (metric tonnes CO_2 Eq/ year)	Estimated CO_2Reduction (metric tonnes CO_2Eq/ year) in 20 years	Estimated CO_2Reduction (metric tonnes CO_2Eq/ year) in 10 years**
		1	2	3	4	5	6	7	8	9	10
1	Ravi	NL Himachal Pradesh	4080.00	0.47	2.35	1.52	0.28	7.879356	32147.77	642955.4	514364.32
		AL Himachal Pradesh	204.00	0.47	2.35	1.52	0.28	7.879356	1607.389	32147.78	25718.22
		Institutional Plantation, HP	104.00	0.47	2.35	1.52	0.28	7.879356	819.45	16389.00	13111.2

		NL J&K	1540.00	0.43	2.15	1.51	0.25	6.993502	10769.99	215399.8	172319.84
		AL J&K	245.00	0.43	2.15	1.51	0.25	6.993502	1713.408	34268.16	27414.53
		Institutional Plantation, J&K	121.49	0.43	2.15	1.51	0.25	6.993502	849.64	16992.8	13594.24
		NL Punjab	795.35	0.7	3.5	1.57	0.27	12.02654	9565.309	191306.18	153044.94
		AL Punjab	818.00	0.7	3.5	1.57	0.27	12.02654	9837.71	196754.20	157403.36
		Institutional Plantation, Punjab	88.00	0.7	3.5	1.57	0.27	12.02654	1058.33	21166.6	16933.28
Total =			**7995.84**					**8.97 (Mean)**	**68368.99**	**1367379.92**	**1093903.94**

*A conservative productivity rate of 5m^3/ha/year has been considered assuming that the plantations will be maintained for at least 20 years with usual harvesting/rotation schedule.

Natural Landscape also includes area of NL, Natural regeneration and ETF area.

* Values taken from Kaul *et al*. (2009)

** assuming that plantation will attain 80% of its productivity in 10 years period

Assuming a modest productivity of plantations at 5 m^3/ha/year, the carbon dioxide captured by the plantations raised under the project will be capable of capturing 8.97 metric tonnes of $CO_{2\ eq}$ /ha/year which will be equal to 68368.99 tonnes of CO_2/year for the entire project area. The expected CO_2 reduction for 20 years period will be 1.37 million tonnes of CO_2eq. Thus forestry intervention for enhancing tree cover in the riverscape of Ravi will also serve a major mode of CO_2 mitigation and will continue to make positive contribution towards climate change mitigation at local and regional scale. The estimate has been based on the assumption that the plantation shall be maintained for a minimum of 20 years with usual harvesting at scheduled intervals. It has also been assumed that plantation will attain 80% of its (peak biological potential) productivity in 10 years period.

The proposed plantation raised under the forestry interventions will also contribute in capturing significant amount of carbon dioxide, (the Greenhouse Gas mainly responsible for global warming) and will this contribute towards climate change mitigation among other co-benefits of the proposed plantations. At the time of conceiving the projects, DPR must also indicate that it intends to develop these plantations for the purpose of seeking carbon credits under available market or non-market mechanisms. The agency executing the interventions shall explore the possibility of registering these plantations for the purpose of carbon credits under existing market/ non market mechanisms under UNFCCC or any other robust carbon standard such as Verified carbon standards (VCS). This will help in facilitating determining the additionality of the project. One tonnes of Carbon dioxide equivalent will generate one carbon credit. Thus the

programme has a potential to generate 1367379.92 CER of carbon credits as well over a span of 20 years and 1093903.936 CER carbon credit over a span of 10 years.

Species to be included in the afforestation/reforestation models for the different riverscapes at different altitude will vary in their growth behavior i.e., slow, medium or fast growing. Most of the species likely to be selected for the afforestation/reforestation models will be locally adapted fast growing and native species. Species like *Eucalyptus* and Poplars can attain their peak productivity at the age of 6-8 years. However, it is assumed that about 80% of their peak potential productivity can be attained by most of fast and medium fast growing native species in a span of 10 years period.

8.10 Interventions related to NTFPs for Livelihood Generation

In India, out of the total land area of 329 million ha, only 77 million ha (22%) are classified as forests as against recommended forest coverage of 33%. Around 50 % of forest revenues and 70 % of forest based export income of the country comes from NTFPs (Tejaswi, 2008). Twenty years ago, NTFPs were estimated to provide about 40 % of India's total official forest revenues and 55 % of forest-based employment. Nearly 500 million people living in and around forests in India were said to rely on NTFPs as a critical component of their sustenance (Tewari and Campbell, 1995). More recent estimates of the number of forest dwellers who depend on NTFPs for sustenance and as a supplement to their income range from 50 million (Tejaswi, 2008) to nearly 100 million (Panda, *et al*., 2010). Traditionally Non-Timber Forest Products (NTFPs) refer to all biological materials other than timber extracted from natural forests for human and animal use and have both consumptive and exchange value. Globally NTFP/NWFP are defined as "Forest products consisting of goods of biological origin other than wood, derived from forest, other wood land and trees outside forests". It is estimated that 275 million poor rural people in India 27 % of the total population depend on NTFPs for at least part of their subsistence and cash livelihoods (Malhotra and Bhattacharya, 2010). This dependency is particularly intense for half of India's 89 million tribal people, the most disadvantaged section of society, who live in forest fringe areas. Historically, the NTFP sector was neglected for many decades from main stream forestry, and they were considered as 'minor' (Minor Forest Produce), despite the fact that monopoly rights over several such NTFPs/MFPs fetched a good income for the Forest Department. After the ban on green felling, the income from NTFPs in the total income of the Department became the major one with that from timber marginalized in many States. Non-Timber Forest Products (NTFPs) is a term first coined by de Beer and McDermott (1989) in a groundbreaking publication on the economic value of NTFPs in South East Asia (Belcher, 2003).

Categories and uses of NTFPs: The NTFPs can be classified into different categories, based on the purpose of use (For example, as food, fuel, medicine, house hold utensils and farm implements); the part of plants harvested (i.e., leaf, fruit, stem and roots) and level of use (i.e., self-supporting and commercial). Once viewed as the products of poor unlike that of the timber for the rich, NTFPs provide a green social security to billions of people in the form of food

supplements, traditional medicines, fuel and fodder, low-cost building materials and source of employment and income generation. In some cases, the revenues earned from NTFPs are the only source of cash income, which increases the dependency of people on commercially interesting NTFPs resources (Pandey *et al*., 2016)

8.10.1 Interventions Related to NTFPs for Livelihood Generation Includes Following Areas.

(A) Cultivation of Medicinal Plants: Medicinal plants are valuable natural resources. Unplanned development and overexploitation of medicinal plants from non-managed, natural resources has not only resulted in shortage of various herbs, but extinction of several species in nature. In order to meet the growing demand for these plants, it becomes important to conserve these plant species either by way of domestication and cultivation or by other ex-situ and in situ conservation measures for their sustainable use. Plants have been used since ancient times to heal and cure diseases and to improve health and wellbeing. Medicinal plants are chiefly used for curing stomach pain, fever, cold and cough, bleeding and wounds, fungal infection, burns, rheumatic pain, insect bite, influenza, diarrhoea, jaundice. In order to initiate systematic cultivation of medicinal and aromatic plants high yielding varieties have to be selected. There is an outstanding need to devise and demonstrate effective, appropriate ways of conserving the biological diversity of the State. Conservation is essentially a social issue requiring democratic involvement of the people and local communities whose lives and livelihoods are most affected. Conservation efforts are more likely to be successful and sustained if they are driven by participatory processes and communal decision-making, in which local communities have the central role. Conservation provides the essential foundation for sustainable rural life and livelihoods (Joshi *et al*., 2014).

(B) Bamboo related products: Bamboo is one of the most primitive plant species that survive today as “The Green Gold” of the 21th century. The bamboo is extraordinary and unique plant of our planet because it is the fastest growing plant and is annually renewable and harvestable if managed intensively. Bamboo is productive, sustainable and versatile plant and one of the important Non-Wood Forest Products (NWFP), providing food, raw material and shelter and found in wide variety of climatic and edaphic conditions. Bamboo can be utilized as existing resources of agroforestry system for filling the present needs without threatening the ability to meet their needs for future generation. Bamboo based agroforestry system has great potential to provide employment in planting and provides raw materials for construction, craft and manufacture of value-added products and increases the source of income in the rural areas. Some value added products are Sofa chair, Lamp stand, File tray, Magazine holder, Magazine rack, Dustbin, Flower stand, Hand fan, Hanging basket, Lamp holder, Surahi pot, Corner flower stand, Hanging wallflower pot, Lampshade etc. It has a

greater scope of value-added product that provides income generation for poor rural people (Nirala *et al.*, 2018).

(C) Fodder: Fodder crops are crops that are cultivated primarily for animal feed. Fodder comprises grasses, crop residues and parts of trees and shrubs such as leaves, flowers and fruits that are harvested and used as feed for livestock and other domesticated animals. Livestock keeping is the main source of livelihood for people (Sacande and Parfondry, 2018). Most of the households collect fodder for their livestock. Forests provide fodder from trees, shrubs and climbers. Leaf fodder of several tree species is almost as nutritious as that of agricultural fodder crops. Good fodder yielding tree species includes: *Ailanthus excelsa Moringa oleifera, Sesbania* spp., *Morus alba, Albizia lebbek, Leucaena leucocephala, Pongamia pinnata, Hardwickia binata, Quercus* spp., *Grewia* spp., *Bauhinia* spp., *Celtis* spp., etc. Several shrubs, herbs and climbers also yield good quality fodder leaves.

NTFPs provide a green social security to a vast percentage of people in the form of food supplements, traditional medicines, fuel and fodder, low-cost building materials and source of employment and income generation. List of Non-Timber Forest Products is given in Table 8.6.

Table 8.6 - Non-Timber Forest Products

Edible products	Fruits, Flowers, Seeds, Roots, Rhizomes, Tubers, etc. of several forest species are edible. Fruits and seeds of *Anacardium occidentale, Syzygium cumini, Phyllanthus emblica,* etc., green pods of *Moringa oleifera,* new shoots of bamboo, etc. are in great demand.
Grasses and grazing	Forests provide grazing facility to about 30 % of the total livestock population of the country. Grasses such as *Cenchrus* spp., *Lasiurus* spp., *Heteropogon* spp., *Bothriochloa* spp., *Andropogon* spp., *Eragrostis* spp., *Iseilema* spp., etc. are abundantly found in the forest as a ground cover. Some grasses like *Eulaliopsis binata* are also used for rope and papermaking.
Fodder trees and shrubs	Forests provide fodder from trees, shrubs and climbers. Leaf fodder of several tree species is almost as nutritious as that of agricultural fodder crops. Good fodder yielding tree species includes: *Ailanthus excelsa, Moringa oleifera, Sesbania* spp., *Morus alba, Albizia lebbek, Leucaena leucocephala, Pongamia pinnata, Hardwickia binata, Quercus* spp., *Grewia* spp., *Bauhinia* spp., *Celtis* spp., etc. Several shrubs, herbs and climbers also yield good quality fodder leaves.
Bamboo and canes	India is very rich in bamboo resources. The bamboo is used for housing, for rural agricultural works, for paper pulp, for packaging and other uses.
Oil seeds	Many tree species produce oil-bearing seeds, which are commercially important. Some of these oils are fit for human consumption. Generally, these seeds are used in soap industry. People use these oils for various purposes.

Tans and dyes	A variety of vegetable tanning materials are produced in the forest. Important ones include the myrobalan nuts and bark of wattle *(Acacia mearnsii, A. decurrens, A. nilotica and Cassia auriculata*, etc.) Other tanning materials include, leaves of *Phyllanthus emblica* and *Anogeissus latifolia*, bark of *Cleistanthus collinus*, fruits of *Ziziphus xylopyra*, bark of *Cassia fistula, Terminalia alata, T. arjuna*, etc.
Gums and resins	Gums and resins are exuded by trees as a result of incision or injury to the bark of wood. Gums are collected from several tree species. Resins find wide use in industries and in Indian pharmacy.
Fibres	A wide range of plants, yielding fibre occur in the forests of India. Fibres are obtained from tissues of different parts of certain woody plants, which are used for making cloth, rope and cordage.
Flavouring plants	A variety of plants including Cumin (seeds of *Carum carvi*), Cardamom (dried capsule of *Elettaria cardamomum*), Indian bay leaf (leaves of *Cinnamomum tamala*) are obtained from forests used locally and throughout the world.
Animal products	Animal products include Lac, Honey, Fur and Feathers, Meat etc. Lac is a resinous secretion of the Lac insects, which feed on forest trees, particularly on *Butea monosperma*. Similarly, Silk worm is reared on *Terminalia* spp. and *Morus alba* plantations. Honey is another important product obtained from forests.
Leaves	Leaves of various forest tree species have been used for various purposes since ancient times and help earn forest revenue. Leaves of several trees and shrubs are widely used as food, fodder, medicine, etc. Other than these, leaves of some trees and shrubs are used to make plates, cups, baskets, and umbrella and for thatching like leaves of trees such as *Bauhinia* spp., *Ficus roxburghii*, etc. are used for making plates, 'Dona', etc.

(Source: Nautiyal and Kaul, 2013)

Potential Benefits from NTFPs (Herbaceous Medicinal Plants)

North-Western Himalaya is having the distinction of being one of the richest repositories of medicinal and aromatic plant resources in the country. Himalayan herbs in fact have received unprecedented attention the world over mainly to their uniqueness and high medicinal value. Medicinal and aromatic plants sector has traditionally occupied an important position in the socio cultural, spiritual and medicinal arena of rural and tribal lives in the region. They have traditional rights to collect medicinal herbs as Minor Forest Produce (MFP) or NTFPs (Non-Timber Forest Products) in designated forestland (Anderson, 1886) and have been an important

source of income to the natives (Dobriyal *et al*., 1997; Tondon, 1997; Badola, 1998, 2002). NTFPs cover all forest products other than major forest products. NTFPs of commercial importance in India may be divided into the following classes; (i) Fibers and flosses; (ii) Grasses i.e., other than oil-producing grasses, bamboos and canes; (iii) Essential oils i.e., including oil-yielding grasses; (iv) Oil seeds; (v) Tans and dyes; (vi) Gums, resins, and oleo-resins; (vii) Drugs, spices, poisons and insecticides; (viii) Edible products; and (ix) Minerals and miscellaneous products (FRIC,1972).

The natural resources in forest provide food, fodder, medicine, clothes, house building materials to human civilization. It is estimated that 275 million poor rural people in India i.e., about 27% of the total population depend on NTFPs for at least part of their subsistence and cash livelihoods (Malhotra and Bhattacharya, 2010; Bhattacharya and Faiz, 2009). This dependency is particularly intense for half of India's 89 million tribal people, who live in forest fringe areas. According to an estimate the NTFPs sector alone is able to create about 10 million workdays annually in the country (Anonymous, 2011). NTFP contributes to about 20 - 40% of the annual income of forest dwellers who are mostly disadvantageous and landless communities with a dominant population of tribals. It provides critical subsistence during lean seasons, particularly for primitive tribal groups such as hunter gatherers and the landless. Most of the NTFPs are collected and used/sold by women, so it has a strong linkage to women's financial empowerment in the forest-fringe areas (Anonymous, 2011). In view of their ever increasing demand there is urgent need to grow and propagate the species in *ex-situ* and *in-situ* conditions. It will help not only in fulfilling the demands but will eventually conserve the resource from bio-diversity point of view.

The estimated values of medicinal plants, average value per hectare from various was calculated following previous works (Meena, 2003; NMPB, 2004; Samant *et al*., 2008; Singh *et al*., 2013). The different proposed plantation models in present DPR envisages planting of native species of trees, shrubs, grasses and NTFPs for rejuvenating river and its tributaries. If sustainable harvesting practices and beating up of medicinal plants in the intervention areas are followed, two more harvesting i.e., on 7^{th} year and 10^{th} year can be obtained. In temperate to alpine zones, the average values per hectare were assumed after taking survival rate as 60%. The harvesting of plants is taken as 50% after rotation period of 3.5 years. In 7^{th} year of harvesting schedule, 50% of the remaining part of 3.5 year and in 10^{th} year of harvesting schedule, 40% of the remaining part of 7^{th} year is considered. In tropical and sub-tropical areas, the crop harvesting has to be done after rotation period of 1.5 year. The estimated income from growing, selling and extracting NTFP's from medicinal herbs in Ravi Riverscape through forestry interventions is presented in Table 8.7.

Table 8.7 - Estimated Income Generated through NTFPs in Himachal Pradesh and Jammu & Kashmir UT

State / UT	Model Name	Model No.	No. of Herbacious medicinal plant	Area in Hac	Rate Per Hactre	Estimated income after 3.5 years in Lakhs	Estimated income after 7 years in Lakhs	Estimated income after 10 years in Lakhs	G Total of Income in Lakhs
Himachal Pradesh	**Temperate Conifer Forest**	RV/HP/NL03	1200	513	4800	24.62	12.31	9.85	46.79
	Temperate Mixed Forest	RV/HP/NL04	1200	1283	4800	61.58	30.79	24.63	117.01
Jammu & Kashmir UT	**Temperate Conifer Forest**	RV/JK/NL03	1200	11	4800	0.53	0.26	0.21	1.00
Punjab	**Restoration of Degraded Forests Model**	RV/PB/NL01	-	561.35	54250	-	-	304.53	304.53
	Road Side Plantation	RV/PB/NL02	-	234	30450	-	-	71.25	71.25
Total =						**86.74**	**43.37**	**410.47**	**540.58**

8.11 Mandays generation through forestry intervention in Ravi Riverscape

Total mandays generated through forestry intervention and its constituent activity in Ravi Riverscape in Phase one is Rs 73,26,214.5 and in Phase two is Rs 5,24,568. Total mandays generated as whole in Phase one and Phase two is Rs 78,50,782.5. As above Table 8.5 showing the benefits from Proposed Forestry Intervention, Table 8.7 showing estimated income generated through NTFPs, respectively Table 8.8 displaying the mandays generated through Forestry Intervention.

Table 8.8 - Total Mandays generated from Plantation and Other Conservation Interventions in Ravi Riverscape

States	Activity	Year											Total	Cost
		Phase I (mandays)					Total	Phase II (mandays)					(mandays)	(mandays)
		I	II	III	IV	V	Phase I	VI	VII	VIII	IX	X	Phase II	Phase I+II
Himachal Pradesh	Natural Landscape	81272	246135	474781	484326	357793	**1644307**	188662	101305	45006	3501	-	**338474**	**1982781**
	Fire Protection	164995	119395	48965	43810	33855	**411020**	5980	-	-	-	-	**5980**	**417000**
	Agriculture Landscape	4452	6474	7518	5934	3708	**28086**	1584	-	-	-	-	**1584**	**29670**
	Urban Landscape	10920	94658	125356	48643	32853	**312430**	14370	-	-	-	-	**14370**	**326800**
	Soil Moisture Conservation	396440	517965	536455.5	322599	303987	**2077446.5**		-	-	-	-	-	**2077446.5**
	Other Intervention	18560	141984	120720	81968	53376	**416608**	35712	-	-	-	-	**35712**	**452320**
Jammu & Kashmir UT	Natural Landscape	6659	26029	52377	84083	27782	**196930**	17981	14268	9455	4608	-	**46312**	**243242**
	Fire Protection	141940	32250	18950	17700	16370	**227210**	1080	-	-	-	-	**1080**	**228290**
	Agriculture Landscape	5449	7887	11084	8206	5475	**38101**	2891	-	-	-	-	**2891**	**40992**
	Urban Landscape	11451	112176	58858	30632	21083	**234200**	3592	-	-	-	-	**3592**	**237792**
	Soil Moisture Conservation	111600	76480	46560	25200	2240	**262080**	-	-	-	-	-	-	**262080**
	Other Intervention	-	11380	9300	5900	3480	**30060**	2440	-	-	-	-	**2440**	**32500**
Punjab	Natural Landscape	19028	54640	152561	180053	129826	**536108**	45458	8034	1200	0	-	**54692**	**590800**
	Agriculture Landscape	12120	19580	22210	17910	11690	**83510**	4690	-	-	-	-	**4690**	**88200**
	Urban Landscape	11928	91756	56817	27819	18757	**207077**	4191	-	-	-	-	**4191**	**211268**
	Soil Moisture Conservation	42650	187360	129010	82450	73550	**515020**		-	-	-	-		**515020**
	Other Intervention	1962	39306	32070	19898	12785	**106021**	8560	-	-	-	-	**8560**	**114581**
Grand Total		**1041426**	**1785455**	**1903593**	**1487131**	**750817**	**7326214.5**	**337191**	**123607**	**55661**	**8109**	**-**	**524568**	**7850782.5**

8.12 Projected Water Quantity and Quality Benefit Assessment of the Forestry Interventions in the Ravi River Basin, India

The Rivers originating from the Himalayan Region are an important water resource for millions of people in Asia. However, due to increasing anthropogenic activities and land use changes, the quality of water is continuously decreasing. In addition these rivers also carry the highest sediment loads of all world rivers. Furthermore, climate change is also altering hydrology regimes and posing greater threat to this fragile ecosystem. In this scenario, forest catchments can play important role in regulating water flow, influencing the availability of water resources and maintaining the water quality (Bergkamp *et al*., 2003). Therefore, the relationship between forests and water is a significant issue that must be given high priority.

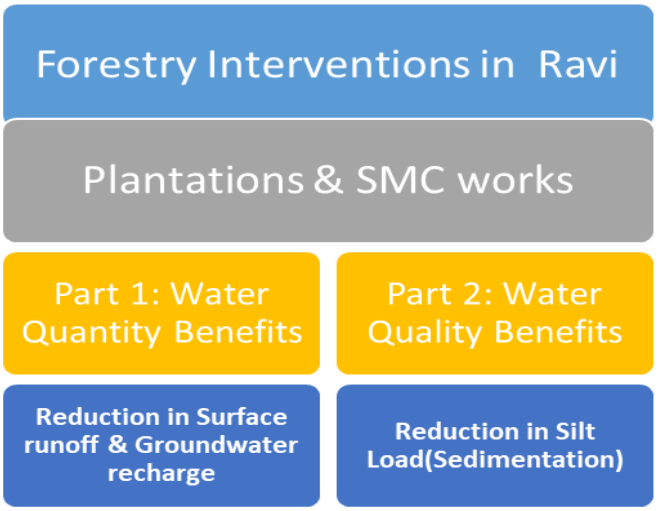


Fig. 8.3 - Benefit Assessment Framework of Ravi River

Watershed service provided by forest ecosystems is gaining acceptance with increased understanding of bio-physical modeling in the research and policy area. These forested catchments provide a high proportion supply of the water for Domestic, Agricultural, Industrial and Ecological needs in both upstream and downstream areas. In addition, it also addresses many environmental problems caused by changes in aspects of the hydrological cycle in terms of water demand and quality.

However, forest managers are facing challenges in implementing scientific management of forest catchment areas due to lack of recognition of the multi-sectoral forest benefits including regulation provision of water resources. It is also important to understand the "Green Water" role in the hydrological cycle. Green Water is a picturesque name for the water available in the soil for plants and the soil biota (i.e., microbes, earthworms, soil insects, etc.) to use. It is the water absorbed by roots, used by plants, and released to the atmosphere through a process called transpiration. To address this challenge, there is an urgent need for formulating an effective plan for restoration and rejuvenation of the forest catchments of major rivers in India. This project is one of the important steps of the Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India (GoI) towards addressing this issue. The overall benefit assessment framework of the Forestry Intervention plan proposed in the Ravi River Catchment area will have 2 components namely; Water Quantity and Water Quality (Fig. 8.3).

- The first component will conservatively estimate the green water benefits of the proposed plantation and SMC works in the Ravi Sub-Basin using SCS Curve Number Method and Groundwater Estimation Committee Methodology, 2015, respectively.

- Second component will quantify the reduction of Silt load (Sedimentation reduction) in the Ravi Sub-Basin from the Forestry Interventions.

The Indus River Basin has is bifurcated into 11 sub basins, namely:

1. Gilgit Sub-Basin
2. Lower Indus Sub-Basin
3. Shyok Sub-Basin
4. Jhelum Sub-Basin
5. Upper Indus Sub-Basin
6. Chenab Sub-Basin
7. Ravi Sub-Basin
8. Beas Sub-Basin
9. Sutlej Upper Sub-Basin
10. Sutlej Lower Sub-Basin
11. Ghaggar and other Sub-Basin

Ravi River is the main tributary of the Ravi Sub-Basin. The total catchment area is 11706 Km^2 which covers part of Himachal Pradesh, Jammu and Kashmir UT and Punjab.

Component 1: Water Quantity Benefit Assessment

Under Component 1, the proposed Forestry Interventions in Ravi Riverscape Area has two major parts namely;(1) Plantations; and (2) SMC Structures (Table 8.9). The quantitative benefits of the activities are assessed in the following sections:

Table 8.9 - Proposed Forestry Interventions Activities in the Ravi River Sub Basin

State/UT	Riverscape Area(ha)	Plantation Area (ha)	Estimated Excavation(m^3)
Himachal Pradesh	5,04,100	4,388.00	2,47,830.5
Jammu and Kashmir UT	297,091	1,906.49	19,590
Punjab	1,16,170	1,701.35	1,85,500
Total	**91,7361**	**7,995.84**	**4,52,920.5**

Part A: Reduction of Surface runoff and recharge from the Plantation Activities

Conceptual Model for Assessment: Water Balance Model

The Water balance is based on the law of conservation of mass which states that any change in the water content of a given soil volume during a specified period must equal the difference between the amount of water added to the soil volume and the amount of water withdrawn from it. It helps to quantify the relationships between precipitation, surface and groundwater runoff,

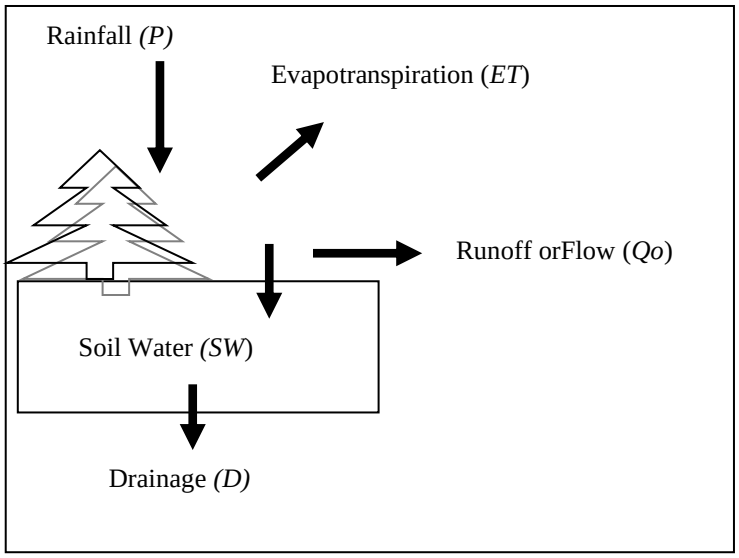


Fig. 8.4 - Water Balance Model

evaporation, transpiration, and aquifer drafts, and provides a framework for future planning of sustainable exploitation of the available water resources.

The water balance of a forest basin can be determined by calculating the input, output and storage changes of water. The major input of water is from precipitation and major output is runoff. A complete water balance model (Fig.8.4) may contain four sub-modeling systems describing the hydrologic cycle, namely, an atmospheric water balance sub-system; a surface water balance sub-system; a soil water balance sub-system; and a groundwater balance sub-system (Equation 1). Depending upon the focus of the analysis, each sub-system can be modeled separately.

The general water balance equation is of the following form:

Equation 1

$$G+P = Q_{dsro} + Q_b + ET + \Delta Sg$$

Where, P = Precipitation; G=Glacial inflow;Q_{dsro}= direct surface runoff; Q_b = base flow; E_t = ET = evapotranspiration; ΔS_g = change in groundwater storage(in soil or the bedrock / ground water);

Assumptions

1. Inflows from Precipitation and Glacial inflows would remain same for both scenarios.
2. Evapo-transpiration (ET) is the sum of evaporation and plant transpiration from the surface to the atmosphere. Evapo-transpiration is an important part of the water cycle. However, for understanding benefits, it is excluded from the calculations showing casing how Forestry Interventions can reduce surface runoff and improve recharge. In addition, it is also important note that the ET values in the Forests are much higher than that of other land uses, but provides ecological functions such as carbon storage, nutrient cycling, water and air purification, soil protection, microclimatic benefits and maintenance of habitat.

3. From the hydro-geological point of view, it is observed that the groundwater occurs in confined (restricted) setting in joints, cracks, fissures, and fractures moving to deeper levels in the weathered zones. As the eastern and south-east part of the Basin has already been overexploited in terms of CGWB classification and very low inter aquifers transfers between complex Basaltic Zones and Alluvial Plains, the changes in groundwater storage (ΔSg) is considered zero for computational purposes.

Equation 2

Changes in Water Balance = (Without Forestry Interventions) – (With Forestry Interventions)

- Changes in surface runoff (Without Forestry Interventions Q_{dsro} – With Forestry Interventions Q_{dsro}) = Changes in base flow(With Forestry Interventions Q_b – Without Forestry Interventions Q_b)

Estimating Changes in Surface runoff = (Without Forestry Interventions Q_{dsro} – With Forestry InterventionsQ_{dsro})

There are many methods offered for rainfall runoff modeling. Soil Conservation Services and Curve Number (SCS–CN) technique is one of the primogenital and simplest method for rainfall runoff modeling (Kumar *et al*., 2017). The surface water outflow from the Riverscape Area will be estimated by the Soil Conservation Service Curve Number (SCS-CN) model. The SCS-CN model is based on the single parameter Curve Number (CN) which depends on the land use, land cover, soil type and the antecedent moisture conditions prevailing in the catchment. The direct surface runoff has been estimated using the SCS-CN model given in Equation 3 and 4.

Equation 3

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)} \; for P > I_a \; ; and \, Q = 0, \; for P \le I_a$$

Equation 4

$$S = \frac{25400}{CN} - 254$$

Where, P = rainfall; Q = direct surface runoff (mm); S = potential retention (mm); CN = curve number; I_a= initial abstraction;

Step 1: Annual Rainfall (P)

The annual rainfall varies from 1200 to 1800 mm in Himachal Pradesh Region, 800 to 1000 mm in Jammu and Kashmir UT regions and Punjab Region of Ravi Sub-basin. In this study, we have taken the average rainfall in Ravi Sub Region between years 1971-2004.

Table 8.10 - Annual Rainfall in Ravi Sub-basin

Name of State/UT	Riverscape Area (ha)	Plantation Area (ha)	Rainfall (mm)
Himachal Pradesh	5,04,100	4,388.00	1215
Jammu and Kashmir UT	297,091	1,906.49	
Punjab	1,16,170	1,701.35	
Total	91,7361	7,995.84	

P= 1,215mm

Step 2: Assessing CN = curve number

CN value for soils (Hawkins *et.al*., 2002) having high infiltration rates and for more than 58 mm precipitation conditions Antecedent Moisture Conditions (AMC-III) are provided below.

Table 8.11 - CN value

Land use	AMC	CN Value
Forest	AMC III	45
Barren/Waste/Agriculture	AMC III	77

Step 3: Calculation of (S) Potential retention (mm)

It is defined as the potential maximum retention after runoff begins. "S" aggregates all variation in the runoff response because of land use, soils, soil moisture, or rainfall pattern, duration, or intensity, plus any other variation into one variable.

Table 8.12 - Potential Retention

S = potential retention (mm)	With Forestry Interventions	Without Forestry Interventions
$S = \frac{25400}{CN} - 254$	310.4 mm	75.87mm

Step 4 Initial abstraction (I_a)

The initial abstraction consists mainly of interception and infiltration during early parts of the storm and surface depression storage. The initial abstraction (Ia) is some fraction of the potential maximum retention (S) where in $\lambda = 0.2$ adopted as a standard value for general soils.

Table 8.13 - Initial Abstraction

Land use	With Forestry Interventions	Without Forestry Interventions
$Ia = \lambda S$	62 mm	15.174 mm

Step 5: Direct Surface Runoff (DSRO)

Direct Surface Runoff is the rain that runs off during the rain event as overland flow or in the vegetation cover above a soil.

Table 8.14 - Direct Surface runoff

DSRO	With Forestry Interventions	Without Forestry Interventions
$Q_{dsro} = \frac{(P - Ia)^2}{P - Ia + S}$	908.43	1128.47

Q = Direct Surface Runoff (mm);

Step 6: Reduction in Surfaceoff and Changes in base flow

Base flow consists of water that infiltrates into the soil and travels laterally down slope through upper soil layers, and groundwater flow that infiltrates and travels through the aquifer. The Proposed Forestry Interventions will reduce surface runoff and increase groundwater recharge, which in turn increase the base flow. The changes in the base flow caused by plantation activity can also be called as "Green Water".

Changes in Base flow Q_b (Green Water/reduction in runoff)

= **Area * (Without** Forestry Interventions **Q_{dsro}** - **With** Forestry Interventions **Q_{dsro})**

= 7,995.84 ha (1,128.47 mm- 908.43 mm)

=1,759.40 ham

= **17.59 MCM**

Part B: Groundwater Recharge from SMC Measures

Estimating groundwater recharge is important to measure effectiveness for water conservation measures. However, a site specific modeling approaches to forecast groundwater recharge typically requires observed historic data to assist calibration. It is generally not possible to physically to observe groundwater recharge activities spreading over large areas. However, the Ground Water Resource Estimation Committee (CGWB GEC-2015) Methodology provides a simple assessment framework for the estimation of ground water recharge due to Soil Moisture Works (SMC). In the present study, this methodology will be employed to project groundwater recharge from the proposed SMC activities.

Assessment Framework

Recharge due to Water Conservation Structures is estimated based on the following formula **(GEC 2015)** (Equation 6):

Equation 5 :

$$RWCS = GS * RF$$

Where:

- RWCS = Recharge due to Water Conservation Structures
- RF =Recharge Factor;
- GS= Gross Storage= Storage Capacity X No. of Fillings

Step1: Estimating Grass Storage

Storage Capacity: AWSA* H *Efficiency* Number of fillings

- AWSA = Storage potential created through excavation
- Efficiency of the structures
- Number of Fillings= Number of fillings during the rainfall season
- H= Height

Conservative Assumptions:

- SMC Activities proposed in the Riverscape Plan
- Efficiency: = 50% ;*Recharge due to Check Dams and Nallah Bunds can be taken as 50% of gross storage (assuming annual de-silting maintenance exists) considering leakages & other factors*
- Number of filling assumed to be 8considering 30-to 50 rainy days in the Ravi River Basin
- AWSA X Height =SMC Excavation Quantity
- Multiplier factor of 2 applied for calculating the Storage Potential from Area under SMC

Table 8.15 - SMC Activities under Forestry Interventions

State/UT	Area under SMC works ('000 Cubic Meter)	Storage potential created through excavation ('000 Cubic Meter)	Number of Fillings	Efficiency	Gross Storage ('000 Cubic Meter)
Himachal Pradesh	247.83	495.67	8	50%	1,982.68
Jammu and Kashmir UT	19.59	39.18	8	50%	156.72
Punjab	185.5	371	8	50%	1,484.00
Total					**3,623.4**

Step 2: Recharge Factor

Expected Groundwater recharge= Gross storage * Recharge Factor

RF = Recharge Factor as per GEC, 2015 norms

Table 8.16 - Expected Groundwater Recharge in Ravi River Basin

State/UT	Gross Storage ('000 Cubic Meter)	Recharge Factor (%)	Expected Groundwater recharge ('000 Cubic Meter)
Himachal Pradesh	1,982.68	10%	198.2
Jammu and Kashmir UT	156.72	10%	15.6
Punjab	1,484	10%	148.4
Total			362.3

Step 3: Expected Groundwater recharge

Total Groundwater Recharge =3,62,340 Cubic Meters
Expected Groundwater recharge from the SMC structures is 0.36 MCM

Summary of Component 1

The Forestry Interventions activities will conserve 17.59 MCM water annually.

Table 8.17 - Potential Benefits of Plantation Activities and SMC Works

Benefits of CAT activities	Component 1: Water Quantity	Plantations	17.59 MCM Water Savings
		SMC works	0.36 MCM Groundwater Recharge
		Total	17.95 MCM

Component 2: Water Quality

Water quality of Ravi Sub-basin is excellent. It deteriorates slightly towards downstream, due to heavy abstraction and discharge of pollutants, but remains very much within permissible limits. Below figure shows schematic representation of some of the main influences on water quality within a river basin (Owens, 2007), Water and sediment of the river exhibit seasonal as well as spatial variability, which is contributed by geological, climatologically, and anthropogenic factors. However many a times, it is difficult to assess the contribution from different sources because of different geological terrain and complex variation in weathering, erosion, transport and anthropogenic activities operating in the river catchment. The legacy data of silt rate provides a realistic estimate for the sediment rates from the basin.

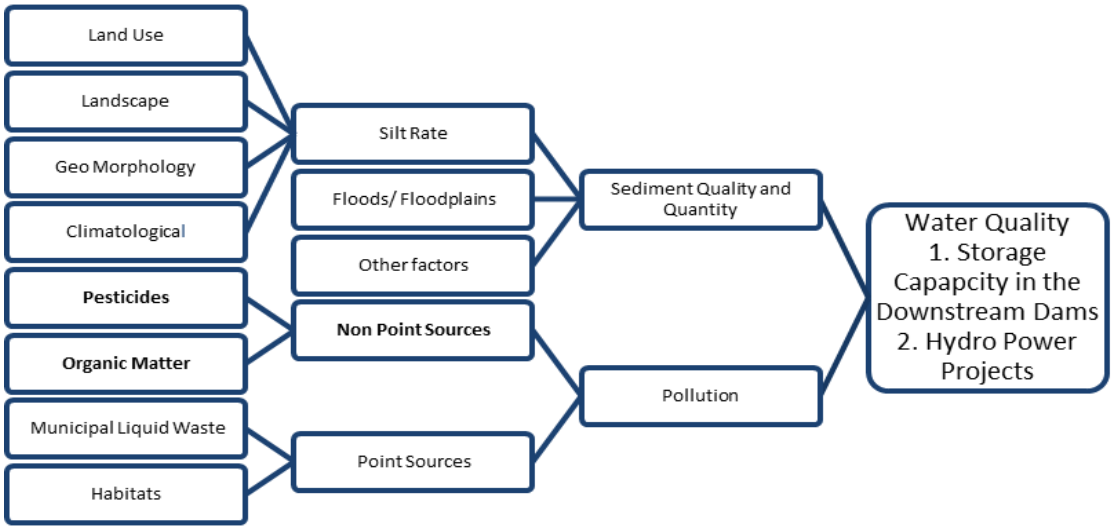


Fig. 8.5 - Main influences on water quality

As per India-WRIS database, there are 9 surface water quality observation stations installed in the Indus River Basin. These stations provide surface water quality in the basin. As per the monitoring results of 2009, the water quality is excellent; however, organic pollution is the predominant reason of pollution in these water resources. Biochemical Oxygen Demand (BOD) and Coliform bacterial Count are the major indicators of extent of water quality degradation.

Role of Forest Catchments

Forest catchments have often been described as 'Sponges' storing rain water and slowly releasing it to maintain groundwater and streams during dry periods (Hamilton and King, 1983). Despite the recognition that trees can improve soil hydraulic conductivity and reduce overland water flow (Sandstrom,1998); their contribution towards groundwater recharge and improvement of water quality is often understated. In the long term, one of the most important ways in which forest catchments can influence water quality is through their effect on absorbing rainfall variability and seasonal climate variations. It is one of the key factors that influences sediment yield from a given basin. If lands are degraded and soils are unstable, rainstorms can lead to heavy sedimentation from riversheds. Under any given condition, forest catchments have an important impact in reducing sediment yield from watersheds (Conroy *et al.*, 2001).

The Indus River Basin is one of the world's most depleted Basin (Sharma *et al.,* 2010). Sometimes, the water do even not reach in the sea, during certain intervals of the year and make it a closed basin (Molle *et al*., 2010). The increasing population, industrialization and urbanization degrade the environment, decrease the water use efficiency and poverty are the main challenges for sustainable management of water resources.

The erosion, flooding and sedimentation lead to increase the river-beds and affecting the capacity of reservoirs. The rehabilitation of flora in the watershed can significantly decrease the sediment flow to the stream. The amount of sediment can be estimated by standard extrapolation techniques from previous estimates (Trimble, 1999) (Equation 7).

Equation 6 :

Sediment load= Catchment area * Sediment factor * Trap Efficiency

Step 1: Catchment Area

The Ravi Sub-Basin covers an area of 11706 ha. Out of this, 7,995 ha area is selected for the Riverscape Management under the proposed project.

Table 8.18 - Riverscape Area and Plantation Area of the Ravi River

State/UT	**Riverscape Area (ha)**	**Intervention through afforestation (Plantation) Area (ha)**
Himachal Pradesh	5,04,100	4,388.00
Jammu and Kashmir UT	2,97,091	1,906.49
Punjab	1,16,170	1,701.35
Total	**9,17,361**	**7,995.84**

Step 2: Sediment Factor

The evaluation of sediment inflow has been always difficult because the sediment content varies considerably for a same river according to the flow and the season. In addition, it also requires complex sediment modeling based on the land use assumptions; besides requires huge time and resources for measurement. Further, the results cannot be very precise and there would be associated uncertainties. However, based on the sedimentation legacy data at the project locations, most reliable sedimentation assessments may be provided (CWC, 2019).

Table 8.19 - Average Silt Rate in Ravi River Sub-Basin

State	Major Reservoir	Observed Sediment Rate
Himachal Pradesh	Chamera-I Reservoir	2.04
Punjab		
Jammu and Kashmir UT		

Source: CWC Compendium on Silting of Reservoirs in India, 2015

Step 3: Trap Efficiency

The rate of sediment production in the catchment area and the actual rate of silting depends on many other factors viz., gradation of silt, maintenance of structures, etc. Therefore, we conservatively estimate 90% efficiency of the CAT activities.

Step 4: Sediment Reduction Due to Forestry Interventions

Table 8.20 - Sedimentation Estimation

State/UT	Sedimentation factor (000' m^3/ km^2 /Yr)	Trap Efficiency	Total CAT Intervention Area km^2	Sedimentation ('000 Cubic Mt/Yr)
Himachal Pradesh	2.04	0.9	43.88	80.56
Jammu and Kashmir UT	2.04	0.9	19.06	34.99
Punjab	2.04	0.9	17.01	31.23
Total	**2.04**	**0.9**	**79.95**	**146.78**

**Assumption: Plantation area has been considered as Intervention Area for the above calculations*

The forestry interventions will reduce **1,46,78 m^3** of sedimentation annually**.**

Summary of Component 2 activities:

Annually, the proposed activities will reduce 146.78 thousand m^3 sedimentation in the Ravi River Sub-Basin.

Table 8.21 - Potential Benefits of Plantation Activities and SMC Works on Sedimentation Reduction

Benefits of Forestry Interventions	Part 2: Water Quality	Sedimentation	1,46,788m^3 sedimentation reduction annually

Table 8.22 - Monitoring Framework

Component	Parameters	Indicators	Timeframe	Rationale
Water Quantity	Water Augmentation through Plantation Activities	Normalized Difference Vegetation Index (NDVI)	Annual	Precise monitoring of improvement in the recharge rates from the Forestry Interventions is only possible with the availability of historical hydrographs from the Piezometers, recordings from the River Gauzing Stations and Forestry Interventions implemented at the landscape level. Therefore, it is not possible to directly measure these indicators in the present context. However, for all practical purposes, NDVI and NDWI can be used as proxy indicators for monitoring the benefits of the forestry interventions
	Groundwater Recharge from SMC Measures	Normalized Difference Water Index (NDWI)	Pre & Post Monsoon	
Water Quality	Silt Rates	NDVI & NDWI		

Note

- The **Normalized Difference Vegetation Index** (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).
- The **Normalized Difference Water Index** (NDWI) is known to be strongly related to the plant **water** content. It is therefore a very good proxy for plant **water** stress. The **Normalized Difference Water Index** (NDWI) is a satellite-derived **index** from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels.

However, consolidated potential benefits in quantitative terms computed based on above stated norms are summarized in Table 8.23.

Table 8.23 - Consolidated Accured Potential Benefits from Proposed Forestry Interventions in Ravi Riverscape

Sr. No.	Potential Benefits	Quantity (20 Years)	Quantity (10 Years)
A	**Biomass, Carbon stock, CO_2 reduction and Carbon Credit**		
1	Biomass Production in Natural, Agriculture and Urban Landscape (t/ha/year) after 20 year	2.66	-
2	Total Biomass Production from 7995.84 ha area of three landscapes (Tonnes)	21268.93	17015.14
3	Contribution to Carbon Stock from 7995.84 ha area of three landscapes (Tonnes) i.e, 47% of biomass (tonnes)	9996.40	7997.12
4	Estimated Carbon Reduction from forestry interventions in three landscapes (7995.84) (metric tonnes CO_2 eq/ha/year) (Here all components i.e., bole, leaf, twigs branches, roots are accounted)	8.97	7.176
5	Estimated Carbon reduction from forestry interventions in three landscapes (7995.84 ha) (metric tonnes CO_2 eq/year)	68368.99	54695.19
6	The expected CO_2 reduction (million tonnes of CO_2 eq.)	1.37	1.096
7	Potential to generate Carbon Credit from plantation in three landscapes (million tonnes) **(CER=**Certified Emission Reductions**)**	1.37	1.096
B	**Water Quality and Quantity**		
8	Water Quantity: Conservation of water through forestry interventions (million Cubic Meter/year)	17.95	
9	Water Quality: Estimated sediment reduction through forestry interventions (‘000 m^3/year)	146.78	
C	**NTFP’s**		
10	The estimated benefit from NTFPs i.e., herbaceous medicinal plants from **2602.35** ha area of Natural Landscape in Ravi Riverscape after ten years (Rs in Lakhs)	540.58	
D	**Mandays to be generated**		
11	Generation of Employment from Plantation Activities and Other Conservation Interventions (Total man days in Phase I and Phase II)	78,50,783	

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Ravi Riverscape



Plate 9.1 - Ranjeet Sagar Dam and Reservoir on Ravi River



Plate 9.2 - Ravi River Catchment in Jammu Region (J&K UT)



Plate 9.3 - General View of Upper and lower Catchment of Ravi River



Plate 9.4 - General View of Catchment of Ravi River Basin in Chamba Region

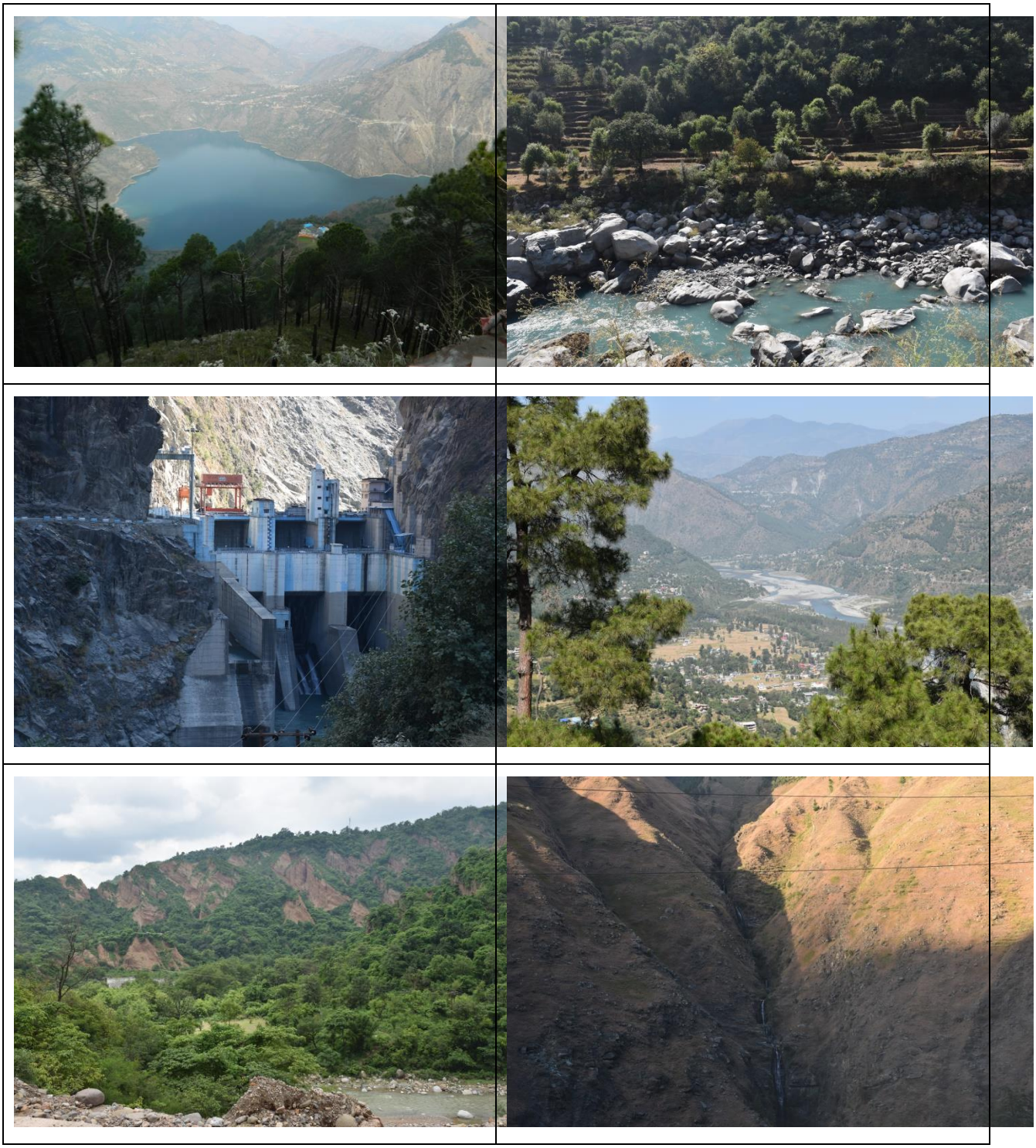


Plate 9.5 - General View of Catchment of Ravi River Basin in Chamba Region

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Annexure – 1: Logical Framework Analysis – The Ravi Riverscape Management

Project Strategy	**Objectively Verifiable Indicators**				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
Project Goal - 1	**Riverscape Management:** Aiming a holistic riverine landscape (Riverscape) approach for sustainable management of Ravi River, its banks, or its riparian areas, within its fluvial system.				
Outcome 1: Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management.	**Project Objective 1:** To promote an enabling environment for sustainable land and river ecosystem-based management approaches focusing on reduced soil erosion, enhanced forest/ vegetation cover in the buffer zone, enhanced connectivity and e-flow, and ecological rejuvenation of Ravi River and its tributaries.				
	Output1.1 Enhanced levels and enabling environment created for: (a) multi-sector convergence, alliances, and integration; (b) favourable national and state level policies (forests, agriculture, animal husbandry, watershed management, river management, tribal welfare, infrastructure development, and tourism) those reflect principles of climate resilience, sustainable land and ecosystem	The target is to create an enabling environment wherein multiple agencies/ sectors working for various production sectors converge and adopt climate resilient and sustainable approaches of land and ecosystem management by mainstreaming biodiversity concerns. Various concerned sectors also work together so as to address gaps and inadequacies in realizing global and national policy objectives relevant to environment, biodiversity,	Integration and convergence of line agencies and various production sectors initiated and notable progress made. Communities mobilized and their active engagement ensured. Biodiversity concerns mainstreamed in production sectors. Gaps and inadequacies in various policies reviewed and actions initiated to address them.	Periodic reports, proceedings of consultative process (workshops, meetings, seminars, etc). Mid-term and final independent evaluations.	Lack of enthusiasm on the part of stakeholders, inadequate sectoral integration, and lack of community participation in the implementation of existing and proposed policies and laws relating to conservation might hinder the promotion of local decision making and also their active engagement in the conservation agenda. Participation of communities particularly marginalized groups is weak due to a fear that their access to natural resources is

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
	management, and mainstreaming biodiversity concerns in production sectors.	water resources, climate change, and sustainable development.			going to be curtailed or restricted in ways that reduce the income they can derive. Conflict between conservation and local community needs might create difficulty in achievement of intended outcomes. Sectoral departments/ agencies are reluctant, not open to integrate/ cooperate for climate resilient and sustainable land and ecosystem management approaches. Project benefits are not captured by intended beneficiaries due to lack of adequate measures, transparency, and appropriate compensation measures. Inadequate and inaccurate flow of information may result in misconceptions

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
					about the project and hence lead to opposition/ non-participation by some agencies and CSOs. Sectors/ agencies primarily responsible for reduced e-flows are rigid, and continue with conventional approaches resulting into fragmentation of rivers, reduced e-flows, and decline in water quality.
	Output 1.2 Capacity of government officials and civil society organizations is developed in promoting community driven, climate resilient, sustainable land and ecosystem approaches, and holistic approach to management of river ecosystem.	Capacity of agencies, government officials and CSOs for sustainable land and ecosystem management, ecological rejuvenation and ecological integrity of river ecosystem is built.	• Training need assessment carried out. Appropriate training learning material developed. Planned awareness and specialized training programmes on priority themes for various target groups successfully organized. Number of government staff and CSO representatives trained in climate resilient ecosystem management	Periodic reports, appraisal of training schedules, learning material and feedback obtained from trainee participants. Mid-term and final independent evaluations.	The concept and need of sustainable land and ecosystem management, and climate and its likely impact are not well appreciated by CBOs/ different sectors and agencies. The implementing agencies are new to the subject and expected outputs and outcomes and also

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
			approaches.		widespread with limited financial management and technical capacity. Lack of interest and support for conservation might result in limited use of training facilities and opportunities. There are flaws in training need assessment and designing appropriate training programmes. Thus, trainings are not appealing and having desired impact.
Project Goal-2	***Aviral Dhara*, *Nirmal Dhara*, Ecological Rejuvenation and Biodiversity Conservation:** Aim to address the drivers and stressors of river ecosystem and promote sustainable use by balancing ecological needs with livelihood needs.				
Outcome 2: Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other interventions demonstrated in adequate extents of natural, agriculture, and urban landscapes of	**Project Objective 2:** To carry out appropriate forestry interventions to restore river connectivity, enhance e-flow, improve water quality, and conserve the terrestrial and aquatic biota within the Ravi Riverscape.				
	Output 2.1 Plans to reduce/ check erosion in the mountainous region and floodplains of Ravi and its tributaries by appropriate soil and moisture conservation works and	Various soil and moisture conservation strategies and works in target area of 452920.5 m^3 proposed to be implemented.	Reduced erosion in the hilly tract, reduced and stabilized landslides, decreased bank erosion, and reduced sedimentation rate. Enhanced moisture regime and flow in streams and rivers.	Appraisal of reports on soil and moisture conservation works undertaken, site visits and field observations and assessments, monitoring reports on sedimentation.	Occurrence of natural calamities (e.g. cloudburst, flood, drought, earthquake, landslides, etc). Increase in biotic pressure and enhanced developmental activities (hydropower

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
the Riverscape.	development of optimal strategy for riverbed mining. Sites of landslides are adequately treated and stabilized				and road networks) in upstream area without adequate catchment area treatment.
	Output 2.2 Plans for restored and sustainably managed forest lands, agriculture lands in targeted villages and forestry interventions in urban environment for improved forest/ vegetation cover achieved. Enhanced assisted natural regeneration through improved protection and other measures.	Forestry interventions by way of various plantations under different treatment models to be undertaken. Plantations in 4790.35.ha Natural Landscapes,- 1267ha in Agriculture Landscapes, and 344.19 ha in Urban Landscapes are established and maintained.	Reduced biotic pressure on forests and improved regeneration. Improved forest cover in forest lands and TOFs in Himachal Pradesh, Punjab and J&K UT. Reduction in fuelwood extraction pressure on surrounding forests. Increase in average fodder yields, livestock grazing pressure reduced. Perennial vegetation cover increased on degraded lands. Private/community lands mobilized for reviving forest cover, enhancement of ecosystem health and services. Rejuvenation and renovation of existing community-based watershed structures.	Field level assessments and verification. Periodic reports on plantation works carried out. Biennial assessment on forest cover by FSI for Himachal Pradesh, Punjab and J&K UT.	Non-availability of suitable nursery techniques, planting material, inadequacies in plantation works i.e., preparation of plantation site, excavation of pits, poor quality of planting material, inadequate protection and constraints of watering, damage by livestock/ wildlife, etc. Non-availability of lands (natural/ agriculture/ urban) for plantations and non-committal and inadequate support of local communities/ farmers/ urban agencies. Occurrence of natural calamities (e.g. cloudburst, flood, drought,

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
					etc.).
	Output 2.3 Plans for improved protected area management by implementing appropriate protection strategies, habitat management (e.g. weed control and water management), research and monitoring inputs, and enhanced capacity.	Strategies for improved PA management implemented, weed control works undertaken, research on priority themes planned and undertaken. Periodic ecological and socio-economic monitoring carried out. Training of frontline/ PA staff and other stakeholders planned and implemented.	Improved protected area management and enhanced management effectiveness. Increased diversity and abundance of species. Enhanced conservation values (e.g., catchment value, carbon sequestration, environmental amelioration, etc). Reduced human-wildlife conflict.	Appraisal of periodic reports and reports of mid-term and terminal evaluation. Report on Management Effectiveness Evaluation (MEE) for respective PAs. Reports on ecological and socio-economic monitoring.	Increased biotic pressure and adverse impact of developmental projects. Increased human-wildlife conflict and non-compatible land use in surrounding lands. Inadequate support of local communities and their engagement. Occurrence of natural calamities (e.g., cloudburst, flood, drought, earthquake, landslides, etc).
	Output 2.4 Plans for improved management of prominent wetlands in the Riverscape by protection, restoration, zoning, habitat management, and wise use of wetland resources.	Improved wetland management and sustainable use of wetland resources implemented.	Improved and effective management of wetlands accomplished. Wetland habitats restored, effective zone planning accomplished and sustainable wise use of wetland resources promoted.	Periodic reports, appraisal of conservation/ management plans. Site visits and field level assessments. Questionnaire survey and stakeholder consultations.	Enhanced biotic pressure, waste disposal, and more effluents, unsustainable harvests, natural calamity (flood and heavy siltation). Inadequate support of local communities.

Project Strategy	**Objectively Verifiable Indicators**				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
	Output 2.5 Plans for improved riverfronts and development of eco-parks.	Riverfronts and Eco-parks to be developed.	Improved Riverfronts, effective Eco-parks, reduced erosion.	Site visits and observations, periodic reports.	Non-compatible land use in surrounds of Riverfronts/ River, enhanced biotic pressure on eco-parks, damage of Riverfronts by excessive floods and mass congregation.
	Output 2.6 Plans for development of forest and river-based ecotourism.	Forest and river/ water resource-based ecotourism.	Healthy forests and rivers/ water resources are maintained. Reduced biotic pressure, ecologically sustainable, and socio-economically viable tourism developed.	Appraisal of periodic reports and ecotourism plans. Site visits and field assessments. Feedback from tourists.	Natural resources are depleted and degraded. Uncontrolled and unregulated mass congregation and adverse impacts.
Project Goal -3 *Outcome 3*: Enhanced ecosystem services from natural (forest, river, and wetland ecosystems), agroecosystem and urban landscapes	**Improved Ecosystem Services and Sustainable Livelihoods**: This goal aims to specifically seek enhanced ecosystem services and sustainable livelihoods.				
	Project Objective 3: To promote improved ecosystem services and support sustainable livelihood opportunities for local communities, particularly forest dwellers and fishermen.				
	Output 3.1 Plans for reduced traditional forest dependence, developed alternate income generation activities, improved livelihoods, and facilitate establishment of viable Small and Micro-	Reduced traditional forest dependence and alternate income generation options developed. Improved livelihoods and well-established	Sustainable livelihoods by way of improved/ enhanced natural resources, effective social institutions, better physical assets, enhanced incomes, improved and skilled human resource, reduced vulnerability, well established SMEs. Change in proportion of project participants who are living above the poverty line.	Household surveys, periodic reports, field level assessments, evidences on reduced conflicts, etc.	Enhanced and frequent natural calamities, external market forces and impact of globalization, neglect and over exploitation of natural resources by local communities.

Project Strategy	**Objectively Verifiable Indicators**				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
Outcome 4: Sustainable livelihoods, particularly of forest dwellers and fishermen	Enterprises (SMEs).	small and micro-enterprises.	Increase in earnings of families from involvement in sustainable management of degraded forest lands. Number of women participants in SMEs increased. Curtailment of distressed migrations. Number of SMEs operationalized.		
	Output 3.2 Plans for enhanced levels of protection, conservation, and sustainable harvests of medicinal and aromatic plants and development of herbal gardens.	Conservation and sustainable harvests practices implemented for *in situ* and *ex situ* conservation of medicinal and aromatic plants.	Diversity, abundance, and productivity of medicinal and aromatic plants in wild are enhanced. Herbal gardens developed.	Appraisal of periodic reports, site visits, and field level assessments.	Inadequate marketing strategies and mechanisms. Fluctuating market demands, supply, and market rates.
Project Goal 4	**Effective Implementation, Knowledge Management, and Innovative Approaches:** This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches (i.e., nursery techniques, afforestation, bio-filters and bioremediation), and adopt modern technology.				
Outcome 5 Capacities for adaptive management, learning, and replication of project lessons are developed.	**Project Objective 4:** To adopt, integrate and implement innovative approaches and modern technology for rejuvenation of Ravi and its tributaries, knowledge management, enhanced capacity, and monitoring and evaluation.				
	Output 4.1 Plans developed for integrated, science based, and community-based monitoring and assessment of impacts, as	Improved research and monitoring capacity targeted. Adaptive management approach being implemented.	Improved research infrastructure, well designed monitoring system, enhanced scientific capacity, and effective documentation and dissemination of research and monitoring findings. Local level	Project/ research and monitoring reports. Peer reviewed publications, databases, improved natural resource management.	Inadequate support for research and monitoring, lack of incentives, inordinate delays in research permissions, isolationist approach of research and

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	**Project Output**	**Target**	**Indicator**	**Source of Verification**	**Risks and Assumptions**
	well as periodic evaluation of the project.		monitoring mechanisms setup. Learnings on best practices and models disseminated within and outside project villages.		monitoring, inadequate management oriented research.
	Output 4.2 Plans for documentation of lessons learned and preparation of information dissemination products for wider audiences and applicability.	Innovative approaches for adaptive management of natural resources, particularly river ecosystem targeted. Successful implementation of community driven management of natural resources and river ecosystems implemented.	Successful and effective NRM and river management. Documentation of successful approaches in project design, development, and implementation. Case study on best practices developed.	Reports and periodic evaluation. Case studies and lessons learned, publications, and other documents.	Ineffective research and monitoring and adaptive management approaches. Lack of support for scaling up of Riverscape conservation approaches. State level implementing agencies and partner organizations lack capacity to coordinate and monitor project effectively and ensure timely fund flows to landscape/ plantation/ treatment sites.

Annexure-2: Field Data format

2.1 DPR Preperation of forestry interventions for Ravi River, Proforma of data collection for proposed site

Set I ④

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS

PROFORMA OF DATA COLLECTION FOR PROPOSED SITE HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS		**NATURAL LANDSCAPE**
B. MODEL NO.		*To be proposed PLANTATION*
C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	Kapei Ghar
2.	AREA (IN HECTARE)	3
D. GEOGRAPHICAL DETAILS		
1.	Name of River	Ravi
2.	State	Himachal Pradesh
3.	District	Chamba
4.	Forest Circle	Chamba
5.	Forest Division	Dalhousie
6.	Forest Range	Bakloh
7.	Forest Block	Mail
8.	Forest Beat	Kandei
9.	Development Block Name	Bhattiyat
10.	Tehsil	Dalhousie
11.	Panchayat	Samleu
E. BASELINE DATA		
1.	Current Status of Flora and Fauna	**Flora** Dalbergia sisoo, Bauhinia veriagata, Toona ciliata, Salix , Kamal , Emblica officinalis, Syzygium cumini , Mangifera indica , Amaltash , lantana sps , **Fauna** Jungli cat , Jackel , Mongoos , Indian Fox , Leopard , Porcupine , Pig , Khaliz pheasant Red Jungle Fall etc
2.	Current land use	Forest Land
3.	Legal Status of land	Forest Land
4.	Geology and Soil type	Sandy Loam
5.	Slope	Moderate to steep
6.	Aspect	Sourthern
7.	Average Annual Rainfall (in mm)	1100 mm Average

8.	Special features of the site e.g. fire prone / landslides / mining areas / avalanche etc.	Degraded with open patches full of Lantana			
9.	Distance from Road (Approximate)	0- 300 M			
10.	Distance from Main River with Name of the river (Approximate)	850 M			
11.	Distance from Main Tributary with name of tributary (Approximate)	Kapei 100 m			
12.	Suggestive species for plantation	Acacia catechu, Dalbergia sisoo, Bauhinia veriagata ,Amaltash , Albizzia lebbeck , Terminalia arjuna , Bamboo			
13.	Pit Size	45 cm^3			
14.	Details of Fencing works, if required before plantation	RCC Fencing with 4 Strand B/Wire (940 Rmt)			
15.	Details of Soil Moisture and Conservation works, if required before plantation	Check Wall			
16.	Planting Cost including nursery cost (Approximate)	Attached			
17	Maintenance Cost of plantation with years (Approximate)	Attached			
18.	Remarks, if any				
19.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 32°34'53.68"N 75°53'56.99"E Ele (m) 850	2. N : 32°34'58.60"N E: 75°54'1.32"E Ele (m)750	3. N : 32°35'1.64"N E: 75°53'56.17"E Ele (m) :750-	4. N : 32°35'3.17"N E: 75°53'51.45"E Ele (m) :749
		5. N : 32°34'56.19"N E: 75°53'51.41"E Ele (m) :808	6. N : 32°34'53.93"N E: 75°53'34.37"E Ele (m) :850		
F. ROUGH SKETCH OF TREATMENT SITE / MAP (AS AN ATTACHMENT)	Attached				
G. CURRENT PHOTOGRAPH (AS AN ATTACHMENT)	Attached				
Name and Designation **Sanjay Kumar Forest Guard**	**Contact Number** **9736824505**	**Signature of Forest Officer / Official**			

2.2 DPR for forestry intervention for Ravi River

Set - II

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS

PROFORMA OF DATA COLLECTION FOR PROPOSED SITE

HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS	✓ AGRICULTURE LANDSCAPE
B. MODEL NO.	*To be proposed*

C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	Bhariam
2.	AREA (IN HECTARE)	0.15 ha

D. GEOGRAPHICAL DETAILS						
1.	Name of River	Satluj	Chenab	✓ Ravi	Beas	Jhelum
2.	State	✓ Himachal Pradesh		Punjab		Jammu & Kashmir
3.	District	CHAMBA				
4.	Forest Circle	CHAMBA				
5.	Forest Division	CHAMBA				
6.	Forest Range	L/ Rang CHAMBA				
7.	Forest Block	CHHABARU				
8.	Forest Beat	BHALKA				
9.	Development Block Name	MEHALA				
10.	Tehsil	CHAMBA				
11.	Panchayat	KUPADA				

E. BASELINE DATA		
1.	Current Status of Flora and Fauna	
2.	Current land use	Private land
3.	Legal Status of land	Private land
4.	Geology and Soil type	Clayed loamy
5.	Slope	Gentle

6.	Aspect	North- east
7.	Average Annual Rainfall (in mm)	22.15 mm
8.	Special features of the site	
9.	Distance from Road (Approximate)	100 mtr
10.	Distance from Main River with Name of the river (Approximate)	1 Km Ravi River
11.	Distance from Main Tributary with name of tributary (Approximate)	700 mtr Kaded Khad
12.	Suggestive species for plantation	Akhroot, Apple, Lemon
13.	Pit Size	60 x 60 x 60 cm
14.	Details of Fencing works, if required before plantation	R.C.C P/post
15.	Planting Cost including nursery cost (Approximate)	7500 7 — 10200 2700
16	Maintenance Cost of plantation with years (Approximate)	10000/hq
17.	Remarks, if any	

18.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 32°32'20.9" E: 076°07'27.4" Ele (m) :	2. N : 32°32'17.0" E: 076°07'28.0" Ele (m) :	3. N : 32°32'29.20 E: 76°07'29.9" Ele (m) :	4. N : 32°32'22.84 E: 076°07'29.6" Ele (m) :
		5. N : E: Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :

F. ROUGH SKETCH OF TREATMENT SITE / MAP (AS AN ATTACHMENT)		
G. CURRENT PHOTOGRAPH (AS AN ATTACHMENT)		
Name and Designation Dharam Chand Forest Guard	Contact Number 94182-47932	Signature of Forest Officer / Official

2.3 DPR For forestry interventions for Ravi River

Set - III

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS

PROFORMA OF DATA COLLECTION FOR PROPOSED SITE

HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS	URBAN LANDSCAPE
	a. Bioremediation & Bio-filtration b. River Front Development & Ecotourism ✓ c. Eco Park Development ✓ d. Institutional / Industrial Plantation e. Any Other (Please Specify.....)

B. SITE DETAILS		
1.	NAME OF SITE	Kuddhodi Mata Temple
2.	AREA (IN HECTARE)	0.50 ha
C. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj Chenab Ravi ✓ Beas Jhelum
2.	State	Himachal Pradesh ✓ Punjab Jammu & Kashmir
3.	District	CHAMBA
4.	Forest Circle	CHAMBA
5.	Forest Division	CHAMBA
6.	Forest Range	Lower Chamba
7.	Forest Block	Chhabarn
8.	Forest Beat	Kaded
9.	Development Block Name	Mehla
10.	Tehsil	Chamba
11.	Name of Sub Urban Area /Town	
12.	Municipal Corporation /Committee/ Notified Area Committee (NAC)	
D. BASELINE DATA		
1.	Current land use	forest land
2.	Land Use Status five years ago	forest land
3.	Legal Status of land	forest land
4.	Soil Type	Clayey loam, Covered with Grass

5.	Average Annual Rainfall (in mm)	940 mm			
6.	Special features of the site	Temple			
7.	Distance from Road (Approximate)	4-6 KM			
8	Distance from Main River with Name of the river (Approximate)	5-8 KM			
9.	Distance from Main Tributary with name of tributary (Approximate)	1-2 KM			
10.	Suggestive species for plantation				
11.	Pit Size				
12.	Details of Fencing works, if required				
13.	Planting Cost including Nursery Cost (Approximate)				
14.	Maintenance Cost of plantation with years (Approximate)				
15.	Remarks, if any				
16.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 32°29'58" E: 76°06'32" Ele (m) :	2. N : 32°30'00" E: 76°06'32" Ele (m) :	3. N : 32°30'04" E: 76°06'27" Ele (m) :	4. N : 32°30'01" E: 76°06'27" Ele (m) :
		5. N : 32°30'02" E: 76°06'30" Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :
F. ROUGH SKETCH OF TREATMENT SITE (AS AN ATTACHMENT)					
G. CURRENT PHOTOGRAPH (GEOREFRENCED FROM ONE CORNER AS PER POINT No. 16. (AS AN ATTACHMENT)					

G. SITE SPECIFIC ACTIVITIES

S. NO.	YEAR	NAME OF ACTIVITIES	UNIT (AREA/ NO.)	FINANCIAL OUTLAY (IN RS.)
1.	2021-22	Construction of Temple & Eco Park for Tourism	0.50 ha	10,00,000/-
		GRAND TOTAL		10,00,000/-

Name and Designation	Contact Number	Signature of Forest Officer / Official
Rohit Kumar Forest Guard	85804-57853	

2.4 DPR for forestry interventions for Ravi River

Sr. - IV

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS

PROFORMA OF DATA COLLECTION FOR PROPOSED SITE HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. OTHER INTERVENTIONS		**SOIL & WATER CONSERVATION**
B. MODEL NO.		
C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	**Katori** (Including Nallas of Katori DPF , Chalela No 1 DPF , Chalela No 2 DPF , Chhamber DPF ,)
2.	AREA (IN HECTARE)	
D. GEOGRAPHICAL DETAILS		
1.	Name of River	Ravi
2.	State	Himachal Pradesh
3.	District	Chamba
4.	Forest Circle	Chamba
5.	Forest Division	Dalhousie
6.	Forest Range	Bakloh
7.	Forest Block	Nainikhad
8.	Forest Beat	Katori
9.	Development Block Name	Bhattiyat
10.	Tehsil	Bhattiyat
11.	Panchayat	Tunuhatti
E. BASELINE DATA		
1.	Current Status of Flora and Fauna	Pinus roxburgii, Acacia catechu, Dalbergia sisoo, Bauhinia veriagata,Toona ciliata, Bamboos,Salix , Emblica officinalis, Syzygium cumini , Mangifera indica , Amaltash , Albizzia lebbeck , Oie , lantana sps , Pyrus pashia & Jungli cat , Jackel , Mongoos , Indian Fox , Leopard , Porcupine , Pig , Monal , Khaliz pheasant etc.
1.	Current land use	Forest Land
2.	Legal Status of land	Forest Land
3.	Geology and Soil type	Sandy Loam
4.	Slope	Moderate to steep

5.	Aspect	Nothern			
6.	Average Annual Rainfall (in mm)	1250 mm Average			
7.	Special features of the site e.g. fire prone / landslides / mining areas / avalanche etc.	Sliding Area			
8.	Distance from Road (Approximate)	1 KM			
9.	Distance from Main River with Name of the river (Approximate)	3 KM (Ravi River)			
10.	Distance from Main Tributary with name of tributary (Approximate)	Katori , Chhamber , Duala Danga , Dher etc			
11.	Remarks, if any				
12.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N 32°27'37.27"N 75°53'59.64"E Ele (m) 790	2. N : 32°27'43.12"N E: 75°53'52.31"E Ele (m) 720	3. N :32°27'44.53"N E: 75°54'9.07"E Ele (m) :835	4. N :32°27'48.20"N E: 75°54'5.17"E Ele (m) :796
		5. N 32°27'45.41"N 75°53'50.24"E Ele (m) 706	6. N : 32°27'49.81"N E: 75°54'7.04"E Ele (m) :810	7. N :32°27'48.87"N E: 75°53'57.92"E Ele (m) 745	8. N :32°27'54.91"N E: 75°53'57.49"E Ele (m) :785
		9. N :32°27'50.11"N E: 75°53'55.48"E Ele (m)735	10. N : 32°27'56.18"N E: 75°53'54.14"E Ele (m) :770	11. N :32°28'4.43"N E: 75°54'17.48"E Ele (m) 860	12 N :32°28'2.07"N E: 75°54'2.85"E Ele (m) :750
		13. N :32°28'6.75"N E 75°54'18.06"E Ele (m) 880	14. N : 32°28'7.37"N E: 75°54'4.35"E Ele (m) :760	15. N :32°28'15.99"N E: 75°54'17.19"E Ele (m) 905	16. N : 32°28'15.80"N E: 75°54'16.96"E Ele (m) :902
		17. N :32°28'16.00"N E: 75°53'44.71"E Ele (m) 765	18. N : 32°28'3.72"N E: 75°53'24.95"E Ele : 660	19. N 32°28'17.67"N E: 75°53'30.50"E Ele (m)760	20. N 32°28'4.59"N E:75°53'21.72"E Ele (m) :660
		21. N : 32°28'22.39"N E: 75°53'19.88"E Ele (m)730	22. N : 32°28'15.27"N E: 75°53'7.53"E Ele : 640	23. N : 32°28'28.22"N E: 75°53'12.21"E Ele (m)695	24. N : 32°28'34.31"N E: 75°52'57.39"E Ele (m)610
		25. N : 32°28'42.57"N E: 75°52'58.72"E Ele (m) 665	26. N 32°28'37.58"N E: 75°52'54.01"E Ele : 605	27. N : 32°28'51.42"N E: 75°52'47.66"E Ele (m)630	28. N : 32°28'46.69"N E: 75°52'39.92"E Ele (m) 590
F. ROUGH SKETCH OF TREATMENT SITE / MAP (AS AN ATTACHMENT)		Attached			
G. CURRENT PHOTOGRAPH (AS AN ATTACHMENT)		Attached			

N=North; E=East; Ele=Elevation; m=meter

Annexure – 3: Description of Soil Types within the Ravi Riverscape

Sr.No.	Soil type	Description
1	**Dystric Eutrochrepts**	Deep, well drained, thermic, fine-loamy soils on very steep slopes with loamy surface and severe erosion
2	**Dystric Fluventic Eutrochrepts**	Deep, well drained, thermic, fine-loamy soils on very steep slopes with loamy surface and severe erosion. Soil formed in alluvium in floodplains along streams and rivers. Soil is used for corn, soyabean, tobacco etc.
3	**Fluventic Eutrochrepts**	This soil formed in calcareous alluvium in floodplains along streams and rivers. The content of organic carbon decreases irregulary with depth or it is relatively high at depth. Soil is used for cotton and soyabean.
4	**Lithic Cryorthents**	Poorely developed soils, semi-permanent snow, bank is simply a thin sandy A-horizon over a C-horizon
5	**Lithic Udorthents**	TRhese soils have a lithic contact within 50 cm of the surface. Thay are otherwise like typic Udorthents except that possibly some of them have very high biological activity above the Lithic contact.
6	**Typic Cryorthents**	Soils of glacio-gluvial valley with moderate slopes occupied with moderately shallow, excessively drained, sandy-skeletal, neutral to slightly acidic, moderately eroded, and strongly stony.
7	**Typic Eutrochrepts**	Deep, well drained, thermic, fine-loamy, calcareous soils on moderately steep slopes with loamy surface and severe erosion
8	**Typic Udifluvents**	Have moderately good or good drainage, occur in relatively high areas on flood plains, and the water table is deeper than 50 cm all of the time
9	**Typic Udorthents**	Found on moderate to steep slopes, are slightly to moderately acidic, moderately eroded, and moderate to strong stony
10	**Typic Ustifluvents**	Very deep imperfectly drained fine soils occurring on flat to nearly level active alluvial plain.
11	**Typic Ustipsamments**	Sand that have deep ground water and a thick regolith
12	**Typic Ustochrepts**	Coarse-loamy soils derived from mixed alluviam or residium weathered from sand stone and shale
13	**Typic Ustorthents**	Soils those are deep or moderately deep to hard rock and those do not have ground water within 150 cm

14	**Udic Ustochrepts**	Coarse-loamy soils derived from mixed alluvium or residium weathered from sand stone and shale
15	**Non Soil**	Areas that do not support plant growth are not considered but mapped. These may be glaciers, bedrock outcrops, urban land, active quarries, etc.

Annexure-4: List of Suggested Plant Species with Uses for Planting in Natural, Agricultural and Urban Lanscapes

Sl No	Botanical Name	Common Name	Habit	Special Attributes
1	*Senegalia catechu* (L.f.) Willd.	Khair	Tree	Used for diarrhea, reduce the swelling of throat and nose. It has timber, fodder and medicinal values.
2	*Acacia nilotica* (L.) Delile	Babul, Kikar	Tree	Used for the treatment of human immunodeficiency virus, hepatitis C virus and cancer and also use in timber, fodder and fuel.
3	*Acer acuminatum* Wall.	Tapering leaf mapple	Tree	Used as timber and its leaves are used for making tea and fodder.
4	*Acer caesium* Wall. ex Brandis	Kainju	Tree	Bark is used externally to treat muscular swellings, boils and pimples. Burrs sometimes, made into cups and used as Timber.
5	*Acer cappadocicum* Gled.	Maple	Tree	Used for fuel and woodcarvings. Plant has been suggested as of value in soil stabilization in dry valleys in Turkey, and fodder.
6	*Acer pictum* Thunb.	Yellow paint maple	Tree	Locally used as ornamental plant, food, medicine and source of wood. The leaves are an irritant and the bark is astringent.
7	*Achillea millefolium* L.	Common yarrow, Puthkanda	Herb	Aerial parts of the plant are used to encourage bile flow, and as a diuretic. Alkaloids extract from the leaves have anti-inflammatory and analgesic activity.
8	*Aconitum heterophyllum* Wall. ex Royle	Atish, Patees	Herb	Used as analgesic, anti-inflammantory, anti-pyretic, aphrodisiac and astringent.
9	*Aconitum violaceum* Jacq. ex Stapf.	Dudhia-bis, Mitha Telia, Tilla	Herb	Used in the treatment of snake and scorpion bites, contagious infections and inflammation of the intestines. It also exhibits antidote, anti-inflammatory and febrifuge properties.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
10	*Aegle marmelos* (L.) Correa	Bel, Bael	Tree	Bael fruits are used in the treatment of dysentery, peptic ulcers and as a laxative and chronic diarrhea to recuperate from respiratory affections in various folk medicines.
11	*Aesculus indica* (W9all.ex Cam10bess.) Hook.11	Pangar,Bankhor, Kandur	Tree	Used to cure skin diseases, rheumatism, as an astringent, acrid and narcotic, and in the relief of headaches. Also used as Timber.
12	*Agropyron* spp.	Wheat grass	Grass	Used as forage and in erosion control.
13	*Agrostis gigantea* Roth.	Black bent grass	Grass	Used as a fodder and forage species. Also used as a lawn/turf grass for revegetation purposes and for erosion control.
14	*Agrostis munroana* Aithc. & Hemsl.	Velvet bent grass	Grass	Used as fodder and soil erosion control.
15	*Agrostis pilosula* Trin.	Grass	Grass	Used as fodder and soil erosion control.
16	*Ailanthus excelsa* Roxb.	Indian tree of Heaven, Mahanimb, Maharukh	Tree	Plant used in medicine as the gum and the bitter, aromatic leaves are reported to have medicinal properties. The bark is a febrifuge and can be used as a treatment against asthma, bronchitis and dysentery. The leaves and bark are also in good repute as a tonic that is used after labor.
17	*Ainsliaea aptera* DC.	Karubuti	Herb	Used in the treatment of stomachache, constipation and acute fever.
18	*Ajuga* spp.	Neel Kanthi	Herb	Used to cure fluid retention, coughs, pain and swelling (inflammation).
19	*Albizia chinensis* (Osbeck) Merr.	Silk tree, Kala siris	Tree	It is helpful for slope stabilization and soil improvement. Its wood has low density and used as timber.
20	*Albizia procera* (Roxb.) Benth.	Siris, Siras	Tree	The cooked leaves are eaten as a vegetable. Decoction of the bark is given for the treatment of rheumatism and haemorrhage. It is also considered useful in treating problems of pregnancy and for stomachache. The leaves are poulticed onto ulcers.
21	*Albizia* spp.	Vaakaveru, Siris , Shirish, Sirisa	Tree	Used as medicinal, fodder and timber.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
22	*Allium humile* Kunth	Kunth	Herb	Used for the treatment of stomach diseases, asthma, jaundice, cold and cough.
23	*Alnus nitida* (Spach) Endl.	Piak, Kosh	Tree	A decoction of the bark is applied externally to treat swellings and body pains.
24	*Alopecurus aequalis* Sobol.	Grass, Orange foxtail	Grass	Used in the treatment of oedema, chickenpox and snakebites. The whole plant is antiphlogistic, depurative and diuretic. The seed is small and fiddly, it is very much a famine food.
25	*Alopecurus nepalensis* Trin. ex Steud.	Nepal foxtail grass	Grass	Used as food, fodder and for soil conservation.
26	*Alpinia* spp.	Shell-flower	Herb	Used to cure fever, muscle spasms, intestinal gas, bacterial infections and inflammation.
27	*Alstonia scholaris* (L.) R.Br.	Scholar's tree, Sapatparnachal, Satveen	Tree	Plant has antibacterial, antidiabetic, anticancer, antianxiety, hepatoprotective, anti-inflammatory and analgesic effects.
28	*Angelica glauca* Edgew.	Chaura, Choru, Corakah	Herb	Used in the treatment of constipation, dyspepsia, infantile atrophy, dysentery, menorrhagia, and rinderpest.
29	*Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Guillem. & Perr.	Dhawada, Dhaura, Dhava	Tree	Used to cure skin diseases, snake and scorpion bites, stomach diseases, leprosy, diabetes, colic, cough and diarrhea.
30	*Anogeissus* spp.	Dhau	Tree	Used as fodder, fuel, timber and also exhibit some medicinal properties.
31	*Anthocephalus cadamba* (Roxb.) Miq.	Kadamba, Kadam	Tree	Used for uterine complaints, fever, skin diseases, inflammation, dysentery, anemia and leprosy.
32	*Apluda mutica* L.	Tachula grass	Grass	Used as fodder and for soil conservation.
33	*Araucaria araucana* (Molina) K.Koch	Monkey puzzle tree, Chilean pine	Tree	It is an ornamental tree with valuable timber and seeds are edible.
34	*Arnebia benthamii* (Wall. ex G. Don) I.M. Johnst.	Baalchar	Herb	*Arnebia benthamii* has anti-inflammatory, antifungal and wound-healing properties.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
35	*Arundinella nepalensis* Trin.	River grass	Grass	Used as fodder and for soil conservation.
36	*Arundinella pumila* (Hochst.) Steud.	Dwarf reedgrass	Grass	Used as fodder and for soil conservation.
37	*Arundo donax* L.	Giant reed grass	Grass	Used as fodder and for soil conservation.
38	*Azadirachta indica* A.Juss.	Neem	Tree	Neem leaf is used for the treatment of eye disorders, leprosy, loss of appetite, skin ulcers, bloody nose, intestinal worms, stomach upset, diseases of the heart and blood vessels (cardiovascular disease), fever, diabetes, gum disease (gingivitis) and liver problems.
39	*Bambusa bambos* (L.) Voss	Bambos	Bamboo	Used for making ladders and bridges. Leaves are used as fodder.
40	*Bambusa* spp.	Bamboo	Bamboo	The stems are used as fodder and for construction and fencing. And also used for tool handles, weapons, furniture, handicrafts, stakes, pots, irrigation pipes and bows for fishing nets.
41	*Bauhinia variegata* L.	Kachnar	Tree	Alleviates Kapha and Pitta. Alleviates glandular swellings skin disorders, alternative, etc. Antihelminthic, Amoebic dysentery, Anti-tumour, Anti-microbial, Anti-inflammatory, Anti-goitrogenic, Hepatoprotective.
42	*Berberis lycium* Royle	Kashmal	Shrub	Used for the treatment of diabetes, jaundice, eye infections, fractured bones, internal wounds, rheumatism, stomachache and diarrhea.
43	*Berberis* spp.	Daruhaldi, Rasnajan, Kilmora	Shrub	Used to cure cough, fever, depression, liver disease, hyperlipidemia, hyperglycemia and bleeding.
44	*Bergenia ciliata* (Haw.) Sternb.	Pathar chata, Pashanbedh	Herb	Used for the treatment of kidney stones.
45	*Bergenia stracheyi* (Hook.f. & Thom.) Engl.	Pashanbeha	Herb	Mostly used for the removal of kidney and urinary tract stones due to its antilithic property.
46	*Betula alnoides* Buch.-Ham. ex D.Don	Kath bhuj	Tree	It is considered to be an antidote against snakebites and is used to treat dislocated bones.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
47	*Betula utilis* D.Don	Bhoj patra	Tree	It is considered to be highly astringent agent. By virtue of such quality its external use is recommended as styptic (to stop bleeding) and to stop any purulent discharge. Hence it is used more often to clean the wounds.
48	*Boerhavia diffusa* L.	Punarnava,Punarnava rakta, Rakta punarnava	Herb	Used for its anti-diabetic and diuretic properties, pain relief, anti-inflammation, and treating indigestion.
49	*Bombax ceiba* L.	Simbal	Tree	Used in the treatment of dysentery, haemoptysis in pulmonary tuberculosis, influenza and menorrhagia.
50	*Bothriochloa intermedia* (R.Br.) A.Camus	Bluestem grass	Grass	It is widely used as a fodder and a graze for livestock.
51	*Bothriochloa parviflora* (R.Br.) Ohwi	Grass, Blue grass	Grass	Used as fodder and for soil conservation.
52	*Bothriochloa pertusa* (L.) A. Camus	Couch grass	Grass	Used as fodder and for soil conservation.
53	*Bougainvillea* spp.	Boonganbel	Tree	It has anticancer, antidiabetic, antihepatotoxic, anti-inflammatory, antihyperlipidemic, antimicrobial, antioxidant, and antiulcer properties.
54	*Brachypodium sylvaticum* (Huds.) P.Beauv.	False brome	Grass	Used as fodder. It creates the perfect habitat for rodents that damage tree seedlings and in oak woodlands false brome can suppress the germination of oak seedlings.
55	*Bromus himalaicus* Stapf.	Brome grass	Grass	Used as fodder and for soil conservation.
56	*Bromus ramosus* Huds.	Grass	Grass	Used as fodder and for soil conservation.
57	*Butea monosperma* (Lam.) Taub.	Flame of forest, Palash	Tree	The use of its gum as external astringent application is mentioned by 'Chakradatta'. The leaves are good have astringent, depurate, diuretic and aphrodisiac in pharmacological properties.
58	*Calamagrostis montanensis* (Suribn.) Suribn ex Vosey	Grass	Grass	Used as fodder and for soil conservation.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
59	*Calamagrostis* spp.	Garhwal reedgrass	Grass	It has soil stabilizing properties and also used as fodder.
60	*Callistemon citrinus* (Curtis) Skeels	Bottle brush	Tree	Used for the treatment of diarrhoea, dysentery and rheumatism and also as ornamental tree.
61	*Capparis decidua* (Forssk.) Edgew.	Caper berry, Kair	Shrub	Used to cure arthritis, toothache, asthma, cough, inflammation, intermittent fevers, malaria, rheumatism, and swelling.
62	*Carissa opaca* Stapf. ex Haines	Karabda , Karonda	Shrub	Used as remedy for hepatitis, jaundice, fever and asthma.
63	*Carpinus viminea* Wall. ex Lindl.	Himalayan hornbeam	Tree	Used as fodder, fuel and timber.
64	*Cassia fistula* L.	Amaltas, Golden shower tree	Tree	Used as edible, widely used as a laxative and for fodder.
65	*Causarina* sp.	Kasurina	Tree	Used as fuel wood and timber
66	*Cedrus deodara* (Roxb. ex D.Don) G.Don	Deodar, Diar, Devda	Tree	Used as timber, fuel, religious and making of cedar oil etc.
67	*Celtis australis* L.	Khirk	Tree	Used in the treatment of dysentery, diarrhea and peptic ulcers and aslo as fodder and fuel.
68	*Chrysopogon fulvus* (Spreng.) Chiov.	Dholu, Goria, Reddish-yellow beardgrass	Grass	Used as fodder, used for grazing, as a lawn grass, and to control soil erosion.
69	*Chrysopogon gryllus* (L.) Trin.	Scented grass	Grass	Used as fodder and covering house roof.
70	*Chrysopogon serrulatus* Trin.	Grass	Grass	Used as fodder, widely used as cooling agent, tonic and blood purifier.
71	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	Indian bay leaf, Tej patta	Tree	Used for the treatment of asthma, diabetes, bad breath, excessive crying in infants (colic), common cold, complications after childbirth, cough and diarrhea.
72	*Citrus limon* (L) Osbeck	Nimbu	Shrub	Used as edible fruit, in treatement of high blood pressure and common cold and rich source of Vitamin C,

Sl No	Botanical Name	Common Name	Habit	Special Attributes
73	*Cordia myxa* L.	Indian cheery	Tree	Used in folk medicine to cure cough and chest complaints, as well as for the treatment of wounds and ulcers.
74	*Cornus capitata* Wall.	Himalayan strawberry	Tree	Used as an astringent.
75	*Cornus macrophylla* Wall.	Karchan	Tree	Fruits are edible, used as fuel and fodder.
76	*Cornus oblonga* Wall.	Oblong-Petal Dogwood	Shrub	Used in folk remedies to cure arthritis and injuries.
78	*Corylus jacquemontii* Decne	Findak, Kabasi, Bhotia badam	Tree	Used as edible, fodder and fuel.
79	*Cotoneaster bacillaris* Wall. ex Lindl.	Riyuns, Rockspray cotoneaster, Khareto	Shrub	Used as medicine, walking stick, edible, fuel and fodder.
80	*Cryptomeria japonica* (Thunb. ex L.f.) D.Don	Japanese cedar, Red cedar	Tree	It exhibit medicinal properties and timber is used for the making of staves, tubs, casks, furniture and other indoor applications and aslo an ornamental plant.
81	*Cupressus torulosa* D.Don	Himalayan cypress, Surai	Tree	Used as timber and essential oils, building and furniture making.
82	*Cymbopogon citratus (DC). Stapt*	Lemon grass	Grass	Used in pharmaceutical industries for essential oil and also used for soil conservation
83	*Cymbopogon distans* (Nees ex Steud.) W. Watson	Lemon grass	Grass	Used as essential oil and medicinal, perfumery, cosmetics, and in the pharmaceutical industries.
84	*Cymbopogon martinii* (Roxb.) W.Watson	Ginger grass, Rohisa	Grass	It exhibits exceptionally good antimicrobial, antifungal, antiviral, antihelminthic, antioxidant and cytotoxic properties.
85	*Cyperus rotundus* L.	Nut sedge, Coco grass	Herb	Used for the treatment of diabetes, pyresis, diarrhea, inflammation, malaria and stomach and bowel disorders.
86	*Dactylis glomerata* L.	Cat grass	Grass	Used as fodder and soil conservation.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
87	*Dactylorhiza hatagirea* (D.Don) Soo	Salampanja, Hathpanja	Herb	Used for the treatment of pyorrhea (inflammation of the gum and teeth). Root paste applied on cuts and wounds, religious and aphrodisiac.
88	*Dalbergia sissoo* DC.	Sheesham	Tree	Used as timber and also for the treatment of skin ailments and gonorrhea. Ayurvedics prescribe the leafy juice for eye ailments, the woody bark paste as anthelmintic, antipyretic and analgesic. The wood is also used in India for boils, leprosy and nausea.
89	*Danthonia cumminsii* Hook.f.	Heathgrass, Wallaby grass, Oat grass	Grass	Used as fodder and for soil conservation.
90	*Danthonia* spp.	Oatgrass, Heathgrass	Grass	Used as fodder and for soil conservation.
91	*Daphne papyracea* Wall. ex G.Don	Satpura, Dhak chamboi	Shrub	The plant is bitter, febrifuge and purgative. Also used for paper preparation
92	*Daphne* spp.	Satpura	Shrub	The plant is febrifuge and purgative. Also used for paper preparation.
93	*Debregeasia hypoleuca* (Hochst. ex A.Rich.) Wedd.	Shiaru	Shrub	Used for soil conservation and the fibre is used for making ropes.
94	*Delphinium cashmerianum* Royle	Kashmir larkspur	Herb	Useful in curing aconite poisoning, fungal infection and toothache.
95	*Dendrocalamus* spp.	Baans	Grass	Young shoots used as fodder, stem are used as furniture and for construction purposes.
96	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro	Kako bamboo, Tama bamboo	Grass	Edible young shoots, fodder and commercial used for construction purposes.
97	*Dendrocalamus strictus* (Roxb.) Nees	Calcutta bamboo, Hard bamboo	Grass	Used as timber and for construction purposes.
98	*Deschampsia* spp.	Ghas	Grass	Used as fodder and for soil conservation.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
99	*Desmodium* spp.	-	Shrub	The plant has aphrodisiac, analgesic, diuretic and haemorrhagic properties.
100	*Desmodium elegans* DC.	Chamlai, Elegant desmodium	Shrub	The roots are carminative, diuretic and tonic. The juice of the root, sometimes combined with the bark juice of *Bauhinia malabarica*, is used in the treatment of cholera.
101	*Desmodium gangeticum* (L.) DC.	Shalparni, Salparni, Dhruva	Herb	The plant has febrifuge, aphrodisiac, analgesic, diuretic, inate a ammatory and haemorrhagic properties. It is used to cure postnatal complaints, inate a, chronic fever, biliousness, cough, vomiting, and asthma. It is an important ingredient of dasmoolarishta and chyavanprash.
102	*Deutzia corymbosa* (Airy Shawl) Zaik.	Beans Tree	Shrub	The plant is known to clear toxins and activate blood circulation.
103	*Deutzia* spp.	Ghugtai,	Shrub	Used as an ornamental plant.
104	*Deutzia staminea* R.Br. ex Wall.	Ghugtai, Dalochi	Shrub	The plant is known to clear heat and toxins and activate blood circulation.
105	*Dichanthium annulatum* (Forssk). Stapf.	Marvel grass, sheda grass	Grass	Used as fodder and for soil conservation.
106	*Diospyros edulis* Lodd.	Black sapote	Tree	Fruits are astringent, caustic and bitter.
107	*Diospyros kaki* L.f.	Japani fal	Tree	Fruits are edible.
108	*Diospyros lotus* L.	Date plum	Tree	Fruits are edible and rich in sugar, malic acid and vitamins
109	*Diospyros montana* B.Heyne ex A.DC.	Bistendu, Kala dhao	Tree	The fruit juice is applied to wounds and ulcers and is drunk in cases of dysentery and fever; it possesses antibacterial and antihelminthic activities. Also used as fodder and fuel.
110	*Diospyros* spp.	Bistendu, Kala dhao	Tree	It exhibits medicinal properties. And also used as timber.
111	*Drepanostachyum falcatum* (Nees) Keng f.	Cane	Grass	The canes are used for making hats, baskets, rods, etc.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
112	*Eichhornia* spp.	Water hyacinth	Herb	Used as biomass for biogas production.
113	*Elaeagnus conferta* Roxb.	Wild olive	Shrub	Used as antioxidant, antimicrobial, analgesic and anti-inflammatory.
114	*Eragrostis nigra* Nees ex Steud.	Grass	Grass	Used as fodder and soil conservation.
115	*Erianthus filifolius* ex Steud.	Grass	Grass	Used as fodder and soil conservation.
116	*Erianthus rufipilus* Griseb.	-	Grass	Used as fodder and soil conservation.
117	*Erianthus spp.*	Grass	Grass	Used as fodder and soil conservation
118	*Eriobotrya japonica* Thunb.	Loquat	Shrub	Leaves are analgesic, antibacterial, antiviral, astringent and diuretic. Young shoots are used as intestinal astringent and mouth wash.
119	*Eucalyptus comaldulensis* Dehnh.	River red gum	Tree	Used as timber
120	*Eucalyptus* spp.	Safeda	Tree	Used as timber.
121	*Eucalyptus tereticornis* Sm.	Red irongum	Tree	Used as timber and for railway sleepers. Leaves are good source of eucalyptus oils.
122	*Eulaliopsis binata* (Retz.) C.E.Hubb.	Bal vaja, Sabai grass, Babni	Grass	Used as soil binder and making brooms.
123	*Euonymus* spp.	Dadul, Dharua	Shrub	Wood is traditionally used for the making of spindles for spinning wool. Also used as ornamental plant.
124	*Festuca arundinacea* Schreb.	Tall fescue	Grass	It is used as an ornamental grass and used for polluted soil remediation.
125	*Festuca pratensis* Huds.	Blue grass	Grass	It is used as an ornamental grass and used for polluted soil remediation.
126	*Festuca valesiaca* Schleich.ex Gaudin	Blue grass	Grass	Used as fodder and soil binder.
127	*Ficus benghalensis* L.	Bargad, vata, Vatathwak, Aal	Tree	Astringent to bowels; useful in the treatment of biliousness, ulcers, erysipelas, vomiting, vaginal complaints, fever, inflammations, leprosy etc.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
128	*Ficus racemosa* L.	Gular, Umbar chal, Lakh papal	Tree	Used for the treatment of various diseases/disorders including diabetes, liver disorders, diarrhea, inflammatory conditions, hemorrhoids, respiratory and urinary diseases.
129	*Ficus rumphii* Blume	Kabaipipal, Bettaarli	Tree	It is useful in burning sensations, leucoderma, ulcers, leprosy, itching, biliousness and diseases of blood.
130	*Ficus* spp.	Bargad, Gular, Kabipipal, dhudah	Tree	Used as timber, edible and shows medicinal properties.
131	*Flacourtia indica* (Burm.f.) Merr.	Ramontchi, Batoko plum, Pilkhan, Kapitanah	Tree	The leaves and roots are used in herbal medicine for the treatment of snakebite. The bark is believed to be effective for arthritis. Most parts of the plant are used for cough, pneumonia, and bacterial throat infection.
132	*Fritillaria roylei* Hook.	Jagli Lahusan	Herb	Medicinal plant, used in the treatment of asthma and tuberculosis.
133	*Geranium wallichianum* D.Don ex Sw.	Laljari, Rantanjot	Herb	Decoction of the root mixed with the bark of *Prunus cerasoides*, is used in the treatment of peptic ulcers. It has been used as a cure for toothache and has been applied externally to the eyes.
134	*Gmelina arborea* Roxb.	Gambhari	Tree	Used as timber and fuel wood. The wood is also used for packing, matches and plywood.
135	*Grevillea robusta* A.Cunn. ex R.Br.	Silver oak, Silk oak	Tree	Timber has been used in the manufacture of furniture, cabinetry, and fences.
136	*Grewia elastic* Royle.	Dhaman	Tree	Used as timber, fuel, fodder and fibre.
137	*Grewia optiva* J.R. Drumm. ex Burret	Beul	Tree	Used as timber, fodder, fuel and fibre.
138	*Haldina cordifolia* (Roxb.) Ridsdale	Haldu , Kadami	Tree	Used to cure chronic cough and jaundice, stomachache and swelling in stomach, constipation and also useful in diarrhea and dysentery.
139	*Hedychium spicatum* Sm.	Ban haldi	Herb	It is a rhizomatous herb, used in medicines, food, cosmetics and perfumery industries.
140	*Heracleum candicans* Wall. ex DC.	Krandel, Chitra	Herb	It exhibit medicinal properties and used for the treatment of leucoderma.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
141	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.	Black speargrass, Tanglehead	Grass	Used as fodder and soil stabilizers.
142	*Hierochloe laxa* Hook.f.	Sweet grass	Grass	Used as fodder and soil conservation.
143	*Holarrhena antidysenterica* Wall.	Coral swirl	Shrub	Used to cure amoebic dysentery and chronic diarrhea.
144	*Holoptelea integrifolia* Planch.	Aavitholi, Aval , Cirabilva, Kanju, Indian elm	Tree	Cures inflammation, gastritis, dyspepsia, leprosy, colic, intestinal worms, vomiting, wound healing, diabetes, hemorrhoids, dysmenorrhea and rheumatism.
145	*Hyoscyamus niger* L.	Khursani ajwain, Parasikayav ani	Herb	Cures ailments of the bones, rheumatism, nervous diseases, asthma, cough and stomach pain.
146	*Hypericum oblongifolium* Choisy	Chava, Chaya, Chitroi	Shrub	Cures antinociceptive, antidepressant, antiviral, antipyretic, antimicrobial, anti-inflammatory and healing properties.
147	*Indigofera heterantha* Brandis	Kathi, Sakina	Shrub	It is used as strong herbicides and insecticide; also as fuel and fooder.
148	*Jacaranda mimosifolia* D.Don	Blue Jacaranda, Neeli gulmohur	Tree	It is used to cure neuralgia and infection, also as ornamental.
149	*Juglans regia* L.	Walnut, Akhrot	Tree	The leaves are alterative, antihelminthic, anti-inflammatory, astringent and depurative. It cures chronic coughs, constipation, asthma, diarrhoea, dyspepsia, etc.
150	*Justicia adhatoda* L.	Adusa, Basuti, Vasa	Shrub	It is used to cure cough, colds, asthma, bronchial catarrhea, liquefy sputum, bronchodilator, bronchitis and tuberculosis.
151	*Kigelia pinnata* (Jacq.) DC.	Sausage tree, Balam khira	Tree	Plant is antileprotic, anticancerous, antimalarial, antibacterial, analgesic and anti-inflammatory, antidiarrhoeal, antiurolithiasis, antioxidant, antidiabetic, etc.
152	*Koeleria* spp.	Grass	Grass	Fodder, astringent and apllied externally to the skin in the form of poultice to heal the wounds.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
153	*Lemna* spp.	Common duckweed	Herb	Used in the treatment of colds, oedema, measles and difficulty in urination.
154	*Litsea chinensis* Lam.		Tree	Used as oil and fuel.
155	*Lonicera quinquelocularis* Hard.	Taknoi	Shrub	Used as fuel, fodder, walking stick and fruits edible.
156	*Lyonia ovalifolia* (Wall.) Drude	Ayar	Tree	The young leaves and buds are toxic, but they are used externally as an infusion to treat skin diseases and external parasites, and asloas piscicidal pland.
157	*Maesa indica* (Roxb.) A.DC.	Wild berry, Sesu, Machpora	Shrub	It has significant nutritional, radical scavenging, antioxidant and anti-diabetic properties; edible and fodder.
158	*Mallotus philippinensis* Muell.Arg	Kameela, Kampilla	Tree	Used as fodder, fuel, dye, and shows some medicinal properties.
159	*Melia composita* Benth.	Malabar neem	Tree	Used as timber and its various parts have antimalarial, antihelminthic, cathartic, emetic, and emmenagogic properties, and are also used to treat skin diseases.
160	*Moringa oleifera* Lam.	Drumstick tree, Senjana	Tree	Moringa is used for the treatment of diabetes, asthma, obesity, symptoms of menopause and many other conditions.
161	*Morus alba* L.	White mulberry, Shahtoot	Tree	Fruits are edible and also used as fodder, fuel wood, timber and fiber.
162	*Murraya koenigii* (L.) Spreng.	Curry leaves	Shrub	Used in treating itching, piles, dysentery, inflammation, fresh cuts, bruises, and edema. The roots are purgative to some extent. They are stimulating and used for common body aches.
163	*Murraya paniculata* (L.) Jack	Jasmine orange	Shrub	Used as remedy for rheumatism, hysteria and coughs.
164	*Murraya* spp.	Curry leaves	Shrub	Used as remedy for rheumatism, hysteria and coughs.
165	*Myrica esculenta* Buch-Ham. ex D.Don	Bay berry, Kaphal	Tree	Fruits are edible. It is used as fuel and medicine to treat several ailments such as chronic bronchitis, asthma, cough, fever, ulcers, inflammation, anemia, diarrhea and ear, nose and throat disorders.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
166	*Myrsine africana* L.	Chapra, Vidanga	Shrub	Used as laxative and antihelminthic, especially for curing infection of tape worm.
167	*Nelumbo* spp.	Lotus, Kamal, Padma	Herb	Consumed as copper rich vegetable. The ample amount of potassium helps to reduce heart problems, fatigue, high blood pressure and irritability.
168	*Neolitsea pallens* (D.Don) Momiy. & H.Hara	Kaalu	Tree	Used as antioxidant, antibacterial activity and also to cure infections and prevention of several diseases.
169	*Nerium indicum* Mill.	Kaner	shrub	It has medicinal properties such as bitter, acrid, antihelminthic, analgesic, adaptogenic, aphrodisiac anticancer:, anti-inflammatory: stomachic, febrifuge, diuretic astringent, emetic, expectorant, cardio tonic, anticancer, etc.
170	*Nyctanthes arbor-tristis* Craib.	Night flowering jasmine, Parijat	Shrub	Used in various ailments like fever, enlargement of the spleen, blood dysentery, malaria, cough and gastritis. Juice of leaves is used as digestives and antidote to reptiles venome.
171	*Olea ferruginea* Wall. ex Aitch.	Wild olive, Brown olive	Tree	Used as medicinal, fodder and oil.
172	*Oroxylum indicum* (L.) Kurz	Indian Trumpet flower, Bhut-vriksha	Tree	The root is used as anti-inflammatory, astringent, aphrodisiac, expectorant, antihelminthic and tonic. The bark is diuretic and stomachic and useful in diarrhoea and dysentery.
173	*Panicum maximum* L.	Buffalo grass	Grass	Used as soil stabilizer and fodder.
174	*Phleum pratense* L.	Timothy grass, Common cat's tail grass	Grass	Used to reduce symptoms of hay fever.
175	*Phragmites karka* (Retz.) Trin. ex Steud.	Narkul, Doka –ghas	Grass	Used as soil stabilizer and fodder.
176	*Phragmites* spp.	Doka –ghas	Grass	Used as soil stabilizer and fodder.
177	*Phyllanthus emblica* (Retz.) Trin. ex Steud.	Amla, Anwala, Aonla,Amalaki,	Tree	Fruits are edible and also used as fodder, fuel and shows many medicinal properties.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
178	*Phytolacca acinosa* Roxb.	Indian pokeweed	Herb	It is an edible and also used in the treatment of urinary disorders, oedema, nephritis, and abdominal distension.
179	*Picea smithiana* (Wall.) Boiss.	Rai	Tree	Used in construction, shingles, crates, household purposes etc. It is also used in the pulp industry to make paper. An indifferent fuel but it yields a fairly good charcoal.
180	*Picrorhiza kurroa* Royle ex Benth.	Karoo	Herb	It exhibit medicinal properties (hepato - protective, antipyretic and to treat dyspepsia, respiratory disorders,chronic diarrhea, and scorpion sting)
181	*Pinus gerardiana* Wall. ex D.Don	Chilgoza, Neoja, Nikocaka	Tree	Used as timber, fuel and have antiviral, antibacterial, antifungal, antihypertensive, antiseptic, expectorant and diuretic properties
182	*Pinus roxburghii* Sarg.	Kail	Tree timber	Used as fuel, timber and resin. The wood is antihelminthic, aromatic, haemostatic, stimulant, digestive, liver tonic, diaphoretic and diuretic.
183	*Pinus wallichiana* A.B. Jacks.	Kail	Tree	Used as timber and fuel. It is beneficial treatment for a variety of skin complaints, wounds, sores, burns, boils, etc. and also used in the form of liniment plasters, poultices, herbal steam baths and inhalers. The wood is diaphoretic and stimulant.
184	*Pistacia integerrima* J.L. Stewart ex Brandis	Kakarsinghi, Karkatasrngi	Tree	The leaf galls are used in traditional herbalism for asthma, cough, fever, vomiting and diarrhea.
185	*Poa alpina* L.	Grass	Grass	Used as fodder and soil stabilizer.
186	*Poa annua* L.	Blue grass	Grass	Used as fodder and lawn grass.
187	*Poa pratensis* L.	Blue grass	Grasses	Used as fodder and in golf grounds.
188	*Polyalthia longifolia* (Sonn.) Thwaites	Ashok, Mast tree	Tree	The bark and leaves of this plant show effective cytotoxic function, antimicrobial, antiulcer and hypoglycemic activities and hypotensive effect.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
189	*Polygonatum cirrhifolium* (Wall.) Royle	Medha, Coiling leaf	Herb	Used in the treatment of pain in the kidneys and hips, loss of vigour, swelling and accumulation of fluids in bone joints, fullness in the abdominal region, skin eruptions and coughs.
190	*Polygonatum multiflorum* (L.) All.	Solomon's seal	Herb	It is used in the treatment of stomach inflammations, chronic dysentery, etc. Root is astringent, demulcent, emetic and tonic.
191	*Polygonatum verticillatum* (L.) All.	Khinraula, Shirkakoli	Herb	Used to cure various health troubles as antiperiodic, cardiotonic, demulcent, aphrodisiac, diuretic, energizer, sedative, hypoglycemic, antitumor, general tonic, pain reliever, nervine tonic etc.
192	*Pongamia pinnata* (L.) Pierre	Pongam tree, Karanj	Tree	As crude drug used for the treatment of tumors, piles, skin diseases, and ulcers. The root is effective for treating gonorrhea, cleaning gums, teeth, and ulcers, and is used in vaginal and skin diseases.
193	*Populus deltoids* Marshall	Populus, Poplar	Tree	Used as timber, fuel wood as well as in paper and packaging industry.
194	*Prinsepia utilis* Royle	Bhekhal, Bhekoi	Shrub	Used as a treatment for rheumatism and muscular pain caused by hard work. The oil is also applied to the forehead and temples in the treatment of coughs and colds. The heated oilcake is applied as a poultice to the abdomen in the treatment of stomachaches.
195	*Prunus armeniaca* L.	Chuli	Tree	Decoction used to soothe inflame skin and irritated skin condition, seed is analgesic and antihelminthic, treatment of asthma cough , crinic bronchitis.
196	*Prunus ceracifera* Ehrh.	Cherry plum	Tree	Used as an ornamental plant, edible fruit and used as rootstock in grafting.
197	*Prunus cerasoides* Buch. Ham. ex D. Don	Pajja	Tree	Used as fodder, fuel wood, analgesic, antiabortifacient. It is useful in stomach trouble, common cold and cough.
198	*Prunus cornuta* (Wall. ex Royle) Steud.	Jamoi	Tree	Used as edible, fuel and fodder.
199	*Prunus domestica*	-	Tree	Fruits edible.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
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200	*Prunus persica (*L.) Batch	Aadu	Tree	Fruits edible, kernel paste is applied on forehead for headache, twigs used as toothbrush, fodder.
201	*Psidium guajava* L.	Amrood	Tree	Fruits edible.
202	*Pterocarpus marsupium* Roxb.	Indian Kino tree, Beeja patta, Malabar kino tree	Tree	Used in the treatment of hemorrhages, fractures, constipation, skin diseases, ophthalmology, depurative, leprosy, rectalgia and leucoderma, rheumatoid arthritis, skin diseases, external use for sores, boils, stomach pain and gastrointestinal disorders.
203	*Punica granatum* L.	Anar	Tree	Used in the treatment of Cancer, Osteoarthritis and Other Diseases. The pomegranate has been used in natural and holistic medicine to treat sore throats, coughs, urinary infections, digestive disorders, skin disorders, arthritis and to expel tapeworms.
204	*Pyrus pashia* Buch.-Ham.ex D.Don	Kainth, Indian wild pear	Tree	It is used to cure gastrointestinal disorders, fever, headache, hysteria, epilepsy and sweating of body (diaphoretic). The fruits of this plant are sedative, febrifuge and laxative.
205	*Quercus floribunda* Lindl. ex A.Camus	Moru	Tree	Used as timber, fuel and fodder.
206	*Quercus ilex* L.	Holly oak	Shrub	The tree's wood is hard and only used for smaller woodcrafts, such as handles and carpentry tools.
207	*Quercus oblongata* D.Don	Ban oak	Tree	It is variably used in treating wide range of diseases such as diarrhea, stomachache, urinary infection, toothache, piles, astringent, gonorrhea, asthma, dysentery and stomach pain.
208	*Quercus semecarpifolia* Sm.	Kharsu	Tree	Used as fodder and fuel.
209	*Rheum moorcroftianum* Royle	Revand chini, Amalparni	Herb	It is commonly used for the treatment of renal function disorder, hyperlipidemia, cancer and improves the memory in senile patients.
210	*Ricinus communis* L.	Castor bean	Shrub	Leaf, root and seed oil are used in hypoglycemic, liver disorders, inflammation treatment and as a laxative.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
211	*Rosa moschata* Herrm.	Kunja, Kujoi	Shrub	It is rich in anti- oxidants and used for the treatment of abdominal spasm and diarrhea.
212	*Rosa* spp.	Kunai, kujoi, Gulab	Shrub	It is used as an ornamental plant.
213	*Rubus biflorus* Buch.- Ham. ex Sm.	Blackberries	Shrub	Root extract is a catharctic and emetic in nature. Fruits are edible.
214	*Rubus ellipticus* Sm.	Golden Himalayan raspberry	Shrub	Fruits are edible and has medicinal properties.
215	*Rubus niveus* Thunb.	Hill raspberry, huftoo, Kale hinure	Shrub	Fruit are edible and used as an ornamental due to the striking red-purple colour of its stems.
216	*Rubus* spp.	Heenr	Shrub	Fruit are edible and used as an ornamental due to the striking red-purple colour of its stems.
217	*Saccharum spontaneum* L.	Wild sugar cane, Kans grass	Grass	Roots are sweet, astringent, emollient, refrigerant, diuretic, lithotriptic, purgative, tonic, aphrodisiac and useful in treatment of dyspepsia, burning sensation, piles, sexual weakness, gynecological troubles, respiratory troubles, etc. Planted to check soil-erosion.
218	*Salix alba* L.	Indian willow	Tree	It is used to cure cold, fevers and joint pains.
219	*Salix babylonica*	willow	Tree	Used as timber, fodder and fuel.
220	*Salix* spp.	willow	Tree	Used as timber, fodder and fuel.
221	*Santalum album* L.	Indian Sandalwood, Sandal	Tree	To cure common colds, bronchitis, skin disorders, heart ailments, general weakness, fever, infection of the urinary tract, inflammation of the mouth and pharynx, liver and gallbladder complaints and other maladies.
222	*Sapindus mukorossi* Gaertn.	Soapberry, reetha	Tree	Used for cleansing and pharmacological.
223	*Saraca asoca* (Roxb.) Willd.	Sita Ashoka tree	Tree	Used in the treatment of internal bleeding, infertility, hemorrhoids and insomnia. It can rejuvenate the complexion, reduce freckles and calm down inflammation.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
224	*Sarcococca saligna* Mull.- Arg.	Geru, Willow leaf sweet box	Shrub	Leaves are laxative and used as blood purifier and muscular analgesic. The aqueous-methanolic extract of *S. saligna* has saponins, flavonoids, tannins, phenols, and alkaloids which have calcium channel blocking activity.
225	*Saussurea costus* (Falc.) Lipsch.	Kuth, uplet, Rauta	Herb	Costus oil is used for asthma, cough, gas, and severe intestinal diseases such as dysentery and cholera.
226	*Scirpus grossus* L.f.	Kaseru, rush or Bulrush	Herb	Used to cure nausea, diarrhea, thirst, scanty micturition, jaundice, improving the sperm count and weakness of the cardiac muscles.
227	*Selinum tenuifolium* Salisb.	Bhootkeshi	Herb	The fruits have sedative and aphrodisiac properties and are also used to treat rheumatism and kidney disease.
228	*Selinum vaginatum* C. B. Clark	Bhootkeshi	Herb	The fruits have sedative and aphrodisiac properties and are also used to treat anxiety, painful condition, vaat an cough rog.
229	*Setaria glauca* (L.) P.Beauv.	Wild foxtail millet	Grass	It is edible and used as fodder.
230	*Sinopodophyllum hexandrum* (Royle.) T.S.Ying	Bankakri,Vanatrapusi	Herb	Used for the treatment of cancer, ulcers, cuts and wounds.
231	*Sphaeralcea munroana* (Douglas ex Lindl.) Spach ex A.Gray	Munro's globemallow	Herb	Used in sore throats and irritation along the digestive track.
232	*Spiraea canescens* D.Don	Jhar Mairala	Shrub	Fodder for goats and twigs used in providing strength to baskets and Kiltas.
233	*Spiraea* spp.	Jhar mairala, Double bridal wreath	Shrub	Plants are ornamental and used as asprin.
234	*Spirodela polyrrhiza* (L.) Schleid.	Common duckweed	Aquatic	It is rich in protein and used as fodder.
235	*Sporobolus diander* (Retz.) P.Beauv.		Grass	Used as fodder and soil conservation.
236	*Stipa roylei* (Nees) Duthie	Needle grass	Grass	The bulb is antirheumatic, antiasthmatic, febrifuge, oxytoxic, ophthalmic and galactogogue.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
237	*Swertia angustifolia* Buch. Ham. ex D. Don	Chirayta	Herb	Used to treat liver disorder, malaria, diabetes and in farmocological activities
238	*Swertia cordata* Wall. ex G. Don	Heart leaf	Herb	Used against gastroenterological disorder, high blood sugar.
239	*Swertia paniculata* Wall. D. Don	Chirayta	Herb	Decoction taken as tonic and treatment of malaria.
240	*Syringa emodi* Wall. ex Royle	Himalayan lilac	Shrub	It is used as fuel and also used in traditional medicines.
241	*Syzygium cumini* (L.) Skeels	Jamun, Naaval, Jambu	Tree	Fruits are edible and also shows medicinal properties.
242	*Syzygium venosum* DC.	Jamun	Tree	Astringent to bowels treatment of sorethroat, dysentery and ulcers.
243	*Taxus wallichiana* Zucc.	Thuner	Tree	Used to cure cough, common cold, fever and pain.
244	*Tecoma stans* (L.) Juss. ex Kunth	Yellow trumpet bush, Pilia	Shrub	Used as fuel wood, for making charcoal and curing diabeties and cyphilis.
245	*Tecomella undulata* (Sm.) Seem.	Roheda , Honey tree, Rohida	Tree	Bark of stem is used as a remedy for syphilis. It is also used to cure enlargement of spleen, urinary disorders, gonorrhoea, leucoderma and liver diseases. Seeds are used against abscess.
246	*Tectona grandis* L.f.	Teak, Sagun	Tree	The wood is considered as a laxative, sedative for the uterus, good for piles, leucoderma and dysentery and timber.
247	*Tephrosia hamiltonii* Gamble	Sarphonka, Ban- nil	Herb	Plant is alexiteric, antithelminthic, restorative and antipyretic.
248	*Terminalia arjuna* (Roxb. Ex DC) Wight Avn	Arjun	Tree	Tassar cultivation, timber, fencing, fuel wood, medicinal (heart tonic).
249	*Terminalia bellirica* (Gaerth.)Roxb.	Bahera	Tree	Used as fodder, fuel, fruit (myrobalan), timber, medicicinal, ingredient of ‘triphala’.
250	*Terminalia chebula* Retz.	Harar	Tree	Used as fodder, fuel, fruit (myrobalan), timber, medicicinal, ingredient of ‘triphala’.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
251	*Terminalia* spp.	Harar, Bahera	Tree	Plant is edible, used as fodder and fuel and also used in traditional medicine to treat bacterial infectious diseases including diarrhea, dysentery, pneumonia, and sore throats.
252	*Thamnocalamus spathiflorus* (Trin.) Munro		Grass	Used as fuel and fodder.
253	*Themeda anathera* (Nees ex Steud.) Hack.	Loonder grass	Grass	Plant is used to produce fodder for livestock and for thatching.
254	*Themeda arundinacea* Roxb.	A. Camus	Grass	Used as sourse of fiber and thaching material
255	*Thuja orientalis* L. Biota	Oriental thuja	Tree	Used to cure respiratory track infection, bacterial skin infection, cold sores and nerve disorders.
256	*Thymus linearis* Benth.	Himlayan thyme, Jangli ajwain	Herb	Plant is edible and also has medicinal properties. It is used externally as an antiseptic, to treat wounds, to combat eczema , or to reduce swelling.
257	*Thysanolaena maxima* (Roxb.) Kuntze	Naktura, Nastura	Grass	Plant is used as soil stabilizer. Leaves and the tips are used as fodder; the bushy and fox-tail-like panicles are used for making brooms.
258	*Tinospora cordifolia* (Willd.) Miers.	Giloy, amrithaballi, Seendhil . Gulje, Galo, Guduci	Climber	Plant is used as fodder and it is used for high cholesterol, diabetes, upset stomach, allergic rhinitis (hay fever), gout, lymphoma and other cancers, rheumatoid arthritis (RA), hepatitis, peptic ulcer disease (PUD), fever, gonorrhea, syphilis, and to boost the immune system.
259	*Toona ciliata* M.Roem.	Toon	Tree	Used as timber. The bark may be used for tanning leather, and has been traditionally used to make twine and string bags. Its bark is used as an astringent and tonic and to treat dysentery and to heal wounds.
260	*Trifolium repens*	Dutch clover	Herb	Antirheumatic, tonic, fodder and soil conservation.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
261	*Trifolium pratense* L.	Red clover	Grass	Used as fodder and in traditional medicine of India as antispasmodic, sedative, deobstruent, expectorant, anti-inflammatory and antidermatosis agent.
262	*Trillium govanianum* Wall. ex D.Don	Nag chhatri, Satva	Herb	It has medicinal properties and used to cure dysentery, wound healing, menstrual and sexual disorders.
263	*Typha* sp.	Vileurnum	Shrub	Muscle relaxant to relieve cramps asthma and hypertention.
264	*Ulmus wallichiana* Planch.	Emroi, Imroi	Tree	Plant is used as fodder, fuel and timber. A strong fibre is obtained from the inner bark and used for cordage, slow matches and sandals.
265	*Viburnum* spp.		Shrub	Plant is used as fodder and fuel.
266	*Viburnum cotinifolium* D.Don	Talanj	Shrub	Plant is used as fodder, fuel and it is edible. It is used to treat menstrual pain, morning sickness and cramps of the digestive tract or the bile ducts. Black haw's primary use was to prevent miscarriages.
267	*Valeriana jatamansi* Jones	Balchhari, Mushkbala	Herb	Plant is well-known in traditional Indian medicine. It is used to cure diseases of eye, blood and livers, remedy for hysteria, hypochondriasis, nervous unrest and emotional stress. Also useful in clearing voice and acts as stimulant in advance stage of fever and nervous disorder.
268	*Viburnum grandiflorum* Wall. ex DC.	Talanj	Shrub	The plant has laxative properties. It is also used as fuel and fodder.
269	*Viola canescens* Wall. ex Ging.	Banafasha	Shrub	The plant has diaphoretic and antipyretic properties. In inflorescence are used to treat sore throat, cough , kidney diseases and disorder in liver.
270	*Vitex negundo* L.	Nirgundi	Shrub	The plant is very good soil binder. It cures joint pain and muscle aches. It is also used for curing skin diseases and also used as fuel wood.

Sl No	Botanical Name	Common Name	Habit	Special Attributes
271	*Woodfordia fruiticosa* (L.) Kurz	Dhaula	Shrub	It is used as fuel and fodder. It is also used in the treatment of piles, diarrhea and dysentery.
272	*Zanthoxylum armatum* DC.	Tejbal, Timru,Tumburu, Tejovati	Shrub	The fruits are edible and it is used to cure bronchitis, asthma, varicose veins and diarrhea.
273	*Ziziphus jujuba* Mill.	Ber, beri, Jhar beri	Shrub	The fruits are edible and it is used as a fuel wood. It cures liver ailment and bladder diseases and constipation. The leaves can be used as fodder.
274	*Ziziphus nummularia* (Burm.f.) Wt. & Arn.	Ber, Beri	Shrub	The fruits are edible and it is used as a fuel wood. The leaves can be used as fodder.
275	*Ziziphus* spp.	Ber, Beri, jhar beri	Shrub/ tree	The fruits are edible and it is used as a fuel wood. The leaves can be used as fodder.

Annexure–5: Model-Wise List of suggested Plant species for planting in Natural, Agriculture and Urban Landscapes

Botanical Name	Natural Landscape																												Agriculture Landscape						Urban Landscape									
	RV/HP/NL													RV/JK/NL												RV/PB/NL		Hills (HP/J&K/AL)				Plain(PB/AL)		Hills (HP/J&K/UL)						Plains (PB/UL)			
	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	1	2	1	2	1	2	1	2	1	2	3	1	2	3	1	2	3	4
Senegalia catechu (L.F.) Willd.									.	.	.								.	.	.	.	.			.																		
***Acacia nilotica* (l.) Dilile.**																										.	.								.					.				
***Acer acuminatum* Wall. Ex D. Don**		.																																									
***Acer caesium* Wall. Ex Brandis**				.											.																												
***Acer pictum* Thumb.**						.																																					
***Acer* spp.**																	.																											

***Achillea millefolium* L.**																.	.																														
***Aconitum heterophyllum* Wall. Ex Royle**		.	.	.	.									.	.	.	.																													
***Aconitum violaceum* Jacquem. ex Stapf**	.													.																																
***Aegle marmelosa* (L.) Correa**							.	.	.	.		.								.	.	.	.	.				.																	
***Agropyron* spp.**	.					.	.	.	.					.				.		.	.																									
***Agrostis gigantean* Roth.**	.						.	.	.					.					.	.	.																									
***Agrostis munroana* Aithc. & Hemsl.**	.													.																																
***Agrostis pilosula* Trin.**	.													.																																
***Ailanthus excelsa* Roxb**.																											.	.																		
***Ainsliaea aptera* DC.**	.													.																																
***Ajuga* spp.**					.												.																												

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***Anogeissus* spp.**									.	.		.										.	.	.																					
***Anthocephalus cadamba* (Roxb.) Miq.**																												.									.					.			
***Apluda mutica* L.**										.										.	.	.																							
***Araucaria araucana* (Molina) K. Koch**																																				.	.		.	.			.	.		
***Arnebia benthamii* (Wall. ex G. Don)**	.	.												.	.																														
***Arundinella nepalensis* Trin.**						.				.		.						.					.	.																					
***Arundinella pumila* (Hochst.) Steud.**						.												.																											
***Arundo donax* L.**							.	.	.										.	.	.	.	.																						
***Azadirachta indica* A. Juss.**																									.				.	.	.	.											.		
***Bambusa arundinacea* Willd.**									.																																				
***Bambusa bambos* (L.) Voss**									.																																				

***Bambusa* spp.**										.	.										.	.	.																				
***Bauhinia variegata* L.**							.	.	.	.	.									.	.	.	.	.																				
***Berberis lycium* Royle**																				.	.																							
***Berberis* spp.**					.			.									.											.															
***Bergenia ciliata* (Haw.) Sternb.**				.	.											.	.																										
***Bergenia stracheyi* (Hook. f. & Thomson)**		.													.																												
***Betula alnoides* Buch.-Ham. ex D. Don**						.											.																										
***Betula utilis* D. Don**		.													.																												
***Boerhavia diffusa* L.**							.	.	.	.	.									.	.	.	.	.																				
***Bombax ceiba* L.**							.		.											.	.		.	.			.																
***Bothriochloa intermedia* (R. Br.) A. Camus**							.	.	.											.	.	.																						
***Bothriochloa parviflora* (R.**						.												.																										

Br.) Ohwi																																									
***Bothriochloa pertusa* (L.) A. Camus**						.	.	.	.										.	.		.	.																			
***Bougainvillea* spp.**																										.							.		.	.		.		.		.
***Brachypodium sylvaticum* (Huds.) P. Beauv.**	.													.																											
***Bromus himalaicus* Stapf**	.													.																											
***Bromus ramosus* Huds.**														.																											
***Butea monosperma* (Lam.) Taub.**																										.							.		.	.		.		.		.
***Calamagrostis montanensis* (Scribn.) Scribn. ex Vasey**	.					.																																			
***Calamagrostis* spp.**							.	.	.											.	.	.																			
***Callistemon citrinus* (Curtis) Skeels**																																	.	.	.	.	.	.				.
***Cappadocicum* spp.**						.																																			

***Capparis decidua* (Forssk.) Edgew.**																										.																			
***Carissa opaca* Stapf ex Haines**							.	.	.											.	.	.																							
***Carpinus viminea* Wall. Ex Lindl.**						.											.																											
***Cassia fistula* L.**									.													.					.																		
***Casuarina* spp.**																																													
***Cedrus deodara* (Roxb. ex D. Don) G. Don**			.	.	.											.	.																											
***Celtis australis* L.**			.				.	.	.	.		.										.	.																					
***Chrysopogon fulvus* (Spreng.) Chiov.**							.	.	.											.	.	.	.																					
***Chrysopogon gryllus* (L.) Trin.**						.												.																											
***Chrysopogon serrulatus* Trin.**							.	.	.											.	.	.																							
***Cinnamomum tamala* (Buch.-Ham.) T. Nees**							.	.	.											.	.	.																							

& Eberm.																																										
***Citrus limon* (L.) Osbeck**																											.																
***Cordia myxa* L.**																										.																
***Cornus capitata* Wall.**					.																																				
***Cornus macrophylla* Wall.**						.											.																								
***Cornus oblonga* Wall.**				.												.																								
***Corylus jacquemontii* Decne.**		.													.																										
***Cotoneaster bacillaris* Wall. Ex Lindl.**				.	.											.	.																								
***Cryptomeria japonica* (Thunb. ex L. f.) D. Don**																																				.	.		.	.			.	.
***Cupressus torulosa* D. Don**				.												.																										
***Cymbopogon citratus* (DC.) Stapf**																					.	.																				
***Cymbopogon distans* Nees ex Steud.) W. Watson**						.												.																								

***Cymbopogon martinii* (Roxb.) W. Watson**							.	.	.										.	.	.																						
***Cyperus rotundus* L.**																																								.			
***Dactylis glomerata* L.**	.				.									.				.																									
***Dactylorhiza hatagirea* (D. Don) Soo**	.	.												.	.																												
***Dalbergia sissoo* DC.**									.	.		.							.	.	.	.	.				.							.	.	.	.	.	.		.	.	.
***Danthonia cuminsii* Hook. f.**	.													.																													
***Danthonia* spp.**	.					.																																					
***Daphne papyracea* Wall. ex G. Don**				.	.												.																										
***Daphne* spp.**																.																											
***Debregeasia hypoleuca* (Hochst. ex A. Rich.) Wedd.**				.	.			.	.							.	.			.	.																						
***Delphinium cashmerianum* Royle**														.																													
***Dendrocalamus hamiltonii* Nees**																			.																									

& Arn. ex Munro																																											
***Dendrocalamus* spp.**									.	.										.	.	.																					
***Dendrocalamus strictus* (Roxb.) Nees**							.	.	.		.									.	.	.	.																					
***Deschampsia* spp.**										.	.											.	.																					
***Desmodium elegans* DC.**				.												.	.																										
***Desmodium gangeticum* (L.) DC.**									.												.																							
***Deutzia corymbosa* R.Br. ex G. Don**					.			.	.												.																							
***Deutzia* spp.**																	.																											
***Deutzia staminea* R. Br. ex Wall.**					.			.	.											.	.																							
***Dichanthium annulatum* (Forssk.) Stapf**																						.	.																					
***Diospyros edulis* Lodd. ex Sweet**																												.	.															

***Diospyros kaki* L.f.**																												.	.													
***Diospyros lotus* L.**																												.	.													
***Diospyros montana* B. Heyne ex A.DC.**							.	.	.	.		.																														
***Diospyros* spp.**																				.		.	.	.																		
***Drepanostachyum falcatum* (Nees) Keng f.**			.	.	.												.	.										.													
***Eichhornia* spp.**																																						.				
***Elaeagnus conferta* Roxb.**					.				.									.			.																				
***Eragrostis nigra* Nees ex Steud.**										.		.											.	.																		
***Erianthus filifolius* ex Steud.**							.	.	.											.	.	.																				
***Erianthus rufipilus* Griseb.**							.	.	.											.	.	.																				
***Erianthus* spp.**	.					.								.				.																								
***Eriobotrya japonica* (Thunb.) Lindl**																												.													

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***Ficus racemosa* L.**																											.																		
***Ficus* spp.**								.	.											.	.	.	.	.																				
***Flacourtia indica* (Burm. f.) Merr.**							.	.																																				
***Fritillaria roylei* Hook.**	.	.												.	.																														
***Geranium wallichianum* D. Don ex Sw.**	.	.	.	.	.									.	.	.	.																												
***Gmelina arborea* Roxb.**																															.	.	.	.										
***Grevillea robusta* A. Cunn. ex R. Br.**																																			.	.	.	.	.	.		.	.	.
***Grewia elastic* Royle.**																											.																		
***Grewia optiva* J. R. Drumm. ex Burret**							.	.	.	.	.									.	.	.	.	.																				
***Haldinia cordifolia* (Roxb.) Ridsdale**								.	.	.										.	.	.																						
***Hedychium spicatum* Sm.**				.	.											.	.																											

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***Juglans regia* L.**						.											.																													
***Justicia adhatoda* L.**							.	.											.	.	.	.																							
***Kigelia pinnata* (Jacq.) DC.**																																				.	.	.	.			.	.	.	
***Koeleria* spp.**	.				.									.				.																											
***Lemna* spp.**																																									.				
***Litsea chinensis* Lam**									.	.											.	.	.																						
***Lonicera quinqueloculari s* Hard**				.																																									
***Lyonia ovalifoli a* (Wall.) Drude)**					.		.	.									.		.	.																								
***Maesa indica* (Roxb.) A.DC.**							.	.	.										.	.	.				.																			
***Mallotus philippinensis* Muell. Arg**							.	.		.									.	.		.	.																					
***Mangifera indica* L.**																											.																	
***Melia composite* Benth.**																									.	.			.	.	.	.								.			.	
***Moringa oleifera* Lam.**																									.																			

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***Panicum maximum* Jacq.**										.		.											.	.																				
***Phleum pretense* L.**							.	.	.												.	.	.	.	.																		
***Phragmites karka* (Retz.) Trin. ex Steud**							.	.	.												.	.	.	.	.																		
***Phragmites* spp.**																																												
***Phyllanthus emblica* (Retz.) Trin. ex Steud.)**							.	.	.	.		.										.	.	.	.																				
***Phytolacca acinosa*Roxb.**		.		.												.	.																											
***Picea smithiana* (Wall.) Boiss.**				.	.												.	.																										
***Picrorhiza kurroa* Royle ex Benth.**	.	.	.	.											.	.	.																											
***Pinus gerardiana* Wall. ex D. Don**			.																																								
***Pinus roxburghii* Sarg.**							.														.																						
***Pinus wallichiana* A.B. Jacks.**		.	.	.	.											.	.	.																										

***Pistacia integerrima* J. L. Stewart ex Brandis**			.		.			.											.	.																									
***Poa annua* L.**	.				.									.				.																										
***Poa pratensis* L.**	.					.	.	.	.					.				.	.	.	.																								
***Polyalthia longifolia* (Sonn.) Thwaites**																																		.	.	.	.	.	.		.	.	.	
***Polygonatum cirrhifolium* (Wall.) Royle**	.				.												.																												
***Polygonatum multiflorum* (L.) All.**	.	.												.																															
***Polygonatum verticillatum* (L.) All.**	.	.	.	.	.									.	.		.																												
***Pongamia pinnata* (L.) Pierre**																											.								.			.				.		
***Populus deltoids* Marshall**																														.	.	.	.										
***Prinsepia utilis* Royle**				.	.											.	.																											
***Prunus armeniaca* L.**																												.	.															

***Prunus ceracifera* ex Poir.**																												.	.													
***Prunus cerasoides* Ham. ex D. Don**																.																										
***Prunus cornuta* (Wall. ex Royle) Steud.**		.			.										.		.																									
***Prunus domestica* L.**																												.	.													
***Prunus persica* (L.) Batsch**																												.	.													
Psidium guajava L.																												.														
***Pterocarpus marsupium* Roxb.**																									.																	
***Punica granatum* L.**							.	.											.																							
***Pyrus pashia* Buch.-Ham. exD. Don.**																																										
***Quercus floribunda* Lindl. ex A. Camus**																.																										
***Quercus ilex* L.**																																										
***Quercus oblongata* D.**			.			.	.	.	.							.		.	.																						

Don.																																											
***Quercus semecarpifolia* Sm.**		.				.									.																												
***Rheum australe* D. Don.**	.													.																													
***Rheum moorcroftianum* Royle.**	.													.																													
***Ricinus communis* L.**																			.	.	.																						
***Rosa moschata* Herrm.**				.	.																																					
***Rosa* spp.**		.						.	.							.				.	.					.							.		.	.		.		.		.
***Rubus biflorus* Buch.-Ham. ex Sm.**					.																																					
***Rubus* spp.**																	.										.																
***Rubus ellipticus* Sm.**							.	.	.										.	.	.	.	.																				
***Rubus niveus* Thunb.**				.																																						
***Saccharum spontaneum* L.**						.												.																								
***Salix alba* L.**																																			.	.	.		.			.	.

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***Trillium govanianum* Wall. ex D. Don**		.		.	.										.	.	.																														
***Typha* spp.**																																												.			
***Ulmus wallichiana* Planch.**						.											.																													
***Valeriana jatamansi* Jones**			.		.												.																													
***Viburnum cotinifolium* D. Don**				.																																										
***Viburnum grandiflorum* Wall. ex DC.**				.	.																																								
***Viburnum* spp.**																.	.																													
***Viola canescens* Wall.**																.																													
***Viola serpens* Wall. ex Ging**				.	.											.	.																													
***Vitex negundo* L.**						.	.	.											.	.	.						.																	
***Woodfordia fruticosa* (L.) Kurz**						.	.	.									.		.	.	.					.																	
***Zanthoxylum armatum* DC.**				.				.	.								.			.	.				.																	

***Ziziphus jujuba* Mill.**																			.																												
***Ziziphus nummularia* (Burm.f.) Wight & Arn.**																			.																												
***Ziziphus* spp.**						.	.	.												.	.																											

Annexure – 6: Model-Wise/Activity-Wise List of Forest divisions for Forestry Interventions of Ravi Riverscape

State	Landscape	Model/Activity	Area (ha)	Cost (Rs. in Crore)
Himachal Pradesh	Natural	RV/HP/NL/01- Sub-Alpine Conservation	-	-
		RV/HP/NL/02- Sub Alpine Enrichment	-	-
		RV/HP/NL/03- Temperate Conifer Forest	513	15.5943
		RV/HP/NL/04- Temperate Mixed Forest	1283	39.0985
		RV/HP/NL/05- Pasture and Grazing Land Development	100	2.2755
		RV/HP/NL/06- Himalayan Chir Pine Forest	351	10.6513
		RV/HP/NL/07- Himalayan Mixed Forest	54	1.4739
		RV/HP/NL/08- Sub Tropical Dry Deciduous Forest	59	1.5831
		RV/HP/NL/09- Eradication of Lantana (> 50%)	-	-
		RV/HP/NL/10- Control/ Removal of Invasive Species or <50% Lantana	-	-
		RV/HP/NL/11- Protection Model for Natural Regeneration	720	12.9042
		RV/HP/NL/12- Fire Protection Model	185	2.3851
		RV/HP/NL/13- Eco-Task Force Model	1000	41.27
	Agriculture	RV/HP/AL/01 - Boundary Plantation Model	175	0.4282
		RV/HP/AL/02 –Planting of Economic Trees in Block Plantation	29	0.3782
	Urban	RV/HP/ UL/01 - Riverfront Development	2	4.95
		RV/HP/ UL/02 -Institutional and Industrial Plantation	104	4.4616
		RV /HP/UL /03 -Eco-park Development	7.2	17.82
	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/HP/CI/01-Broushwood Intervention	14830	0.4449
		RV/HP/CI/02-Dry Stone Activities	132933	23.92
		RV/HP/CI/03-Create wire Activities	58817.5	26.46
		RV/HP/CI/04-Water Pond	39620	1.38

		RV/HP/CI/05- Silt Detention Dam Type Activities	1630	0.978
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/HP/CI/06-Riparian Wildlife Management	235	23.50
		RV/HP/CI/07-Wetland Management (Natural and Artificial)	53	4.77
		Sub Total =	**4870.20 ha. + 247830.5**	**236.72**
J&K UT	Natural	RV/JK/NL/01- Sub-Alpine Conservation	-	-
		RV/JK/NL/02- Sub Alpine Enrichment	-	-
		RV/JK/NL/03- Temperate Conifer Forest	11	0.3196
		RV/JK/NL/04- Temperate Mixed Forest	-	-
		RV/JK/NL/05- Pasture and Grazing Land Development	-	-
		RV/JK/NL/06- Himalayan Chir Pine Forest	38	0.9786
		RV/JK/NL/07- Himalayan Mixed Forest	-	-
		RV/JK/NL/08- Sub Tropical Dry Deciduous Forest	120	3.2359
		RV/JK/NL/09- Eradication of Lantana (> 50%)	46	1.0211
		RV/JK/NL/10-Control/ Removal of Invasive Species or <50% Lantana	15	0.3603
		RV/JK/NL/11- Protection Model for Natural Regeneration	310	4.7198
		RV/JK/NL/12-Fire Protection Model	190	1.1748
		RV/JK/NL/13- Eco-Task Force Model	1000	42.35
	Agriculture	RV/JK/AL/01 -Planting of Economic Trees	207	0.5217
		RV/JK/AL/02 –Planting of Economic Trees in Block Plantation	38	0.4955
	Urban	RV/JK/ UL/01 - Riverfront Development	-	-
		RV/JK/ UL/02 - Institutional and Industrial Estate Plantation	121	5.1909
		RV /JK/UL /03 -Eco-park Development	5.59	12.6225

	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/JK/CI/01-Broushwood Intervention	-	-
		RV/JK/CI/02-Dry Stone Activities	10810	1.9458
		RV/JK/CI/03-Create wire Activities	8780	3.951
		RV/JK/CI/04-Water Pond	-	-
		RV/JK/CI/05- Silt Detention Dam Type Activities	-	-
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/JK/CI/06-Riparian Wildlife Management	20	2.00
		RV/JK/CI/07-Wetland Management (Natural and Artificial)	-	-
		Sub Total =	**2121.59 ha. + 19590.00m^3**	**80.908**
Punjab	Natural	RV/PB/NL/01- Restoration of Degraded Forests Model	561.35	13.0185
		RV/PB/NL/02- Road Side Plantation	234	10.5217
	Agriculture	RV/PB/AL/01 -Boundary Plantation Model	700	1.766
		RV/PB/AL/02 – Block Plantation Model	118	1.5408
	Urban	RV/PB/ UL/01–Bioremediation and Biofiltration	9.1	2.2524
		RV/PB/ UL/02 - Riverfront Development	2.7	6.6825
		RV/PB/ UL/03 - Institutional and Industrial Estate Plantation	88	3.9897
		RV /PB/UL /04 -Eco-park Development	4.6	11.385
	Conservation Interventions	**Soil and water Conservation**	**(m3)**	
		RV/PB/CI/01-Broushwood Intervention	24120	0.7236
		RV/PB/CI/02-Dry Stone Activities	43580	7.8444
		RV/PB/CI/03-Create wire Activities	3400	1.53
		RV/PB/CI/04-Water Pond	114400	4.004
		RV/PB/CI/05- Silt Detention Dam Type Activities	-	-
	Other Interventions	**Other Interventions**	**Area (ha)**	
		RV/PB/CI/06- Riparian Wildlife Management	57	5.70
		RV/PB/CI/07- Wetland Management (Natural and Artificial)	56	5.04
			1830.75 ha+185500m^3	**75.9987**
Grand Total =			**8822.54 ha +452920.5m^3**	**393.6267**

Annexure: 7- Consent letter regarding availability of land for forestry Intervention in Ravi Riverscape in Punjab

Government of Punjab
Department of Forest & Wildlife Preservation
O/o Principal Chief Conservator of Forests (HoFF),
Forest Complex, Sector 68, SAS Nagar (Mohali)

To

Director General,
Indian Council of Forestry Research &Education,
P.O. New Forest,
Dehradun.

No.
Dated:

Subject: **Feedback and comments on availability of land for forestry Interventions proposed in the DPR for Rejuvenation of Rivers.**

Reference: Your letter No. 41-58/2019/ADG (M&E) /ICFRE/DPR/ VOl.II/ 113 dated 12/10/2020 and NAEB letter No.12-4/2017 B-III (NAEB) dated 17/09/2020

With reference to above mentioned letters concerning the availability of land to carry out the prescribed forestry interventions, it is intimated that the required information has been provided by the respective divisions of the Punjab Forest Department with regard to the locations along the river scapes of Beas, Ravi and Satluj and its tributaries. The proposed forestry interventions have been deliberated in the stake holders meeting.

In view of above, it is intimated that the sufficient land is available to take up the forestry interventions along the river scapes of Beas, Ravi and Satluj in respective forest divisions of Punjab State.

Principal Chief Conservator of Forest (HoFF)
Punjab, SAS Nagar, Mohali.

No. SPL/1730-31 Dated :- 27/10/2020

Copy is forwarded to the following for information and necessary action.

1. Assistant Commissioner (Forest), Ministry of Environment Forest & Climate Change (NAEB), New Delhi.
2. Director, HFRI, Shimla, Himachal Pradesh.

Principal Chief Conservator of Forest (HoFF)
Punjab, SAS Nagar, Mohali.

Annexure: 8- Consent letter regarding availability of land for forestry Intervention in Ravi Riverscape in Himachal Pradesh

Office of
Principal Chief Conservator of Forests
(Head of Forest Force)
Himachal Pradesh Forest Department Headquarters, Talland, Shimla-171 001

स्वच्छ भारत
एक कदम स्वच्छता की ओर

No. Ft.15-642/2019(D)DPR/IRB
Himachal Pradesh Forest Department

To

The Director,
Himalayan Forestry Research Institute,
Conifer Campus, Panthaghati, Shimla-1710013.

Dated Shimla-1, the - 3 NOV 2020

Subject Request to provide information on availability of land for forestry interventions and certificate of verification of plantation and cost.

Sir,

Kindly refer to your office letter No.4 (Vistar-28) Hi.v.a.s./2020/ 1288 dated 25.09.2020 on the subject cited above.

2. In this regard it is certified that land is available in the concerned Forest Divisions for proposed forestry inventions as mentioned in the Draft Detailed Project Reports (DPRs) for rejuvenation of five major rivers i.e. Beas, Chenab, Jhelum, Ravi & Satluj prepared/finalized by the Himalayan Forest Research Institute, Shimla in consultation with the field officers of this department as per geo-coordinates given in the DPRs.

Yours faithfully,

Chief Conservator of Forests (Fin.)
Himachal Pradesh.

3.11.2020

Annexure: 9- Consent letter regarding availability of land for forestry Intervention in Ravi Riverscape in Jammu and Kashmir UT

Office Address
May to October: Forest Complex, Shiekh Bagh, Lal Chowk, Srn-190001 | Phone: 0194-2483837, Fax: 0194-2455827
Nov. to April: Van Bhawan, Below Canal, Jammu-180001 | Phone: 0191-2566585, Fax: 0191-2547276
URL Address: www.jkforest.gov.in
E-mail: pccfjkforest@gmail.com

Government of Jammu & Kashmir
Office of the Pr. Chief Conservator of Forests & HoFF
Jammu & Kashmir Forest Department

Director General of Forest
& Special Secretary, Government of India,
MoEFCC, New Delhi.

No: PCCF/Plg/208/1405-07 **Dated: 26 -11-2020**

Reference No.: D.O. No. 12-4/2017-B-III (P) dated 17.11.2020

Subject: DPR on Forestry Interventions for Chenab, Jhelum & Ravi for Jammu & Kashmir.

Sir,

The J&K Forest Department is providing all necessary assistance to Himalayan Forest Research Institute for the preparation of DPR on Forestry Interventions for rejuvenation of Jhelum, Chenab & Ravi rivers in Jammu & Kashmir. The Director, Himalayan Forest Research Institute has shared certain information and has sought inputs with regard to the availability of land in various forest divisions in the riverscapes of aforementioned rivers for the proposed forestry interventions. After getting the inputs from the concerned DFOs, the necessary information have also been sent to DG ICFRE vide this office No. PCCF/Plg/Himalaya/208/1320-23 dated 12.11.2020.

It is once again reiterated that J&K Forest Department will continue to provide the necessary assistance for implementation of the projects as per the approved DPRs.

Yours faithfully,

(Dr. Mohit Gera) IFS
Pr. Chief Conservator of Forests (HoFF), J&K

Copy for information to:
1) DG ICFRE, P.O. New Forest, Dehradun-248006
2) Director HFRI, Panthaghati, Shimla.

PHOTO CREDITS

Sr. No.	Name of the Person	Plate No.
1.	Dr. S. S. Grewal, Director (Retd.) Punjab Agricultural University Ballowal, Saunkhri, Nawanshahar	Plate 5.4, Plate 5.5, Plate 5.6, Plate 5.7, Plate 5.8, Plate 5.9, Plate 5.10.
2.	Ms. Savita Kumari Banyal, Chief Technical Officer, HFRI, Shimla	Plate 1.1, Plate 1.2, Plate 1.3, Plate 1.4, Plate 1.5, Plate 1.6, Plate 2.1, Plate 2.2, Plate 2.3, Plate 2.4, Plate 2.5 , Plate 2.6, Plate 2.7 , Plate 2.10, Plate 2.11, Plate 2.12, Plate 2.13, Plate 2.14, Plate 2.15, Plate 2.16, Plate 2.18, Plate 2.19, Plate 2.20, Plate 2.21, Plate 2.24, Plate 2.25, Plate 2.26, Plate 2.27, Plate 3.2, Plate 3.6, Plate 5.2, Plate 5.2, Plate 5. 3, Plate 9.3, Plate 9.4, Plate 9.5, Plate 9.6.
3.	Sh. Kulwant Rai Gulshan, Sr. Technician, HFRI, Shimla	Plate 2.17, Plate 2.22, Plate 2.23, Plate 3.1, Plate 3.3, Plate 3.4, Plate 3.7, Plate 3.8, Plate 3.13, Plate 3.14, Plate 9.1, Plate 9.2.
4.	Sh. Shyam Sunder, Sr. Tech; HFRI, Shimla	Plate 3.15, Plate 3.16, Plate 3.17, Plate 3.18, Plate 3.19
5.	Sh. Manjeet, Technician, HFRI, Shimla	Plate 3.20.
6.	Aman Singh, Project Assistant, HFRI, Shimla	Plate 2.8, Plate 2.9, Plate 3.5.
7.	Sh. Pankaj Kumar, Project Assistant, HFRI, Shimla	Plate 3.9, Plate 3.10.
8.	Sh. Mayank Negi, Junior Project Fellow, HFRI, Shimla	Plate 3.11, Plate 3.12.

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