Undertaking a study to define the extent and intensity of habitat degradation, to identify the drivers of degradation and prepare a study proposal for developing model mitigation plan in alpine and sub-alpine areas in SECURE Himalaya project landscapes of Himachal Pradesh

Final Report

Submitted By

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Contents

Executive Summary

Over a span of a time frame from December 2018 to January 2022, the high altitude pasturelands in the SECURE Himalaya landscape of Himachal Pradesh were studied in detail. The extent and intensity of degradation in these pasturelands was assessed. A multi-conceptual approach (comprising of ecosystem service approach, biodiversity assessment approach, RS- GIS based approach and climate change vulnerability assessment approach) was followed. Data collected with regard to these approaches (through primary and secondary data collection) was mapped to develop four thematic maps, which were then super-imposed to develop the degradation profile of the project landscape. In order to delinate the degradation of pasturelands in the sub-rover basins, the change in NDVI and the Net Primary Productivity of the pasturelands, over a period of 15 years was analysed. On the basis of these four sub-river basins, with issues of pastureland degradation were identified. These are Miyar and Kundal in Lahual and Parmas and Kanyun in Pangi. The pasturelands in these four sub-river basins were studied in detail (through quadrat anaylsis, community consultation and GIS based approach) to map the intensity of degradation. The reasons for degradation in these pasturelands were identified as change in species composition, legume deficiency, anthropogenic pressures, landslides, issues due to livestock, scarcity of water and winter rain and livelihood related issues. Detailed consultations with subject matter experts, officials in the landscape and community members, along with analysis of the data led to the identification of pasturelands in Miyar sub-river basin and Kundal sub-river basin needing immediate restoration attention. Detailed grassland action plans for both the sub-river basins have been developed. While addressing the causes of degradation, each of the action plans has detailed out the steps that need to be taken to mitigate the impacts of degradation due to each factor. The plans also provide a table where convergence from existing Government schemes has been drawn. The role of community members and nomadic gaddi pastoralists in implementing these action plans, along with the officials of Forest and other line departments has also been highlighted for each action point. The grassland action plan for each sub-river basin has been developed based on the altitude and includes the species that need to be planted and cultivation protocols for the same. A holistic approach has been followed while developing these action plans. While on one hand they are aimed at improving the grassland ecosystem and thereby improve the ecosystem services provided by the same; on the other hand these plans also focus on generation of additional livelihood opportunities for the local communities and the nomadic pastoralists. This in turn will help to reduce anthropogenic pressures on the grasslands and thus support long term addressal of degradation. The report is divided into 4 parts. Part A focusses on development of the degradation profile of the landscape and identification of degraded sub-river basins; Part B and C deal with development of the restoration plans for two degraded sub-river basins and Part D focusses on a monitoring framework. This detailed monitoring framework has been developed for measuring the success of the action plans at every stage of implementation. The action plans have been developed in a manner that is easy to understand, implement and replicate to other high-altitude Himalayan grasslands as well.

PART A: DEVELOPING THE DEGRADATION PROFILE AND IDENTIFICATION OF DEGRADED SUB-RIVER BASINS

1 Introduction

This report presents the details of the work conducted in the SECURE Himalaya project landscape (Figure 1), under the project between December 2018 to January 2022. The report encompasses the process of mapping levels of degradation, identification of the sub-river basins with maximum degradation and development of restoration plans for the two sub-river basins. The report details the restoration plan, along with the monitoring mechanism for the two sub-river basins (Miyar and Kundal). Both of them fall in the Lahual landscape of the project area. The restoration plan has been developed in a scientific and participatory manner. This report will act as a model mechanism to develop a restoration plan for high altitude grasslands and can be upscaled to other high-altitude regions as well, particularly in the Himalayas.

Project Objectives

- To develop an understanding of the issues related to pastureland specifically in the context of degradation
- To identify the areas of intensive degradation which have the potential of impacting the habitat characteristics of the landscapes
- To prescribe interventions for eco-restoration

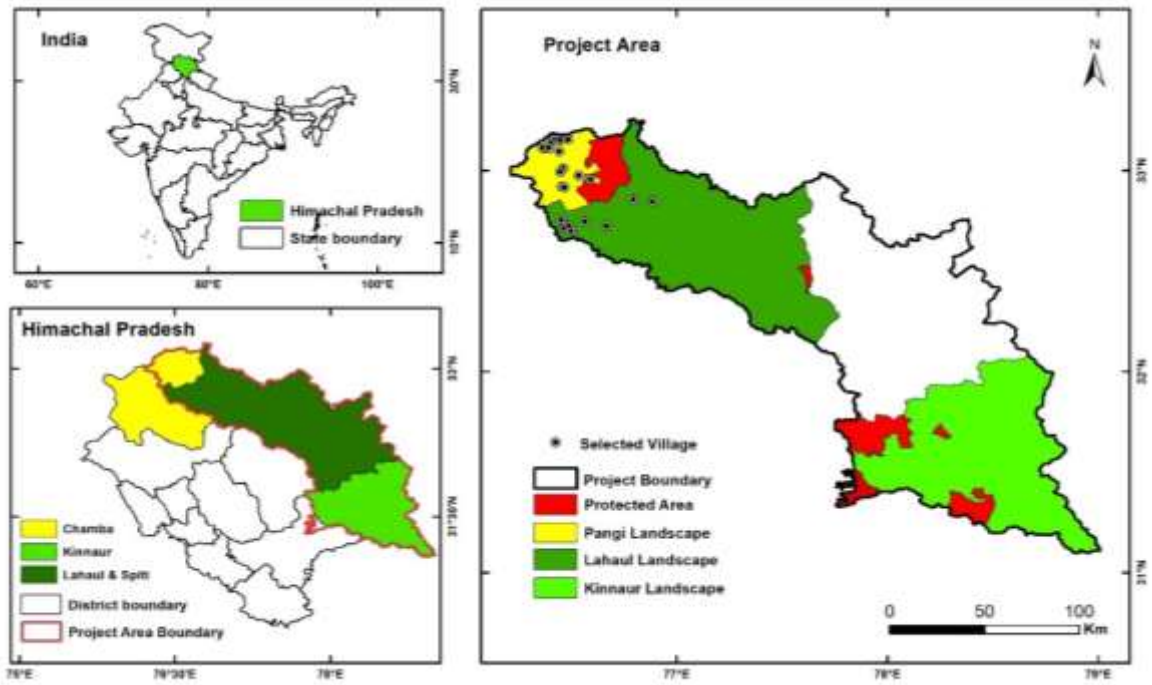


Figure 1: Study area

2 Methodology

2.1 Mapping degradation profile

In order to address the objectives of the study in its coherence, we followed a multi-conceptual approach, including qualitative and quantitative data collection.

For the first objective, related to the understanding of the issues related to pasture land in the context of degradation, we used a fourfold approach which draws from various conceptual backgrounds. The fourfold multi-conceptual approach (Figure 2) is discussed in detail below.

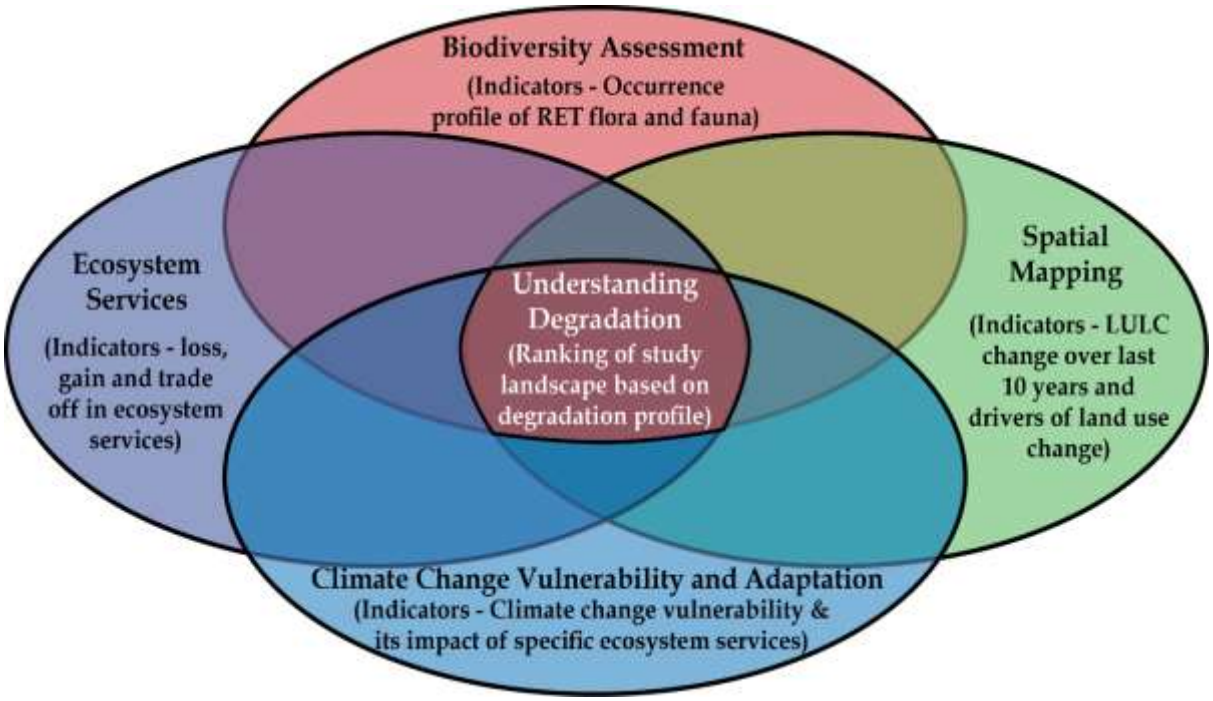


Figure 2: Multi-conceptual approach to understanding degradation

I. **Ecosystem service approach**: - The overall objective of this approach is to understand and spatially map the ecosystem services availed from various important ecosystem services in the study landscape. Information on the utilization pattern of ecosystem services was collected through focus group discussions and household surveys. In the next step of analysis, the areas with higher levels of service extraction and decrease in availability will be delineated to define the hotspots of degradation.

II. **Biodiversity assessment approach**: The presence of Rare, Endangered and Threatened species makes a landscape an important area for conservation activities and interventions. Spatial mapping of this data can be useful in prioritizing the areas for conservation action. The biodiversity data has been collected through opportunistic surveys (birds), using repeat photography technique and through discussions with the community and forest department officials (mammals and birds). Secondary data from existing literature is also being compiled.

III. **RS-GIS based approach:** RS-GIS based approach is central to all other approaches. It will help to identify the change in land use and land cover, through a time series analysis (by keeping the important ecosystem identified during the focus group discussions as the major land use categories). In addition, the results from all other approaches are also being plotted on the spatial platform for better comprehension of the prevailing situation.

IV. **Climate change vulnerability assessment:** Changing climate is an important aspect that contributes to the degradation of the habitat. We looked at the climate vulnerability of villagers in availing the ecosystem services in the landscape. The ICLEI ACCCRN Process (IAP) has been used for this purpose[1].

The four thematic layers thus obtained, were super-imposed to develop the landscape degradation profile (Figures 3, 4, 5, 6 and 7).

[1] ICLEI ACCCRN Process

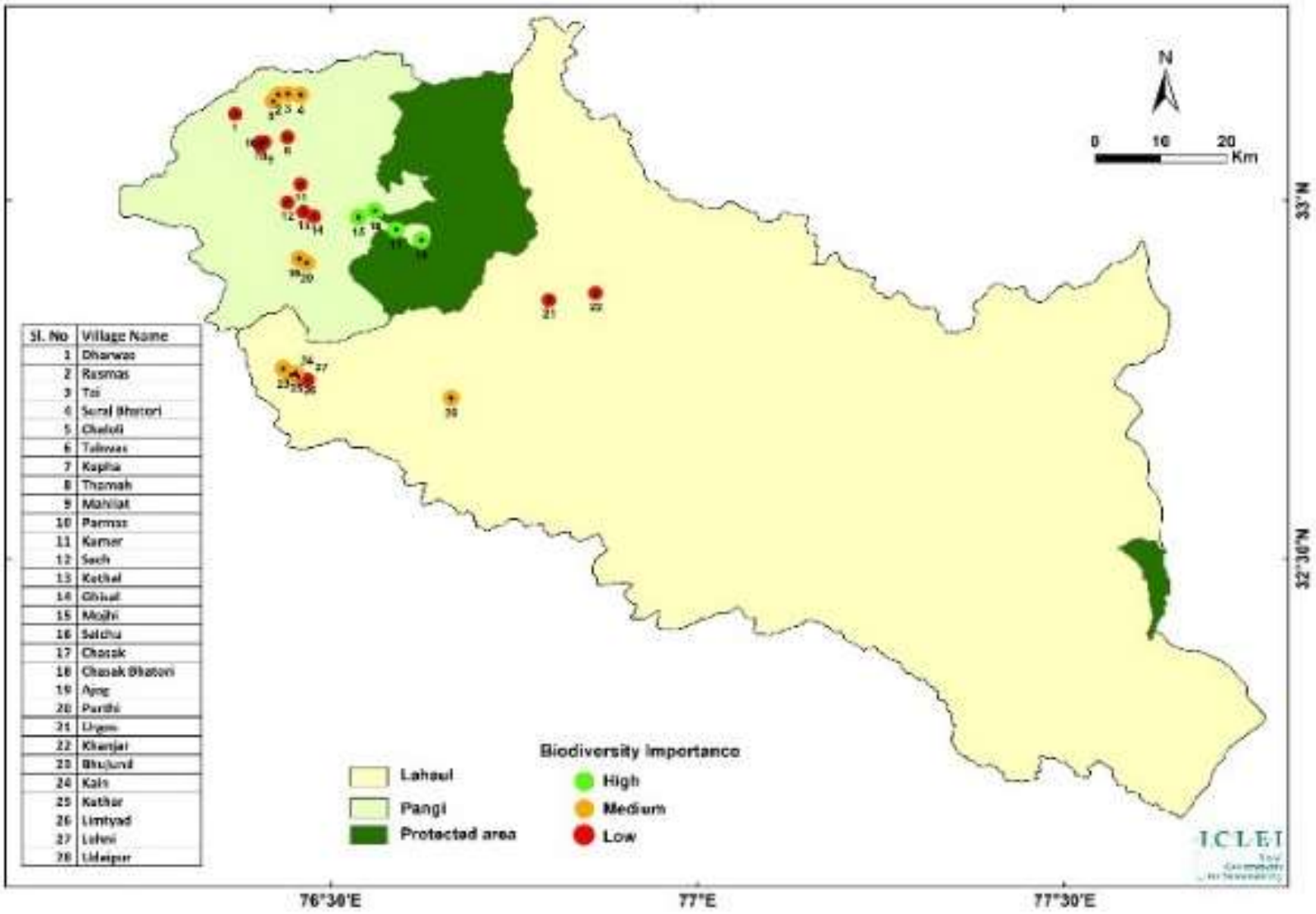
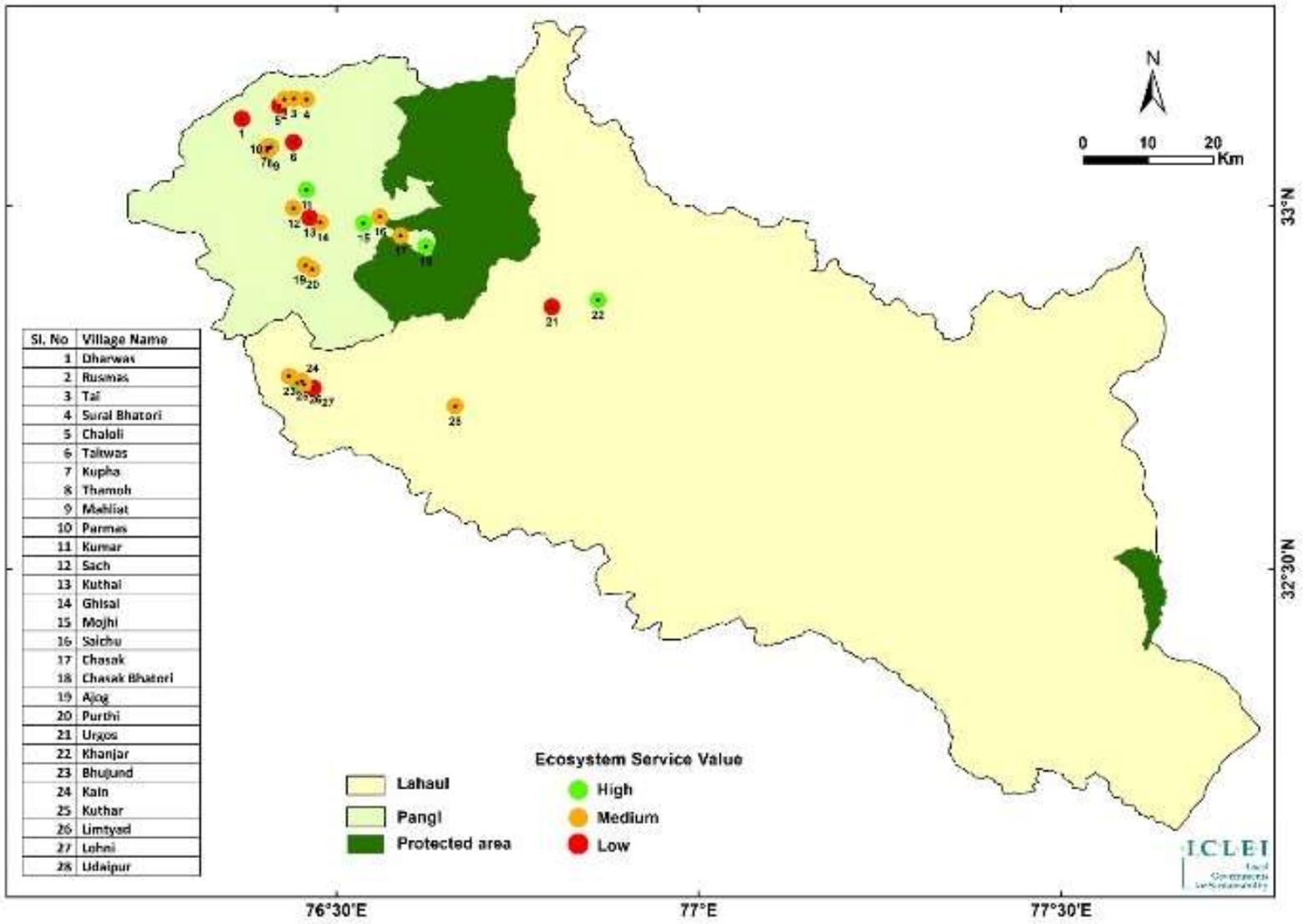
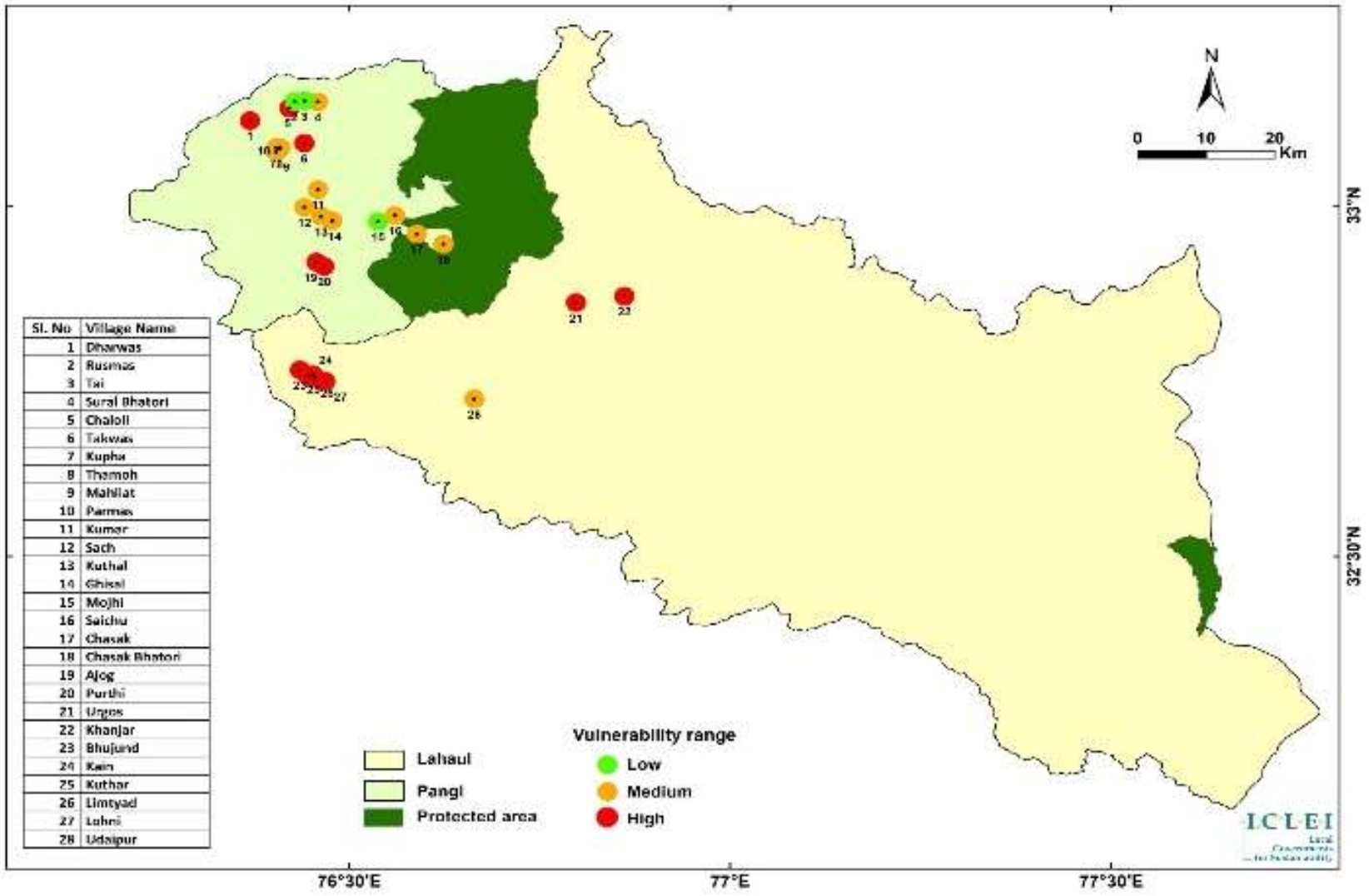


Figure 3: Thematic Layer- Biodiversity



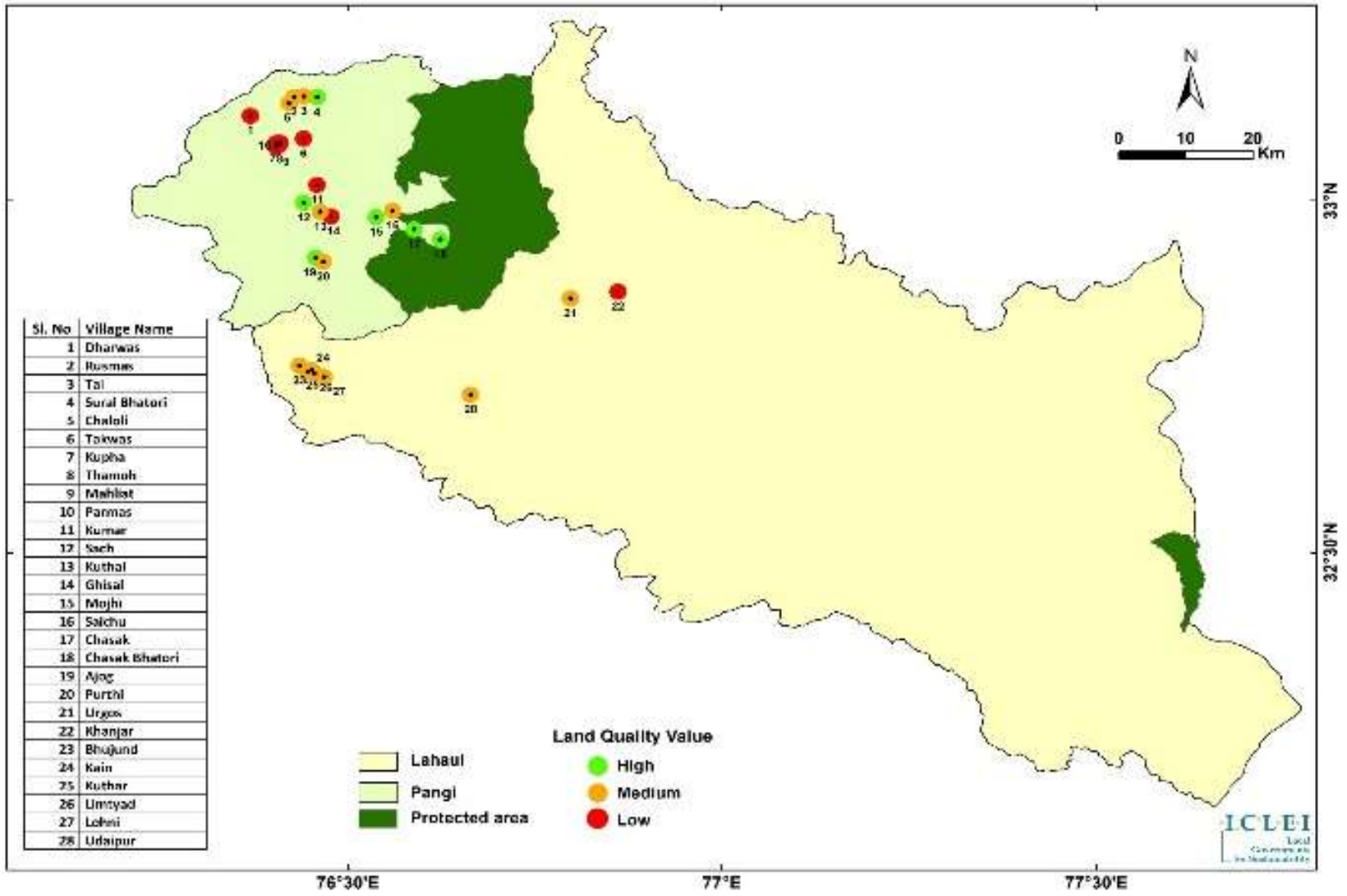
Sl. No	Village Name
1	Dharwas
2	Rusmas
3	Tal
4	Sural Bhatori
5	Chaloli
6	Talwas
7	Kupha
8	Thamoh
9	Mehliat
10	Parmas
11	Kumar
12	Sach
13	Kuthal
14	Ghisal
15	Mojhi
16	Saichu
17	Chasak
18	Chasak Bhatori
19	Ajog
20	Purthi
21	Urgos
22	Khanjar
23	Bhujund
24	Kain
25	Kuthar
26	Limtyad
27	Lohni
28	Udaipur

Figure 4: Thematic Layer- Ecosystem Service



Sl. No	Village Name
1	Dharwas
2	Rusmas
3	Tai
4	Sural Bhatori
5	Chaloli
6	Takwas
7	Kupha
8	Thamoh
9	Mahilat
10	Parmas
11	Kumar
12	Sach
13	Kuthal
14	Ghisni
15	Mojhi
16	Saichu
17	Chasak
18	Chasak Bhatori
19	Ajog
20	Purthi
21	Urgos
22	Khanjar
23	Bhujund
24	Kein
25	Kuthar
26	Limtyad
27	Lohni
28	Udaipur

Figure 5: Thematic Layer- Climate Vulnerability



Sl. No	Village Name
1	Dharwas
2	Rusmas
3	Tal
4	Sural Bhatori
5	Chaloli
6	Tokwas
7	Kupha
8	Thamoh
9	Mahliat
10	Panmas
11	Kumar
12	Sach
13	Kuthal
14	Ghisal
15	Mojhi
16	Salchu
17	Chasak
18	Chasak Bhatori
19	Ajog
20	Purthi
21	Urgos
22	Khanjar
23	Bhujund
24	Kain
25	Kuthar
26	Umtyad
27	Lohni
28	Udaipur

Figure 6: Thematic Layer- Land Quality

2.2 Landscape level NDVI analysis

Vegetation indices derived from satellite data are one of the principal sources of information for monitoring and assessment of the Earth's vegetative cover (Gilabert et al. 2002). Land productivity considered as one of the indicators of land degradation NDVI has been considered as the proxy for land productivity based on numerous and rigorous studies that have identified a strong relationship between NDVI and NPP (Prince and Goward 1995; Vlek et al. 2010; Field et al. 1995). Reduction of primary productivity is a reliable indicator of the decrease or destruction of biological productivity (Wessels et al. 2004; Li et al. 2004). Temporal NDVI analysis has been shown to be significant in studies like land-use and land-cover change, drought, desertification, soil erosion, vegetation fires, biodiversity monitoring and conservation, and soil organic carbon. (Yengoh et al. 2015).

Normalized Difference Vegetation Index (NDVI) was used to quantify the vegetation greenness by measuring the difference between near-infrared (vegetation strongly reflects) and red light (vegetation absorbs). NDVI is the most commonly used vegetation index. NDVI is useful in understanding vegetation density and plant health. Healthy vegetation (chlorophyll) reflects more near-infrared (NIR) and green light compared to other wavelengths, it absorbs more red and blue light. NDVI is the ratio of the difference between the near-infrared band (NIR) and the red band (R) and the sum of these two bands (Rouse Jr et al. 1974).

NDVI change analysis for the landscape for the duration of 1994 - 2020 has been done using various Landsat images for the month of October to November, downloaded from the Earth Explorer website facility of USGS. We used cloud-free (<10 % cloud) Landsat 5 – TM, Landsat-7 ETM+ and Landsat-8 OLI satellite images for the analysis of indices. 14-year images that were used for the NDVI change analysis. Their data specification and the temporal details of the satellite images have provided in Table 1.

After the preprocessing of the satellite data, the Normalised Difference Vegetation Index was calculated as the ratio between the Red and near-infrared (NIR) values of the satellite images by the following equation NDVI = (NIR -Red)/ (NIR + Red). In Landsat 5 and Landsat -7, Band 3 (Red) and Band 4(NIR) whereas in Landsat 8, Band 4 (Red) and Band 5(NIR) with 30m resolution were used for the NDVI map of each images using ERDAS Imagine software. Pixel-to-pixel linear change (trend) was analysed using a bitemporal approach and NDVI change Index spatial layers prepared with respect to year span and satellite sensor type using Eqn 1. Cumulative NDVI index map was prepared by adding and averaging these NDVI change index spatial thematic layers, using raster calculator function of ArcGIS 9. 3.

NDVI change Index = $[(NDVI_1 – NDVI_2) + (NDVI_2 – NDVI_3)$ …….. $NDVI_{n-1} - NDVI_n)n-1$ ….. ('n' is total number of images) **Eqn - 1**

The spatial resolution of the cumulative index map is 30m X 30 m which was again reclassified into 100m X 100m grid (1ha) by averaging the pixel value in each 1h grid using zonal statistics function. The NDVI Change map of the study area was prepared by the reclassification of the Cumulative NDVI Change index raster layer into 7 NDVI change classes - High decrease, Medium decrease, Marginal decrease, No Significant change, Marginal increase, Medium increase and High increase, according to equal interval classification.

Table 1: Landsat Satellite data used for the NDVI analysis

Year	Satellite data used	Date of acquisition	Cloud cover (%)
1994	Landsat 5 TM (P148. R37)	15-November - 1994	5
	Landsat 5 TM (P147. R37)	24-November - 1994	3
	Landsat 5 TM (P147. R38)	08_November - 1994	7
1996	Landsat 5 TM (P148. R37)	04-November - 1996	5
	Landsat 5 TM (P147. R37)	13-November - 1996	1
	Landsat 5 TM (P147. R38)	29- November -1996	10
1998	Landsat 5 TM (P148. R37)	10 – November - 1998	6
	Landsat 5 TM (P147. R37)	19 – November - 1998	3
	Landsat 5 TM (P147. R38)	19 - November - 1998	6
2000	Landsat 7 ETM (P148. R37)	22 – October – 2000	1
	Landsat 7 ETM (P147. R37)	15 - October – 2000	1
	Landsat 7 ETM (P147. R38)	15 - October – 2000	1
2001	Landsat 7 ETM (P148. R37)	10 -November - 2001	2
	Landsat 7 ETM (P147. R37)	19 – November - 2001	1
	Landsat 7 ETM (P147. R38)	18 - October – 2001	2
2002	Landsat 7 ETM (P147. R37)	22 -November - 2002	1
	Landsat 7 ETM (P148. R37)	29 -November - 2001	3
	Landsat 7 ETM (P147. R38)	22 - November - 2002	4
2008	Landsat 5 TM (P148. R37)	21 - November - 2008	4
	Landsat 5 TM (P147. R37)	30 - November - 2008	2
	Landsat 5 TM (P147. R38)	30 - November - 2008	5
2010	Landsat 5 TM (P148. R37)	11 - November - 2010	5
	Landsat 5 TM (P147. R37)	20 - November - 2010	3
	Landsat 5 TM (P147. R38)	3 – October - 2010	5
2011	Landsat 5 TM (P148. R37)	14- - November – 2011	5
	Landsat 5 TM (P147. R37)	22- October – 2011	3
	Landsat 5 TM (P147. R38)	22- October – 2011	3
2013	Landsat 8 OLI (P148. R37)	03- November – 2013	3.26
	Landsat 8 OLI (P147. R37)	28- November – 2013	1.23
	Landsat 8 OLI (P147. R38)	12 - November – 2013	3.09
2015	Landsat 8 OLI (P148. R37)	08- October - 2015	4.71
	Landsat 8 OLI (P147. R37)	18 – November – 2015	1.43
	Landsat 8 OLI (P147. R38)	18 – November – 2015	4.92
2017	Landsat 8 OLI (P148. R37)	30- November – 2017	4.85
	Landsat 8 OLI (P147. R37)	7 – November – 2017	0.41
	Landsat 8 OLI (P147. R38)	7 – November – 2017	2.13
2019	Landsat 8 OLI (P148. R37)	4 – November - 2019	9.23
	Landsat 8 OLI (P147. R37)	28 – October – 2019	1.45
	Landsat 8 OLI (P147. R38)	28 – October – 2019	4.04
2020	Landsat 8 OLI (P148. R37)	6 – November - 2020	1.0
	Landsat 8 OLI (P147. R37)	30 – October – 2020	1.53
	Landsat 8 OLI (P147. R38)	30 – October – 2020	2.28

2.3 Landscape level NPP analysis of grasslands

Net Primary Productivity (NPP) refers to the net carbon gain by vegetation over a particular time period—typically a year. It is the balance between the carbon gained by photosynthesis and the carbon released by plant respiration. It is equal to the difference between the rate at which the plants in an ecosystem produce useful chemical energy (GPP) and the rate at which they use some of that energy during respiration (Amthor & Baldocchi 2001, Chapin & Eviner 2003). The U.S. National Aeronautics and Space Administration's (NASA) MODIS (Moderate Resolution Imaging Spectroradiometer) primary production products (MOD17) provide data of vegetation primary production on vegetated land at 1km resolution at an 8-day interval (Zhao et al., 2005). The latest MODIS annual NPP global dataset (MOD17A3, version 055) has been produced and is available from the Numerical Terradynamic Simulation Group (NTSG)/University of Montana (UMT) (http://files.ntsg.umt.edu/data/NTSG_Products/MOD17/GeoTIFF/MOD17A3/GeoTIFF_30arcsec/). We downloaded the global annual NPP dataset for the period 2000 to 2015, representing the total NPP for the year in gC/m^2. The global layers were cropped to the extent of Lahual- Pangi landscape and resampled using the nearest-neighbour algorithm to prepare the NPP thematic layer for each year. A pixel-to-pixel linear change was analysed and NPP change 2000 – 2015 index spatial layers were prepared with respect to year span using the Eqn 2. Cumulative NPP index map was prepared by adding and averaging these NPP change index spatial thematic layers using raster calculator function of ArcGIS 9. 3. The NPP change map of the study area was prepared by the reclassification of the Cumulative NPP change index raster layer into 7 NPP change classes - High decrease, Medium decrease, Marginal decrease, No Significant change, Marginal increase, Medium increase and High increase, according to equal interval classification. Change in NPP of grasslands 2000 – 2015 map was developed by extraction of NPP change raster layer by the grassland polygon spatial layer, delineated from the Landuse / Land cover map.

NPP change Index = [(NPP1 – NPP2) + (NPP2 – NPP3) …….. NPPn-1 - NPPn)n-1 …..('n' is total number of images) …… **Eqn - 2**

2.4 Delineation of four Sub-River Basins

Based on the four approaches (Ecosystem services, Biodiversity importance, Climate risk and Land quality) described in the section 2.1 of this report and in the fourth and fifth reports, a landscape degradation profile of the landscape (based on conservation priority index) was prepared using spatial multi-criteria decision-making analysis. The index value of the same ranged between low priority value – 1.8 to a high priority value 4.5. The sub – river basin vector layers for the study area were prepared using ASTER Global Digital Elevation data of 30 m resolution. Two sub-river basins from each part of Landscape (Lahaul landscape and Pangi landscape) which have more degradation (with regard to the 4 spatial indices, NDVI and NPP of grasslands) were identified by overlay analysis.

2.5 Sub-River Basin level degradation mapping

For the present study potential degradation in the selected SRBs have been mapped in terms of cumulative changes in NDVI, NPP, and GPP over the past two decades (Bai & Dent 2006, Bai & Dent 2009; Yengoh et al. 2015; Gichenje & Godinho 2018; Nuarsa et al. 2018, Pereira

et al. 2018). Potential degradation index map was prepared by overlay analysis of the classified and ranked NDVI, NPP and GPP change spatial raster layers, using raster calculator function of Arc GIS 9.3 GIS software. The potential degradation map of each sub-river basin was prepared by the reclassification of the degradation index raster layer into 7 potential degradation change classes - High degradation, Medium degradation, Low degradation, No Significant change, Low improvement, Medium improvement, and High improvement, according to equal interval classification. The method of the preparation of NDVI and NPP change spatial layer has been described in detail in the previous sections.

2.6 Elevation wise level degradation mapping in each Sub-River Basin

The Digital Elevation Layer for each of the four sub - river basins was extracted from the Digital Elevation Model Spatial Layer of the study area, which was developed from the downloaded ASTER GDEM - 30 m resolution data from NASA Earth Data repository. The Digital Elevation Raster Spatial Layer of each sub- river basin was reclassified into three elevation classes (Low, Medium, High), according to the equal interval classification method, and each elevation class was converted into vector layers. The potential degradation spatial layer of each SRB was extracted with the elevation class vector layer and degradation class-wise maps were developed and analysed.

2.7 Soil analysis

Soil samples were collected from the grasslands in each of the four sub- river basins and from the control site (Seichu). The details of the same have been provided in the fifth report. The soil samples were analysed for the following parameters- pH, electrical conductivity, organic carbon, nitrogen, phosphorus and potassium. The analysis was carried out in two laboratories- G.B. Pant National Institute of Himalayan Environment in Kullu and Central Agroforestry Research Institute, Indian Council of Agricultural Research in Jhansi. The methodology followed for each parameter is provided in Annexure 1.

2.8 Quadrat analysis

Quadrat studies had been carried out in the grasslands in each of the four sub-river basins and the control site (Seichu). The details of the same have been provided in the fifth report. Specimens of each species were preserved. In addition, each species was photographed as well. The plant species were identified with support from Botanical Survey of India. BD Pro was used to calculate the Shannon diversity of grasslands of each sub-river basin and the control site. Family wise analysis and an analysis of the number of palatable species present in each sub-river basin and the control site was carried out. Based on the list of wild herbivores (developed through the biodiversity assessments, as detailed in the third and fourth reports), a list of the species preferred grass species was also developed for the grasslands in each sub-river basin.

2.9 Expert Discussions

In order to develop a framework for the mitigation plan and develop an in-depth understanding of the aspects to be covered in the same, one to one online discussions were carried out with several experts and practitioners (refer Table 2). During each of these interactions, discussions were also carried out on possible interventions that can be taken up in each sub-river basin. Discussion with some of the officials of the forest department (of Himachal Pradesh and other states in the Himalayas) was also carried out to understand some interventions that have been implemented earlier and learnings from the same.

Table 2: List of experts consulted

S.No.	Name	Designation	Organisation
1	Professor C R Babu	Professor Emeritus	Centre for Environmental Management of Degraded Ecosystems, University of Delhi
2	Mr A R Sinha, IFS	Ex-PCCF, Working Plan, Uttarakhand	Uttarakhand Forest Department
3	Dr A Arunachalam	Director	Central Agroforestry Research Institute, ICAR
4	Dr A K Handa	Scientist	Central Agroforestry Research Institute, ICAR
5	Mr Sanjeeva Pandey, IFS	Ex-PCCF, Himachal Pradesh	Himachal Pradesh Forest Department
6	Professor Virender Singh	Ex-Chief Scientist	CSK Himachal Pradesh Agricultural University, Palampur
7	Dr B S Sajwan, IFS	Ex- PCCF, Arunachal Pradesh, and Former Expert Member, National Green Tribunal	Arunachal Pradesh Forest Department and National Green Tribunal
8	Dr. Yash Veer Bhatnagar	Senior Scientist	Nature Conservation Foundation
9	Dr Sudesh Ratodra	Principal Scientist	Regional Research Centre, Indian Grassland and Forest Research Institute, Palampur
10.	Mr Hem Pande, IAS (Retired)	Retired IAS officer	Government of India
11.	Dr Lal Singh	Director	Himalayan Research Group, Shimla
12.	Mr Kunal Satyarthi, IFS	Principal	Central Academy for State Forest Service
13.	Professor K.G. Saxena	Professor	School of Environmental Sciences, Jawaharlal Nehru University
14.	Dr. J. C. Kuniyal	Scientist-G & Head	Centre for Environmental Assessment and Climate Change (CEA&CC) G.B. Pant National Institute of Himalayan Environment
15.	Dr. K. M. Jayahari	Country Coordinator	Food and Landuse Coalition
16.	Dr. Vijay Ramprasad	Senior Researcher	CEDAR

3 Results and Discussion

3.1 Mapping degradation profile

Figure 7 details the degradation profile of the landscape.

3.2 Landscape level NDVI analysis

Figure 8 showcases the landscape level NDVI analysis.

3.3 Landscape level NPP analysis of grasslands

Results of this analysis are showcased in Figure 9.

3.4 Delineation of four Sub-River Basins

The delineated sub-river basins are detailed in Figure 10.

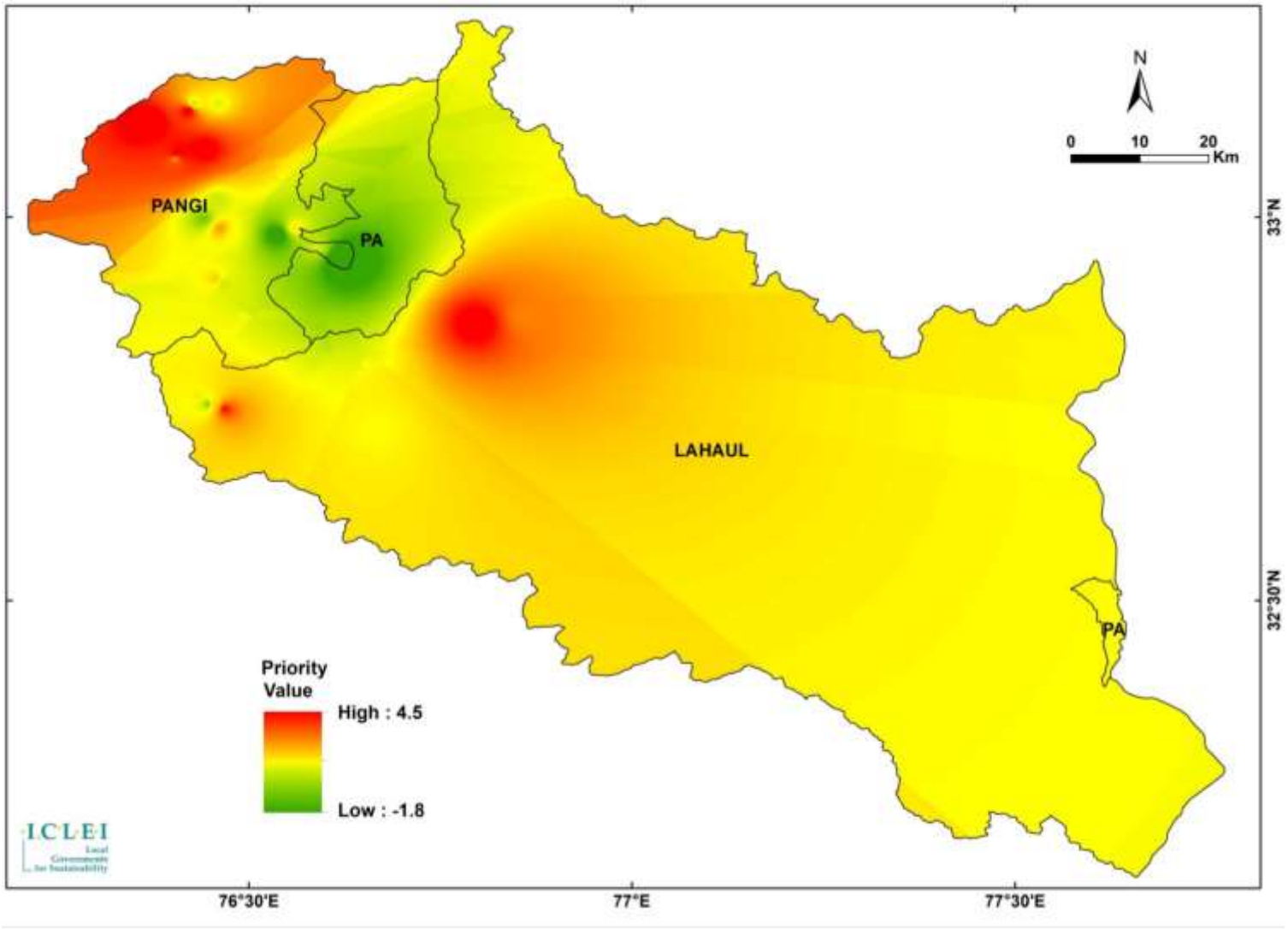


Figure 7: Degradation profile of the landscape

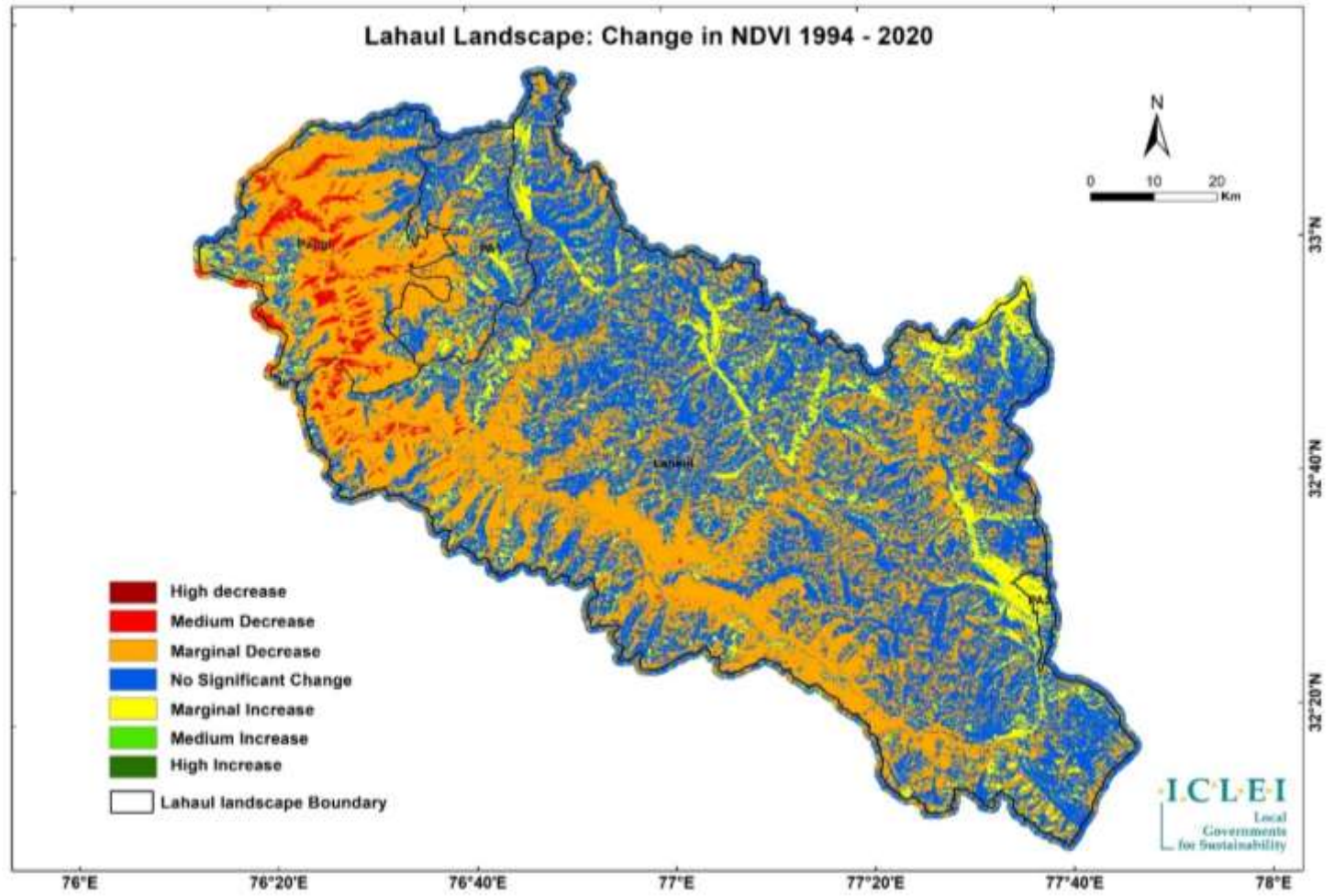


Figure 8: Landscape level NDVI analysis

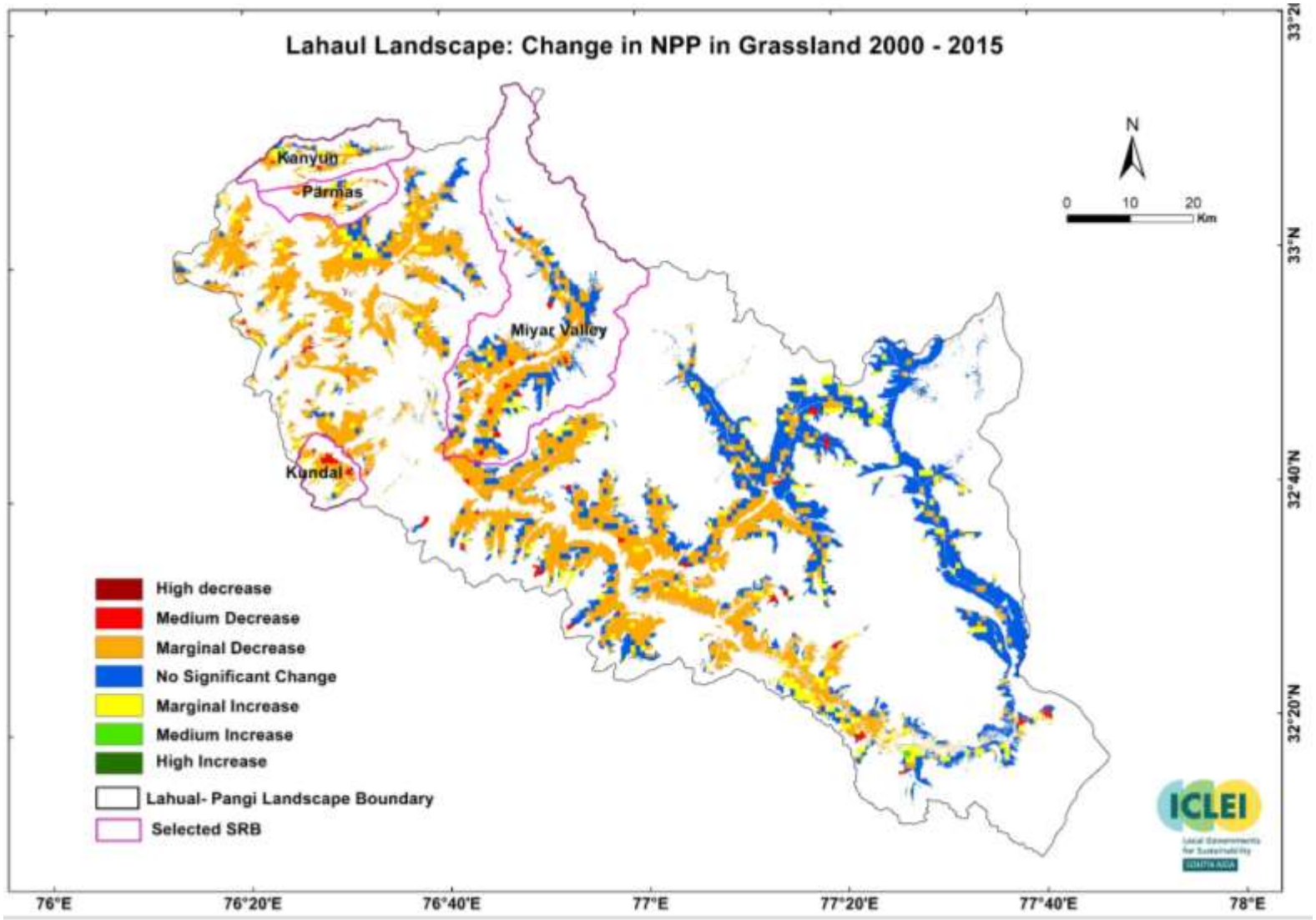


Figure 9: NPP analysis of the grasslands in the landscape

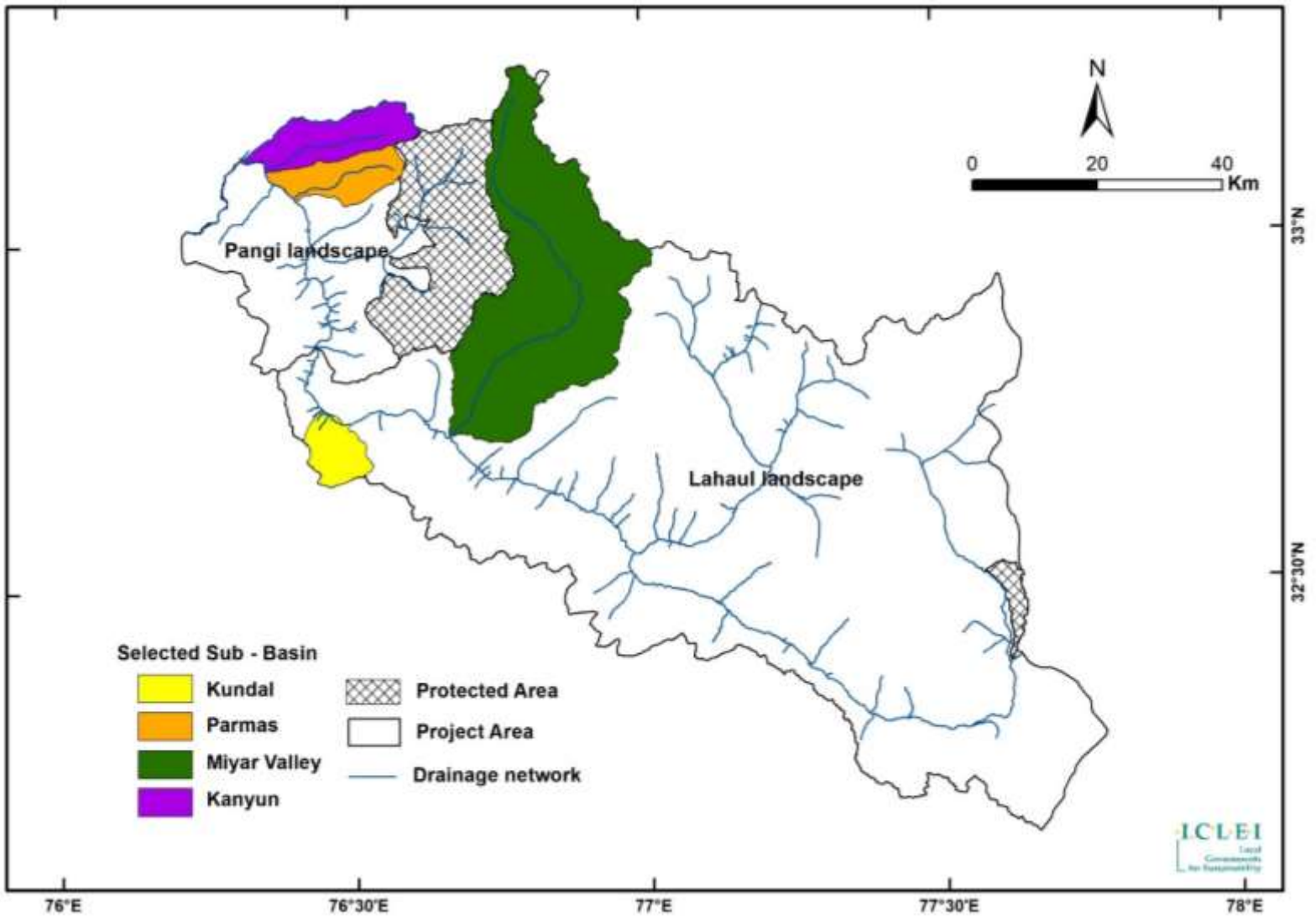


Figure 10: Delineated sub-river basins

3.5 Sub-River Basin level degradation analysis

3.5.1 Miyar Sub-River Basin

Miyar sub-river basin extends from 76^0 39'23'' to 77^0 1' 41'' East longitude and 32^0 42'23'' 33^0 15'42'' North latitude. The elevation of the sub-river basin varies from 2585m to 6421m MSL. The total area of the sub river basin is 967.31 km^2.

Landuse in the sub-river basin

Figure 11 details the landuse in the sub-river basin. The analysis shows that grasslands cover 26 percent of the sub-river basin (Table 3).

Table 3: Land Classes in Miyar Sub-River Basin

Land class	Area	Area %
Agriculture	271.11	0.28
Barren Land	22657.54	23.54
Dry Alpine Pasture	25087.92	26.07
River/ Dry river/Water body	56.27	0.06
Fan Deposit	240.99	0.25
Glaciers	15173.44	15.77
Moraines	1919.83	1.99
Dry temperate forest	681.46	0.71
Moraines	1036.80	1.08
Marshy land	48.26	0.05
Moraines	421.73	0.44
River/ Dry river/Water body	246.35	0.26
Settlement	9.83	0.01
Snow cover	28067.54	29.16
Sub Alpine forest	310.37	0.32
River/ Dry river/Water body	18.01	0.02

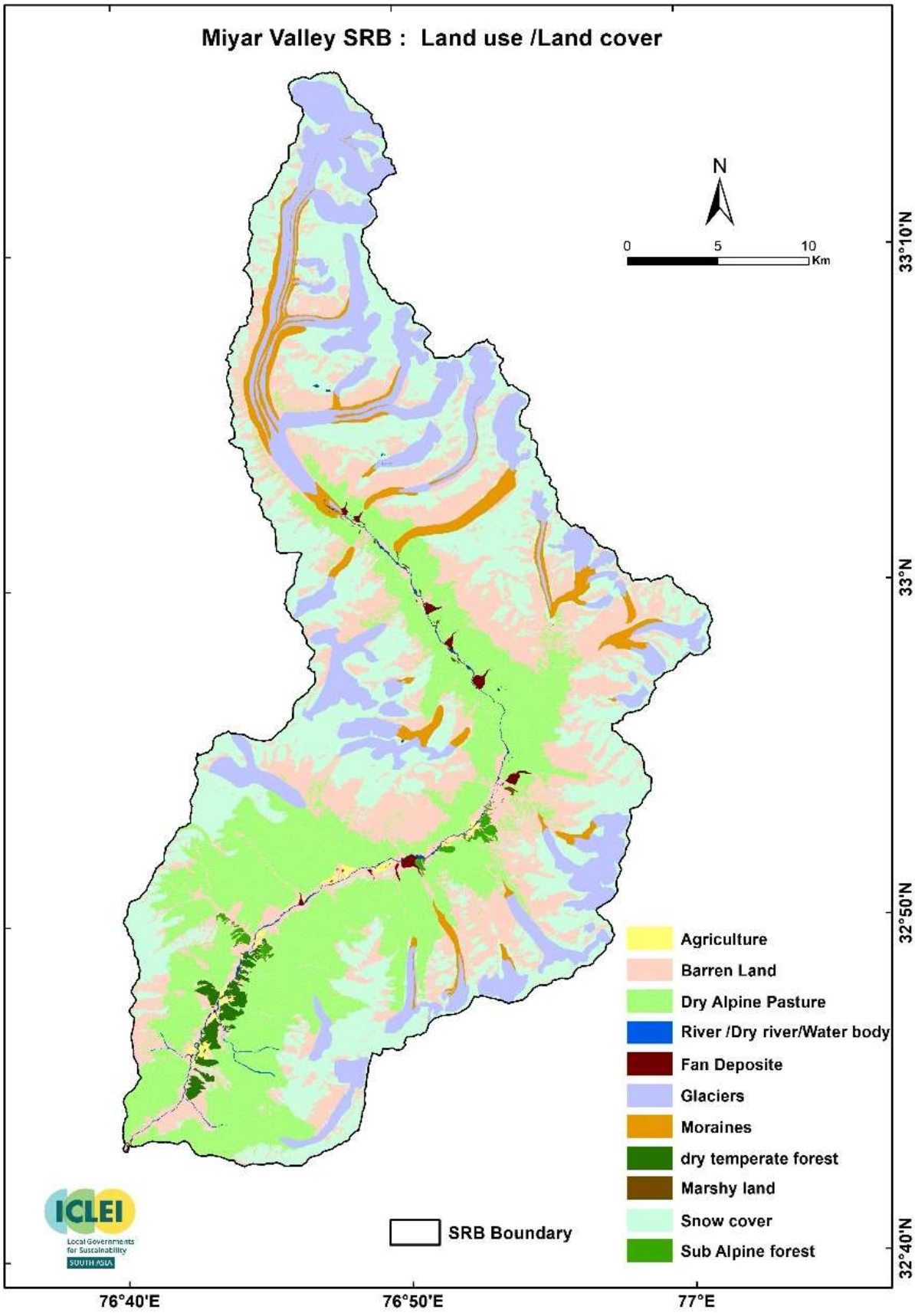


Figure 11: Land Use Land Cover Map of Miyar Sub-River Basin

An elevation-wise analysis of the land use of Miyar sub-river basin shows that the grasslands primarily fall in the medium elevation zone (18655.41ha), followed by low elevation zone (6293.13 ha). Only a very small area of grasslands falls in high elevation zone (135.42 ha). Table 5 and Figure 12 provide the details.

Table 4: Elevation wise distribution of Land Classes in Miyar Sub-River Basin

Land class	**Area (in ha)**		
	Low Elevation	**Medium Elevation**	**High elevation**
Agriculture	270.92	0	0
Barren Land	2360.80	15509.70	4781.84
Dry Alpine Pasture	6293.13	18655.41	135.42
Dry river	37.40	18.87	0
Fan Deposit	138.10	102.89	0
Glaciers	0	7411.85	7742.57
Ground/ End/ Terminal moraines	0	1914.50	5.33
Himalayan dry temperate forest	681.46	0.01	0
Lateral moraines	0	1019.05	17.74
Marshy land	20.71	27.55	
Medial moraines	0	414.50	7.22
River	198.36	47.99	0
Settlement	9.78	0	0
Snow cover	188.05	12918.37	14910.42
Sub Alpine forest	277.63	32.74	0
Water body	3.05	14.97	0

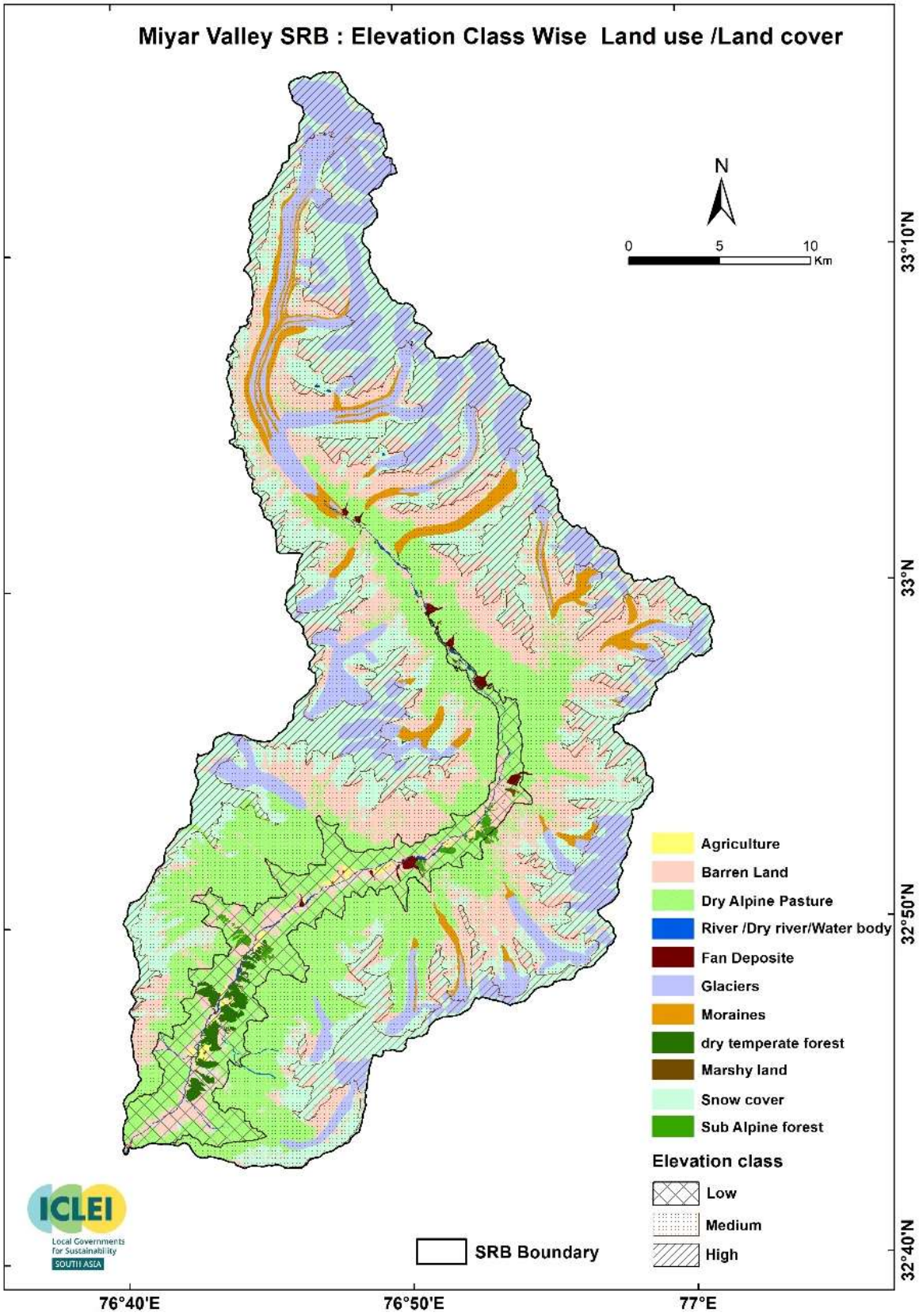


Figure 12: Land Use Land Cover Map of Miyar Sub-River Basin

NPP change analysis in the sub-river basin

NPP change analysis (Figures 13 and 14) shows that in the years between 2005-2010, there was a sharp decline in the NPP. One of the factors for the same can be the decline in winter rain during that period. Winter rain is essential for the germination of perennial herbs and also contributes to the growth of shrubs and trees. Figure 13 details the areas where changes in NPP have been observed.

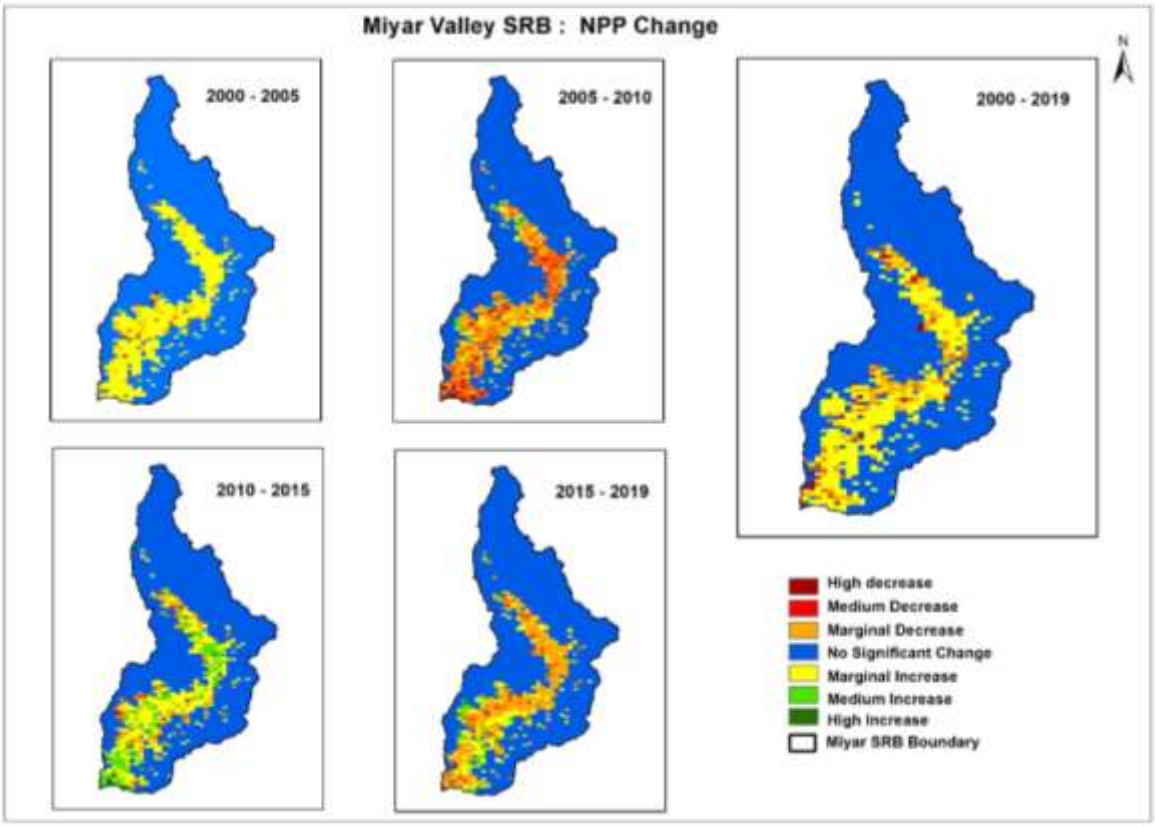


Figure 13: NPP change in Miyar Sub-River Basin

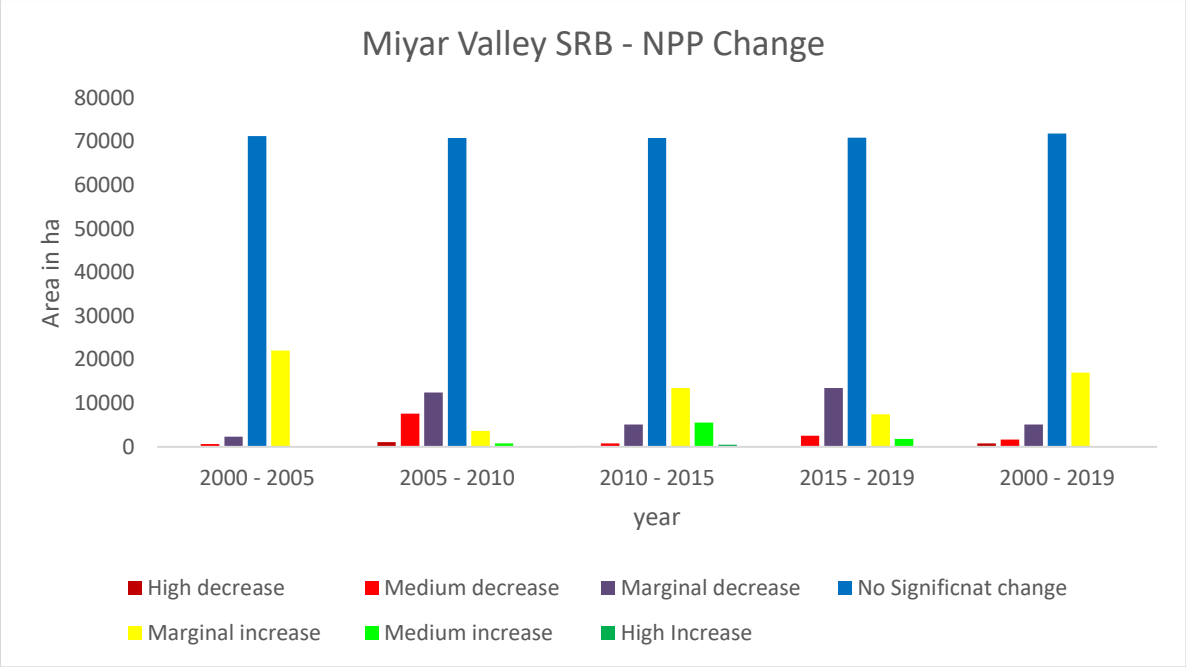


Figure 14: Graph depicting NPP change in Miyar Sub-River Basin

NPP change analysis in the grasslands of the sub-river basin

An analysis of the NPP change in the grasslands (Table 5 and Figure 15) in the sub-river basin shows the same trend of significant decline in NPP in the duration of 2005-2010. Decline in winter rain is one of the factors as winter rain is essential for germination of the grasses and other annual herbs in the grasslands. Figure 9 details the areas where changes in NPP have been observed in the grasslands.

Table 5: NPP change in Miyar Sub-River Basin

NPP Change class	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2019	2000 - 2019
High decrease	51.84	834.03	186.39	49.86	594.54
Medium decrease	333.09	5665.41	510.57	1844.73	1034.55
Marginal decrease	1572.30	8603.28	3476.16	9388.26	3734.10
No Significant change	7730.37	7388.55	7468.02	7539.39	7978.14
Marginal increase	15390.27	2003.85	9038.97	4702.86	11736.54
Medium increase	0.00	581.76	4115.61	1472.31	0.00
High Increase	38.25	39.24	320.40	118.71	38.25

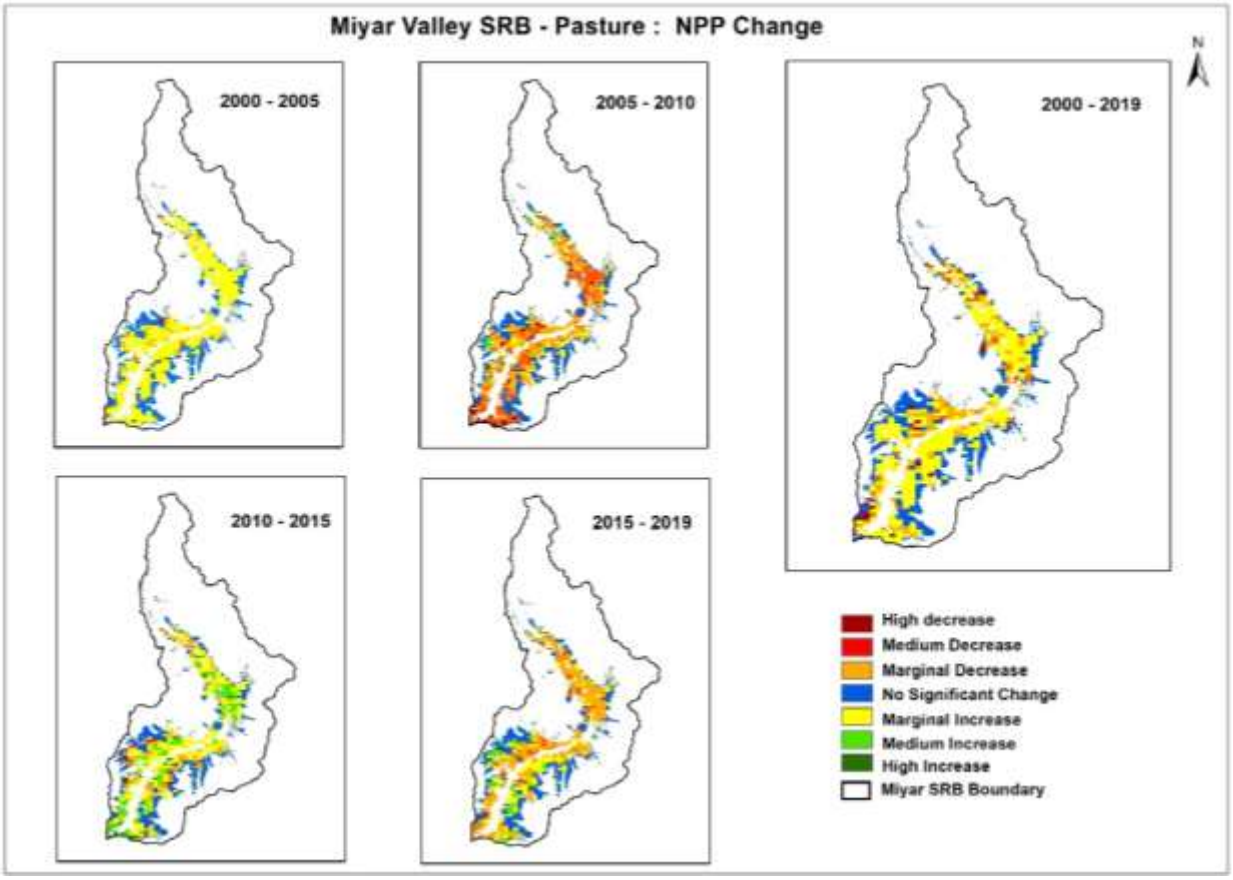


Figure 15: NPP change in grasslands in Miyar Sub-River Basin

Mapping degradation in the sub-river basin

Degradation was mapped for Miyar sub-river basin. Figure 16 provides details of degradation in the sub-river basin.

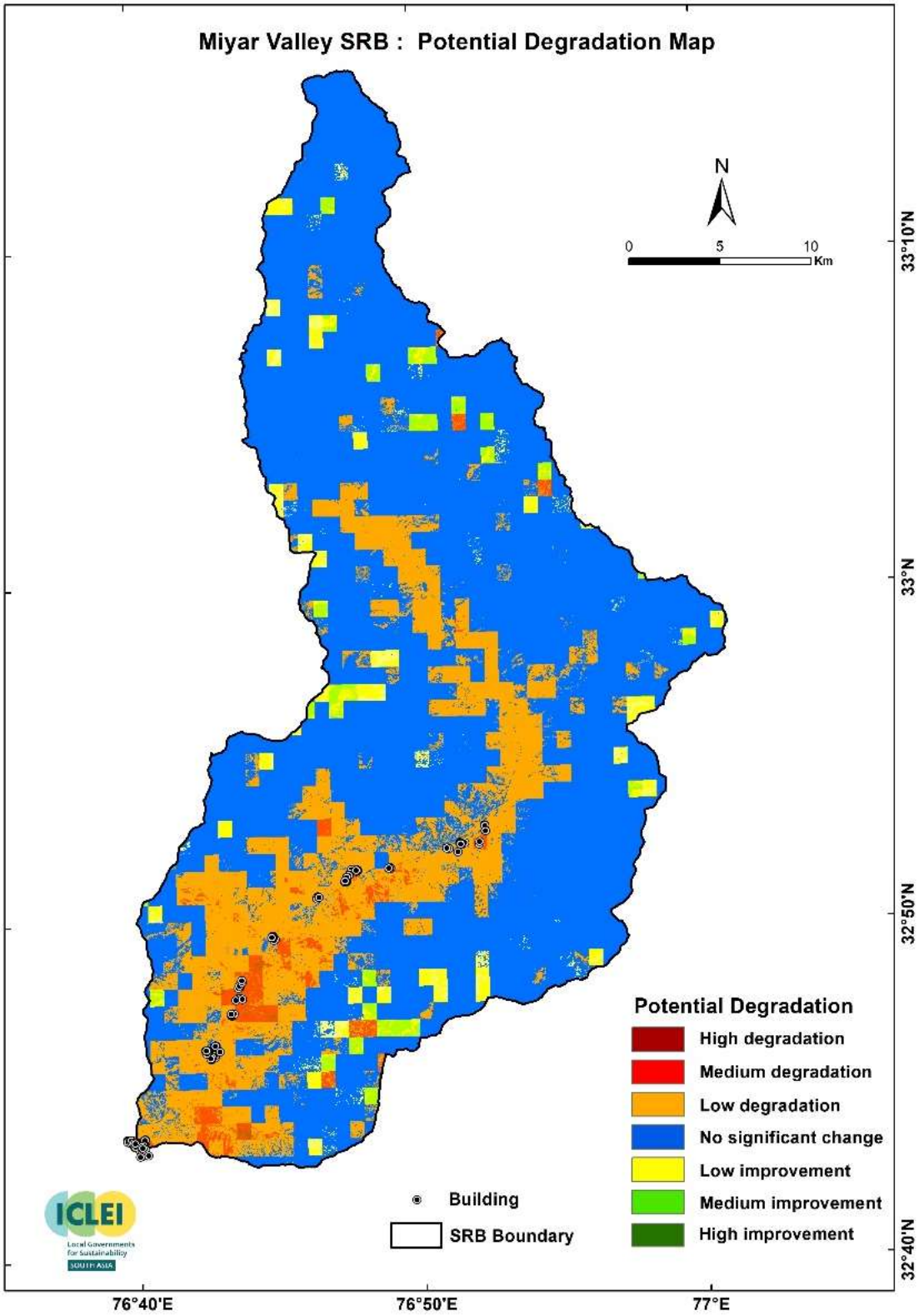


Figure 16: Degradation in Miyar Sub-River Basin

An elevation-wise analysis of the degradation in Miyar sub-river basin (Figure 17 and Table 6) shows that majority of the degradation has taken place in the areas at middle elevation, followed by the areas at low elevation. With regard to the intensity of degradation, the sub-river basin faces majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the sub-river basin.

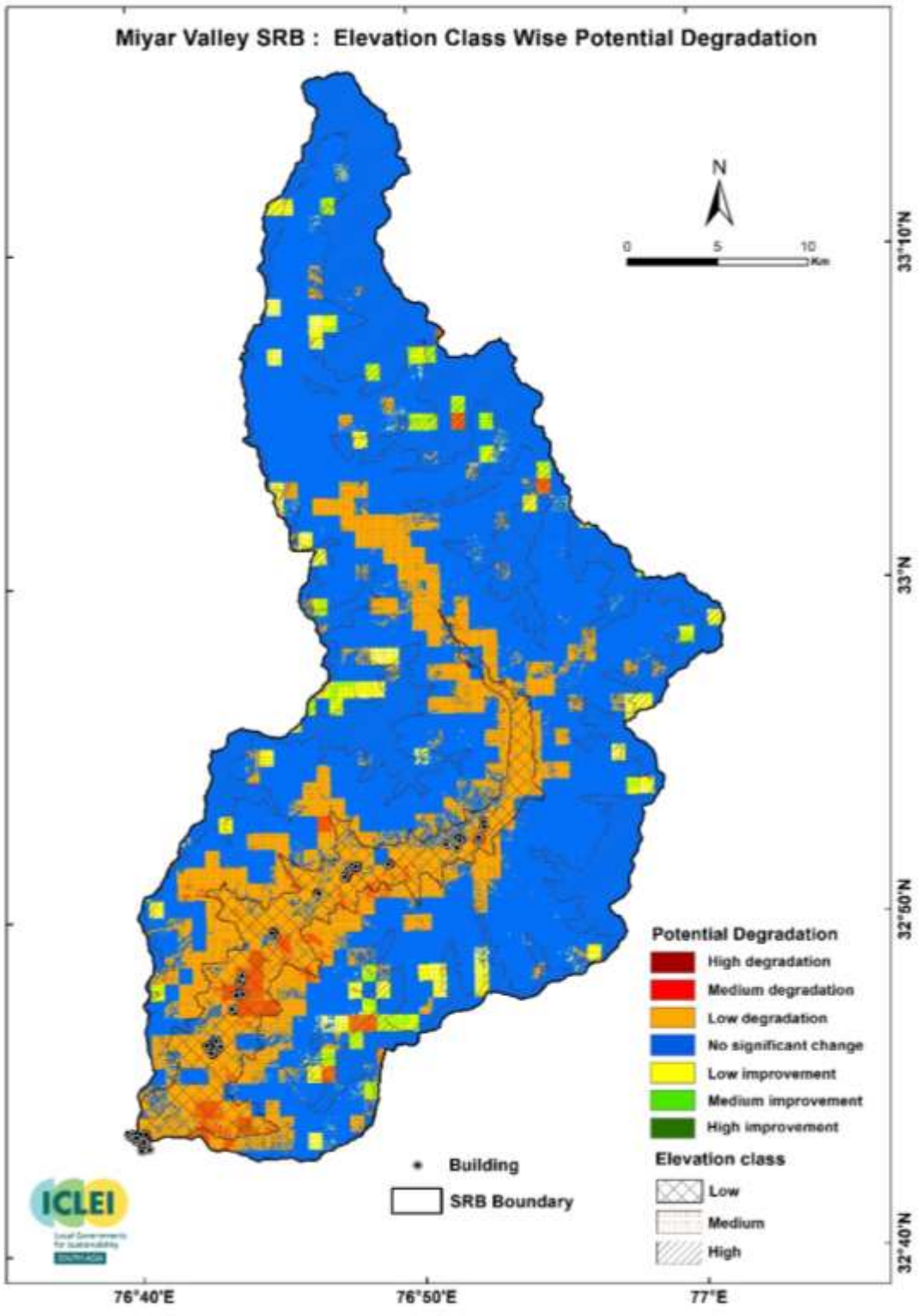


Figure 17: Elevation-wise degradation in Miyar Sub-River Basin

Table 6: Elevation-wise degradation in Miyar Sub-River Basin

Degradation class	Area (in ha)		
	Low Elevation	**Medium Elevation**	**High elevation**
High degradation	55.26	3.33	0.27
Medium degradation	1301.13	440.55	256.14
Low degradation	7753.23	12606.84	475.47
No Significant change	1371.51	42010.38	25151.22
Low Improvement	0.99	2302.65	1370.34
Medium Improvement	0	723.60	575.82
High Improvement	0	3.96	0.63

Mapping degradation in the grasslands in the sub-river basin

Figure 18 and Table 7 detail the levels of degradation in the grasslands in Miyar Sub-River Basin. It can be seen that around 58.95 percent of the grasslands in this landscape are under various levels of degradation. Figure 18 showcases the areas of degradation, along with the intensity of the same.

Table 7: Degradation in grasslands in Miyar Sub-River Basin

S. No	Change Class	Area (in h)	Area % (to total GA of SRB)
1	High degradation	35.55	0.14
2	Medium degradation	969.39	3.87
3	Low degradation	13748.94	54.94
4	No significant change	10103.85	40.37
5	Low improvement	167.58	0.67
6	Medium improvement	25.47	0.10

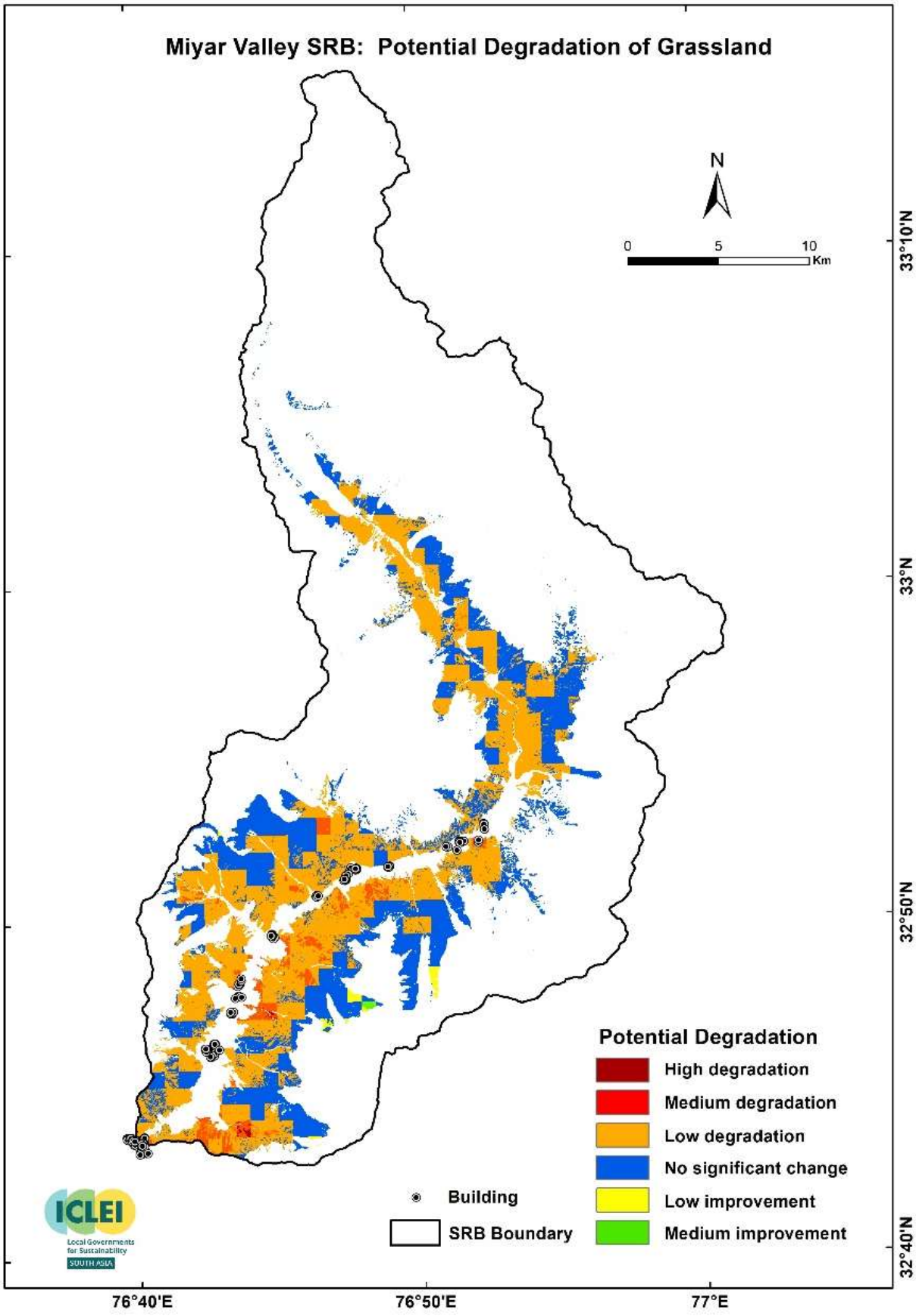


Figure 18: Degradation in grasslands in Miyar Sub-River Basin

An elevation-wise analysis of the degradation in the grasslands in Miyar sub-river basin (Figure 19 and Table 8) shows that majority of the degradation has taken place in the areas at middle elevation, followed by the areas at low elevation. With regard to the intensity of degradation, the grasslands in the sub-river basin face majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the grasslands in the sub-river basin.

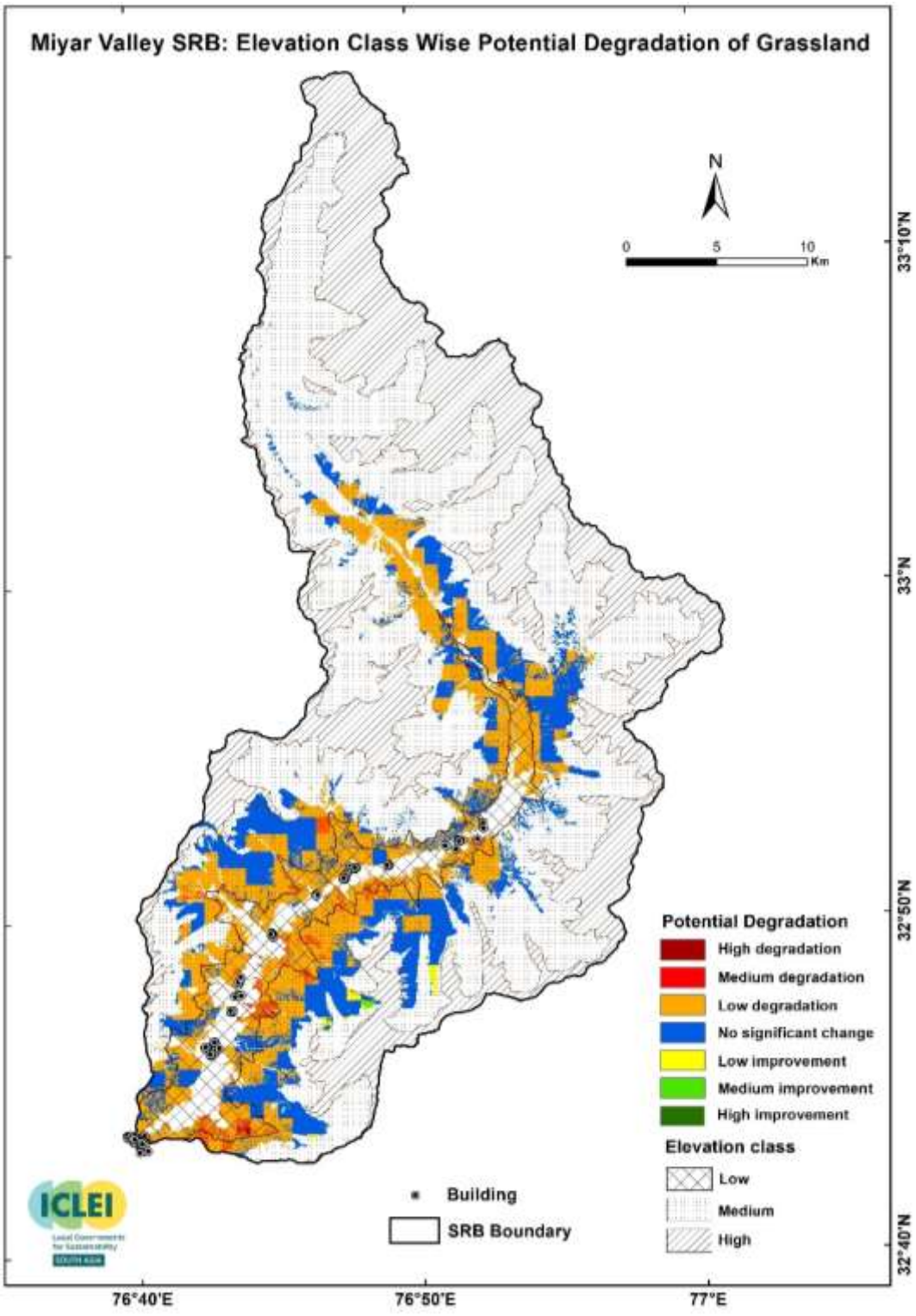


Figure 19: Elevation-wise degradation in grasslands in Miyar Sub-River Basin

Table 8: Elevation-wise degradation in grasslands in Miyar Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	Medium Elevation	High elevation
High degradation	32.04	3.33	0
Medium degradation	576.63	391.05	0
Low degradation	4696.83	9046.89	1.8
No Significant change	982.98	8997.03	122.58
Low Improvement	0	161.82	5.76
Medium Improvement	0	23.58	1.89
High Improvement	0	0	0

Analysis of soil of the grasslands in the sub-river basin

Analysis of the soil samples of the grasslands in the sub-river basin and that of the control site were carried out. A comparison of the same (Figure 20 and Table 9) shows that the soils in the grasslands of the sub-river basin have lower electrical conductivity, organic carbon, nitrogen, phosphorus and potassium, as compared to the soils of the control site.

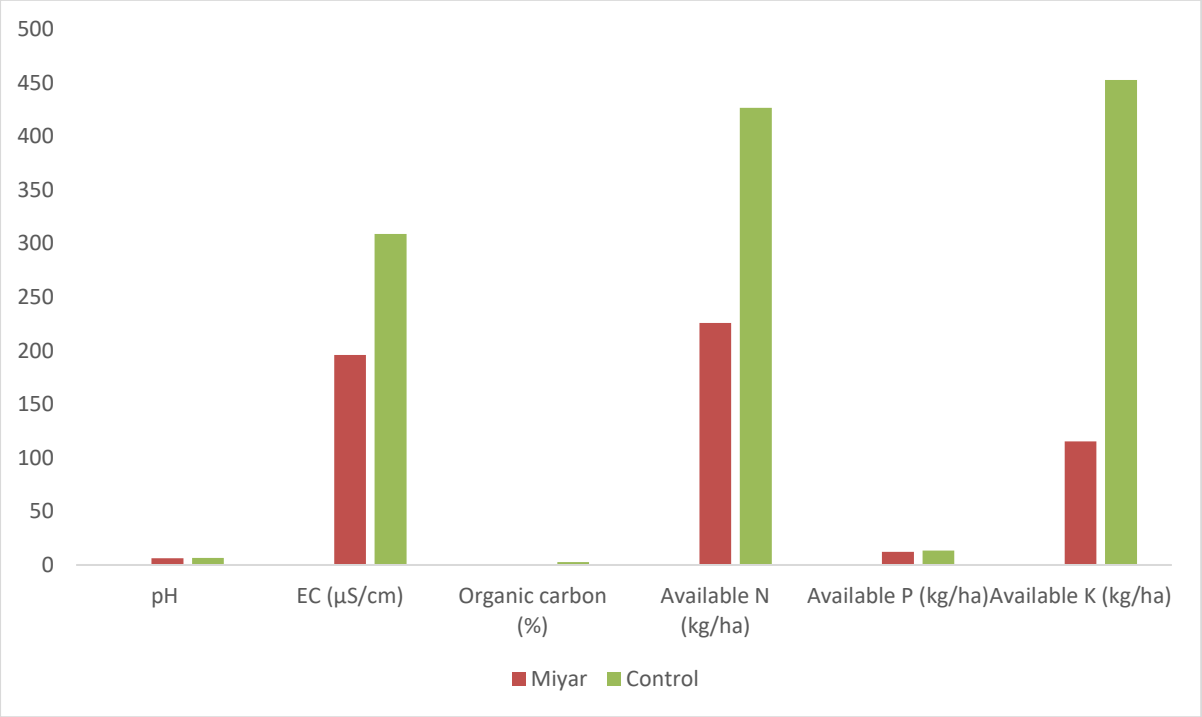


Figure 20: Comparative analysis of soil parameters of grasslands in Miyar Sub-River Basin and grasslands at control site

Table 9: Comparative analysis of soil parameters of grasslands in Miyar Sub-River Basin and grasslands at control site

Sample ID	pH	EC (µS/cm)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Miyar	6.29	196	0.916	225.79	12.32	115.36
Control	6.55	309	2.843	426.5	13.44	452.48

Analysis of quadrat studies conducted in the grasslands of the sub-river basin

A comparative analysis of the families of floral species recorded from grasslands in Miyar sub-river basin and that from the control site shows that the number of species of grasses (family Poaceae) is much lower in the grasslands of Miyar sub-river basin. In addition, there is a complete absence of legumes (Family Fabaceae) in the grasslands in Miyar sub-rover basin. Legumes are nitrogen fixing plants, and their absence explains the low nitrogen values in the soils in grasslands of Miyar sub-river basin. As depicted in Figure 21, there has been a significant change in the species composition in the grasslands of Miyar sub-river basin, as compared to the grasslands in the control site, which is also an indicator of the degradation in the grasslands in the sub-river basin.

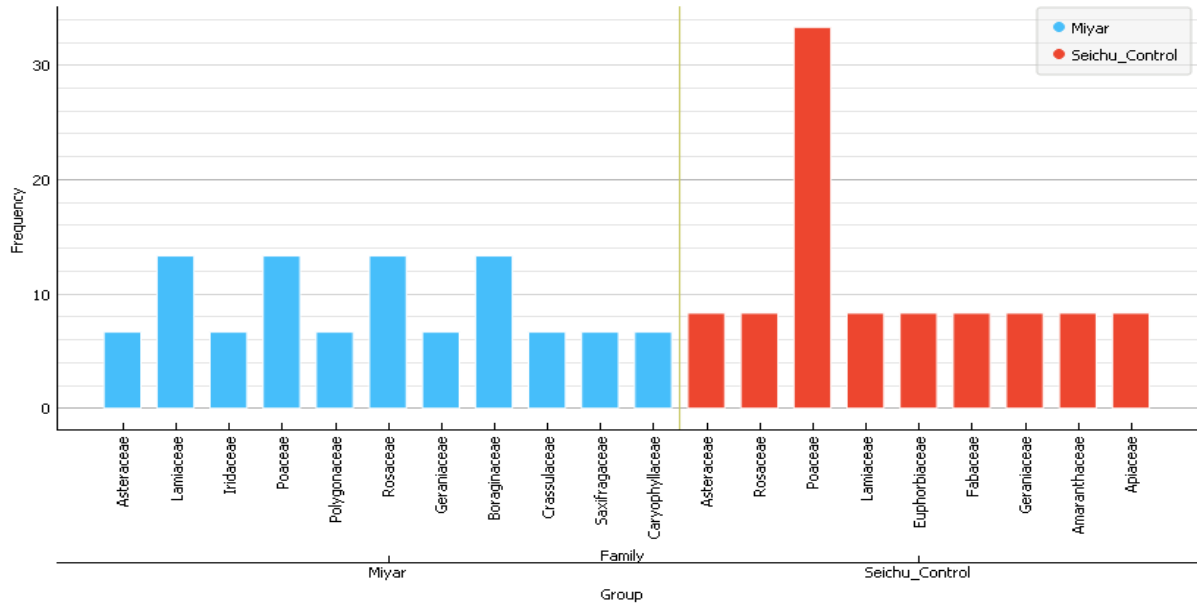


Figure 21: Comparative analysis of plant families found in grasslands in Miyar Sub-River Basin and grasslands at control site

Comparative analysis of the Shannon diversity of grasslands in Miyar sub-river basin and those in control site shows closeness (Figure 22). This indicates that the diversity of plant species in Miyar sub-river basin is nearly as high as that in the control site, but the composition has changed from that of the grasslands in the control site (Figure 21).

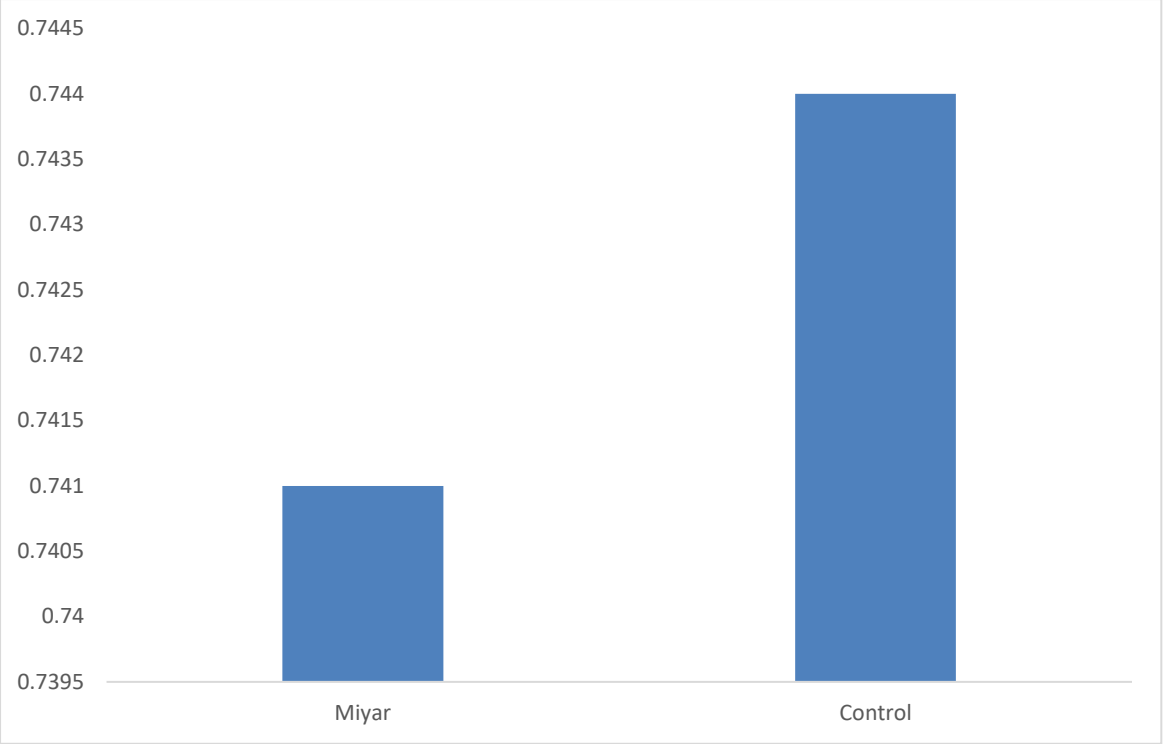


Figure 22: Comparative analysis of the Shannon diversity of grasslands in Miyar sub-river basin and in control site

An analysis of the presence of unpalatable species, which is also an indicator of degradation of the grasslands shows that the grasslands in Miyar sub-river basin have 67 percent palatable and 33 percent unpalatable species. In contrast, the grasslands in the control site are comprised of 83 percent palatable and 17 percent unpalatable species (Figure 23 and Figure 24).

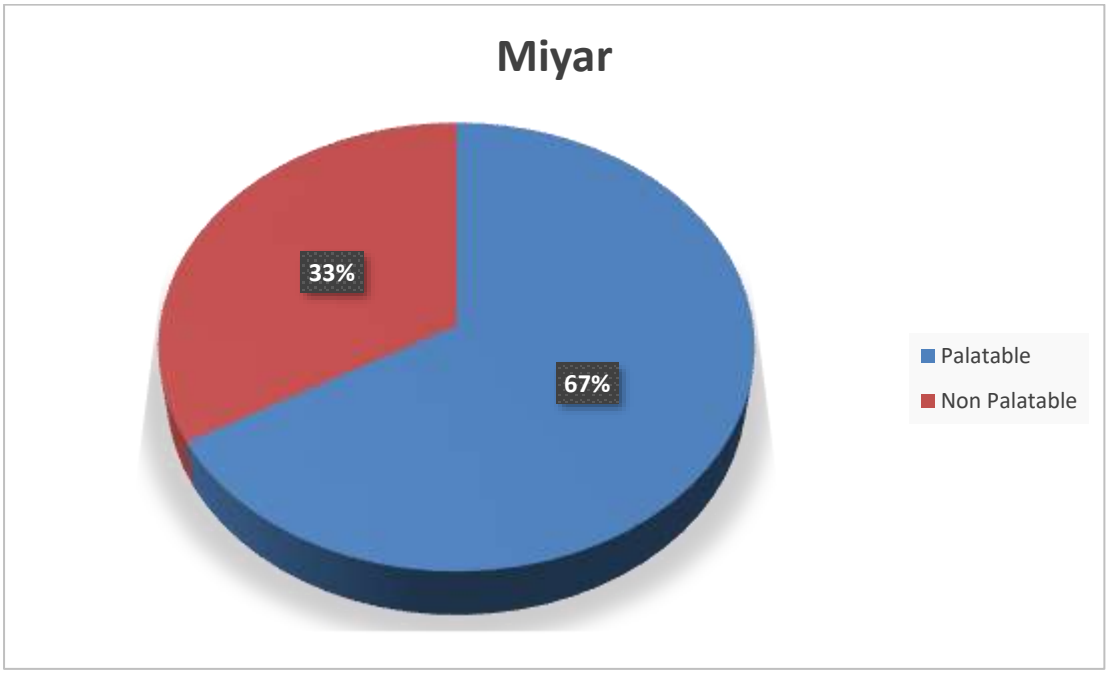


Figure 23: Comparative analysis percent palatable and unpalatable species in grasslands in Miyar sub-river basin

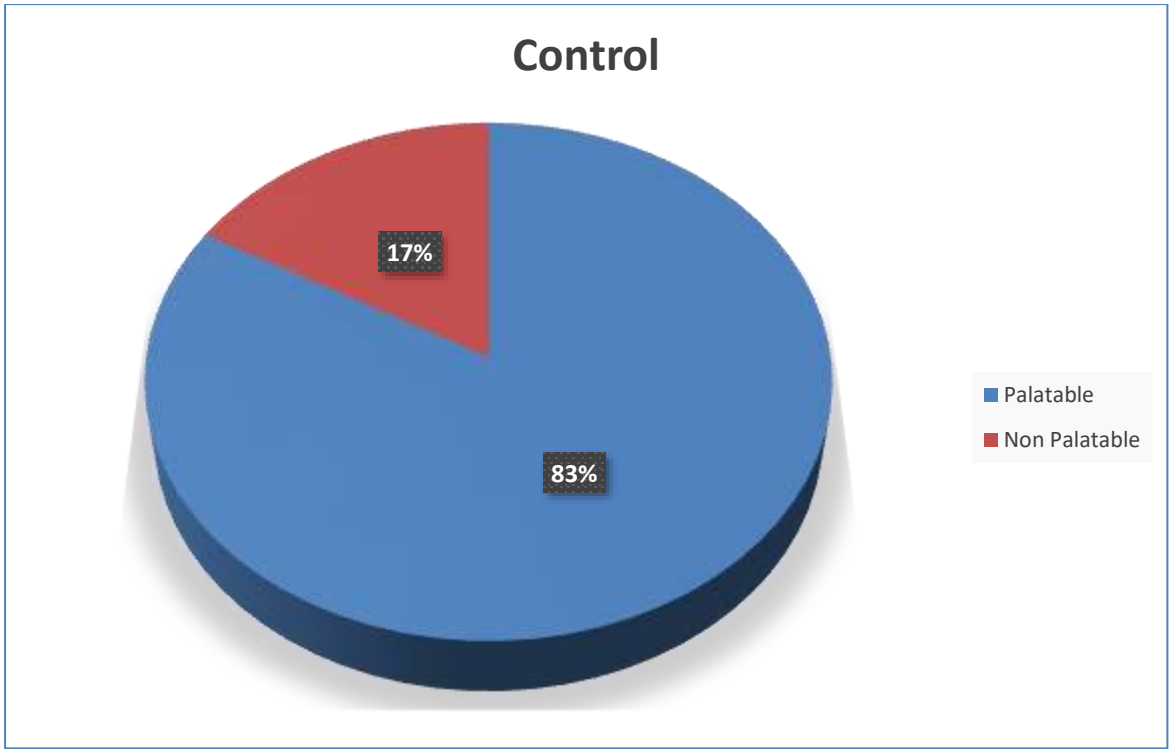


Figure 24: Comparative analysis percent palatable and unpalatable species in grasslands in control site

Views of the nomadic pastoralists on grassland degradation in the sub-river basin

As mentioned in the fifth report, detailed discussions were carried out with the nomadic pastoralists- Gaddis to understand their views and perceptions on grassland degradation and impacts of the same. Gaddis have reported change in the species composition in the grasslands, which has led to decline in fodder availability by around 50 percent. The prominent palatable species that have declined include *Festuca gigantica*, *Sibbaldia* sp.,*Potentilla* sp. and *Phleum alpinum*. They feel this has happened due to climate change, as a result of which winter rain has declined significantly. This has impacted the germination of species. In addition, increase in temperature has led to changes in plant phenology, thereby resulting in changes in the species composition in the grasslands in the sub-river basin. A discussion on the impact of grassland degradation on the weight gain by livestock in two months now, as compared to the gain 20 years back showed a decline in the weight gain (Table 10).

Table 10: Comparative analysis change in weight gain by livestock

Animal	Weight-increase in 2 months (20 year back)	Weight-increase in 2 months (now)
Goat	5-6kg	3-4kg
Sheep	7-8kg	5-6kg

Drivers of degradation in the sub-river basin

A list of the drivers of degradation in the sub-river basin (not limited to grasslands) was developed. The major drivers of degradation are:

a) **Change in cropping pattern**- There has been a shift in crops from traditional crops (local paddy, maize and wheat) to cash crops such as peas, cauliflower, and tomato. This on one hand has reduced the food self-sufficiency and on the other hand has increased pressure on the grasslands for fodder. The traditional crops were also a major source of fodder, in absence of which, the villagers have to depend more on the fodder from the grasslands.
b) **Human wildlife conflict**- Change in cropping pattern has led to increased conflicts with monkeys who come to the fields for pea. The conflict earlier was more with Himalayan Black Bear which used to raid the fields for maize.
c) **Pesticide use**- Unlike in the past, the community is now using pesticides and chemical fertilizers in order to increase agricultural production. Discussions with the community from Urgos and Khanjar villages revealed that the traditional use of cow dung as the major fertilizer has been replaced with chemical fertilizers. Respondents believe that the use of chemical fertilizers and pesticides degrading the soil quality and affecting the biodiversity of the area.
d) **Reduction in pollinator (bee) population**- The community attributes this to the rampant use of chemical pesticides and fertilisers. The reduction in bee population is so significant that over the years there is a growing demand for hired bee boxes in the apple orchards.
e) **Increase in temperature, leading to phenological changes** – A significant example of the same is the increase in apple plantations in the high-altitude village of Urgos. Twenty years back apple did not flower or fruit there due to very low temperatures. Now due to increase in temperature, apple is nicely fruiting and several orchards have come up in the landscape.
f) **Waste increase and lack of management**- Waste management is an emerging issue and a big challenge. There is absence of a proper waste management mechanism in the villages. They either burn solid waste near the house itself or dump in the nearby streams or river.
g) **Short duration high intensity rainfall and landslides**- Increased incidences of both are leading to loss of land and soil, which is impacting the grasslands and other land use classes in the sub-river basin.

3.5.2 Kundal Sub-River Basin

Kundal sub river basin lies between 76^0 24'52'' to 76^0 32' 18'' East longitude and 32^0 39'3'' to 32^0 45'44'' North latitude and elevation of the river basin varies from 2398 m to 5947 m MSL. The total area of the sub river basin is 86.56 km^2.

Landuse in the sub-river basin

Figure 25 details the landuse in the sub-river basin. The analysis shows that grasslands cover 33.74 percent of the sub-river basin (Table 11).

Table 11: Land Classes in Kundal Sub-River Basin

Land class	Area	Area %
Agriculture	85.89	1
Barren Land	1734.99	20.24
Dry Alpine Pasture	2892.66	33.74
River/ Dry river	21.5	0.25
Dry temperate forest	1038	12.11
River/ Dry river	29.7	0.35
River sediments	0.28	0
Settlement	9.1	0.11
Snow cover	2663.74	31.07
Sub Alpine forest	97.35	1.14

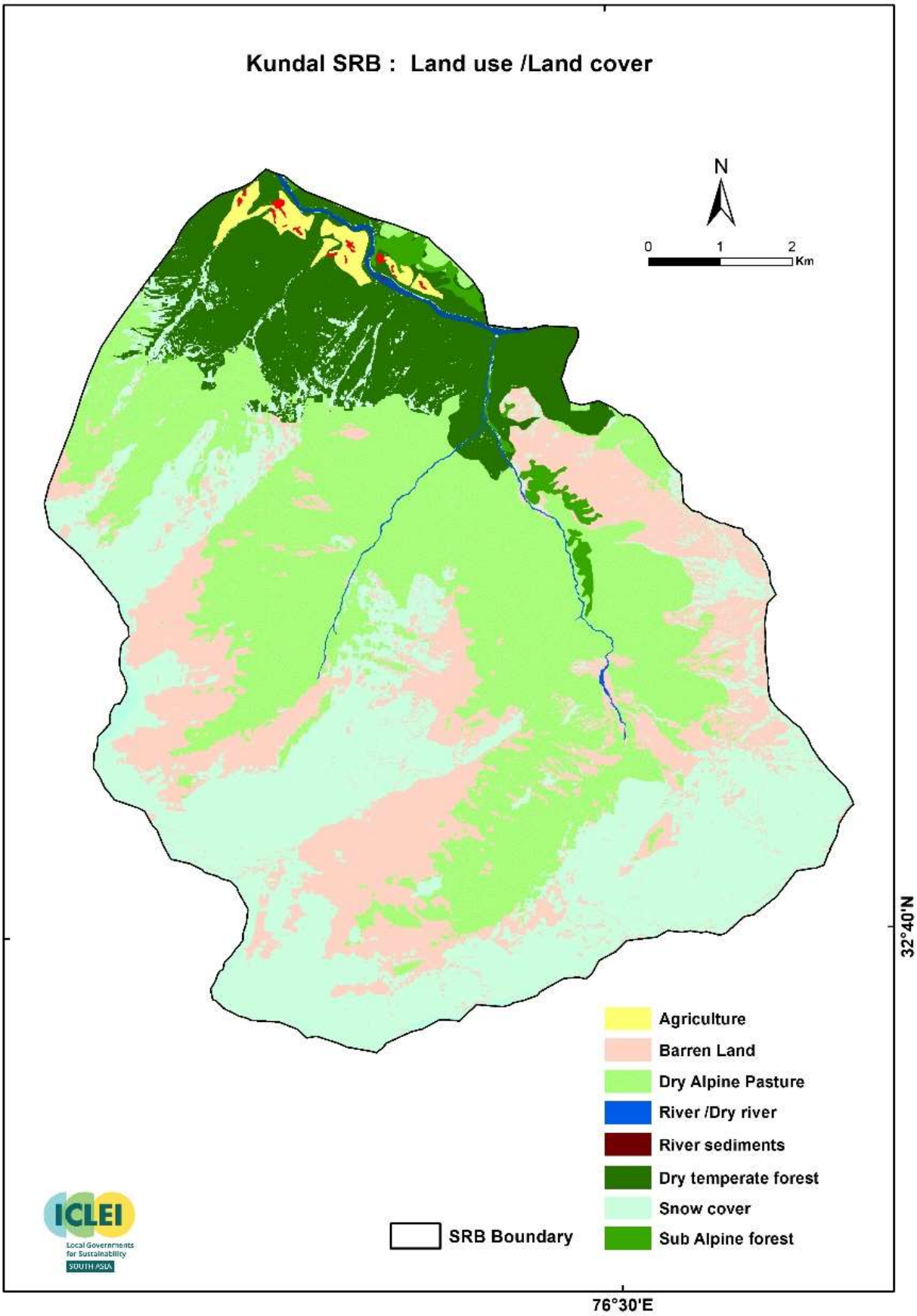


Figure 25: Land Use Land Cover Map of Kundal Sub-River Basin

An elevation-wise analysis of the land use of Kundal sub-river basin shows that the grasslands primarily fall in the medium elevation zone (1835. 85ha), followed by low elevation zone (1056.17 ha). Only a very small area of grasslands falls in high elevation zone (0.02 ha). Table 12 and Figure 26 provide the details.

Table 12: Elevation wise distribution of Land Classes in Kundal Sub-River Basin

Land class	**Area (in h)**		
	Low Elevation	**Medium Elevation**	**High elevation**
Agriculture	85.89	0	0
Barren Land	183.34	1366.69	184.48
Dry Alpine Pasture	1056.17	1835.85	0.02
Dry river	20.53	0.98	0
Himalayan dry temperate forest	1003.51	33.11	0
River	29.51	0	0
River sediment	0.28	0	0
Settlement	9.10	0	0
Snow cover	149.39	1829.49	682.87
Sub Alpine forest	97.17	0	0

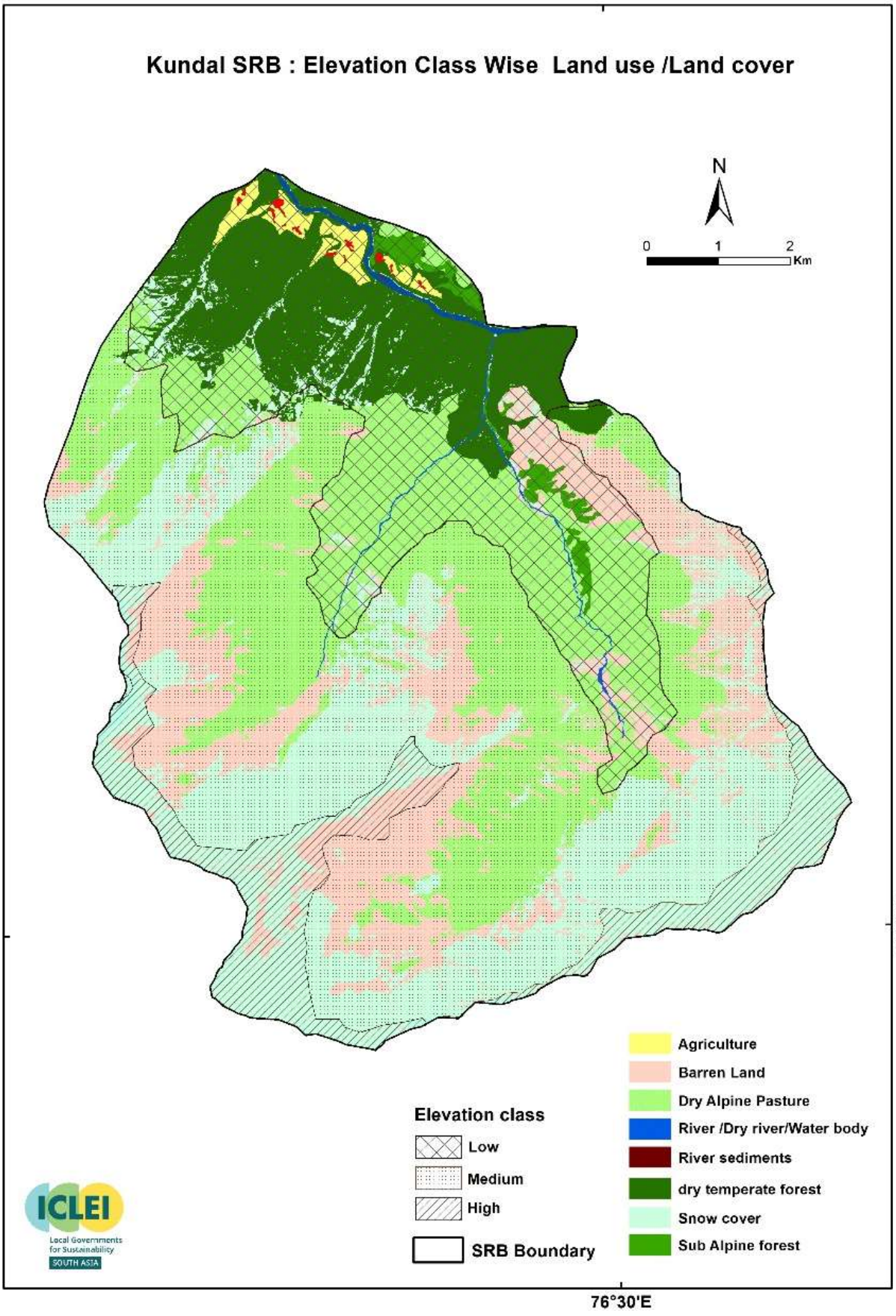


Figure 26: Land Use Land Cover Map of Kundal Sub-River Basin

NPP change analysis in the sub-river basin

NPP change analysis (Figures 27 and 28) shows that in the years between 2005-2010, there was a sharp decline in the NPP. One of the factors for the same can be the decline in winter rain during that period. Winter rain is essential for the germination of perennial herbs and also contributes to the growth of shrubs and trees. Figure 27 details the areas where changes in NPP have been observed.

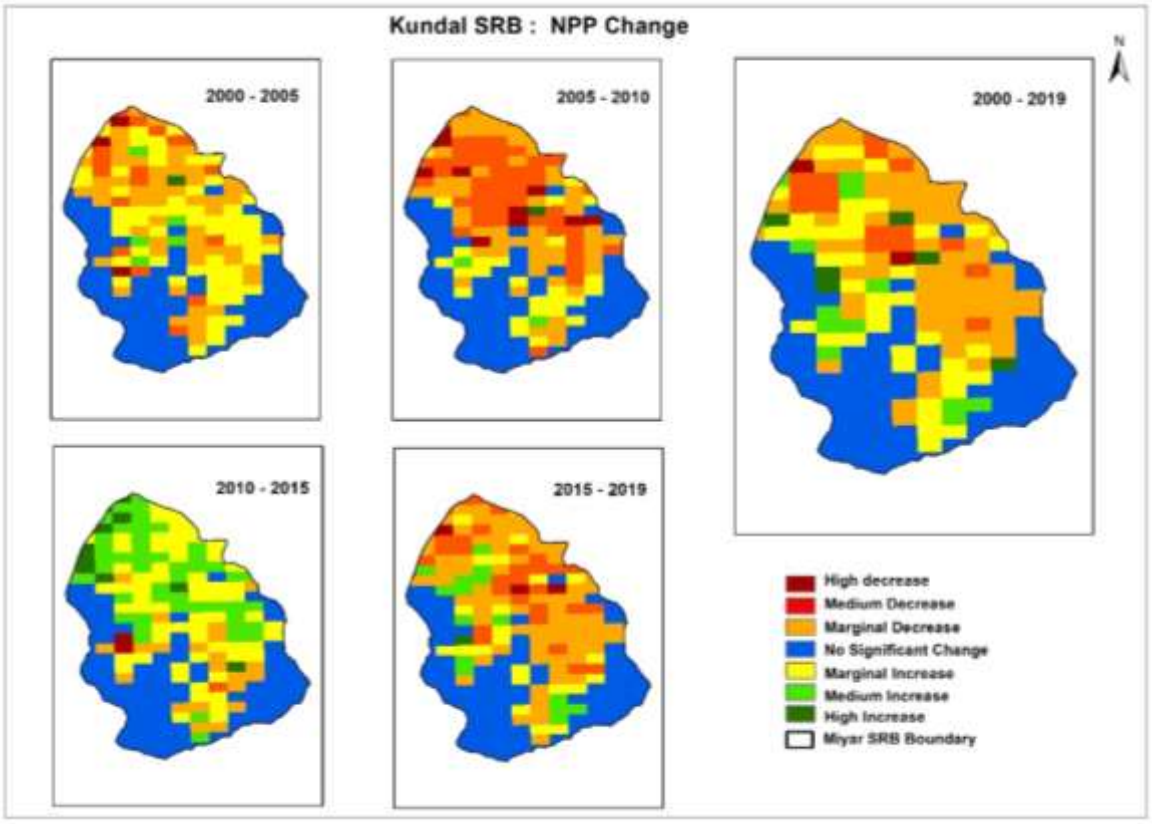


Figure 27: NPP change in Kundal Sub-River Basin

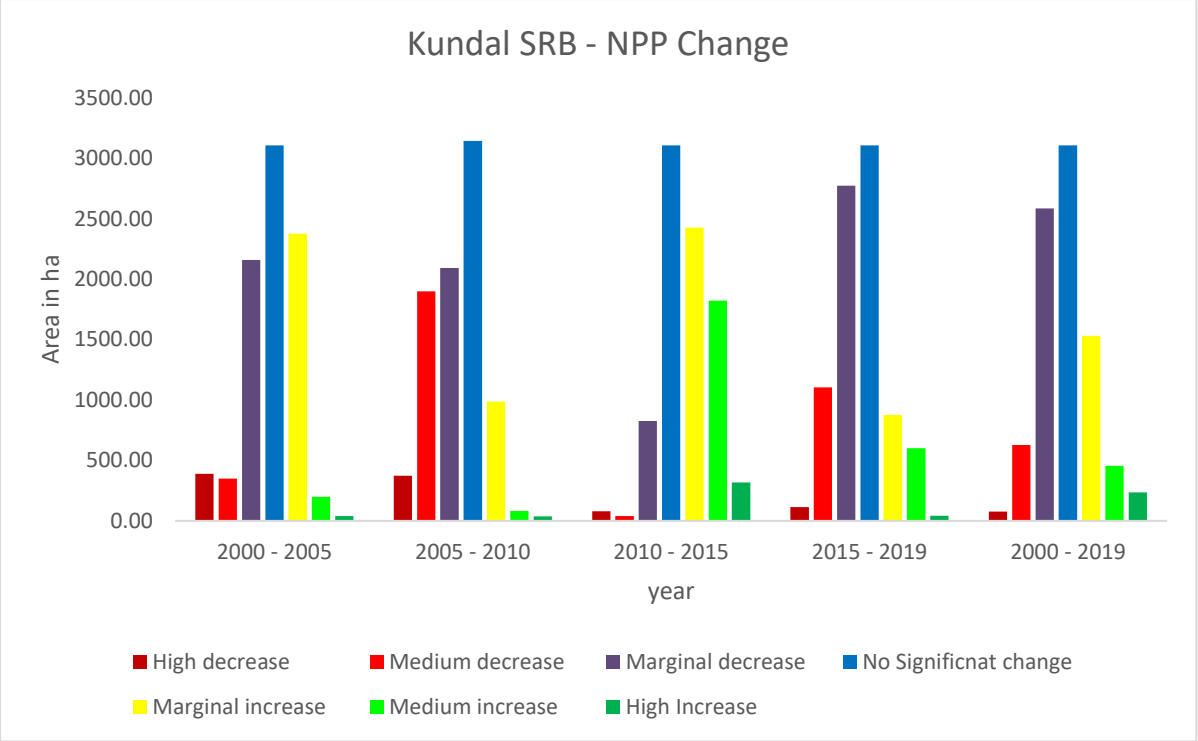


Figure 28: Graph depicting NPP change in Kundal Sub-River Basin

NPP change analysis in the grasslands of the sub-river basin

An analysis of the NPP change in the grasslands (Table 13 and Figure 29) in the sub-river basin shows the same trend of significant decline in NPP in the duration of 2005-2010. Decline in winter rain is one of the factors as winter rain is essential for germination of the grasses and other annual herbs in the grasslands. Figure 29 details the areas where changes in NPP have been observed in the grasslands.

Table 13: NPP change in Kundal Sub-River Basin

NPP Change class	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2019	2000 - 2019
High decrease	91.62	231.75	42.84	42.48	41.94
Medium decrease	157.50	955.44	37.35	576.36	324.45
Marginal decrease	1035.00	938.07	364.50	1467.54	1305.54
No Significant change	230.22	259.83	230.22	230.22	230.22
Marginal increase	1236.96	409.77	1088.91	296.55	660.33
Medium increase	112.95	62.55	956.07	258.12	145.35
High Increase	30.96	37.80	175.32	23.94	187.38

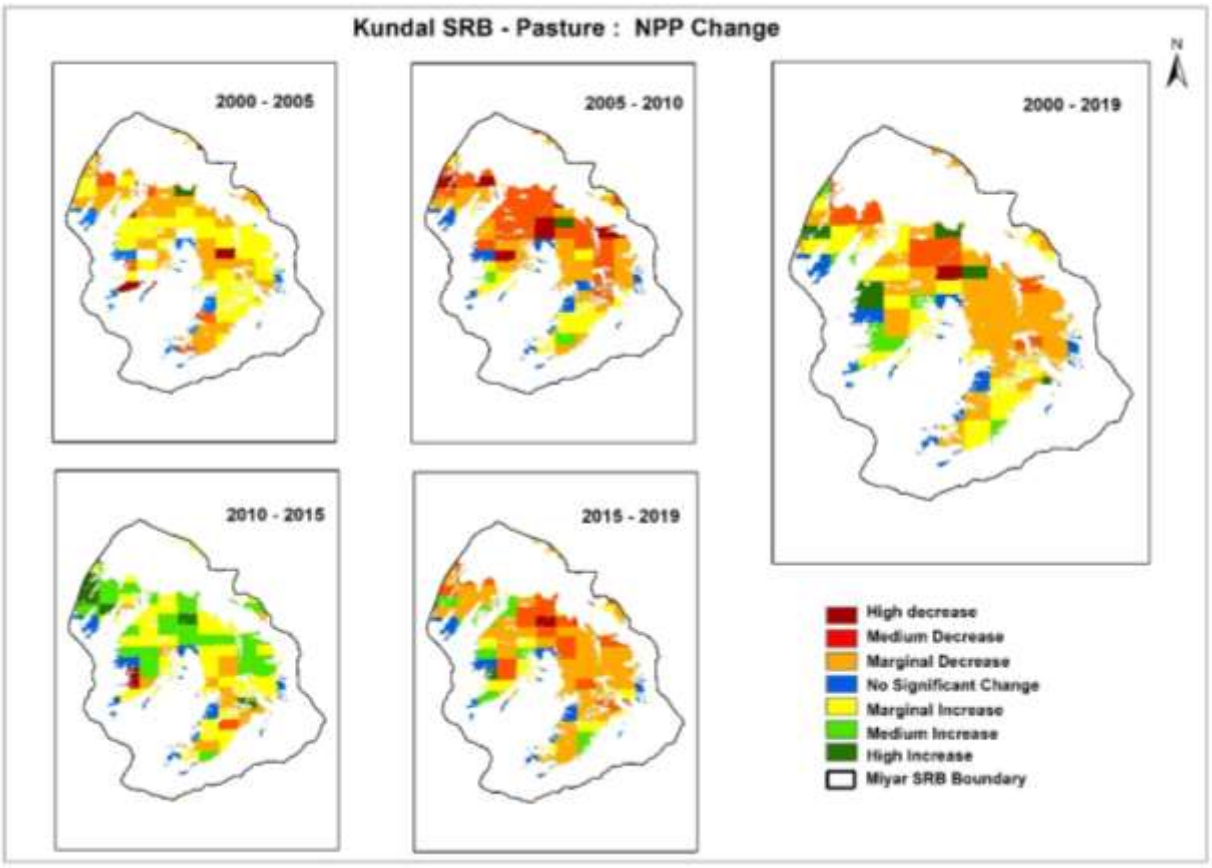


Figure 29: NPP change in grasslands in Kundal Sub-River Basin

Mapping degradation in the sub-river basin

Degradation was mapped for Kundal sub-river basin. Figure 30 provides details of degradation in the sub-river basin.

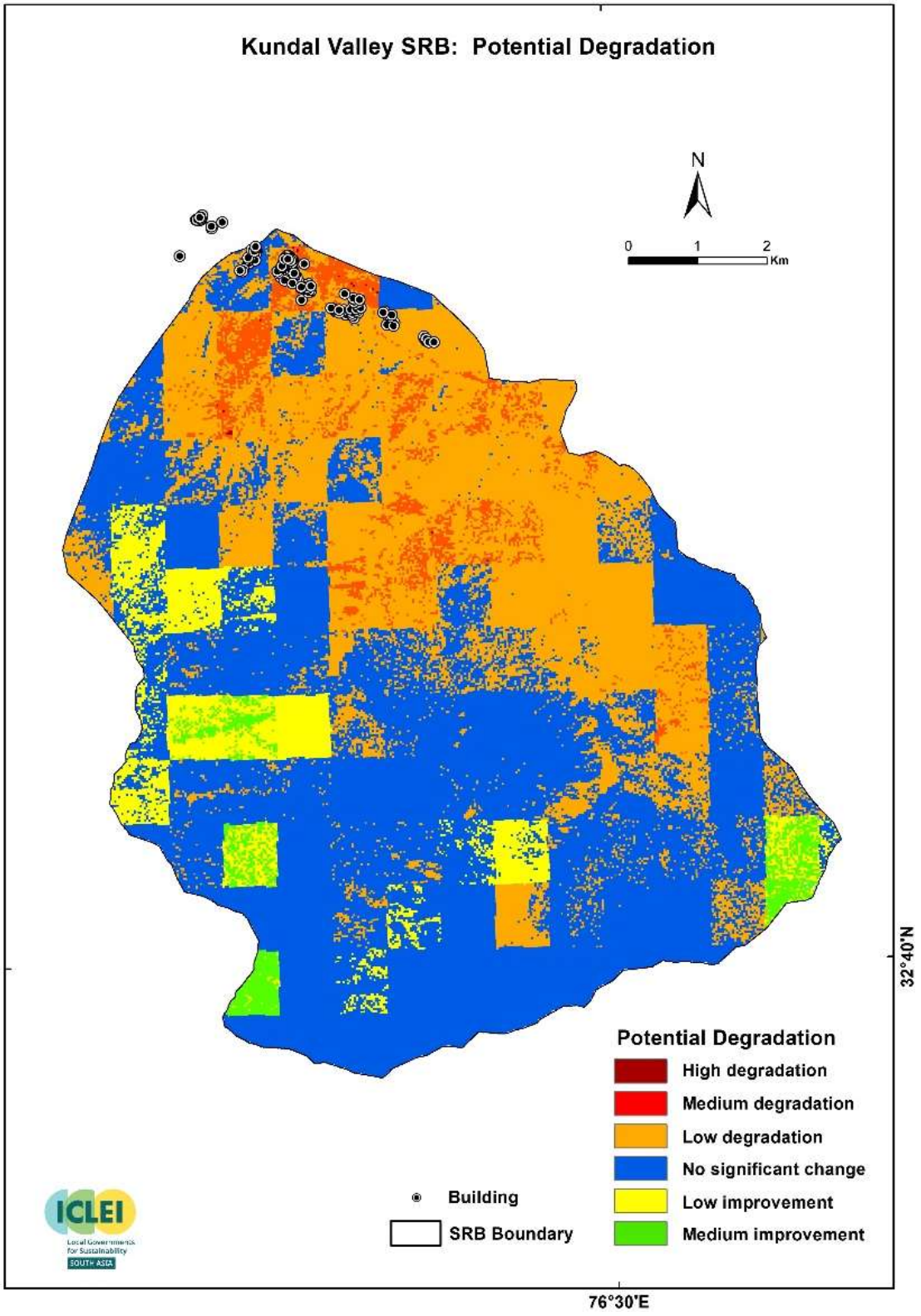


Figure 30: Degradation in Kundal Sub-River Basin

An elevation-wise analysis of the degradation in Kundal sub-river basin (Figure 31 and Table 14) shows that majority of the degradation has taken place in the areas at low elevation, followed by the areas at middle elevation. With regard to the intensity of degradation, the sub-river basin faces majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the sub-river basin.

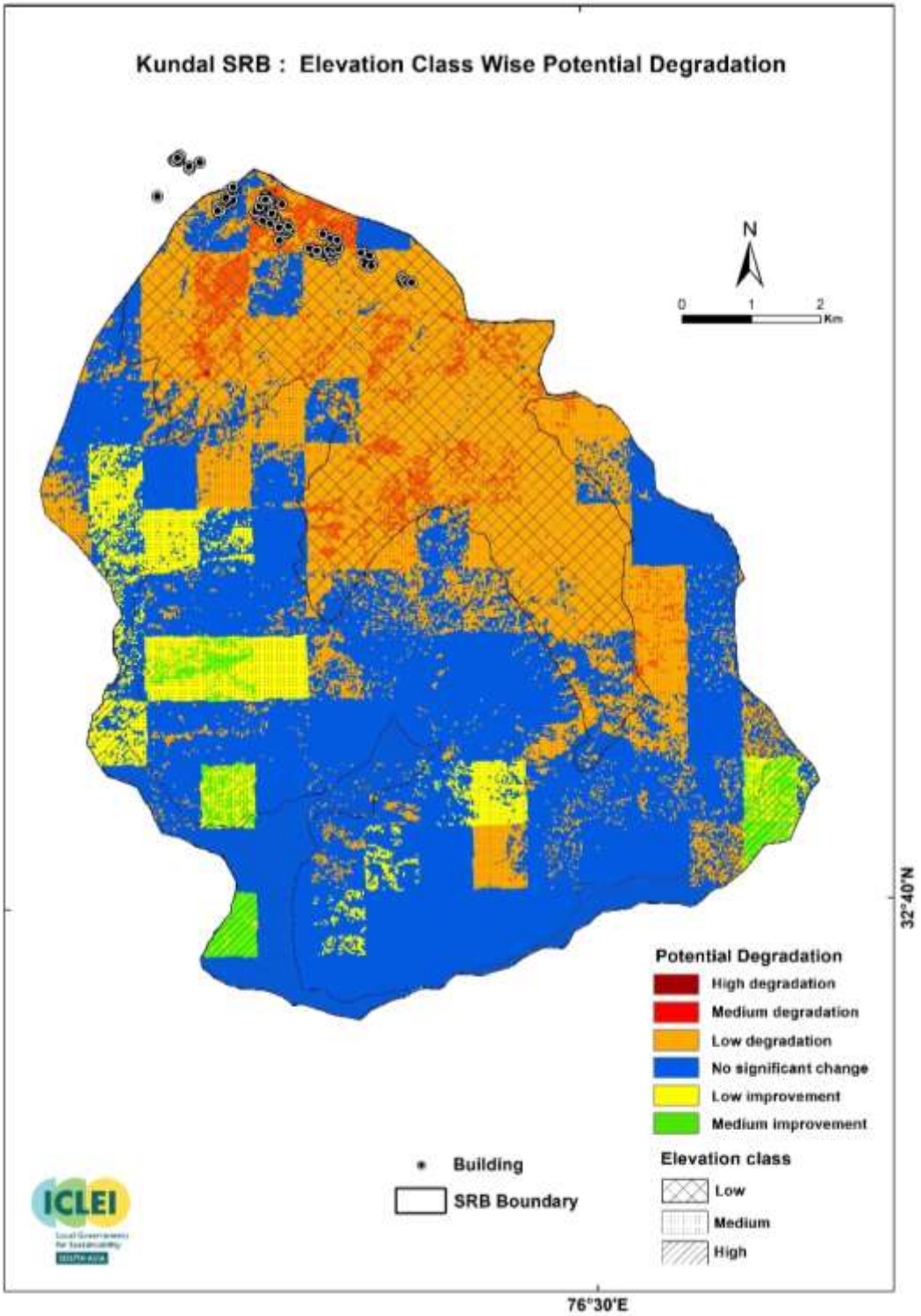


Figure 31: Elevation-wise degradation in Kundal Sub-River Basin

Table 14: Elevation-wise degradation in Kundal Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	**Medium Elevation**	**High Elevation**
High degradation	1.8	0	0
Medium degradation	329.94	25.29	0
Low degradation	1933.74	999	49.77
No Significant change	378.27	3445.47	652.86
Low Improvement	0	546.3	101.43
Medium Improvement	0	75.69	103.68
High Improvement	0	0	0.45

Mapping degradation in the grasslands in the sub-river basin

Figure 32 and Table 15 detail the levels of degradation in the grasslands in Kundal Sub-River Basin. It can be seen that around 47.71 percent of the grasslands in this landscape are under various levels of degradation. Figure 32 showcases the areas of degradation, along with the intensity of the same.

Table 15: Degradation in grasslands in Kundal Sub-River Basin

S No	Degradation class	Area (in h)	Area % (to total GA of SRB)
1	High degradation	0.54	0.02
2	Medium degradation	117.27	4.05
3	Low degradation	1264.77	43.64
4	No significant change	1275.66	44.01
5	Low improvement	225.36	7.78
6	Medium improvement	14.76	0.51

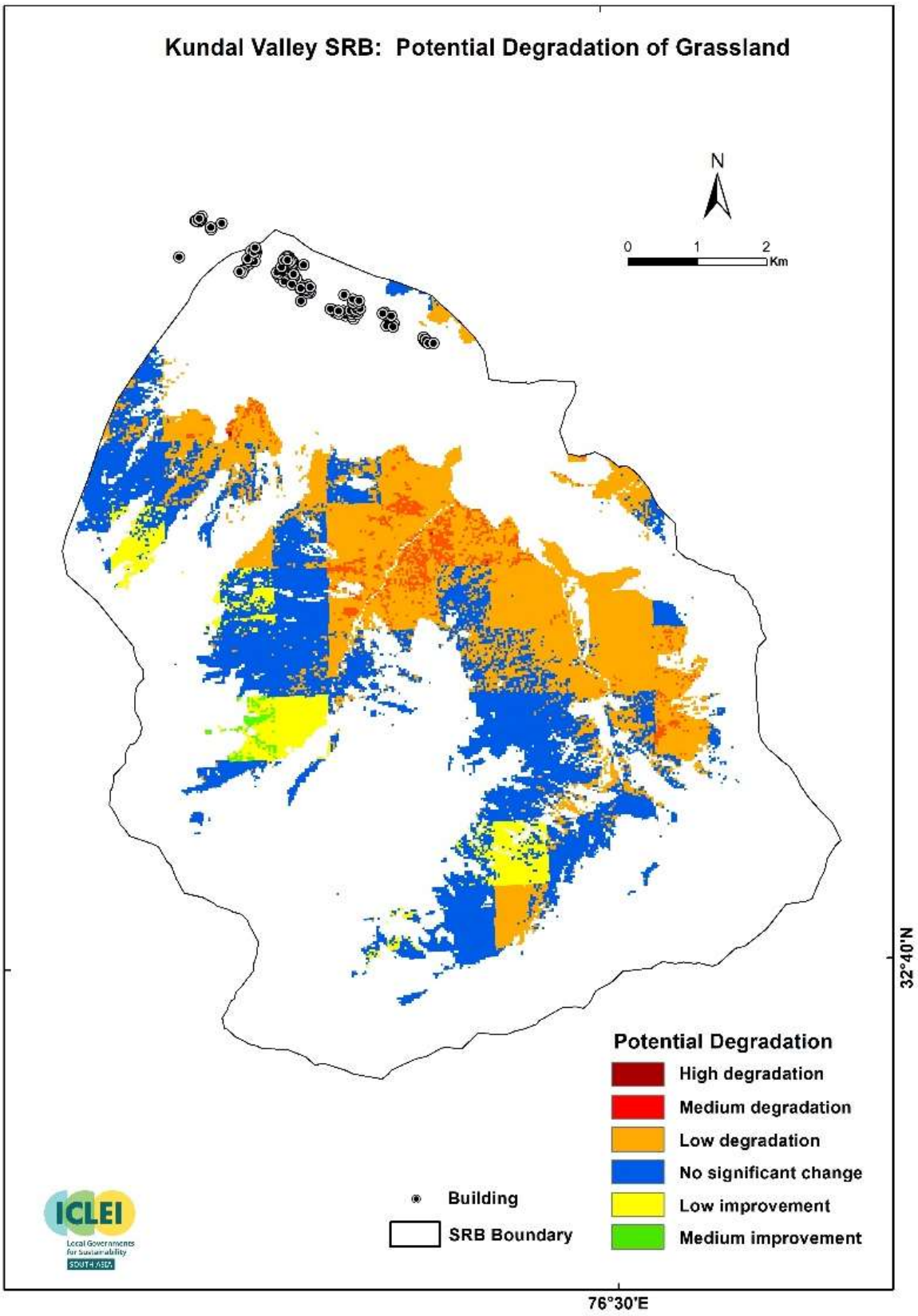


Figure 32: Degradation in grasslands in Kundal Sub-River Basin

An elevation-wise analysis of the degradation in the grasslands in Kundal sub-river basin (Figure 33 and Table 16) shows that majority of the degradation has taken place in the areas at low elevation, followed by the areas at low elevation. With regard to the intensity of degradation, the grasslands in the sub-river basin face majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the grasslands in the sub-river basin.

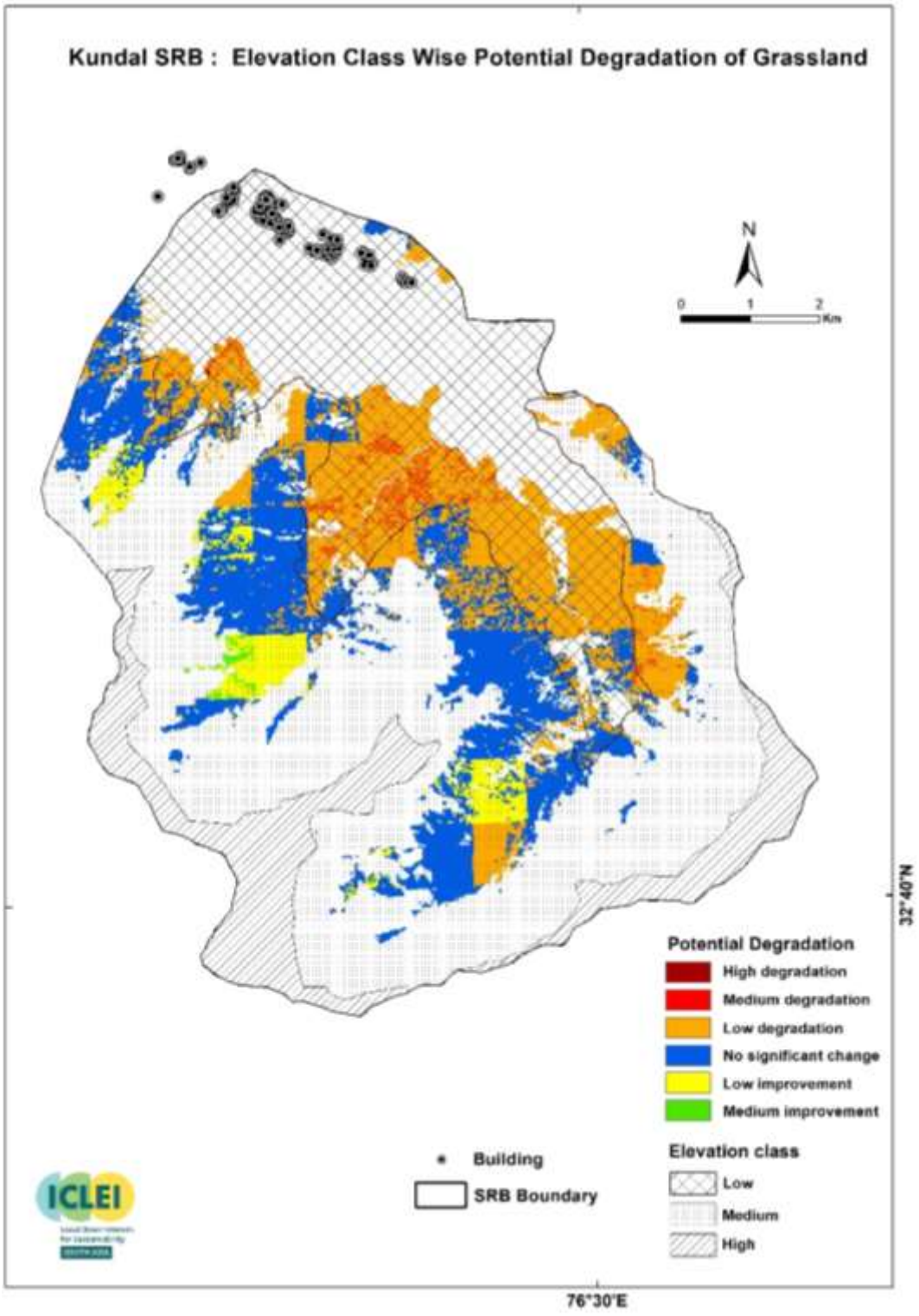


Figure 33: Elevation-wise degradation in grasslands in Kundal Sub-River Basin

Table 16: Elevation-wise degradation in grasslands in Kundal Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	Medium Elevation	High elevation
High degradation	0.54	0	0
Medium degradation	102.69	15.03	0
Low degradation	800.55	463.95	0
No Significant change	152.37	1118.34	0
Low Improvement	0	225.36	0
Medium Improvement	0	14.76	0
High Improvement	0	0	0

Analysis of soil of the grasslands in the sub-river basin

Analysis of the soil samples of the grasslands in the sub-river basin and that of the control site were carried out. A comparison of the same (Figure 34 and Table 17) shows that the soils in the grasslands of the sub-river basin have lower electrical conductivity, organic carbon, phosphorus and potassium, as compared to the soils of the control site.

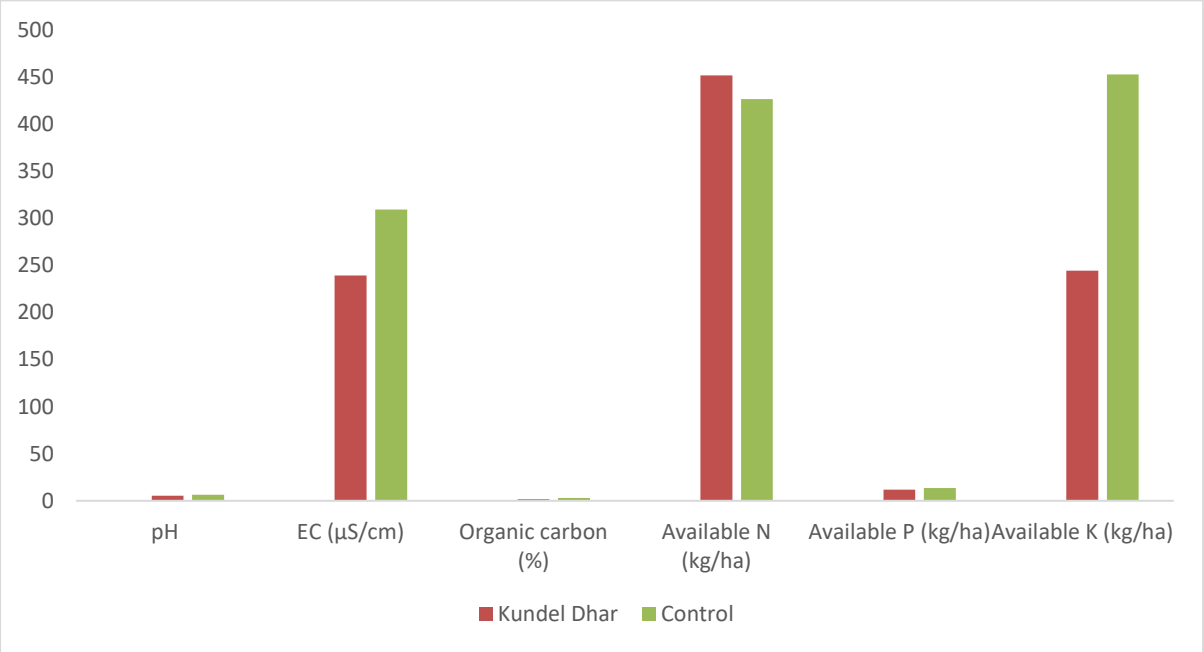


Figure 34: Comparative analysis of soil parameters of grasslands in Kundal Sub-River Basin and grasslands at control site

Table 17: Comparative analysis of soil parameters of grasslands in Kundal Sub-River Basin and grasslands at control site

Sample ID	pH	EC (µS/cm)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Kundal	5.43	239	1.771	451.58	11.82	244.16
Control	6.55	309	2.843	426.5	13.44	452.48

Analysis of quadrat studies conducted in the grasslands of the sub-river basin

A comparative analysis of the families of floral species recorded from grasslands in Kundal sub-river basin and that from the control site shows that the number of species of grasses (family Poaceae) is much lower in the grasslands of Kundal sub-river basin. In addition, there is a complete absence of legumes (Family Fabaceae) in the grasslands in Kundal sub-rover basin. Legumes are nitrogen fixing plants, and thus essential for plant growth and overall soil health maintenance. As depicted in Figure 35, there has been a significant change in the species composition in the grasslands of Kundal sub-river basin, as compared to the grasslands in the control site, which is also an indicator of the degradation in the grasslands in the sub-river basin.

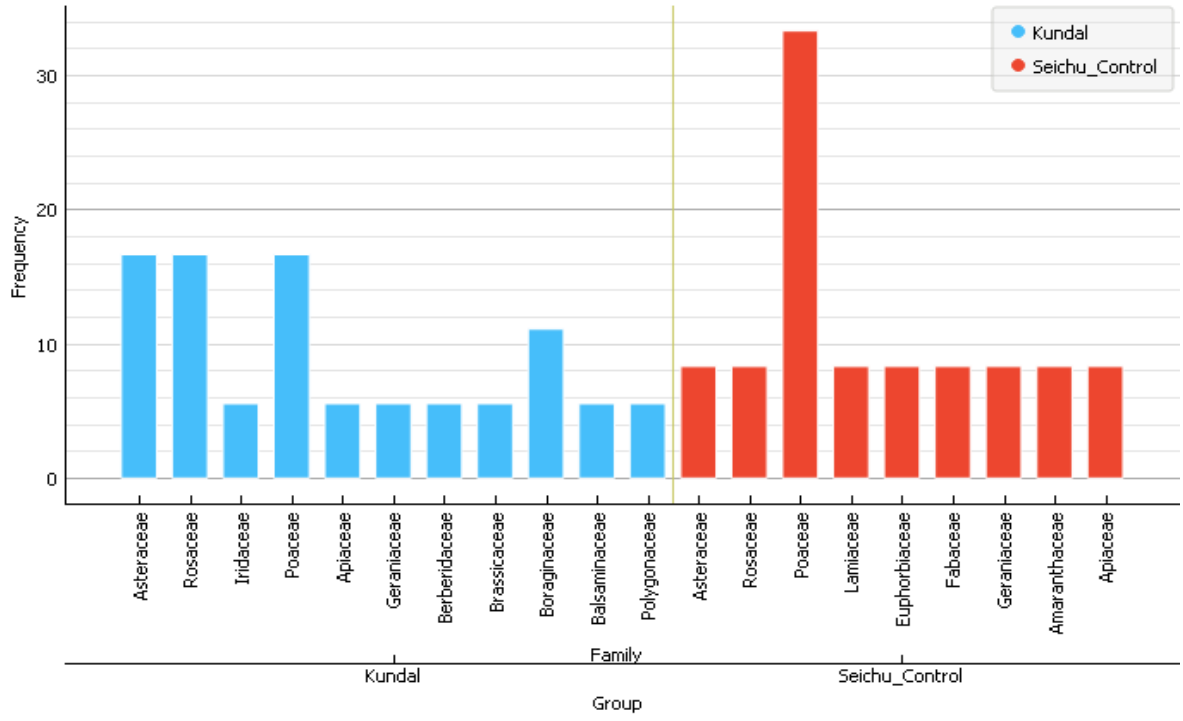


Figure 35: Comparative analysis of plant families found in grasslands in Kundal Sub-River Basin and grasslands at control site

Comparative analysis of the Shannon diversity of grasslands in Kundal sub-river basin and those in control site shows lesser diversity in Kundal grasslands (Figure 36). This indicates that the diversity of plant species in Kundal sub-river basin and the composition has changed from that of the grasslands in the control site (Figure 35).

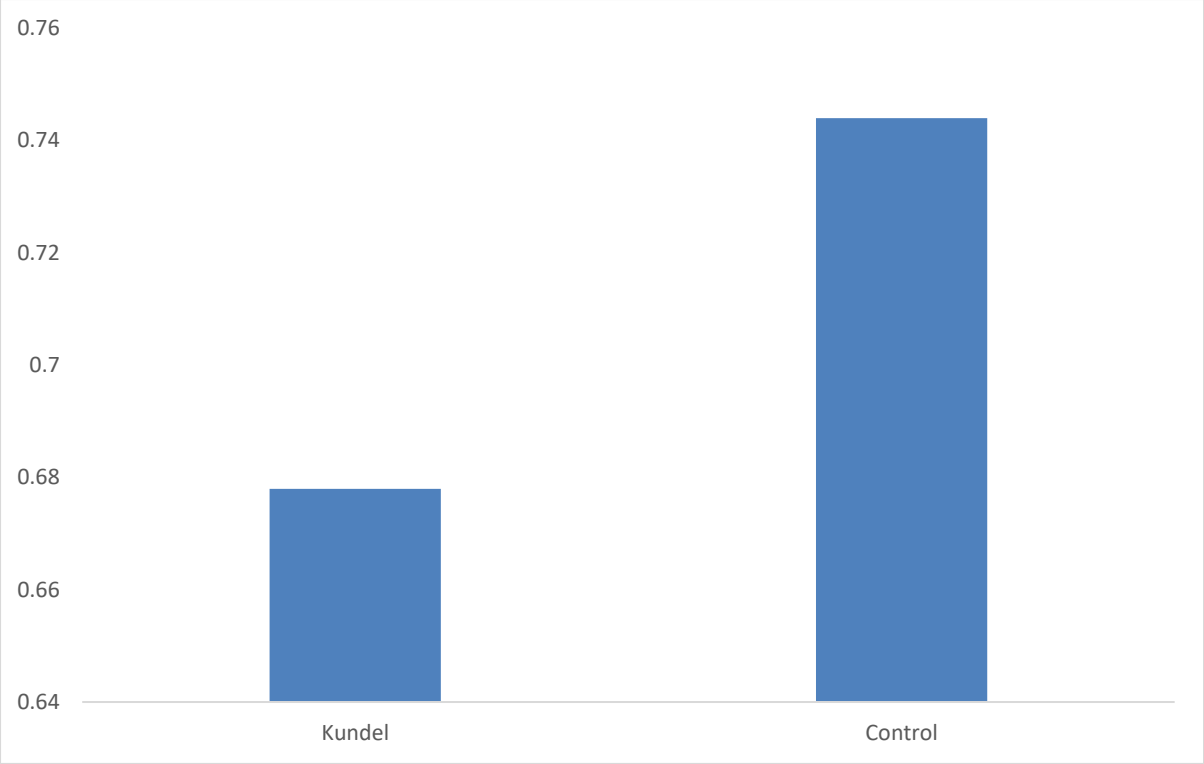


Figure 36: Comparative analysis of the Shannon diversity of grasslands in Kundal sub-river basin and in control site

An analysis of the presence of unpalatable species, which is also an indicator of degradation of the grasslands shows that the grasslands in Kundal sub-river basin have 53 percent palatable and 47 percent unpalatable species. In contrast, the grasslands in the control site are comprised of 83 percent palatable and 17 percent unpalatable species (Figure 37 and Figure 38).

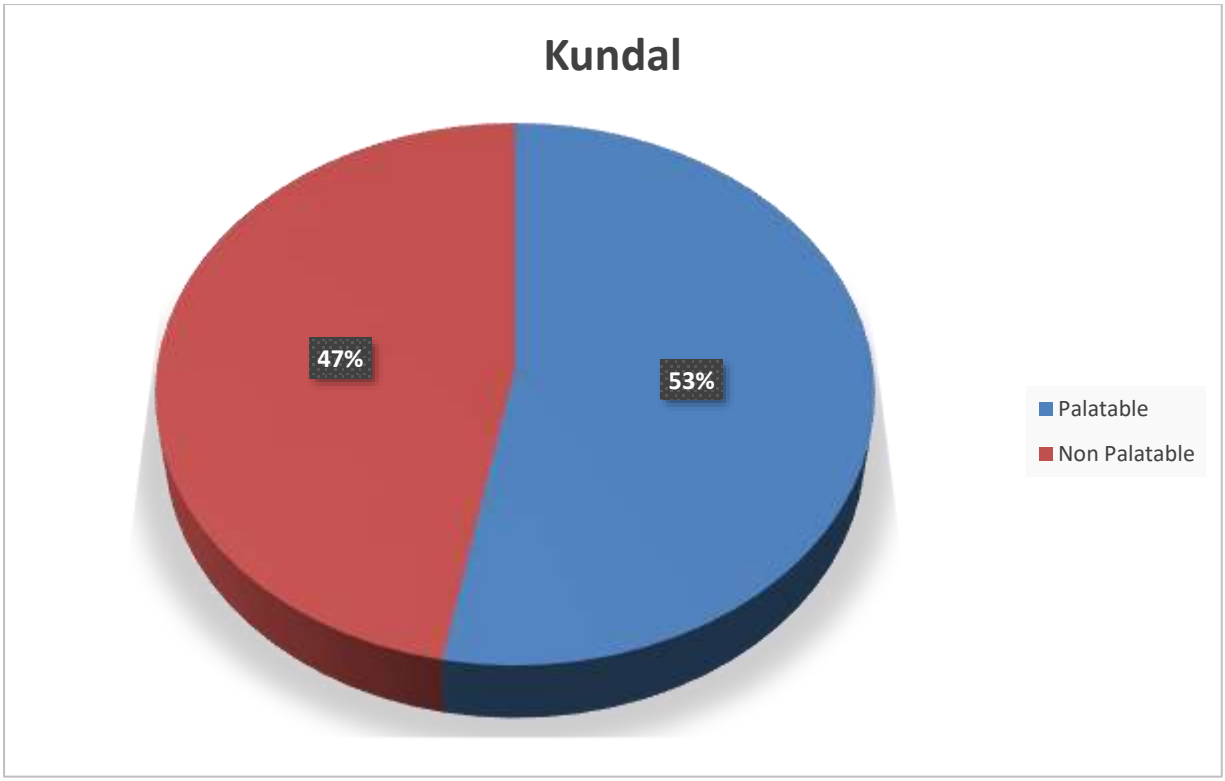


Figure 37: Comparative analysis percent palatable and unpalatable species in grasslands in Kundal sub-river basin

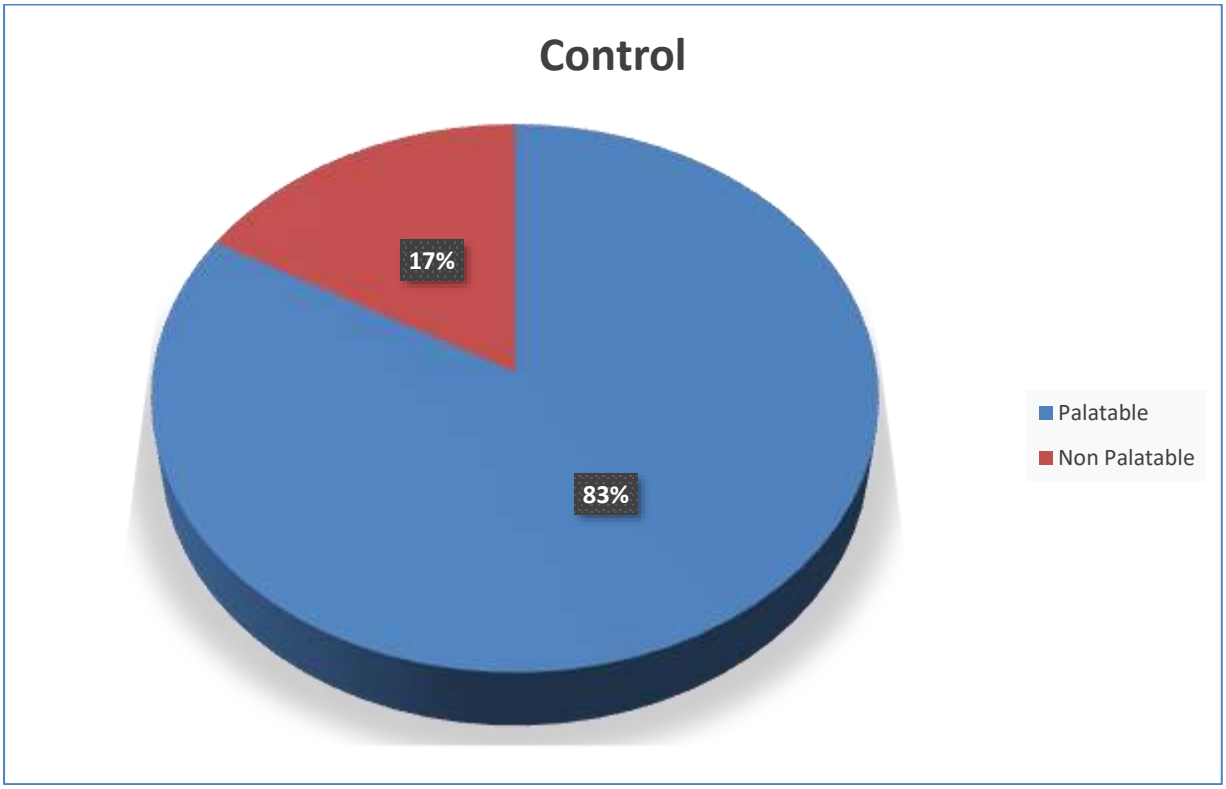


Figure 38: Comparative analysis percent palatable and unpalatable species in grasslands in control site

Views of the nomadic pastoralists on grassland degradation in the sub-river basin

As mentioned in the fifth report, detailed discussions were carried out with the nomadic pastoralists- Gaddis to understand their views and perceptions on grassland degradation and impacts of the same. Gaddis have reported change in the species composition in the grasslands, which has led to decline in fodder availability by around 20-30 percent. In addition, it was reported that due to the reduction in availability of fodder in the grasslands close to the villages in this sub-river basin, the local residents are also grazing their livestock in the medium and high-altitude grasslands, leading to further resource conflicts. Due to the severity of this resource conflict, some of the gaddis have been reported to leave the area earlier as compared to the duration they used to stay earlier. The prominent palatable species that have declined include *Festuca gigantica* (20-30 percent) and *Rheum austral* (10-20 percent). They feel this has happened due to climate change and the grazing of local livestock in the gaddi grasslands. Due to climate change winter rain has declined significantly. This has impacted the germination of species. In addition, increase in temperature has led to changes in plant phenology, thereby resulting in changes in the species composition in the grasslands in the sub-river basin. A discussion on the impact of grassland degradation on the weight gain by livestock in two months now, as compared to the gain 20 years back showed a decline in the weight gain (Table 18).

Table 18: Comparative analysis change in weight gain by livestock

Animal	**Weight-increase in 2 months (20 year back)**	**Weight-increase in 2 months (now)**
Goat	10 kg	3-4 kg
Sheep	7-8 kg	2-3 kg

Drivers of degradation in the sub-river basin

A list of the drivers of degradation in the sub-river basin (not limited to grasslands) was developed. The major drivers of degradation are:

a) **Change in cropping pattern**- There has been a shift in crops from traditional crops (local paddy, maize and wheat) to cash crops such as peas, cauliflower, and tomato. This on one hand has reduced the food self-sufficiency and on the other hand has increased pressure on the grasslands for fodder. The traditional crops were also a major source of fodder, in absence of which, the villagers have to depend more on the fodder from the grasslands.
b) **Human wildlife conflict**- Crop raiding by bear has been a major problem in the village. They usually come to eat maize. However, since the extent of maize cultivation is reduced now the presence bear in the farms is less. At the same time number of monkeys in the village increased when maize is replaced by peas. They not only come to the farms but also create problems in the road. Change in the cropping has also affected the biodiversity in the region. According to the villagers, there were pigeons who come to feed earlier when cereals used to be cultivated. After change of the cropping pattern to peas and cauliflower pigeons are not able to get food from the agriculture fields. These birds now come to the village to look for food. Earlier pigeons were not seen in the village at all and were restricted to the agricultural fields.

c) **Pesticide use**- Unlike in the past, the community is now using pesticides and chemical fertilizers in order to increase agricultural production. Respondents believe that the use of chemical fertilizers and pesticides degrading the soil quality and affecting the biodiversity of the area.
d) **Increase in temperature, leading to phenological changes** – Several phenological changes are taking place in the plant species, leading to changes in species composition.
e) **Waste increase and lack of management**- There is no proper waste management mechanism in the villages in the sub-river basin. Solid waste is thrown in the stream, away from the villages. Even though waste segregation has started in the villages, all the waste is dumped in the stream, without processing. During the winter months, the stream is covered by snow and in summers when the snow melts the waste moves downstream.
f) **Short duration high intensity rainfall and landslides**- Increased incidences of both are leading to loss of land and soil, which is impacting the grasslands and other land use classes in the sub-river basin.
g) **Melting of glaciers** – Increased rate of melting of glaciers has led to the increase in incidences of landscape, causing degradation.
h) **NTFP extraction**- Tindi is one of the heavily NTFP extracted areas in the Udaipur block. Proper quantification of the extraction is needed to understand the anthropogenic pressures on the forests here. Detailed resource assessments of medicinal plants at the range or division level are lacking.
i) **Firewood collection**- The villagers told that even though they rely on drywood from the forests, sometimes they collect firewood by cutting trees to use in winters.
j) **Water scarcity**- Inhabitants of Lohni village mentioned that water was a big issue due to the increased population and high water demand. At present they use IPH scheme by the government where the water is sourced from far away stream named Hudsar stream. Satellite image analysis shows the clearance of a forest patch in the catchment area of the stream that used to flow and has now dried up.
k) **Population increase**- In villages like Lohni, there is a sustained increase in the population. This is further affecting the agriculture since the land is being divided among siblings and the available land for cultivation for each family has thus reduced. This situation has implication on the conservation of other landuses since there are chances for expanding agriculture land into other areas.
l) **Resource conflicts with Gaddis**- Apart from the resource conflicts in the alpine pasturelands, there are also conflicts with the Gaddis in the lower elevation. Villagers from Lohni mentioned Gaddi livestock depletes grass available for the village livestock, while they are crossing the villages, and thus leads to conflict between them.

3.5.3 Parmas Sub-River Basin

Parmas sub river basin lies between 76^0 21'18'' to 76^0 35' 50'' East longitude and 33^0 3'26'' 33^0 8'39'' North latitude and elevation of the river basin varies from 2028m to 6073 m MSL. The total area of the sub river basin is 118.8 km^2.

Landuse in the sub-river basin

Figure 39 details the landuse in the sub-river basin. The analysis shows that grasslands cover 18.78 percent of the sub-river basin (Table 19).

Table 19: Land Classes in Parmas Sub-River Basin

Land class	**Area**	**Area %**
Agriculture	459.43	3.88
Barren Land	1790.46	15.13
Deodar	13.04	0.11
Dry Alpine Pasture	2223.59	18.78
River/ Dry river	6.13	0.05
Dry temperate forest	0.05	0
Orchard	1807.12	15.27
River/ Dry river	64.41	0.54
Settlement	73.49	0.62
Snow cover	3920.26	33.12
Sub Alpine forest	1479.54	12.5

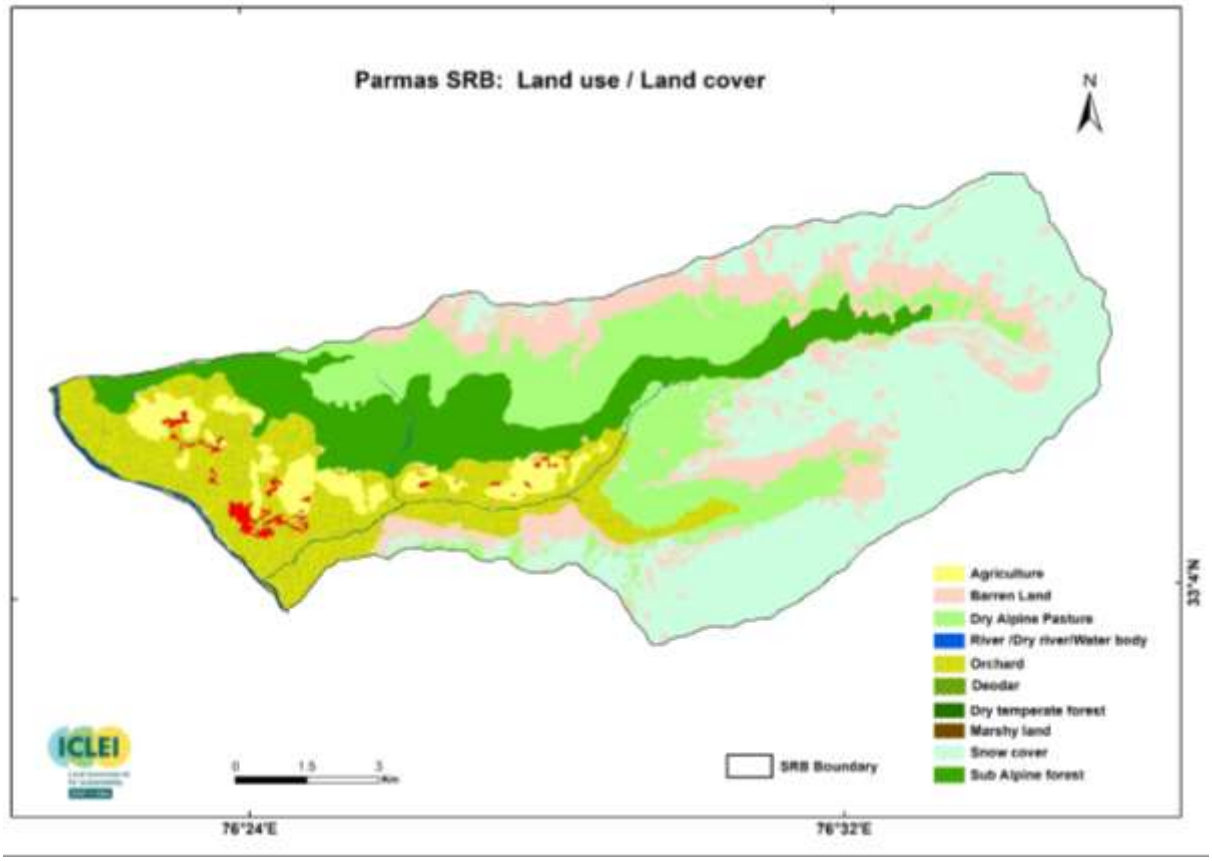


Figure 39: Land Use Land Cover Map of Parmas Sub-River Basin

An elevation-wise analysis of the land use of Parmas sub-river basin shows that the grasslands primarily fall in the medium elevation zone (2214.90 ha), followed by high elevation zone (4.51 ha). Only a very small area of grasslands falls in low elevation zone (0.06 ha). Table 20 and Figure 40 provide the details.

Table 20: Elevation wise distribution of Land Classes in Parmas Sub-River Basin

Land class	**Area (in h)**		
	Low Elevation	**Medium Elevation**	**High elevation**
Agriculture	397.67	61.76	0
Barren Land	36.45	1445.33	304.65
Deodar	10.89	0	0
Dry Alpine Pasture	0.06	2214.90	4.51
Dry river	3.33	2.80	0
Himalayan dry temperate forest	0.05	0	0
Orchard	1504.33	301.56	0
River	57.93	5.40	0
Settlement	69.07	4.42	0
Snow cover	3.27	1954.67	1952.22
Sub Alpine forest	232.02	1246.35	0

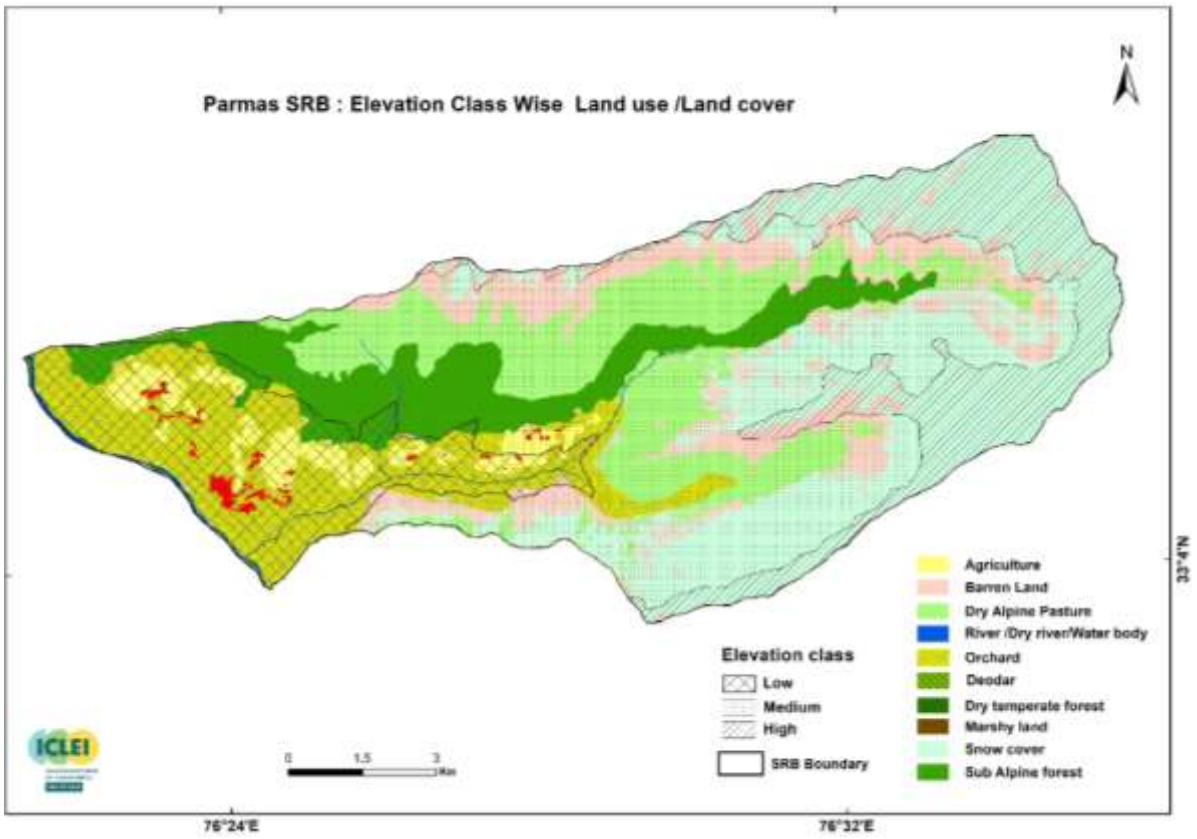


Figure 40: Land Use Land Cover Map of Parmas Sub-River Basin

NPP change analysis in the sub-river basin

NPP change analysis (Figures 41 and 42) shows that in the years between 2005-2010, there was a sharp decline in the NPP. One of the factors for the same can be the decline in winter rain during that period. Winter rain is essential for the germination of perennial herbs and also contributes to the growth of shrubs and trees. Figure 34 details the areas where changes in NPP have been observed.

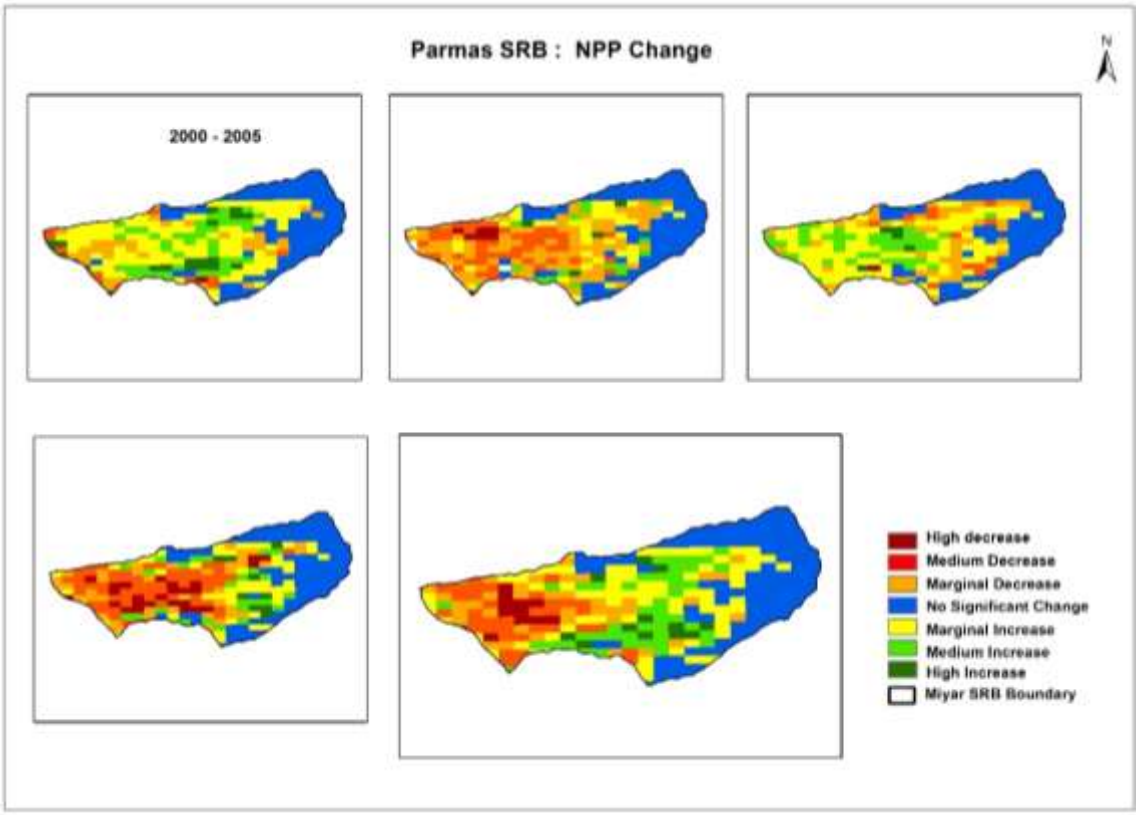


Figure 41: NPP change in Parmas Sub-River Basin

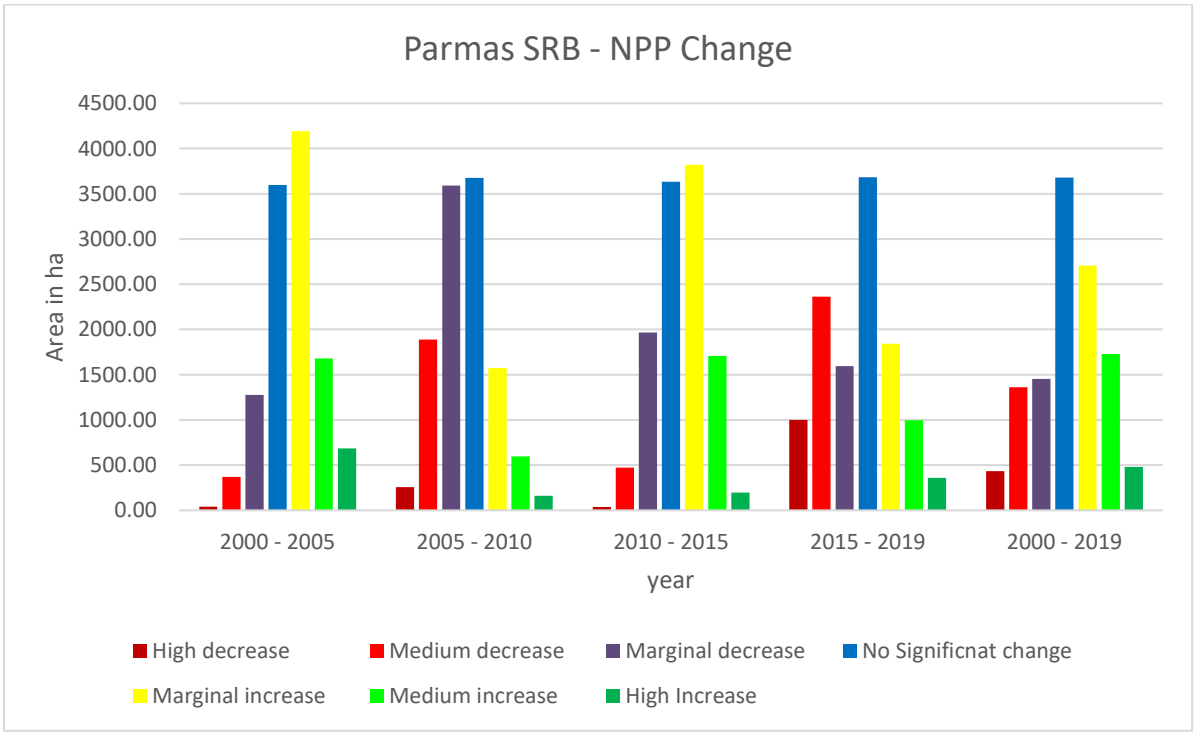


Figure 42: Graph depicting NPP change in Parmas Sub-River Basin

NPP change analysis in the grasslands of the sub-river basin

An analysis of the NPP change in the grasslands (Table 21 and Figure 43) in the sub-river basin shows the same trend of significant decline in NPP in the duration of 2005-2010. Decline in winter rain is one of the factors as winter rain is essential for germination of the grasses and other annual herbs in the grasslands. Figure 43 details the areas where changes in NPP have been observed in the grasslands.

Table 21: NPP change in Parmas Sub-River Basin

NPP Change class	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2019	2000 - 2019
High decrease	7.83	193.77	123.03	54.81	61.92
Medium decrease	23.40	287.10	275.85	570.51	138.69
Marginal decrease	193.77	721.35	437.58	507.15	80.37
No Significant change	49.68	94.32	59.04	101.79	55.35
Marginal increase	778.50	632.70	875.79	483.66	766.35
Medium increase	815.76	209.16	346.41	364.14	709.38
High Increase	347.04	77.58	98.28	133.92	403.92

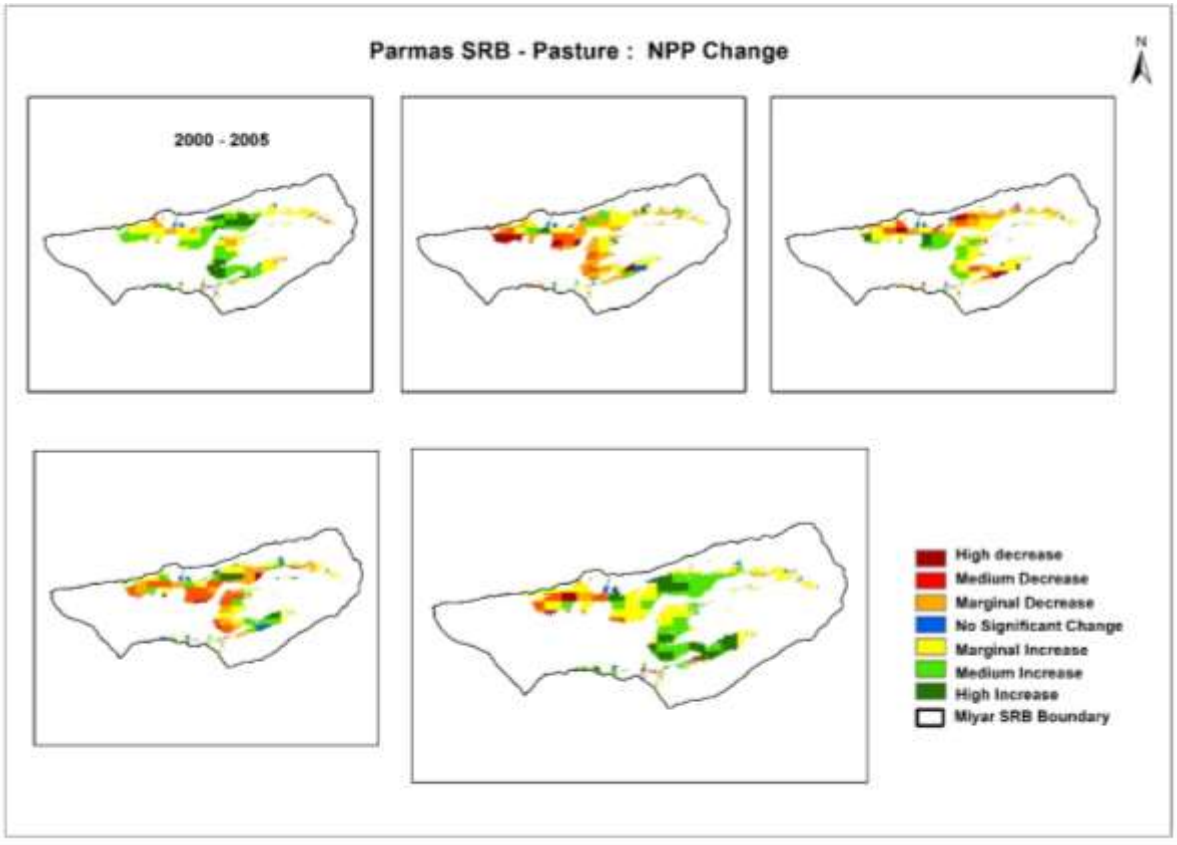


Figure 43: NPP change in grasslands in Parmas Sub-River Basin

Mapping degradation in the sub-river basin

Degradation was mapped for Parmas sub-river basin. Figure 44 provides details of degradation in the sub-river basin.

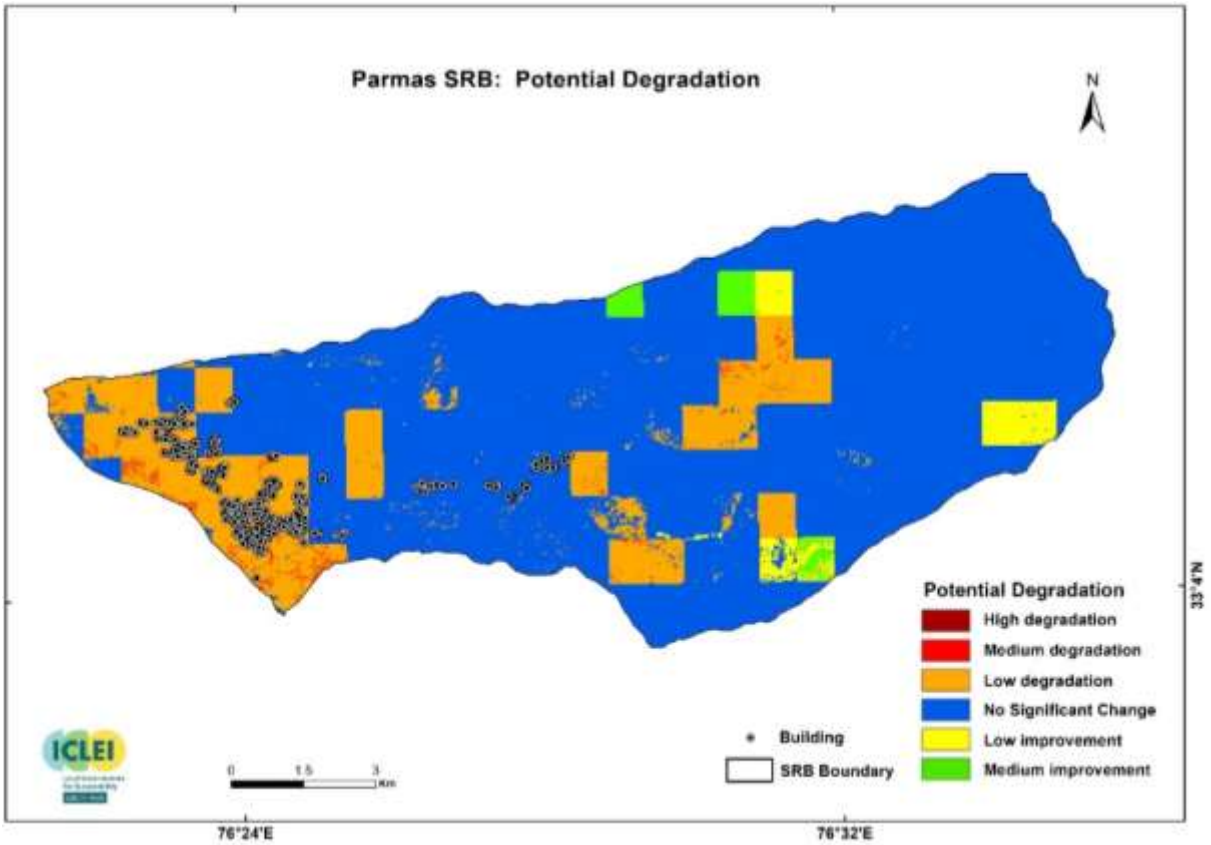


Figure 44: Degradation in Parmas Sub-River Basin

An elevation-wise analysis of the degradation in Parmas sub-river basin (Figure 45 and Table 22) shows that majority of the degradation has taken place in the areas at low elevation, followed by the areas at middle elevation. With regard to the intensity of degradation, the sub-river basin faces majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the sub-river basin.

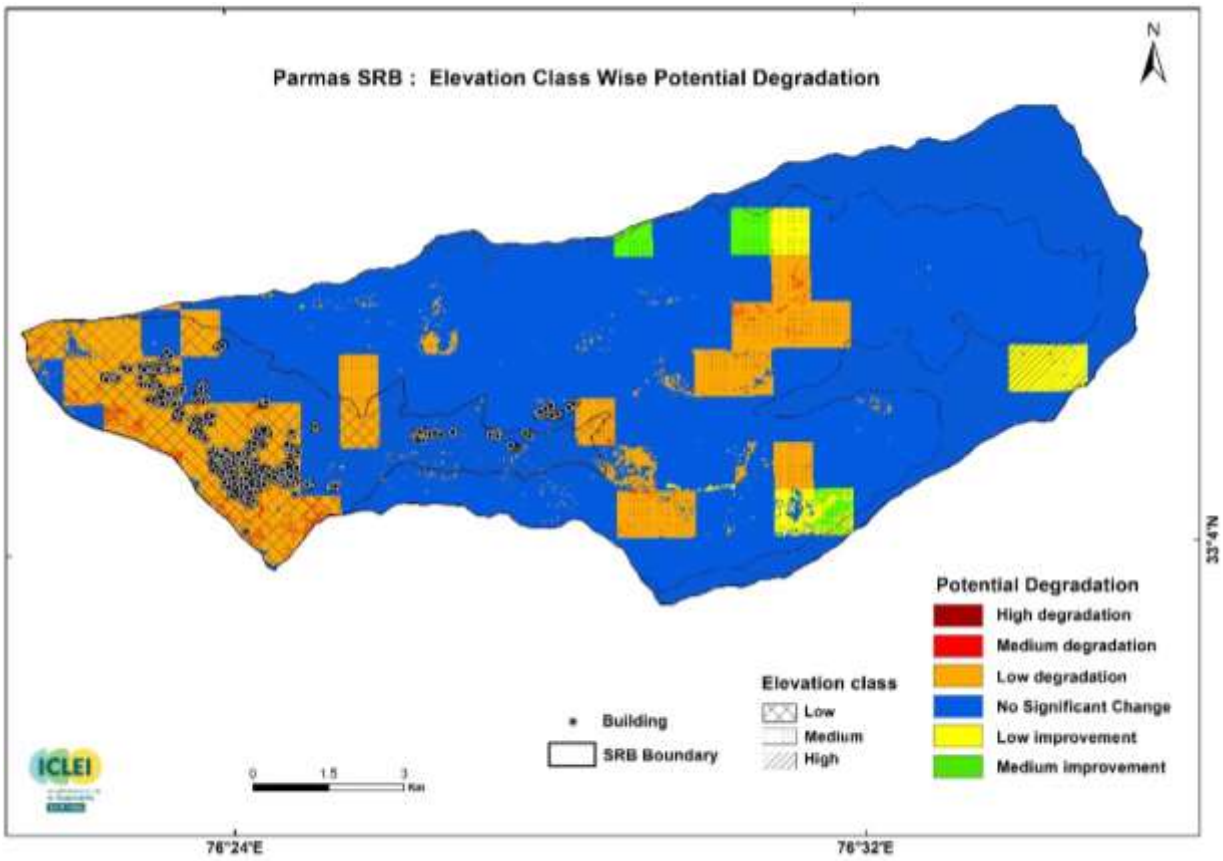


Figure 45: Elevation-wise degradation in Parmas Sub-River Basin

Table 22: Elevation-wise degradation in Parmas Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	Medium Elevation	High elevation
High degradation	0.81	0.09	0
Medium degradation	86.76	29.43	0
Low degradation	1185.93	872.82	1.53
No Significant change	1036.89	6029.91	2096.28
Low Improvement	0.45	157.5	148.41
Medium Improvement	0	142.92	14.76
High Improvement	0	0	0

Mapping degradation in the grasslands in the sub-river basin

Figure 46 and Table 23 detail the levels of degradation in the grasslands in Parmas Sub-River Basin. It can be seen that around 10.36 percent of the grasslands in this landscape are under various levels of degradation. Though the grasslands in this sub-river basin are under lower levels of degradation, as compared to those in Miyar and Kundal sub-river basins, it is worth mentioning that Parmas sub-river basin is a very remote area. Thus, degradation in the grasslands here is a major reason of concern. Figure 46 showcases the areas of degradation, along with the intensity of the same.

Table 23: Degradation in grasslands in Parmas Sub-River Basin

S. No	Degradation class	Area (in h)	Area % (to total GA of SRB)
1	Medium degradation	3.96	0.18
2	Low degradation	225.63	10.18
3	No significant change	1929.60	87.08
4	Low Improvement	26.46	1.19
5	Medium Improvement	30.33	1.37

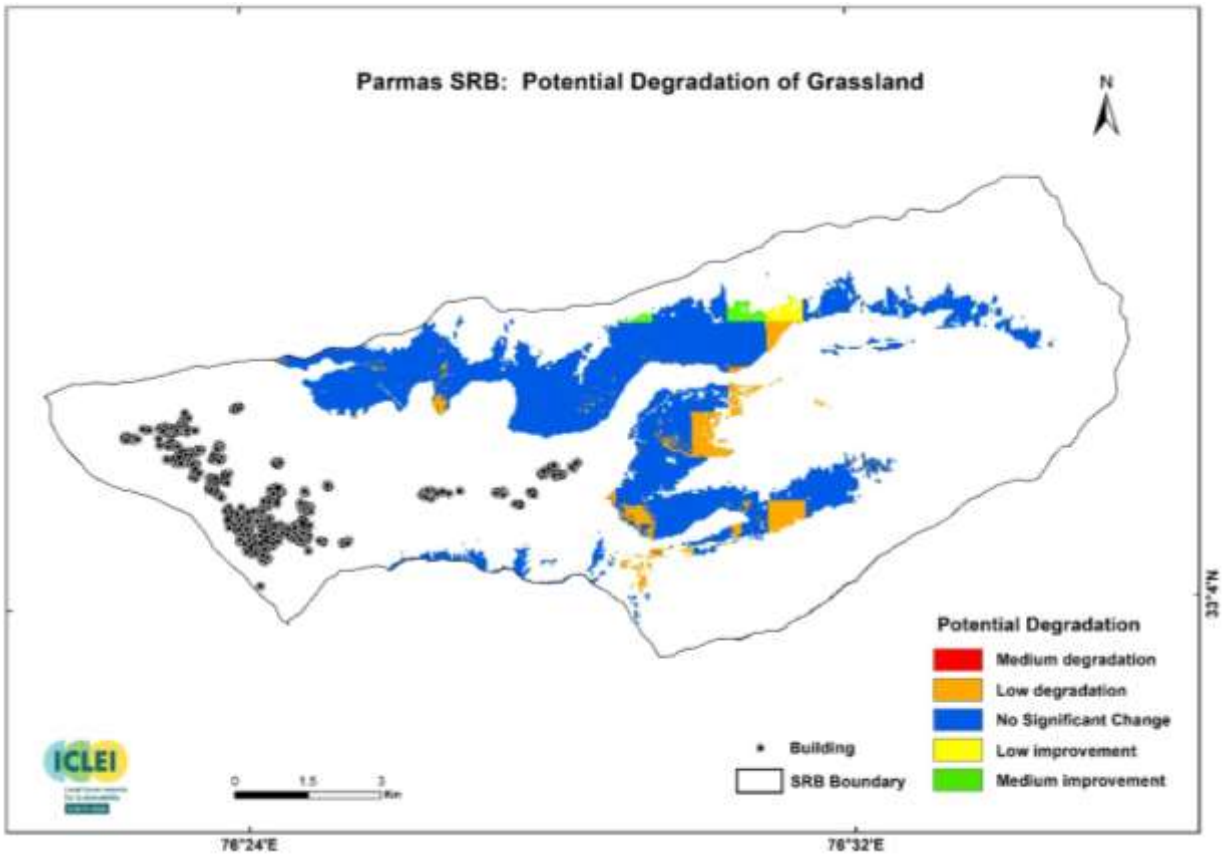


Figure 46: Degradation in grasslands in Parmas Sub-River Basin

An elevation-wise analysis of the degradation in the grasslands in Parmas sub-river basin (Figure 47 and Table 24) shows that all the degradation has taken place in the areas at middle elevation in the sub-river basin.

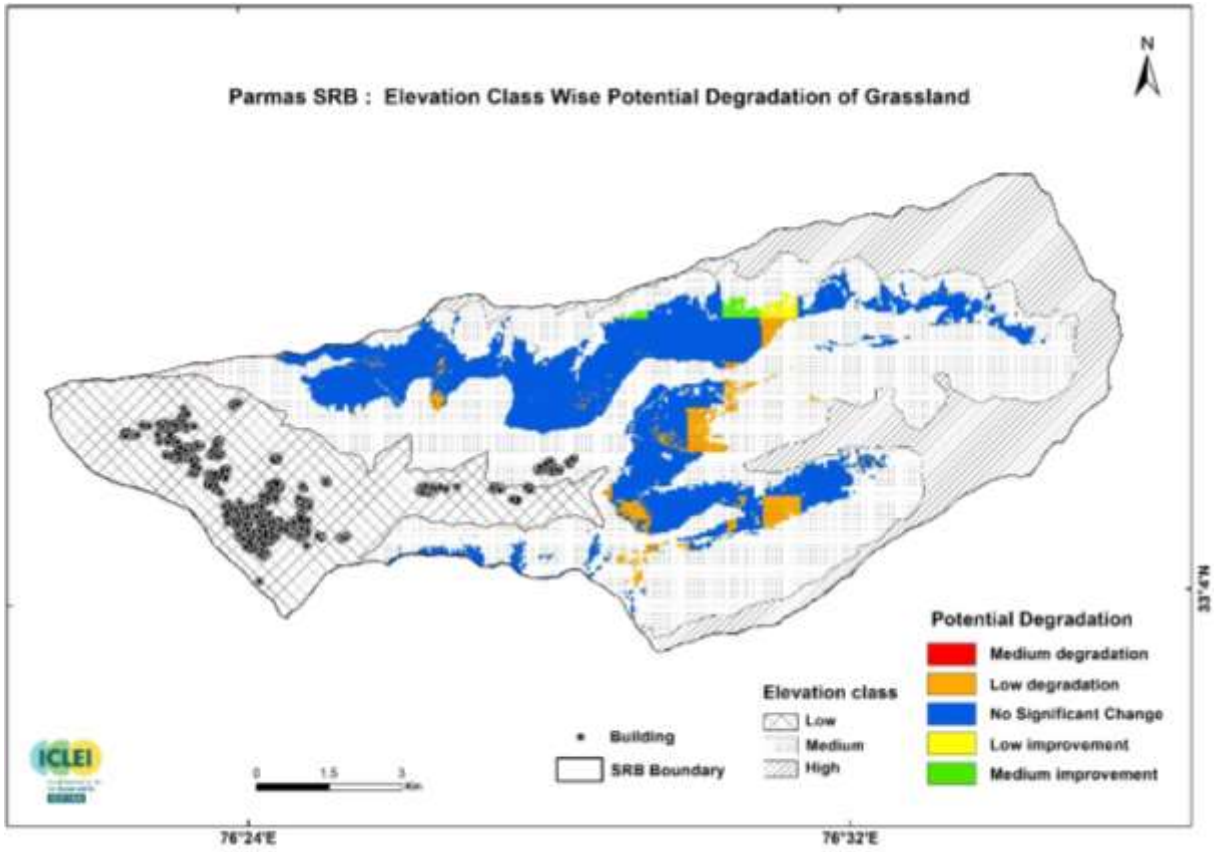


Figure 47: Elevation-wise degradation in grasslands in Parmas Sub-River Basin

Table 24: Elevation-wise degradation in grasslands in Parmas Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	Medium Elevation	High elevation
High degradation	0	0	0
Medium degradation	0	3.96	0
Low degradation	0	225.54	0
No Significant change	0	1918.98	4.05
Low Improvement	0	26.28	0.27
Medium Improvement	0	30.15	0.18
High Improvement	0	0	0

Analysis of soil of the grasslands in the sub-river basin

Analysis of the soil samples of the grasslands in the sub-river basin and that of the control site were carried out. A comparison of the same (Figure 48 and Table 25) shows that the soils in the grasslands of the sub-river basin have lower electrical conductivity, organic carbon, nitrogen and phosphorus, as compared to the soils of the control site.

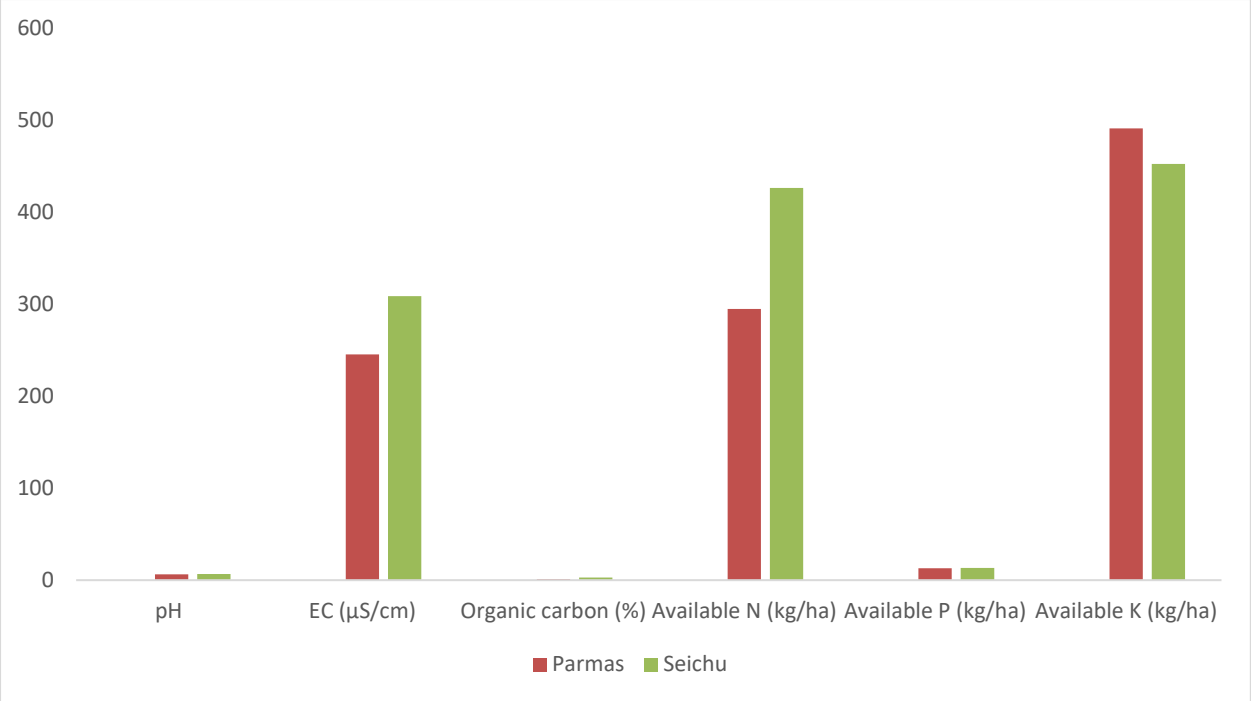


Figure 48: Comparative analysis of soil parameters of grasslands in Parmas Sub-River Basin and grasslands at control site

Table 25: Comparative analysis of soil parameters of grasslands in Parmas Sub-River Basin and grasslands at control site

Sample ID	pH	EC (µS/cm)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Parmas	6.285	245.5	1.06	294.785	12.92	491.12
Seichu	6.55	309	2.843	426.5	13.44	452.48

Analysis of quadrat studies conducted in the grasslands of the sub-river basin

A comparative analysis of the families of floral species recorded from grasslands in Parmas sub-river basin and that from the control site shows that the number of species of grasses (family Poaceae) is much lower in the grasslands of Parmas sub-river basin. However, there is presence of legumes (Family Fabaceae) in the grasslands in Parmas sub-river basin. Legumes are nitrogen fixing plants. As depicted in Figure 49, there has been a significant change in the species composition in the grasslands of Parmas sub-river basin, as compared to the grasslands in the control site, which is also an indicator of the degradation in the grasslands in the sub-river basin.

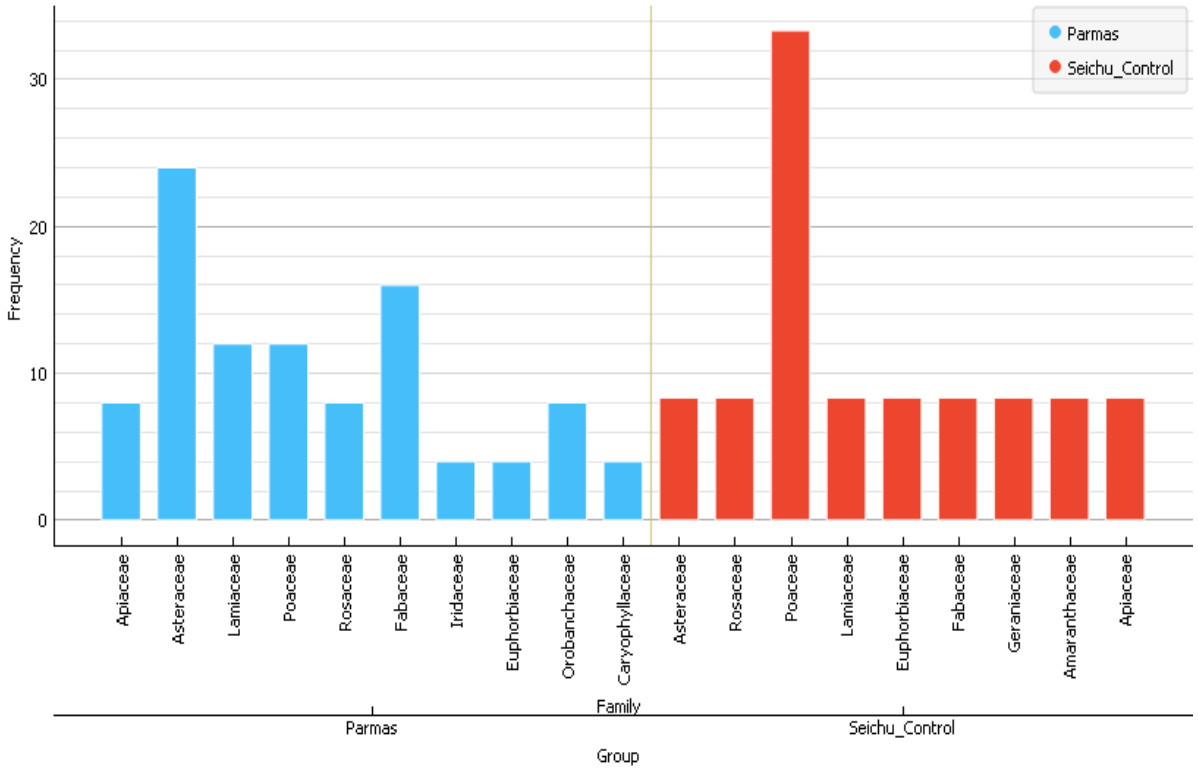


Figure 49: Comparative analysis of plant families found in grasslands in Parmas Sub-River Basin and grasslands at control site

Comparative analysis of the Shannon diversity of grasslands in Parmas sub-river basin is much lower than that of the control site and those in control site shows closeness (Figure 50). This indicates that the diversity of plant species in Parmas sub-river and the composition has changed from that of the grasslands in the control site (Figure 49).

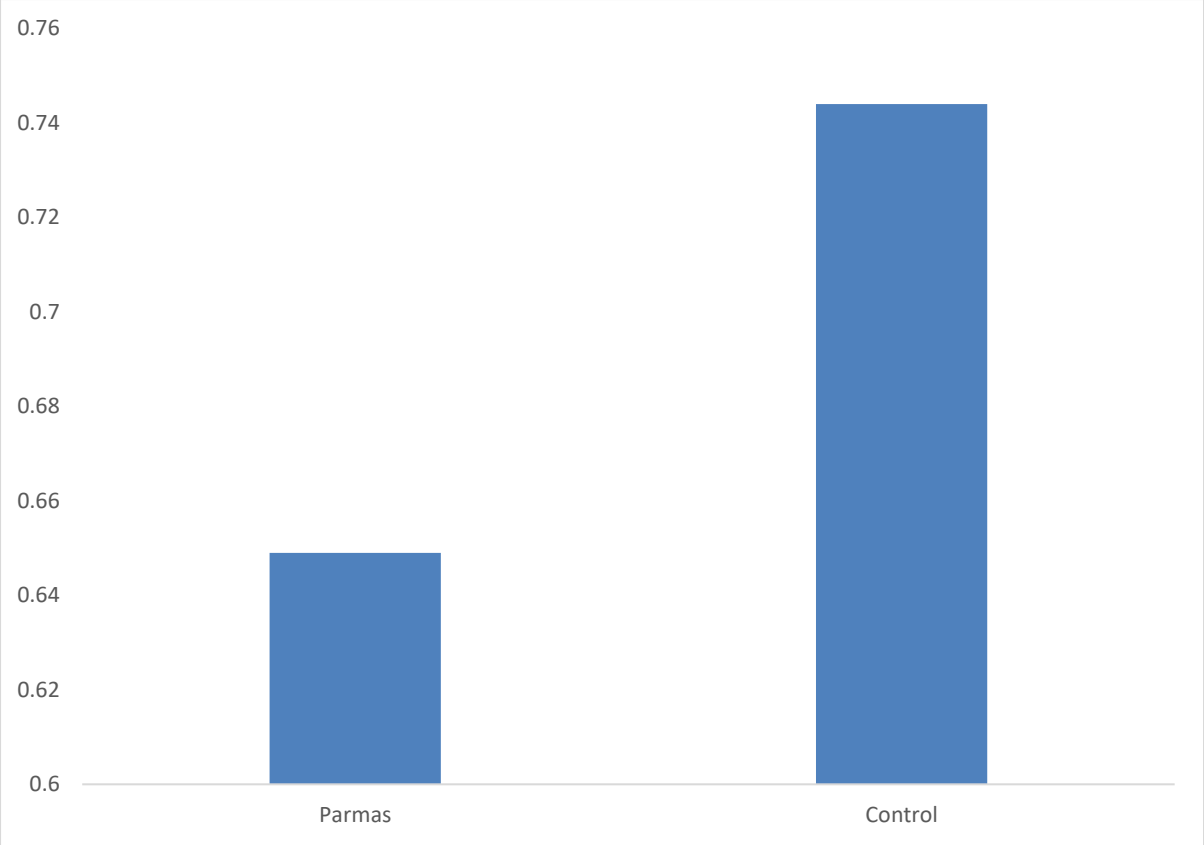


Figure 50: Comparative analysis of the Shannon diversity of grasslands in Parmas sub-river basin and in control site

An analysis of the presence of unpalatable species, which is also an indicator of degradation of the grasslands shows that the grasslands in Miyar sub-river basin have 67 percent palatable and 33 percent unpalatable species. In contrast, the grasslands in the control site are comprised of 83 percent palatable and 17 percent unpalatable species (Figure 51 and Figure 52).

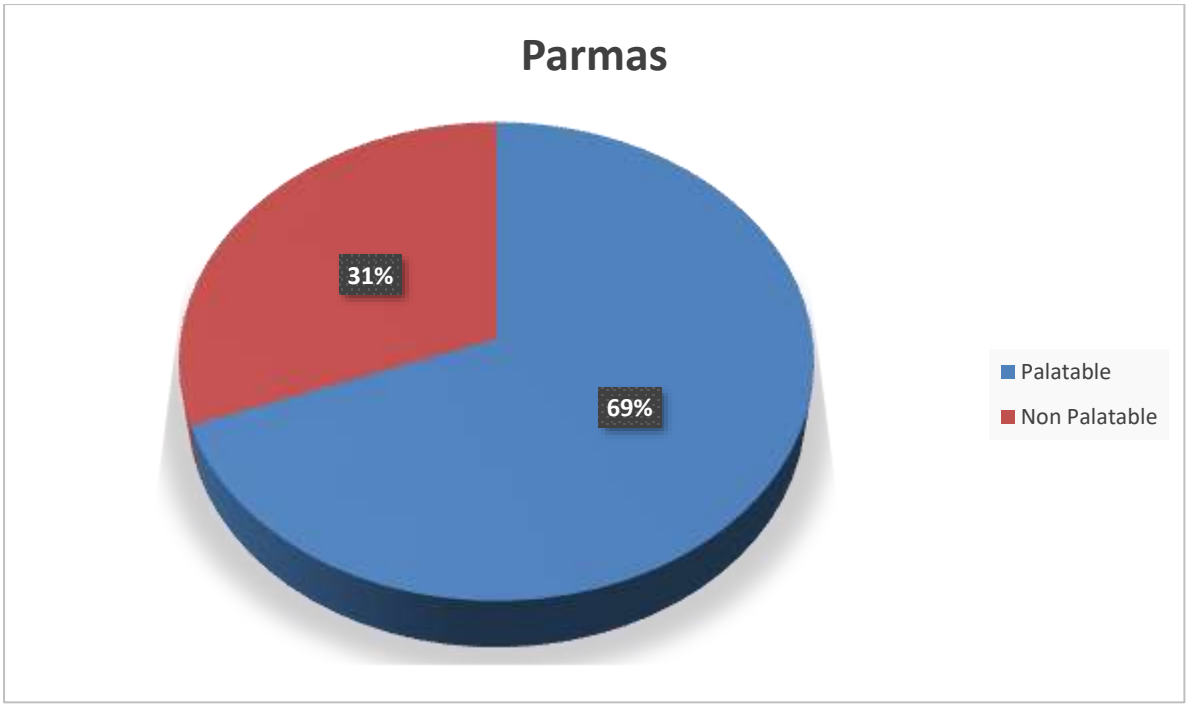


Figure 51: Comparative analysis percent palatable and unpalatable species in grasslands in Parmas sub-river basin

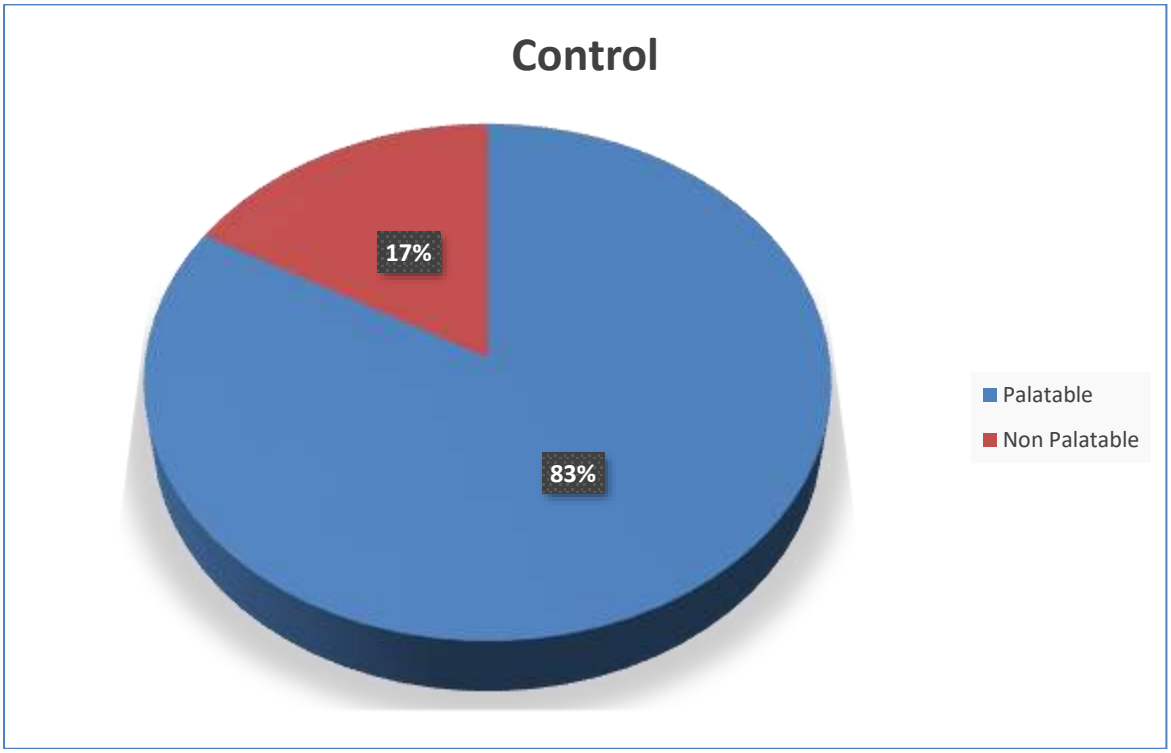


Figure 52: Comparative analysis percent palatable and unpalatable species in grasslands in control site

Views of the residents (who rear livestock) on grassland degradation in the sub-river basin

This sub-river basin is not visited by Gaddis. The local community practices livestock rearing and take them to the adhvaris (details have been provided in the fourth report). Detailed discussions were carried out with these local community members to understand their views and perceptions on grassland degradation and impacts of the same. They have reported change in the species composition in the grasslands, which has led to decline in fodder availability. The prominent palatable species that have declined include *Festuca gigantica* (30 percent), *Cynodon dactylon* (40 percent) and *Cyperus alulatus* (30 percent). They feel this has happened due to climate change, as a result of which winter rain has declined significantly. This has impacted the germination of species. In addition, increase in temperature has led to changes in plant phenology, thereby resulting in changes in the species composition in the grasslands in the sub-river basin. A discussion on the impact of grassland degradation on the weight gain by livestock in two months now, as compared to the gain 20 years back showed a decline in the weight gain (Table 26).

Table 26: Comparative analysis change in weight gain by livestock

Animal	Weight-increase in 2 months (20 year back)	Weight-increase in 2 months (now)
Goat	7-8 kg	4-5 kg
Sheep	4-5 kg	2-3 kg

Drivers of degradation in the sub-river basin

A list of the drivers of degradation in the sub-river basin (not limited to grasslands) was developed. The major drivers of degradation are:

a) **Change in cropping pattern**- There has been a shift in crops from traditional crops (local paddy, maize and wheat) to cash crops such as peas, cauliflower, and tomato. Local cereals like Phagdi and Phulun are no longer cultivated in the area. This on one hand has reduced the food self-sufficiency and on the other hand has increased pressure on the grasslands for fodder. The traditional crops were also a major source of fodder, in absence of which, the villagers have to depend more on the fodder from the grasslands.
b) **Increase in temperature, leading to phenological changes** – Increased temperatures are leading to phenological changes in plants, which is in turn causing changes in species composition.
c) **Construction of roads**- Increase in the construction of roads has also contributed to the degradation of the landscape.
d) **Firewood collection**- There is heavy dependence on firewood, particularly in the winters. Though most of the wood collected from the forest is dry wood, but this factor also contributes to disturbance in the ecology of the sub-river basin.
e) **Human-wildlife conflict**- Even though the conflict is not as severe as in the past, bear at times enter to the agricultural fields and uproots peas. Himalayan Black Bear comes to the fields to eat Bhangdi and peas. Himalayan Black Bear used to come more earlier (as they had more maize, bhangdi etc)
f) **NTFP collection**: The Parmas sub-river basin includes Killar, which is a busy town in Pangi. The increased population and dynamic business activities in the region cause heavy extraction of various NTFP such as Jeera, Thangi and Guchchi from the forests

in large quantities. Villagers reported a decline in these resources due to over extraction in the past.

g) **Melting of Glaciers** - Faster melting of glaciers and unpredictable rainfall pattern are also causes of degradation in the landscape.
h) **Population increase**- The population in Killar region is steadily increasing. This increase has led to overdependence on the forests for timber for house construction. An increase in NTFP collection has also been noticed as more people are collecting the same.
i) **Waste increase and lack of management**- Absence of a proper waste management mechanism in the villages is contributing to degradation of the sub-river basin.
j) **Water scarcity**- Villagers reported water scarcity as a main issue which is due to increase in population and decrease in snow. Dhars, are the major source of water for the villages, which are drying up. Since there in not enough water, agriculture is primarily rainfed.
h) **Pesticide use**- Unlike in the past, the community is now using pesticides and chemical fertilizers in order to increase agricultural production. This is leading to degradation of the soil quality and affecting the biodiversity of the area.
i) **Short duration high intensity rainfall and landslides**- Increased incidences of both are leading to loss of land and soil, which is impacting the grasslands and other land use classes in the sub-river basin.

3.5.4 Kanyun Sub-River Basin

Kanyun sub river basin lies between 76^0 19'1'' to 76^0 37' 35'' East longitude and 33^0 6'30'' to 33^0 12'37'' North latitude and elevation of the river basin varies from 2012 m to 5968 m MSL. The total area of the sub river basin is 166.9km^2.

Landuse in the sub-river basin

Figure 53 details the landuse in the sub-river basin. The analysis shows that grasslands cover 21 percent of the sub-river basin (Table 27).

Table 27: Land Classes in Kanyun Sub-River Basin

Land class	Area	Area %
Agriculture	355.1	2.16
Barren Land	2838.77	17.25
Deodar	790.82	4.8
Dry Alpine Pasture	3503.31	21.28
River/ Dry river	40.87	0.25
Dry temperate forest	49.62	0.3
Orchard	329.16	2
River/ Dry river	58.66	0.36
River sediments	1.67	0.01
Settlement	29.22	0.18
Snow cover	6035.37	36.66
Sub Alpine forest	2428.58	14.75

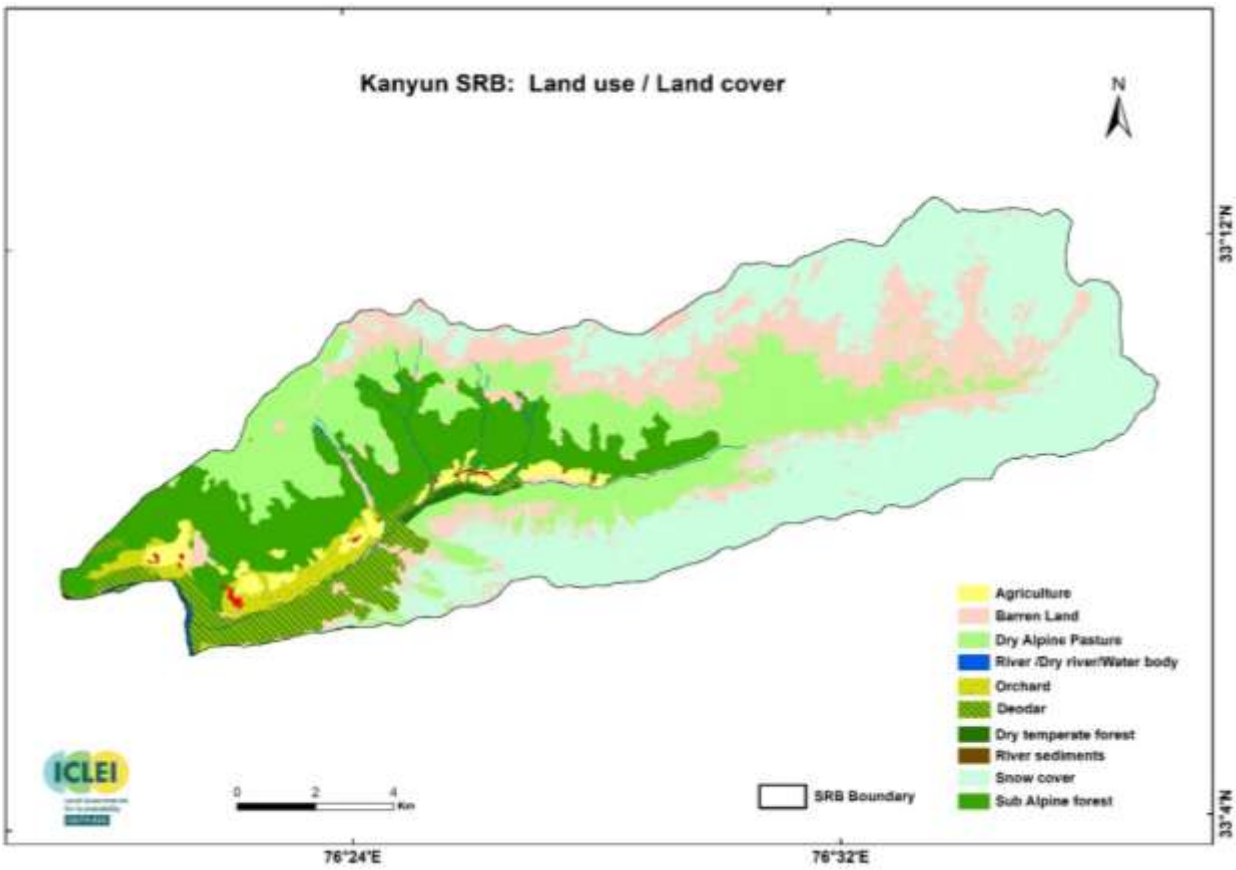


Figure 53: Land Use Land Cover Map of Kanyun Sub-River Basin

An elevation-wise analysis of the land use of Kanyun sub-river basin shows that the grasslands primarily fall in the medium elevation zone (3359.29ha), followed by low elevation zone (110.58 ha). Table 28 and Figure 54 provide the details.

Table 28: Elevation wise distribution of Land Classes in Kanyun Sub-River Basin

Land class	**Area (in ha)**		
	Low Elevation	**Medium Elevation**	**High elevation**
Agriculture	298.12	56.98	
Barren Land	101.00	1988.31	747.18
Deodar	625.00	165.27	32.14
Dry Alpine Pasture	110.58	3359.29	0
Dry river	12.08	28.79	0
Himalayan dry temperate forest	49.62	0	0
Orchard	328.75	0	0
River	49.02	9.49	0
River sediment	1.67	0	0
Settlement	27.61	1.61	0
Snow cover	3.03	2648.76	3371.45
Sub Alpine forest	823.26	1604.82	0

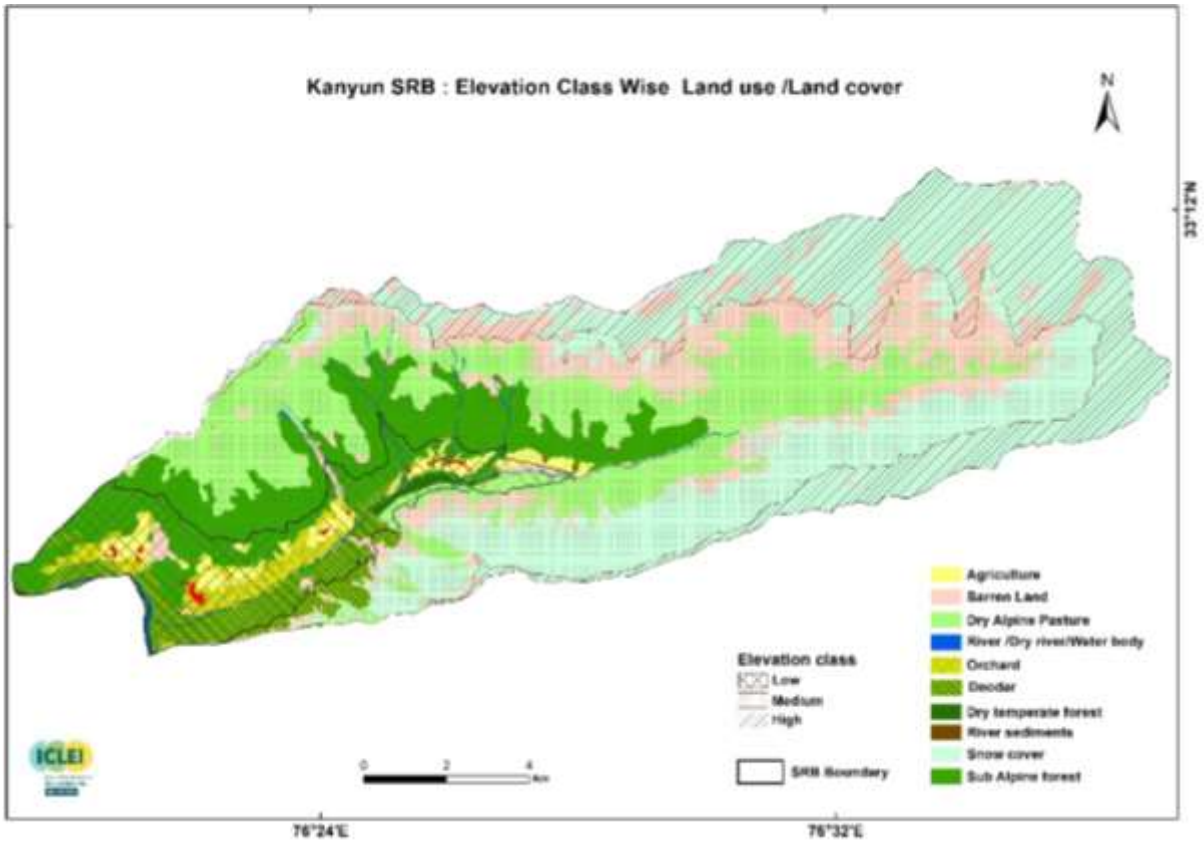


Figure 54: Land Use Land Cover Map of Kanyun Sub-River Basin

NPP change analysis in the sub-river basin

NPP change analysis (Figures 55 and 56) shows that in the years between 2005-2010, there was a sharp decline in the NPP. One of the factors for the same can be the decline in winter rain during that period. Winter rain is essential for the germination of perennial herbs and also contributes to the growth of shrubs and trees. Figure 55 details the areas where changes in NPP have been observed.

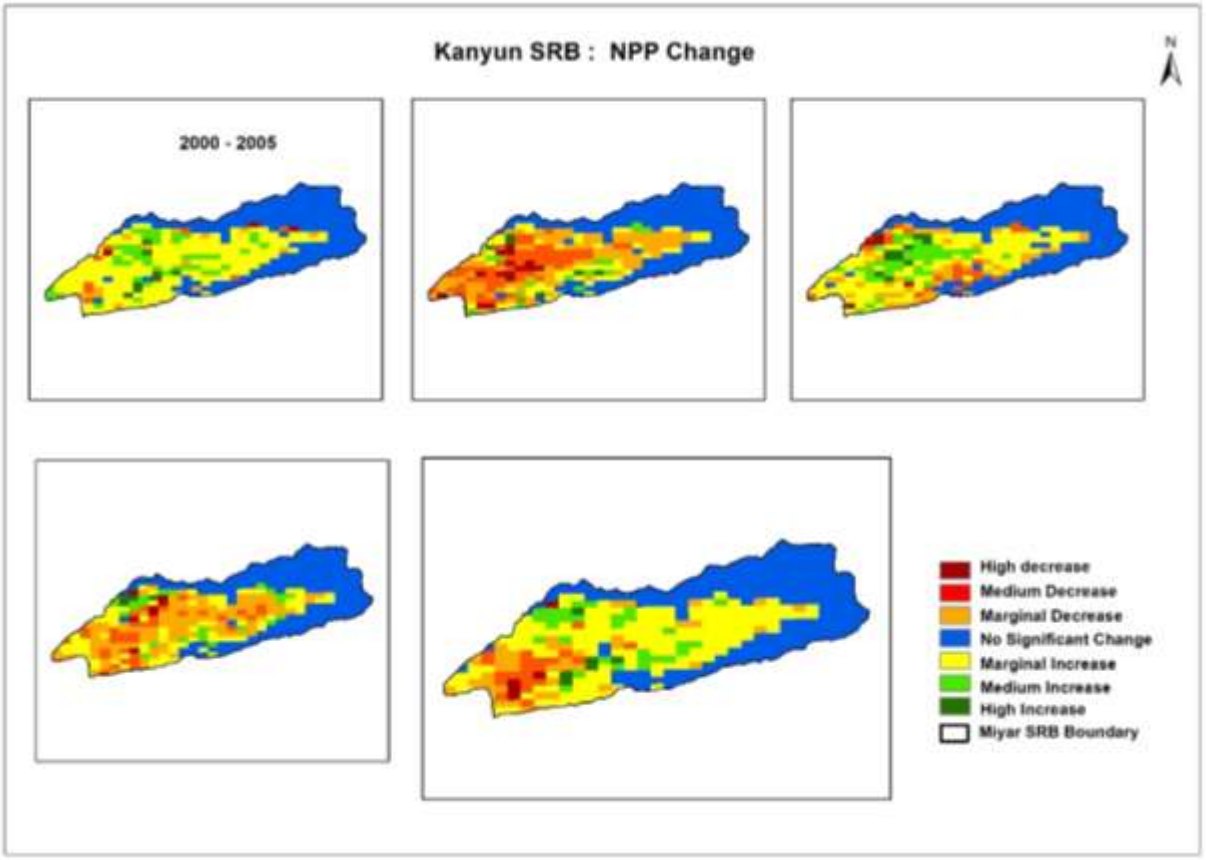


Figure 55: NPP change in Kanyun Sub-River Basin

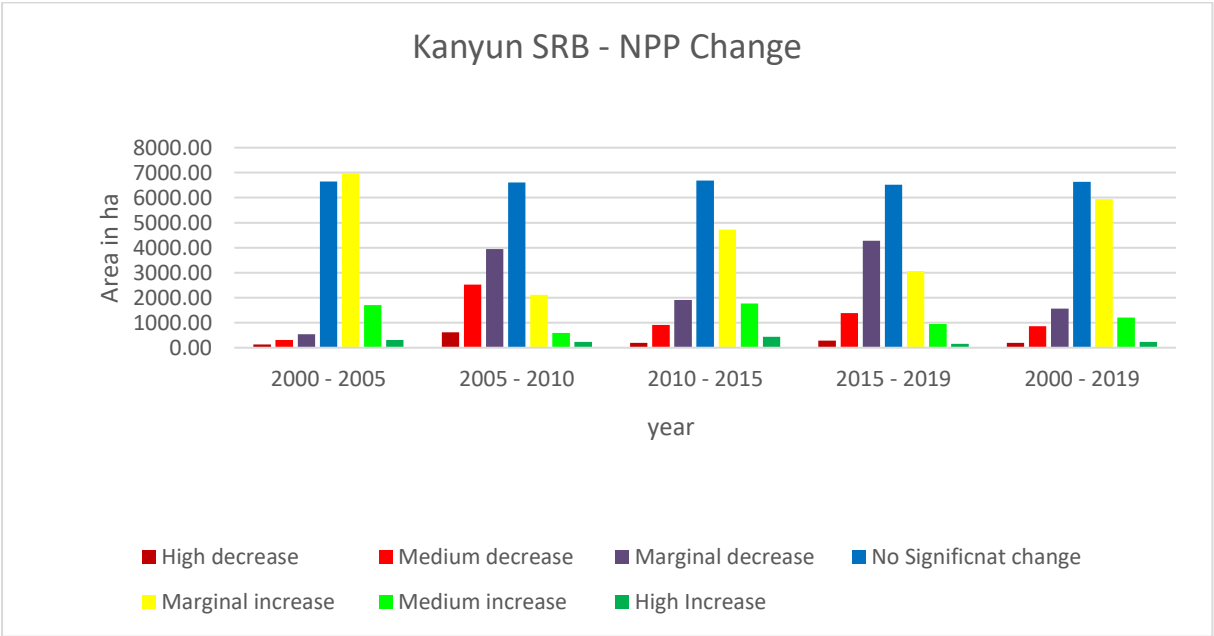


Figure 56: Graph depicting NPP change in Kanyun Sub-River Basin

NPP change analysis in the grasslands of the sub-river basin

An analysis of the NPP change in the grasslands (Table 29 and Figure 57) in the sub-river basin shows the same trend of significant decline in NPP in the duration of 2005-2010. Decline in winter rain is one of the factors as winter rain is essential for germination of the grasses and other annual herbs in the grasslands. Figure 57 details the areas where changes in NPP have been observed in the grasslands.

Table 29: NPP change in grasslands in Kanyun Sub-River Basin

NPP Change class	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2019	2000 - 2019
High decrease	109.98	179.19	179.37	70.92	9.54
Medium decrease	0.00	408.15	384.48	368.73	76.05
Marginal decrease	95.58	1482.03	507.78	1442.16	193.32
No Significant change	131.76	142.92	204.21	143.19	110.52
Marginal increase	2183.49	844.38	1650.15	949.59	2370.60
Medium increase	936.36	272.07	441.36	424.26	693.63
High Increase	53.19	181.62	116.91	111.51	56.70

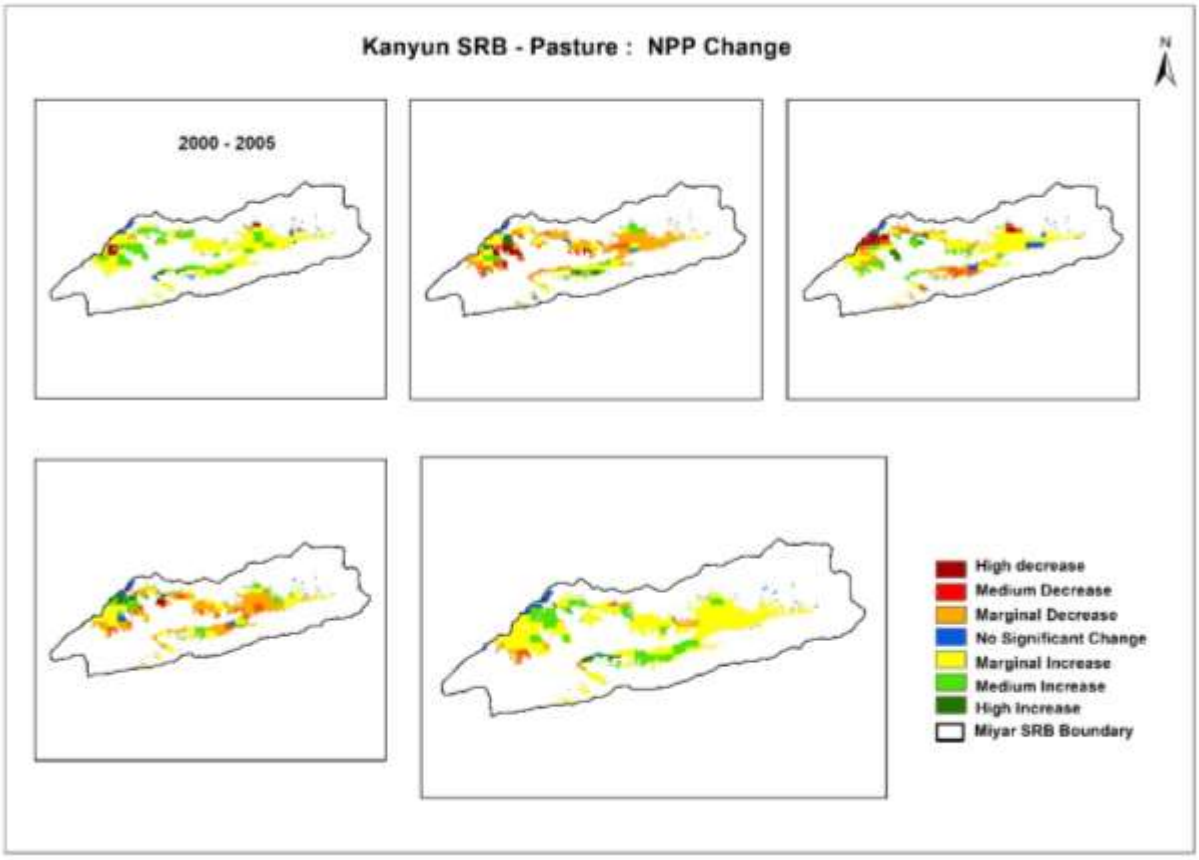


Figure 57: NPP change in grasslands in Kanyun Sub-River Basin

Mapping degradation in the sub-river basin

Degradation was mapped for Kanyun sub-river basin. Figure 58 provides details of degradation in the sub-river basin.

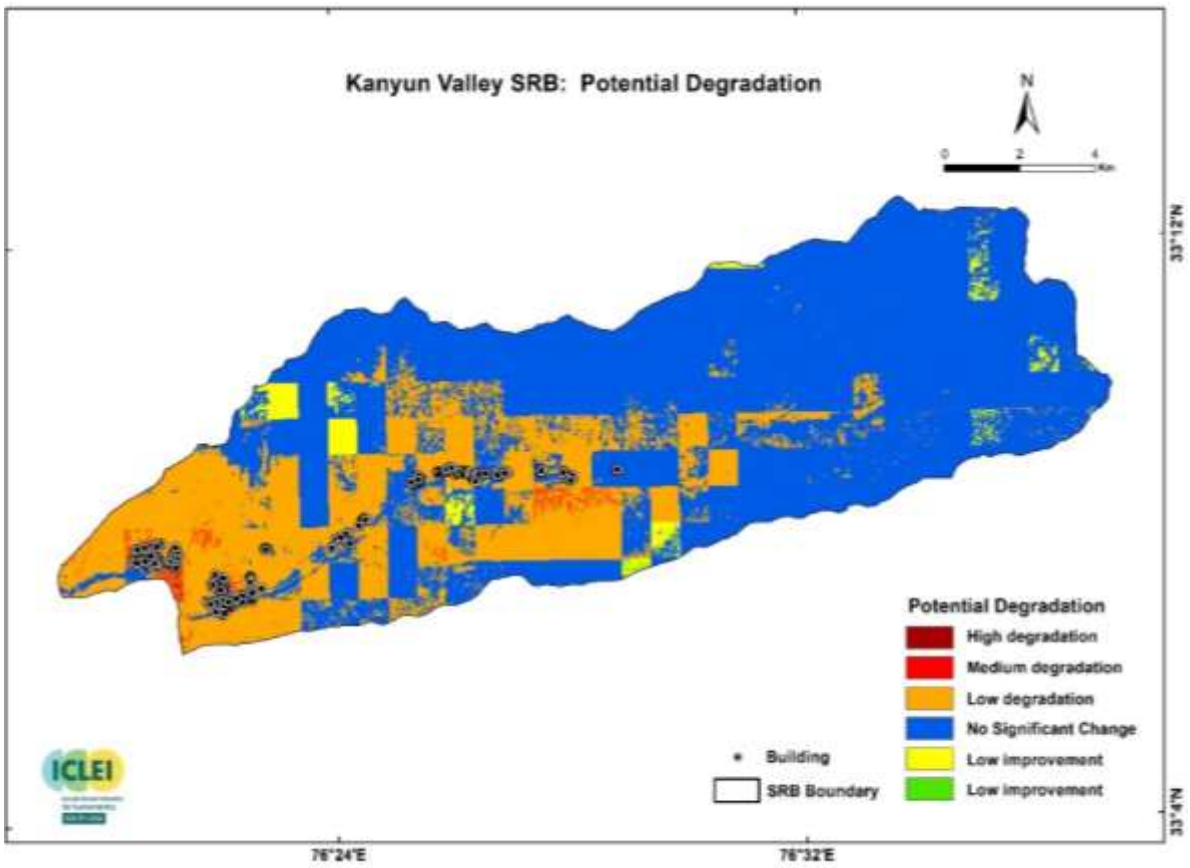


Figure 58: Degradation in Kanyun Sub-River Basin

An elevation-wise analysis of the degradation in Kanyun sub-river basin (Figure 59 and Table 30) shows that majority of the degradation has taken place in the areas at middle elevation, followed by the areas at low elevation. With regard to the intensity of degradation, the sub-river basin faces majorly low levels of degradation, though some areas face medium levels of degradation as well. High levels of degradation are present in very small patches in the sub-river basin.

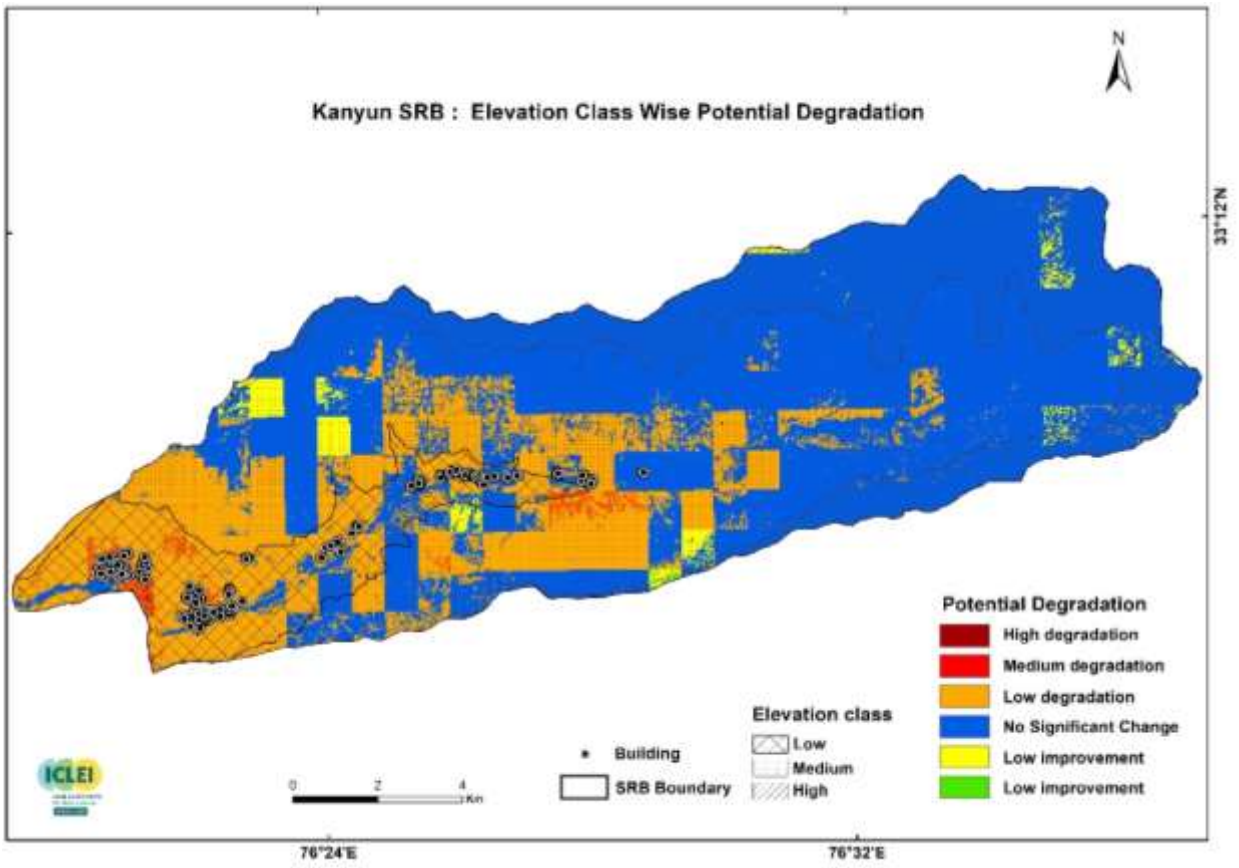


Figure 59: Elevation-wise degradation in Kanyun Sub-River Basin

Table 30: Elevation-wise degradation in Kanyun Sub-River Basin

Degradation class	Area (in ha)		
	Low Elevation	Medium Elevation	High elevation
High degradation	4.14	0	0
Medium degradation	160.02	72.18	0
Low degradation	1800.81	2996.55	25.74
No Significant change	456.03	6514.2	4085.55
Low Improvement	7.11	303.39	95.31
Medium Improvement	0	3.69	4.5
High Improvement	0	0	0

Mapping degradation in the grasslands in the sub-river basin

Figure 60 and Table 31 detail the levels of degradation in the grasslands in Kanyun Sub-River Basin. It can be seen that around 31.46 percent of the grasslands in this landscape are under various levels of degradation. Figure 60 showcases the areas of degradation, along with the intensity of the same.

Table 31: Degradation in grasslands in Kanyun Sub-River Basin

S. No	Degradation class	Area (in h)	Area % (to total GA of SRB)
1	Medium degradation	72.45	2.06
2	Low degradation	1032.21	29.40
3	No significant change	2236.14	63.70
4	Low Improvement	169.56	4.83

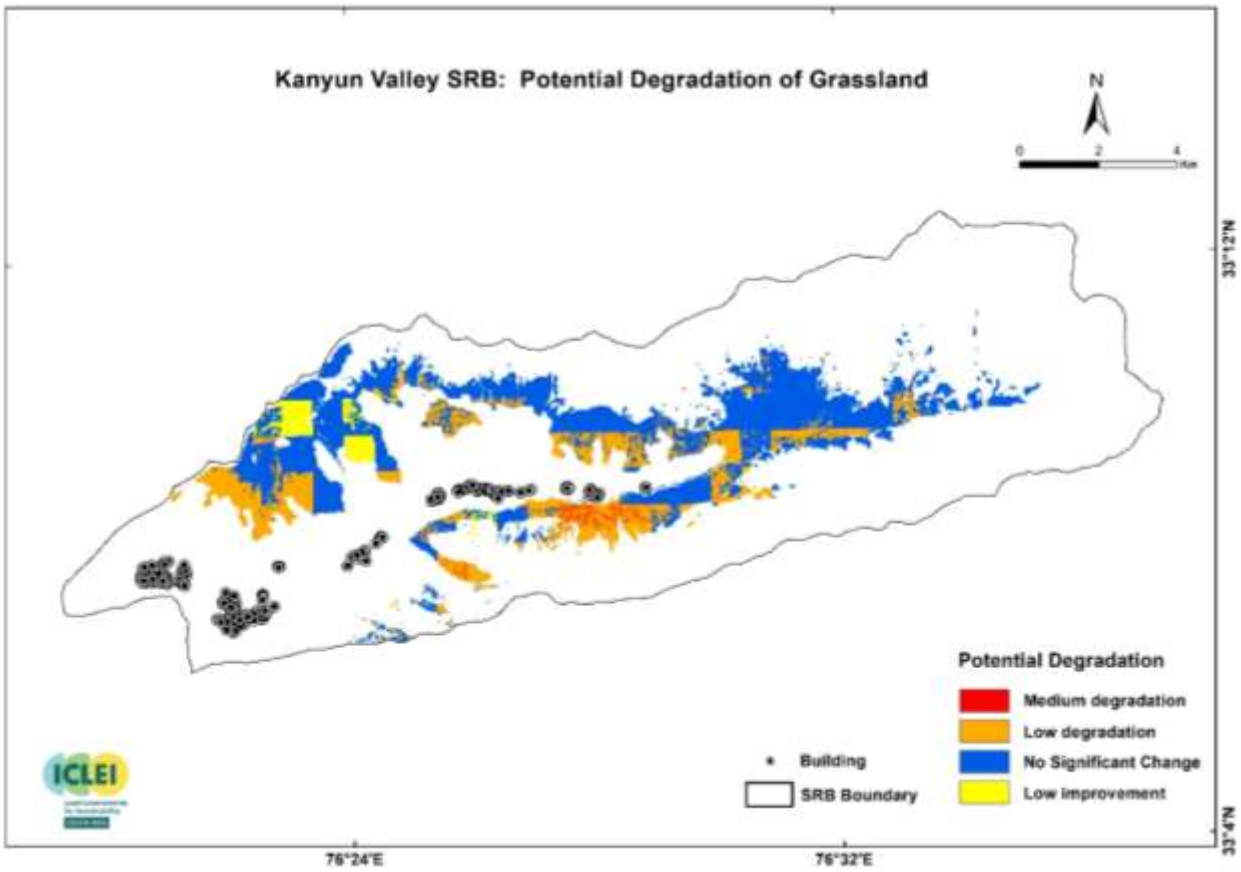


Figure 60: Degradation in grasslands in Kanyun Sub-River Basin

An elevation-wise analysis of the degradation in the grasslands in Kanyun sub-river basin (Figure 61 and Table 32) shows that majority of the degradation has taken place in the areas at middle elevation, followed by the areas at low elevation. With regard to the intensity of degradation, the grasslands in the sub-river basin face majorly low levels of degradation, though some areas face medium levels of degradation as well.

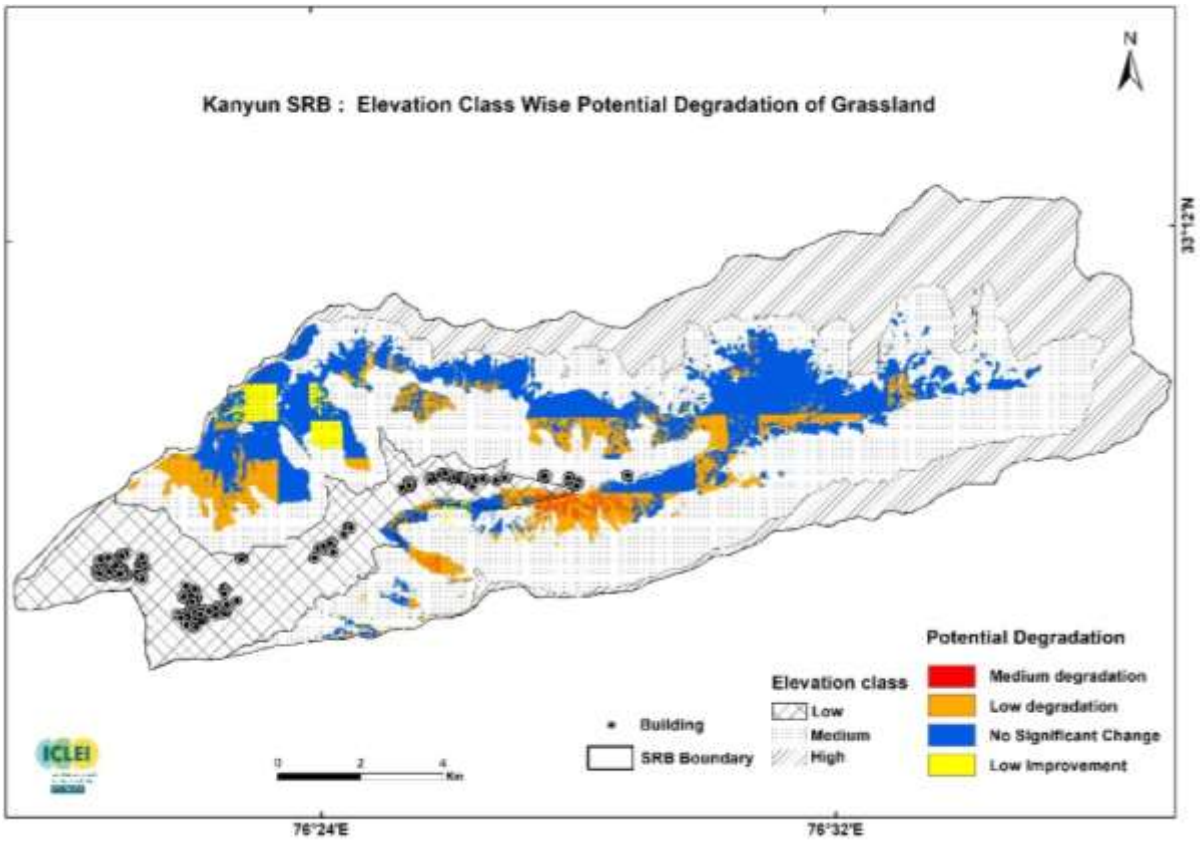


Figure 61: Elevation-wise degradation in grasslands in Kanyun Sub-River Basin

Table 32: Elevation-wise degradation in grasslands in Kanyun Sub-River Basin

Degradation class	Area (in h)		
	Low Elevation	Medium Elevation	High elevation
High degradation	0	0	0
Medium degradation	7.38	65.97	0
Low degradation	48.96	985.59	0
No Significant change	50.4	2162.97	25.56
Low Improvement	5.04	161.46	3.42
Medium Improvement	0	0	0
High Improvement	0	0	0

Analysis of soil of the grasslands in the sub-river basin

Analysis of the soil samples of the grasslands in the sub-river basin and that of the control site were carried out. A comparison of the same (Figure 62 and Table 33) shows that the soils in the grasslands of the sub-river basin have lower electrical conductivity, organic carbon and nitrogen, as compared to the soils of the control site.

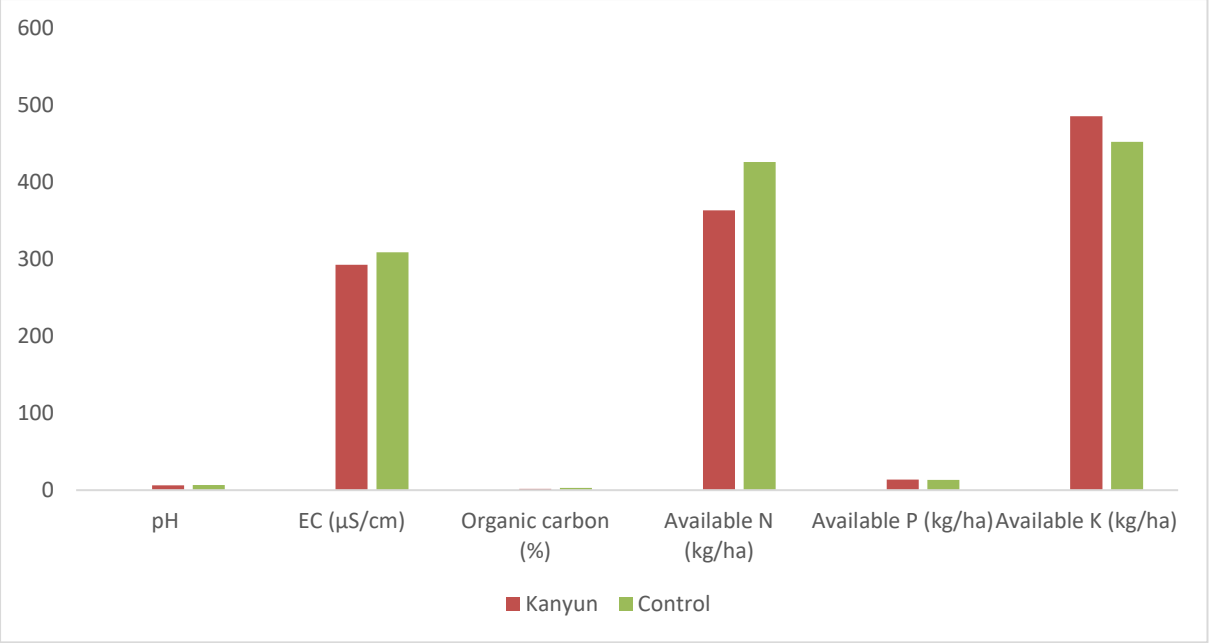


Figure 62: Comparative analysis of soil parameters of grasslands in Kanyun Sub-River Basin and grasslands at control site

Table 33: Comparative analysis of soil parameters of grasslands in Kanyun Sub-River Basin and grasslands at control site

Sample ID	pH	EC (µS/cm)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Kanyun	6.415	293	1.5725	363.775	13.595	485.8
Control	6.55	309	2.843	426.5	13.44	452.48

Analysis of quadrat studies conducted in the grasslands of the sub-river basin

A comparative analysis of the families of floral species recorded from grasslands in Kanyun sub-river basin and that from the control site shows that the number of species of grasses (family Poaceae) is much lower in the grasslands of Kanyun sub-river basin. In addition, the presence of legumes (Family Fabaceae) in the grasslands in Kanyun sub-river basin is also lower as compared to the grasslands in the control site. As depicted in Figure 63, there has been a significant change in the species composition in the grasslands of Miyar sub-river basin, as compared to the grasslands in the control site, which is also an indicator of the degradation in the grasslands in the sub-river basin.

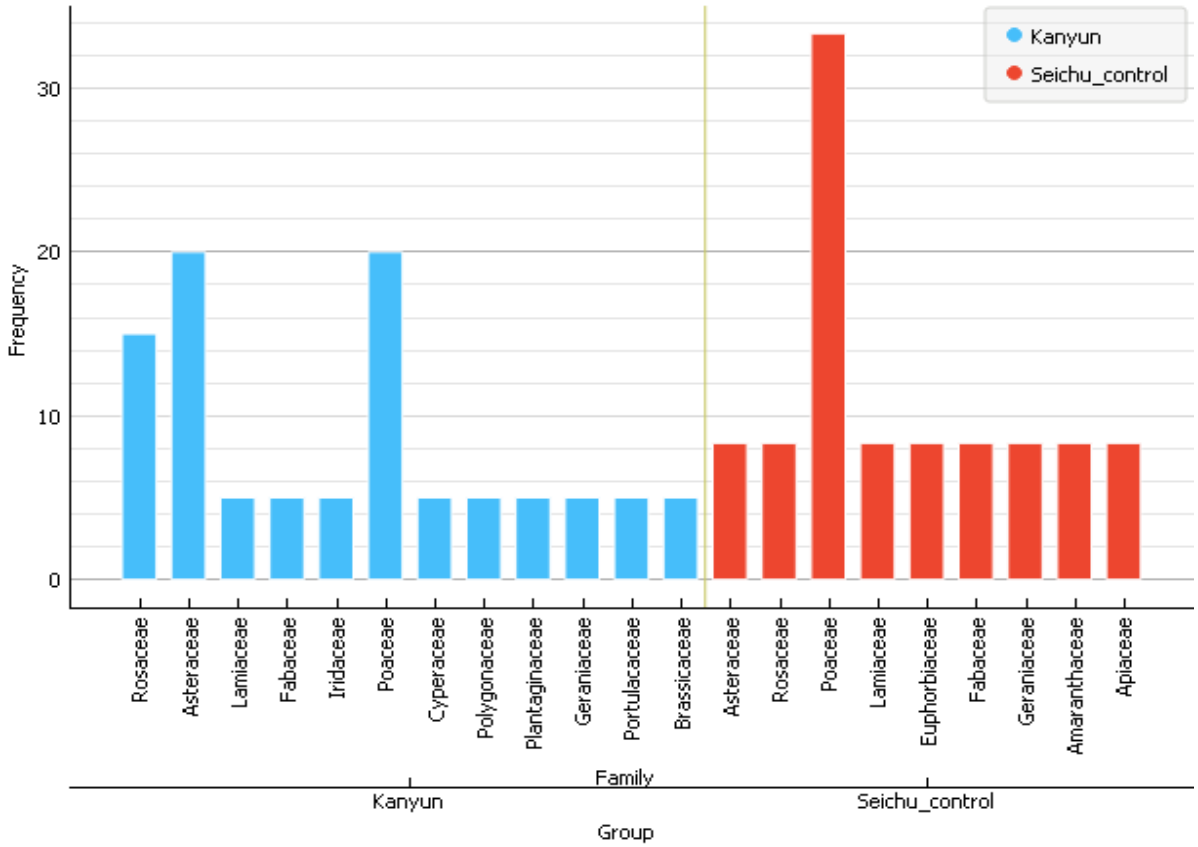


Figure 63: Comparative analysis of plant families found in grasslands in Kanyun Sub-River Basin and grasslands at control site

Comparative analysis of the Shannon diversity of grasslands in Kanyun sub-river basin have a significantly lower diversity as compared to the grasslands in the control site (Figure 57). This indicates that the diversity of plant species in the grasslands in Kanyun sub-river basin and the composition of the same has changed when compared with the grasslands in the control site (Figure 64).

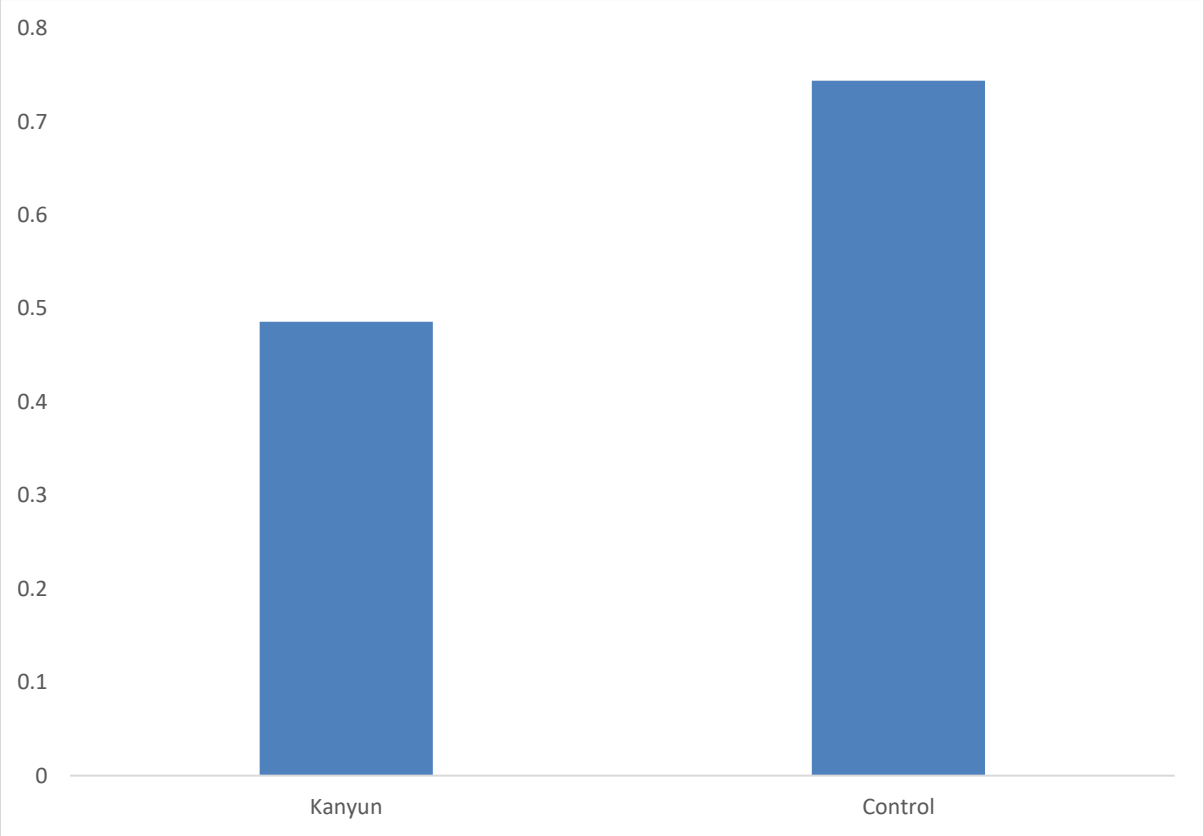


Figure 64: Comparative analysis of the Shannon diversity of grasslands in Kanyun sub-river basin and in control site

An analysis of the presence of unpalatable species, which is also an indicator of degradation of the grasslands shows that the grasslands in Kanyun sub-river basin have 70 percent palatable and 30 percent unpalatable species. In contrast, the grasslands in the control site are comprised of 83 percent palatable and 17 percent unpalatable species (Figure 65 and Figure 66).

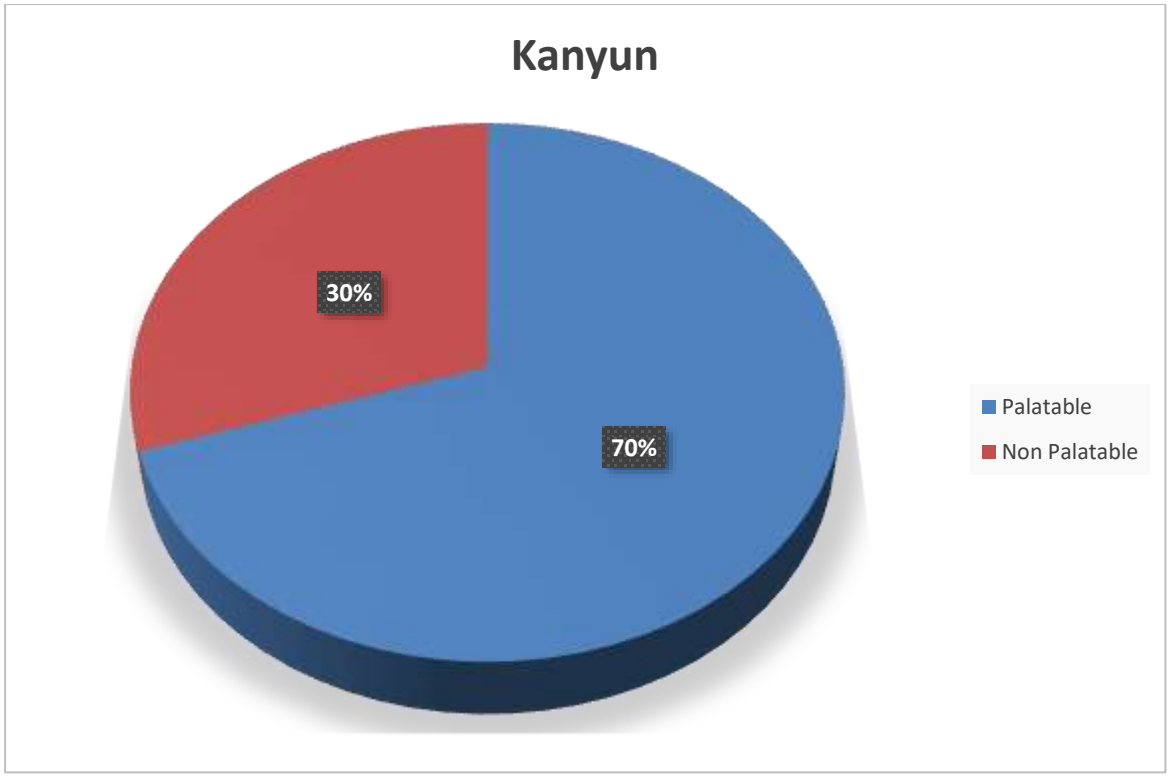


Figure 65: Comparative analysis percent palatable and unpalatable species in grasslands in Kanyun sub-river basin

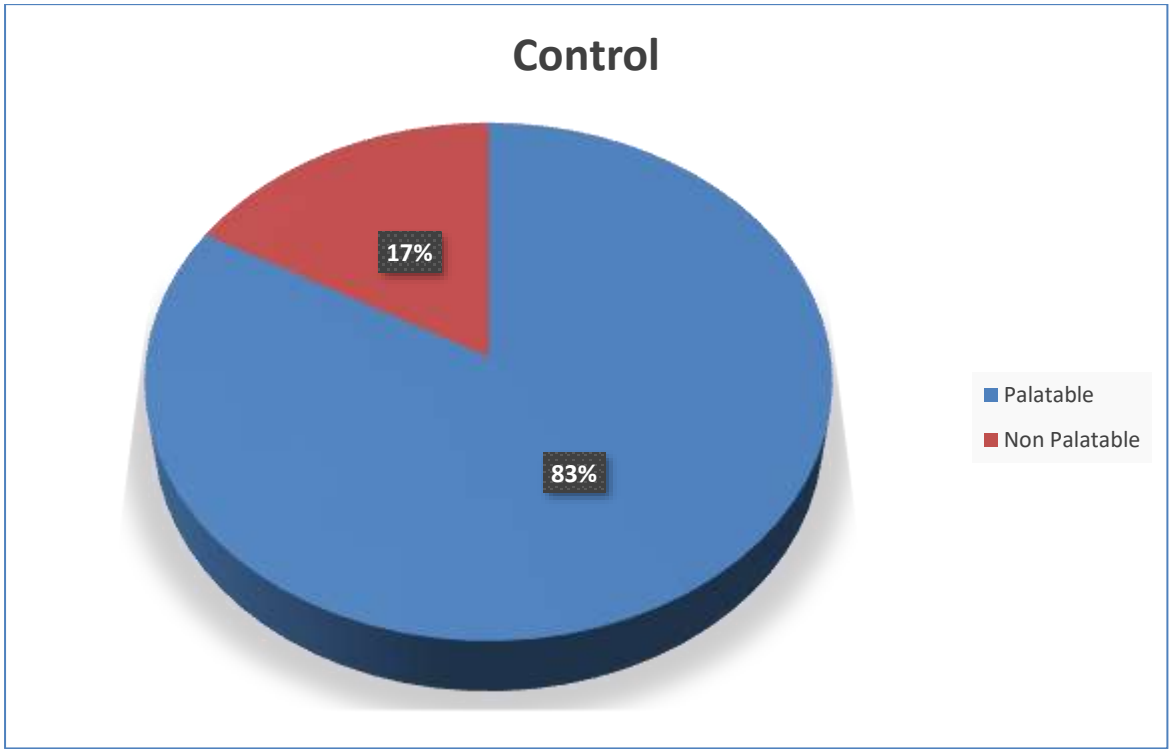


Figure 66: Comparative analysis percent palatable and unpalatable species in grasslands in control site

Views of the residents (who rear livestock) on grassland degradation in the sub-river basin

This sub-river basin is not visited by Gaddis. he local community practices livestock rearing and take them to the adhvaris (details have been provided in the fourth report). Detailed discussions were carried out with these local community members to understand their views and perceptions on grassland degradation and impacts of the same. They have reported change in the species composition in the grasslands, which has led to decline in fodder availability. The prominent palatable species that have declined include *Festuca gigantica* (10-20 percent) and *Cynodon dactylon* (20-30 percent). They feel this has happened due to climate change, as a result of which winter rain has declined significantly. This has impacted the germination of species. In addition, increase in temperature has led to changes in plant phenology, thereby resulting in changes in the species composition in the grasslands in the sub-river basin. Another reason for decrease in availability of fodder species has been identified as the increase in livestock population in this sub-river basin. A discussion on the impact of grassland degradation on the weight gain by livestock in two months now, as compared to the gain 20 years back showed a decline in the weight gain (Table 34).

Table 34: Comparative analysis change in weight gain by livestock

Animal	Weight-increase in 2 months (20 year back)	Weight-increase in 2 months (now)
Goat	7 kg	4-5 kg
Sheep	4-5 kg	3 kg

Drivers of degradation in the sub-river basin

A list of the drivers of degradation in the sub-river basin (not limited to grasslands) was developed. The major drivers of degradation are:

a) **Change in cropping pattern**- Like other sub-river basins, villages in Kanyun sub-river basin have also been gradually shifting from traditional crops to cash crops. This on one hand has reduced the food self-sufficiency and on the other hand has increased pressure on the grasslands for fodder. The traditional crops were also a major source of fodder, in absence of which, the villagers have to depend more on the fodder from the grasslands.
b) **Pesticide use**- Unlike in the past, the community is now using pesticides and chemical fertilizers in order to increase agricultural production. The use of chemical fertilizers and pesticides is degrading the soil quality and affecting the biodiversity of the area.
c) **Increase in temperature, leading to phenological changes** – Increase in temperature is leading to phenological changes in the plant species and causing changes in species composition.
d) **Waste increase and lack of management**- Waste management is an emerging issue and a big challenge. There is absence of a proper waste management mechanism in the villages. They either burn solid waste near the house itself or dump in the nearby streams or river.
e) **Short duration high intensity rainfall and landslides**- Increased incidences of both are leading to loss of land and soil, which is impacting the grasslands and other land use classes in the sub-river basin.
f) **Increase in livestock**- Increase in livestock population in villages like Dharwas in this sub-river basin has led to increased grazing pressure on the adhvaris and also

increased demand for fodder for stall feeding in the winters. Both these are leading to degradation of the pasturelands in this sub-river basin.

g) **Melting of Glaciers** - Faster melting of glaciers and unpredictable rainfall pattern are also causes of degradation in the landscape.

h) **Population increase**- Increase in population is leading to reduction in the area of grasslands available to each family (near the villages) as the land is being used to construct new houses to meet the needs of the growing population. This is leading to higher pressures on the adhvaris and degradation of the grasslands.

i) **Water scarcity**- Villagers reported water scarcity as a main issue which is due to increase in population and decrease in snow. Dhars, are the major source of water for the villages, which are drying up. Since there in not enough water, agriculture is primarily rainfed.

3.6 Expert consultations and development of the mitigation plan

As already explained in the methodology section, above, one to one online discussions have been carried out with experts and practitioners. Based on the results obtained through the field work (explained sub-river basin wise in the previous section) and discussions with experts and practitioners, a broad sketch of the mitigation plan has been drawn up. This needs to be discussed with the community members and officials of Forest Department and other line departments in the landscape (once Covid-19 situation improves and travel is opened), in order to develop the detailed sub-river basin specific mitigation plan and the implementation framework for the same. As of now four sub-river basins have been shortlisted. Based on the discussions in the landscape, two sub-river basins (out the four shortlisted ones) will be selected for development of the mitigation plan and implementation framework.

The overall issues with regard to grassland degradation can be grouped into 7 categories (refer Figure 67).

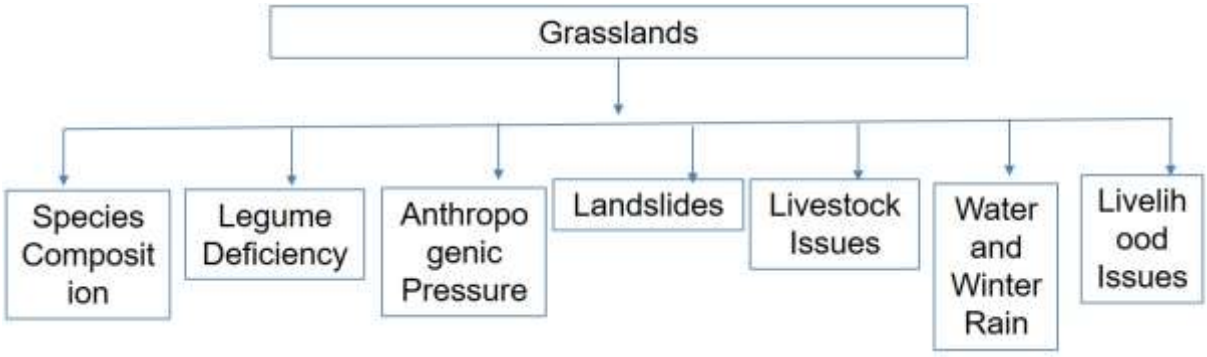


Figure 67: Addressing grassland degradation

Species Composition

It has been clearly demonstrated that the composition of the grasslands in all the sub-river basins have changed, due to the various degrading factors. Plantation of the grass species needs to be undertaken. The primary focus will need to be on native, tussock forming grasses. Plantations can be carried out through seed broadcast, development of nurseries and transplantation of culms, from within the entire Lahual-Pangi Landscape. The roots of these grasses need to be inoculated with Arbuscular Mycorrhizal Fungi. The areas in the grasslands where this activity is carried out, will need to be barricaded so that no grazing can occur there till the plants establish and the soil is also able to rejuvenate. This will need a minimum period of three years.

Based on the expert discussions, feedback from local herders and migratory pastoralists, quadrat studies and list of wild herbivores sighted in the grasslands of each sub-river basin, species composition of the grasses that need to be planted have been developed for each sub-river basin (refer Table 35).

Table 35: Species to be planted in each sub-river basin

Sub-River Basin	**Species**
Miyar	*Festuca gigantica, Calamagrostis canescens, Poa alpina , Stipa* sp*., Deschampsia* sp*., Kobresia* sp., *Carex infuscata., Phleum alpinum Alopecurus aequalis, Festuca ovina , Koeleria cristata , Agropyron cristatum, Arundinaria* sp*., Cynodon dactylon*, *Cyperus* sp*., Danthonia cachemeriana ,Thamnocalamus spathiflora, Poa annua, Themeda anathera, Elymus longe-aristatus, Themeda anaethera, Heteropogon contortus, Chrysopogon echinulatus, Bothriochloa intermedia.*
Kundal	*Calamagrostis sp., Poa sp., Stipa sp., Deschampsia sp., Kobresia sp., Carex sp, Festuca gigantica, Cynodon dactylon, Cyperus sp., Danthonia cachemeriana ,Thamnocalamus spathiflora, Poa annua, Elymus longe-aristatus, Themeda anaethera, Heteropogon contortus, Chrysopogon echinulatus, Bothriochloa intermedia, Elymus dahuricus, Poa alpina Phleum alpinum, Alopecurus aequalis, Festuca ovina , Koeleria cristata , Agropyron cristatum , Avena sp.*
Parmas	*Kobresia sp., Carex sp., Elymus dahuricus, Poa alpina , Stipa sp., Phleum alpinum, Alopecurus aequalis, Festuca ovina , Koeleria cristata, Agropyron cristatum , Avena sp., Ptilagrostis sp., Festuca gigantica, Chrysopogon echinulatus, Bothriochloa intermedia, Cynodon dactylon, Cymbopogon martini, Themeda anathera, Poa annua*
Kanyun	*Deschampsia sp., Deyeuxia sp., Bothriochloa ischaemum , Poa alpina , Stipa sp., Phleum alpinum, Festuca gigantica, Cynodon dactylon, Cymbopogon martini, Poa pagophila, Heteropogon contortus, Chrysopogon echinulatus*

Legume Deficiency

The soils in the grasslands in all the sub-river basins have low nitrogen and the number of legume species (which fix nitrogen) is very low or non-existent in the grasslands. It is crucial to ensure the growth of legume species in the grasslands in order to restore them. Native species of legumes need to be planted. This can again be carried out through seed broadcast and raising nurseries. Some of the legume species that have been identified include *Desmodium elegans, Indigofera heterantha ,Oxytropis sp, Hedysarum sp , Lotus corniculatis, Trifolium repens, Indigofera geradiana, Astragalus* sp. , *Caragana nepalensis.*

Anthropogenic Pressures

As stated in the results and discussion section, anthropogenic pressures on the grasslands have increased due to increase in dependence on the grasslands for grazing and fodder requirements. In order to reduce this pressure, activities need to be taken up in the agriculture fields and areas in vicinity to the villages. The activities that can be undertaken include:

a) Grass cultivation along the field bunds and edges- Some of the species that have been identified are *Festuca gigantica, Pennisetum orientale, Panicum antidolate, Cynodon dactlyon, Arthraxon lancifolius, Poa annua, Heteropogon contortus, Chrysopogon echinulatus, Desmodium intortum*
b) Undertake plantation of fodder trees in agricultural fields as well as in areas around the houses in the village. Some of the species that have been identified are *Bauhinia varigata, Dendrocalamus* sp*., Grewia optiva, Quercus incana, Rhododendron lepidotum*
c) The community needs to be encouraged to cultivate traditional crops to augment fodder base. This includes *Fagopyrum esculentum,* Millets, Black Pea, Barley*, Heracleum* sp*., Trigonella foenum-graecum, Allium wallichii, Cousinia thomsonii, Aconogonum mole.*
d) Extensive training and capacity building activities need to be undertaken for the local community on improved forage cultivation practices. These trainings need to be help by the district administration, in collaboration with agriculture, horticulture and forest department officials in the landscape.

Landslides

Landslides, as stated in the section on results and discussion are a major cause of land loss and degradation. There are several methods to address the same

a) Undertaking plantation of tussock grasses in landslide prone areas. This will help to stabilise the soil. These grasses can be raised in nurseries or culms can transplanted from other sites within the Lahual-Pangi landscape.
b) Plantation of *Hippophae* sp. in landslide prone slopes. This will also help to stabilise the soil. The saplings will need to be raised in nurseries and then planted along the slopes.
c) Bioengineering methods can be followed. These methods have been successfully used in Ladakh. Techniques like Wattling and staking method and Brush matting can be used (refer Box 1).

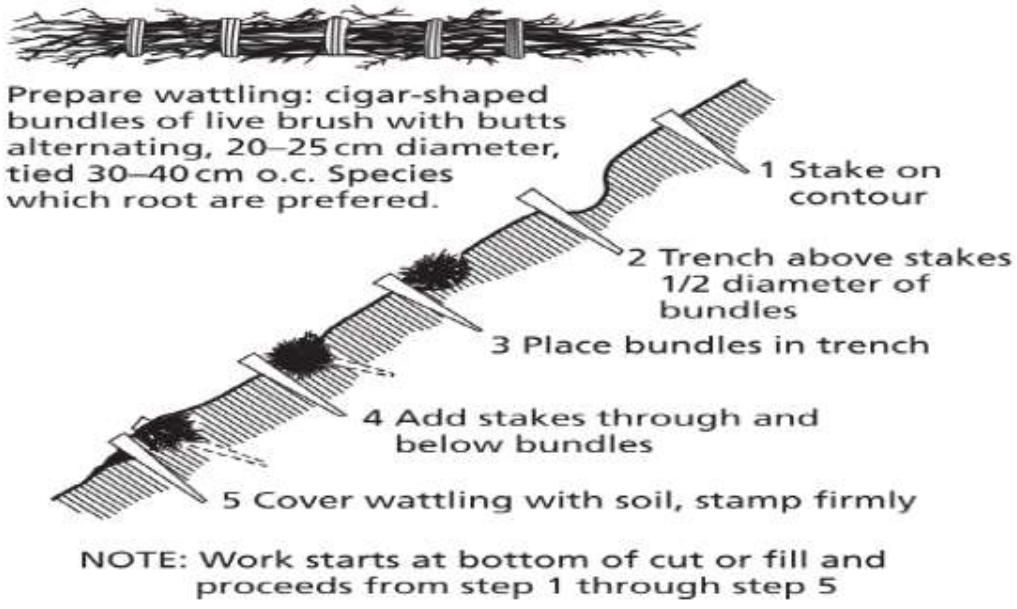
Box 1: Bioengineering techniques (Tundup et al, 2017)

Wattling and staking method:

Wattles, also termed fascines, are cigar-shaped bundles of six to eight live cuttings, each 200–250mm in diameter, arranged with butt ends alternating, and tied at 300–400mm intervals. Species that root easily are used, such as Salix, Leucaena, Baccharis and Tamarix. The wattles are placed in shallow trenches on the contour, 0.3m wide, up to 0.5m deep and spaced at 4m intervals on slopes less than 30° and at 2m intervals on slopes of 30–45°. The lines where the fascines will be installed are marked out on the slope. Then, starting from the bottom of the slope, 5m lengths of trench, 100mm deep and 200mm wide, are dug at any one time. The fascines are placed in the trench, covered with soil so that about 10 per cent of the fascine is exposed and pegged to the slope at 0.5–0.8m intervals using wooden stakes, 0.6m long, driven vertically into the ground. Grasses and shrubs can be planted between the wattles.

Brush matting:

Brush mats can be used as an alternative to geotextiles to provide an immediate cover to the slope and prevent surface erosion. Since they also provide the basis for the long-term vegetation cover, they are only suitable for sites where the species used is appropriate as the final land cover. With brush matting, cuttings of stems and branches of live willow are placed on the slope, butt ends downslope, at 20–50 stems per running metre, to give a minimum of 80 per cent ground cover. The thicker ends of the branches are covered with soil to aid rooting and then fixed with stones or pegs. The whole is covered with soil and the brush fixed to the slope using stakes or wires.



Livestock issues

Activities that need to be undertaken to address the livestock issues include:

a) Awareness generation and discussions on the need to have reasonable herd size. Presently the herder is concerned about quantity and not quality as large herd reduces risk of the failure of livestock rearing. Extensive awareness generation activities, coordinated by the district administration (with support from local NGOs, Mahila Mandal, Praja Mandal etc) needs to be undertaken on regular basis.
b) Change in livestock composition needs to be encouraged and enforced. The number of goats in the livestock of each herder (both resident and nomadic) needs to be limited as goats nibble and destroy the vegetation. Herders need to have more sheep in their herds.
c) Reduce the impacts of inbreeding depression in herds. In order to reduce the same, cross breeding needs to be encouraged.

Water and rain water

Winter rain and water availability in the grasslands from glacial melt is essential for the germination of annual grasses and other herbs. In order to ensure the same, some of the methods that can be adopted include tapping glacial waters (as illustrated in Spiti, Ladakh and Rupal Valley), Snow Stupa or a collection of stupas along the slope (as practiced in Leh). Another example of the same is what has been practiced in Lahual (Khangsar Panchayat) by Mr. Balbir Singh, a retired Block Development Officer (refer Figure 68).

Figure 68: Tapping glacial water (Source: Mr Balbir Singh)

With regard to addressing the water scarcity in Lohni, catchment revival will need to be undertaken. The forest that had been cleared needs to be restored through native forest species plantations. In order to undertaken stream revival in Parmas and Kanyun sub-river basins, the learnings from Dhara Vikas Programme that was successfully implemented in Sikkim can be used. With the aim of conserving available water in the villages, focus needs to be laid on replacement of sprinklers with drip irrigation. Extensive trainings and capacity building programmes need to be undertaken for the farmers. The provision of incentives to farmers for using drip irrigation will also help to make this technique more popular and adopted widely.

Livelihood issues

Community participation is critical for ensuring the success of any conservation initiative. Addressing livelihood issues and providing additional sources of income, as a trade off for conservation is an age-old tried and tested model. Some such activities that can be taken up in the selected sub-river basins include:

a) Developing an eco-tourism based model for pasture tourism. In this model, both local community as well as the Gaddis will benefit. The local community will benefit by providing homestays and the pasture trekking will be coordinated by Gaddis. The modalities of operationalisation of this model need to be discussed in detail. This can also be coordinated by the Biodiversity Management Committee (in collaboration with Mahila Mandal/Praja Mandal and the Gaddis). This model will help to increase community and gaddi support for grassland conservation due to the additional economic returns.
b) Enterprise based conservation. This can be developed for Seabuckthorn. Seabuckthorn has been selected as the biological resource for Lahual Spiti district by the Ministry of Food Processing, Government of India under its flagship One District One Product Scheme. Seabuckthorn based livelihood initiatives are also being promoted by the Government of Himachal Pradesh.

Capacity Building

In order to ensure continuity and success of all the restoration activities, regular and extensive capacity building and awareness generation activities need to be undertaken in the landscape for officials, political leaders, local community and the Gaddis. This needs to be carried out through a network of NGOs, under the coordination of a local body like the Biodiversity Management Committee.

Research Needs

Our work has led to identification of several areas of research, which will support long term grassland restoration and conservation. Detailed study of grasslands to map extent, altitude, composition etc need to be undertaken. Studies to understand the issues of inbreeding of livestock and solutions are needed. It is also essential to calculate the feed value of native pastures and foliage. Mapping of all streams and springs on GIS platform is also critical.

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5 Annexures

Annexure 1: Soil analysis methodology

Soil pH

Air-dried soil was sieved using mesh no. 8 sieve and the fraction that passed through sieve was collected and used for estimation of pH, percent organic carbon and matter and N, P, K levels. Soil and distilled water was mixed in the ratio of 1:5 and stirred on a magnetic stirrer for 30 min. The soil suspension was allowed to stand for 30 min and clear supernatant was used to measure soil pH. Orion digital pH meter (Model 201) was used to determine the pH. For each sample three replicates were used. The mean of three replicates were taken as a measure of soil pH.

Percent Organic Matter

Walkley and Black's rapid titration method (Jackson, 1973) was used to determine organic carbon. 0.25g sieved soil sample was placed in 500 ml conical flask. 10 ml of 1N $K_2Cr_2O_7$ was added to the soils followed by 20 ml of concentrated H_2SO_4. The flask was gently shaken and then kept covered with watch glass. The flasks were allowed to stand for 30 minutes. At the end of 30 minutes period, 200ml distilled water was added followed by 10 ml of H_3PO_4 and 1 ml of diphenylamine solution (0.5 g of diphenylamine in 80 ml distilled water and 20 ml H_2SO_4). The sample was titrated against 1N Fe $(NH_4)_2$ $(SO_4)_2.6H_2O$ and dull green was taken as the end point. The amount of ferrous ammonium sulphate required to titrate the sample mixture was recorded. A blank (without soil) was used as control. % organic carbon was obtained by the following formula:

$$\% \text{ organic carbon} = \frac{(V_1 - V_2)\ X100X.003}{W}$$

Where,

V_1= Volume of the titre required to neutralize $Cr_2O_7^{2-}$ in the blank,

V2= Volume of the titre required to neutralize the unreduced $Cr_2O_7^{2-}$ in the test sample,

W= Weight of the soil in grams,

0.003= Conversion factor (derived on the basis that 1ml of 1N, and

$K_2Cr_2O_7$ is equivalent to 3 mg carbon).

Percent organic matter was calculated by multiplying the % organic carbon with 1.724 (van Bermmelen factor derived on assumption that the organic matter is represented by 58 % carbon).

Nitrate-nitrogen (NO_3-N)

Soil nitrate-nitrogen was determined by colourimetric method using salicylic acid (Cataldo et al., 1975). 10 g of dried, sieved soil was extracted with 20 ml of 0.5 M K_2SO_4 by constant shaking for 30 minutes. After extraction, the sample was filtered through filter paper (Whatman no.42) to obtain a clear solution. 0.5 ml of the sample was pipetted in test tube and 1 ml of 5 % freshly prepared salicylic acid solution (5g of salicylic acid in 95 ml of conc. H_2SO_4) was added. The reaction mixture was incubated for 30 min and O.D. was taken at 410 nm on a spectrophotometer (Bausch and Lomb, Spectronic 20). The concentration (µg/ml) of the reaction mixture was determined by reading the O.D. from calibration curve.

Nitrate standard was prepared by dissolving 7.223 g KNO_3 (dried at 105^{o}C for 2 hours and cooled in a dessicator) in deionized water. A stock solution of 1000µg/ml concentration was used for preparation of standards ranging in concentration from 1 to 10 µg/ml nitrate. These standards were prepared by appropriate dilution of the stock and processed in the same way as the test sample.

The NO_3-N in the sample was calculated by:

$$NO_3\text{-N } (\mu g/ml \text{ soil}) = \frac{CXV}{W}$$

Where,

C= Concentration of NO_3-N in test sample read from the calibration curve,

V= Extract volume (ml), and

W= Weight of sample (g).

Phosphate-phosphorus (PO_4-P)

Molybdenum blue method was used to estimate the PO_4-P content in the soil samples (Allen et al., 1974). 1 g of air-dried, sieved soil sample was extracted with 25 ml of 2.5% acetic acid by constant stirring for 30 minutes. The suspension was filtered through Whatman filter paper no. 1 and the filtrate was used for phosphate analysis. 10 ml of soil suspension was taken in a 50 ml test tube and 2 ml acidified ammonium molybdate solution [(a) 5 g $(NH_4)_6 Mo_7O_{24}.H_2O$ in 40 ml H_2O, dissolved by warming; (b) 56 ml conc H_2SO_4 added to 80 ml water and cooled; added (a) to (b) and the final volume was adjusted to 200 ml with deionized water] was added to it. After mixing thoroughly, 2 ml $SnCl_2$ (freshly prepared by dissolving 0.5 g $SnCl_2.2H_2O$ in 250 ml of 2% HCl) was added. Reaction mixture was agitated on a cyclomixer and the samples were allowed to stand undisturbed for 30 minutes at room temperature. OD was taken at 700 nm on Bausch and Lomb Spectronic 20 spectrophotometer; 2.5% acetic acid was taken as blank.

Standard solution (100 ppm) of phosphate was prepared by dissolving KH_2PO_4 in deionized water. Six serial standards in the concentration ranging from 0-30 ppm were prepared from the KH_2PO_4 stock standard solution. The concentration of PO_4-P in the test sample was calculated by:

PO_4-P (ppm)= $\frac{AX25}{10}$

Where,

A= Concentration of PO_4-P in the test sample read from calibration graph,

25= Total volume of the sample (ml), and

10= Aliquot (ml) of the sample used.

Potassium (K^+)

Potassium was estimated using the method described by Allen et al. (1974). 1 g of air-dried and sieved soil sample was extracted with 25 ml of 25 % acetic acid by constant stirring for 30 minutes. The suspension was filtered through Whatman filter paper no. 1 and the filtrate was used for potassium analysis by Atomic Absorption Spectrophotometry. Elemental analysis was carried out on Shimadzu (AA-640-12) Atomic Absorption Spectrophotometer and the instrument was calibrated using 1 ppm and 2 ppm potassium standard solutions. Absorbance readings of the soil extract were measured at a wavelength of 766.5 nm.

K in the test sample was calculated by:

K (ppm)= $\frac{C \quad X \quad V}{10^4 X \ W}$

Where,

C= Concentration of the sample (µg/ml),

V= Extract volume of the sample (ml), and

W= Weight of the sample (gm).

PART B: Restoration Plan for Miyar Sub- River Basin

Miyar sub-river basin extends from 76º39'23'' to 77º1'41'' East longitude and 32º42'23'' to 33º15'42'' North latitude. The elevation of the sub-river basin varies from 2,585m to 6,421m MSL. The total area of the sub river basin is 967.31 km^2. The land-use analysis in the sub-river basin shows that grasslands cover 26% of its area which are primarily distributed in the medium elevation zone (18,655.41ha), followed by low elevation zone (6,293.13 ha). Only a small portion of grasslands falls in high elevation zone (135.42 ha) (refer Part A).

As has been detailed already, the grasslands in Miyar sub-river basin face degradation due to change in species composition, legume deficiency, anthropogenic pressures, landslides, livestock issues, issues related to water and winter rain and livelihood issues.

Part A of this report also highlights that the factors causing degradation differ with altitude. The restoration plan for Miyar sub-river basin is also thus formulated altitude wise. As the present study has found no significant degradation in the high-altitude areas of this sub river basin, the restoration plan does not propose specific interventions for this zone.

1 Mid Altitude Grasslands (3800-5100 msl)

The mid altitude region occupies the largest area within Miyar SRB, covering more than 60% (approx. 581 km^2) of the total sub river basin. A majority of the region is covered with alpine grasslands (32%) followed by barren land (26%) and snow cover (22%). Most of the water the grasslands receive is through the snow melt in the summer. Herbs like *Sedum crassipes*, *Androsace* sp., *Primula minutissima*, *Saxifraga imbricate*, *Sedum crenulatum*, *Leontopodium* sp., *Arenaria* sp., *Callianthemum kashmerianum*, *Draba gracillima*, *Potentilla fruticosa* var *inglesii*, *Kobresia duthei*, *Kobresia capellifolia* are known to be predominant in the region (Champion & Seth, 1968).

Grazing by livestock of Gaddis has contributed to the anthropogenic reasons for degradation. This is exacerbated by climate change, due to which there is low winter rain and increase in temperature. Increase in vulnerability to landslides has also contributed to the degradation.

Interventions

1.1 Grassland restoration

The mid elevation grasslands face low intensity of degradation (as has been explained in Part A of this report).

There has been a decline in the palatable grass species, as well as legumes, which has led to degradation of the grasslands (refer Part A). In order to address this, the following restoration activities are proposed

a. Restoration- Plantation of grasses and legumes to restore the species composition

The steps required to restore grasses and legumes within grasslands are the following

a. Species selection
b. Selection and preparation of planting sites
c. Planting

i. Seed broadcasting
ii. Seed balls
iii. Culms

d. Establishment and Aftercare
e. Long-term management

1.1.1 Species selection

Native grass species are the most naturally adapted to the regional climatic and topographic conditions of the area. Collection of culms or seeds from natural local sources ensures usage of local genetic varieties.

Based on a quadrat analysis, stakeholder consultations and expert committee consultations, the following species (Table 1) are recommended for plantation in the mid-altitude elevation gradient.

Table 1: List of Grass species recommended for plantation in the mid-altitude degraded areas of Miyar subriver basin.

S. No	Species	Preferred by	Details
1.	*Calamagrostis canescens*	Livestock & Wild Ungulates (Khadka et al, 2017)	Annexure 1
2.	*Lolium giganteum*	Livestock (Mishra et al, 2004)	Annexure 1
3.	*Poa alpina*	Livestock & Wild Ungulates (Rawat, 1998; Han et al, 2019)	Annexure 1
4.	*Carex infuscata*	Livestock (Negi, 1993)	Annexure 1
5.	*Phleum alpinum*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
6.	*Festuca ovina*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
7.	*Danthonia cachemeriana*	Livestock & Wild Ungulates (Syed & Ilyas, 2016)	Annexure 1
8.	*Poa annua*	Livestock & Wild Ungulates (Ashraf et al, 2017)	Annexure 1
9.	*Elymus longe-aristatus*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
10.	*Chrysopogon echinulatus*	Livestock (Dev et al, 2018)	Annexure 1
11.	*Calamagrostis lahulensis*	Livestock & Wild Ungulates (Shi et al, 2016)	Annexure 1
12.	*Stipa capillacea*	Livestock & Wild Ungulates (Shi et al, 2016)	Annexure 1
13.	*Deschampsia cespitosa*	Livestock & Wild Ungulates (Harris & Miller, 1995; Shi et al, 2016)	Annexure 1
14.	*Kobresia pygmaea*	Livestock & Wild Ungulates (Harris & Miller, 1995; Khadka et al, 2017)	Annexure 1
15.	*Koeleria pyramidata*	Livestock & Wild Ungulates (Wingard, 2005)	Annexure 1
16.	*Cenchrus orientalis*	Livestock (Negi, 1993; Dev et al, 2018)	Annexure 1
17.	*Panicum antidotale*	Livestock (Negi, 1993)	Annexure 1

In landslide-prone mid-altitude grasslands, the species focus should preferably be on native, tussock forming grasses like *Poa alpina*, *Carex infuscate*, *Cenchrus orientalis* etc. Tussock grasses have good soil holding capacities, thus support in protecting against landslides.

Legume species selection

Legumes are important components of grasslands. They provide high quality forage due to their high fibre and protein content (Mortenson et al. 2004) and thereby have an important fodder value. They also promote symbiotic nitrogen fixation thereby contributing to grass regeneration (Suter et al. 2015). Based on primary data collection (through quadrat studies, stakeholder meetings and expert consultations) and secondary literature review, the legume species that have been identified are summarised in Table 2.

Table 2: List of Legume species recommended for plantation in the mid-altitude degraded areas of Miyar sub river basin.

S No	Species	Preferred by	Details
1.	*Desmodium elegans*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1
2.	*Astragalus himalayanus*	Livestock & Wild Ungulates (Harris & Miller, 1995; Ashraf et al, 2014)	Annexure 1
3.	*Astragalus himachalensis*	Livestock (Ashraf et al, 2014)	Annexure 1
4.	*Astragalus oxyodon*	Livestock (Jishtu & Goraya, 2020)	Annexure 1
5.	*Hedysarum astragaloides*	Livestock (Lal et al, 2014)	Annexure 1
6.	*Astragalus candolleanus*	Livestock & Wild Ungulates (Harris & Miller, 1995; Ashraf et al, 2014)	Annexure 1

Seed sourcing collection and storage

It is recommended that seeds be collected within the 30-mile radius of the proposed restoration site to preserve and utilize the ecotype. Collected seeds must be cleaned and stored up to the time of seeding in the restoration plots. Careful storage is required to avoid damage by insects or predation by other animals. Seeds must be kept dry to reduce moisture related fungal infections. Grass planting material may also be sourced from seed banks or grassland institutions like ICAR-Indian Grassland and Fodder Research Institute (IGFRI) situated in Jhansi, Uttar Pradesh. The institute has a grass seed bank. Himachal Pradesh Forest Department also maintains nurseries. The above listed grass species need to be cultivated there as well. In addition, nurseries for the same need to be developed. The nurseries should maintain stocks of all needed plants (grasses and legumes) in ample quantities. Collection of seeds and stocks from the wild for raising in the nurseries is also needed to be practiced. The nurseries can be jointly managed by the Himachal Pradesh Forest Department and Mahila Mandals. Trainings for the same can be provided by experts from IGFRI. Agencies like Navdanya a Dehradun based NGO, that has been working for over 30 years on storing wild agricultural/crop/fodder seeds can be approached with regard to seed sourcing , as well as for community trainings on development and maintenance of community seed banks. .

As a rule of thumb, four to nine kilogram of seed mix is generally used per acre for restoration. Of this amount, one to three kilogram per acre should comprise fast growing species (legumes) while two and a half to four and a half kilograms per acre should comprise slow growing species (perennial grasses). Large seeds should be higher in proportion than the small seeded plants.

Whether it is a plug or seed, the chosen plants can also be collected from local areas that are undisturbed and cultivated in adequate numbers in local nurseries beforehand, prior to initiating the plantation at the restoration sites..

1.1.2 Selection and preparation of planting sites

Grassland restoration sites in the mountains generally depend on physical, climatic and biological factors of the area. Mountain slopes and elevations play a crucial role in the distribution of grass species and compositions. Higher altitude areas usually have small summers and long snow cover. Climatic and seasonal factors such as winter rain and summer length are important for the grass seed germination. Apart from these factors there always remains some factors like flash floods and landslides that impacts the landscape thus affecting the grassland distribution in the upper mountains. Human factors such as grazing livestock and fodder collection should also be taken in to account in determining the most suitable areas for restoration.

Selection of the sites

Using a multi-criteria evaluation method (MCE)[2], specifically Weighted Overlay Linear Combination[3], planting sites were identified within the Miyar sub-river basin. Details of the process can be found in Annexure 2. Parameters that considered included river flow and stream orders as a water source is crucial for plant growth and landscape restoration. The river flow and direction also indicate the probability of unforeseen disasters such as, flash floods or landslides. The other parameters considered were slope which indicates the monsoon waterflow or summer snow melts and provides insight into the soil moisture and stability of the area, and influence of human habitations since this is important to safeguard the planted site. The final parameter considered was landslide vulnerability. The various parameters considered have been summarised in Table 3.

Table 3: Details of the parameters used in the Spatially Weighted Overlay Model for the development of most suitable plantation areas within the Miyar Subriver Basin in the present study (2018-2021).

Parameters	**Source**	**Criteria Values (for details refer Appendix 2)**
Slope	Developed using Digital Elevation Model	<45 Degree
Stream Order and Flow direction	Developed using Digital Elevation Model	Euclidean distance from the rivers. Suitable <7 Km.
Landslide Zones	Developed in the present study	Vulnerability>50%
Human Habitation	Field Data	< 2 km

[2] MCE is a supportive decision-making procedure that uses a set of parameters or set of events and results in a single composite output (Malczewski, 1999). Each of the required parameters are assigned weighted values. These values are assigned based on the expert opinions, field scenarios, geological structure, climate, topology, land cover and land use etc. MCE is considered through multiple qualitative techniques viz. Analytical Hierarchy Process (AHP), Bivariate Statistical Analysis (BSA), Multivariate Statistical Approach (MSA) and Weighted Overlay Linear Combination (WLC) (Saaty, 1990; Ayalew et al, 2004; Basharat et al, 2016).

[3] The Weighted Overlay Linear Combination is one of the most reliable techniques of MCE for determining the required results in landscape ecology studies and for site selection (Saaty, 1990; Basharat et al, 2016).

Parameters	Source	Criteria Values (for details refer Appendix 2)
Grassland Degradation	Developed in the present study	Mid & Highly Degraded Areas

The weighted model estimated 121.9 km^2 area in the entire mid elevation Miyar SRB as the suitable plantation sites for the grassland restoration in the present study out of the total area of 964.3 km^2 of the sub river basin. A total of 291 polygrids (polygonal grids) ranging between an area of 0.1 to 1 km^2 with an average size of 0.4 km^2 were found to be suitable. Gridding helps to identify more robust, easier to maintain restoration sites, which can also be easily monitored and safeguarded by the respective authorities.

Within the identified grids for restoration, sites need to be demarcated for undertaking restoration and plantation. The grid needs to be sub-divided into smaller sites as the entire grid cannot be closed for grazing (refer Figure 1). Smaller sites, within the grid can however be closed for grazing for 1-3 years in order to ensure the growth of the planted grass and legume species. This will not hinder the grazing of livestock by Gaddis as well. The same was also discussed with the forest officials at the landscape and was acceptable to them as well. Some of the proposed sites in Miyar SRB are depicted in Figure 2. These marked sites within the grids should be protected from grazing for at least three years to allow grasses and legumes to establish. Chain link fencing will need to be carried out at the restoration site to prevent trespassing of wild ungulates and livestock in the region. Restoration grids should be monitored very closely.

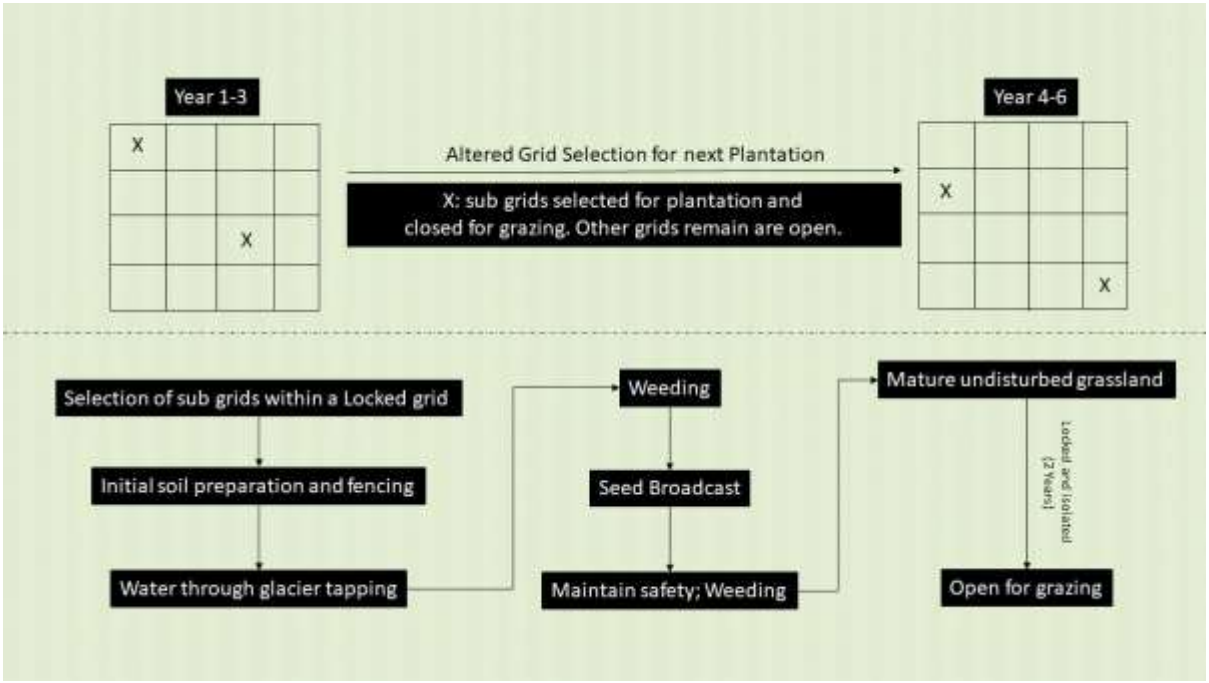

Figure 3: Representative image of the grid lock system in Miyar SRB. Marked grids are depicted as closed within which restoration sites will be fenced and guarded from trespassing of wild ungulates and livestock grazing by Gaddis. Rest of the grasslands will be open for grazing for the tentative year. Each restoration grid should be closed strictly from grazing for up to 4 years, after which they will be opened and new grids will be closed for restoration.

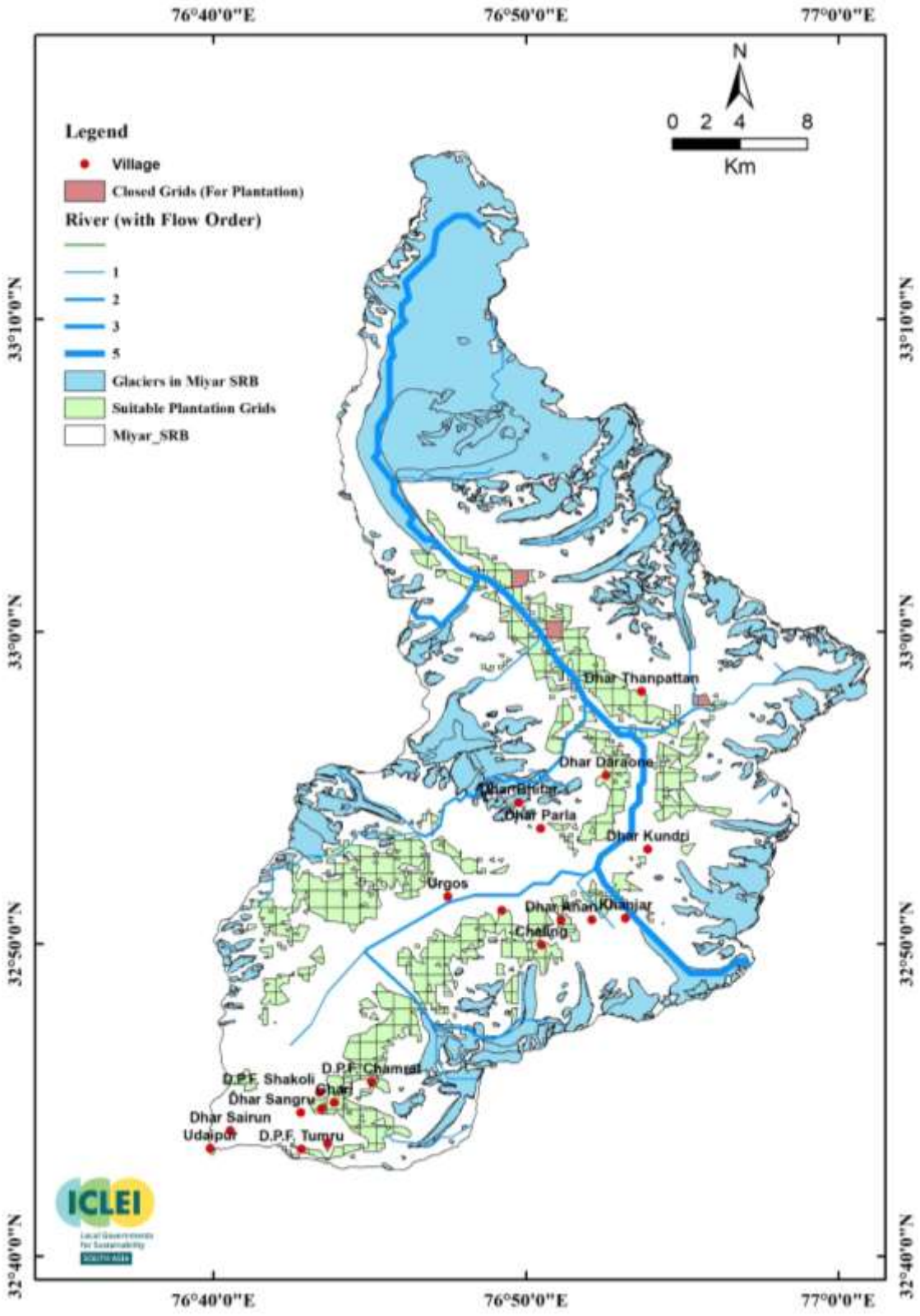

Figure 4: Map of Miyar SRB with suitable polygrids for plantation. Grids closest to the permanent glaciers have been chosen for the first year. Present polygrids chosen for the plantation were prioritized for plantation to ensure enough moisture in summer from snow melt, which is critical for seed germination.

Preparation of the sites

A large portion of the study area in Miyar basin has been reported by the locals to face poor and declining soil quality which has been identified as one of the major causes for the degradation. To facilitate survival of the planted grasses, the following steps are recommended within selected sites:

Undisturbed: Keeping selected plots undisturbed, with leaves, logs, dead plant remains, etc. is one of the natural ways to improve soil health and increase soil biodiversity. Microfauna attracted to the vegetation matter create micro-ecosystems in plots help to increase soil fertility and thus contribute to increasing the vegetation cover, which in turn provides shelter for bees and other pollinators.

Soil adjustments: Enriching soil at the selected plots is beneficial, however, is much more expensive and requires time. Rocky mountain areas have lower soil fertility, lower decomposition rate and fewer nutrients. These can create a difficult environment for the seeds/plugs to establish. Improving soil nutrient and water retention capacity of each plot will improve survival of the grassland species. If the soil within the identified degraded land lacks sufficient fertility for the restoration activities, control areas or available undisturbed pasture can provide reservoirs of good and effective soils to be sprayed on the degraded areas before plantation which will boost the establishment of the planted restoration species in the plots. Another alternative which is subsequently detailed is the introduction of Arbuscular Mycorrhizal Fungi (AMF) to the seed mix which improves survival rates of plugs.

One of the better examples of enriching selected plots are using *Hugelkultur* or creation of raised beds. In this permaculture method, trenches are dug in the soil (not very deep), and are filled with debris like, grasses, branches etc. and then covered up by the soil. Plantations occur over this mounded soil. This type of structure has been found to improve water retention capacities in dry rocky regions of China. They also act as long-term nutrient source. Each mound like structure is sufficient to serve for 5-6 years. In Trans-Himalayan areas, where the soil is buried with snow for a large part of the year and summers are not long enough to have a good decomposition rate with less water availability, these types of plots can serve even longer once installed. These methods have been also proved to improve cultivation of legumes in some parts of the world. Due to the severe conditions in high mountains, it is recommended to install such mounds a year in advance to planting.

Invasive Plant/Weed Control: Before, planting can begin, it is essential to remove the existing weed and invasive plants from the plantation sites as it becomes hard for the native species to establish themselves in the presence of invasive plants/weeds. Some of weeds encountered in the field surveys conducted were *Artemesia annua*, *Achillea millefolium, Cynoglossum zeyanicum, Potentilla arygyrophylla.* Methods for removing invasive plants/ weeds depends upon the size of the plot and available budget. The easiest way is weeding by hand through careful detection of weeds. This method requires a low budget and is effective in small scale plots. However, there are higher chances the seeds of these unwanted plants will remain in the plots thus requiring careful monitoring and time to time repetition of the mechanism. Weeding should be completed within early summer, before seeding or plugging the plots. Community involvement in the same, through Mahila Mandal and Yuva Mandal will be needed. Village level trainings can be provided to local youth, and develop a work force of parataxonomists in each village though the Green Skill Development Programme. This work force will support in regular monitoring of weeds and invasive species.

1.1.3 Planting

Selected plant species need to be collected in the form of clumps or seeds for plantation. While clumps are readily usable, can establish and grow faster, seed plantation requires time to establish. Transplantation must be done in a circular and clumpy manner. This technique reduces the chances of weed invasion due to a lower edge to area ratio.

Timing of undertaking the plantation is critical. The Miyar SRB harbors short summers and the sub river basin stays snow covered even in the lower elevation zones, for a significant portion of the year. Plant species chosen need to be able to establish themselves fast in the early summer. Initial summer snow melt can help establish the seeds/plugs efficiently.

In areas where watering is not possible, seeding just before winter can be considered as the snow cover will help the seed to over winter and the snow melt in early summer will help the see to germinate. .

In the case of the mid-altitude region of the Miyar SRB, human accessibility and mobility is low, seed broadcast or seed balls is recommended within the selected poly grids for planting.

i. Seed broadcasting

For seed broadcasting, the seed bed must be prepared with care as it is one of the crucial success factors. Broadcasting using the seed-mix procedure is considered the most successful technique. Seed mixed with moist saw dust or moss keeps the seed protected and hydrated for a good amount of time. Soil in the seed bed must be tilled or raked before planting the seeds. Manual broadcast of seeds is the most cost effective and successful of methods which is recommended to follow in such a mountainous terrain. Mechanical methods of broadcasting might not be suitable due to adverse environmental, topographical and weather conditions in the region.

Once the seeds are planted, the seed bed should be lightly tilled to improve the seed to soil contact, which helps to improve the germination rate. One of the basic principles of the broadcasting is the usage of centrifugal force to establish the seed into the ground. The weight of the seed mix is very important and must be considered during the broadcasting. Seeds of grass species are light in weight and thus require a carrier object to help settle the seeds in the seed bed properly. Rice hulls, pelletized lime, etc. can be used as the grass seed carriers. Watering is important after seeding. Weed control should be performed in the first year as they can out compete the seedlings and deprive them of nutrients, water, light or space.

It should be noted that seed broadcasting is recommended in areas which show significant degradation and have low diversity of grasses. In cases with an appropriate or healthy density of existing vegetation, minimal seedbed preparation is recommended. This avoids disturbing the established natives or bringing additional weed seeds and rhizomes to the soil surface.

ii. Seed Balls

Seed balls are a low-cost, direct seeding process where varieties of seeds are mixed together (grasses and legumes) with soil and water, and made into small round balls

of half inch. These are stored and dried for optimum plantation time. During plantation these balls can be randomly distributed at the restoration sites. Distribution before winter is advisable in the present study areas as these seed balls will be covered in snow during the winter. In summer the snow will melt and being made of clay, the balls will retain water sufficient enough to germinate and establish the seeds. Another benefit of using seed balls is that the seeds residing inside the soil are safe from any type of predation or insect attacks during the initial establishment period.

The preparation of seed balls includes native grass and legume seeds being mixed together in local soil (with reasonable clay content), which also helps to promote establishment of AMF present in the soil, with the roots of the plants, some husk or coco peat as binding material, manure, and water. AMF can also be purchased and added additionally to the seed ball.

One portion of the soil must be mixed with half portion of manure/compost and some husk/coco peat. To this, one or two parts of water needs to be added. This should be mixed to form a cohesive dough like ball. The soil and manure should be sieved to minimize and remove rocks and other plant parts that may be present. Also, the soil should be dried and powdered beforehand as large chunks will reduce the seed carrying capacity in the seed balls. The clay content also should be monitored as if it is too high, the ball will not split open. In the center of the ball, 5-7 grass seeds should be place and then rolled/compacted such that it binds the seeds and mixture. The seed balls should then be dried in the shade for at least 48 hours. The seed balls should have a dimeter of 2-3 cm. This technique has been successfully used by the Jammu and Kashmir Forest Department in high altitude degraded grasslands.

Students, parataxonomists trained under the MoEFCC Green Skill Development programme, youth from Yuva mandals and women from Mahila Mandals can be involved in the preparation of the seed balls. The dispersal of the seed balls requires lesser manpower and costs, in relation to other methods such as seed broadcast or culm transplantations. Generally, seed balls need to be placed in a shallow hole/cavity or in the case of steep slopes, be broadcasted aerially. The number of seed balls to be used will depend on the nature of the site, its condition and the topography. General estimates vary between 2000-4000 balls per hectare. Seed balls of grasses and legumes (species lists have been provided in the relevant sections) can be used in the high altitude pasturelands. The per hectare costs range between INR 7,500 to INR 25,000.

iii. *Culm Planting*

It is a type of propagation where grass rhizomes with buds are used for plantation in degraded areas for early establishment. Generally, a mix of grass species or single species as a clump with an age of more than 3 months are used in this process. The stems are cut at the height of 100-150mm above the ground and the whole clump is then uprooted carefully without harming the root system. This method is most successful for tussock forming grasses. The culms, once removed from the soil, ideally need to be brought back to the nurseries and grown in the soil with some mulching and if needed with indole acetic acid (IAA). Once, these culms develop more rooting systems, they can be transplanted to the degraded sites. At the plantation sites, these

culms are planted at a minimum depth of 20 cm. AMF is added with mulching, to provide enough nutrition and water for their establishment. Once planted in the degraded areas, these culms grow shoots rapidly, revegetating the degraded areas.

AMF: AMF are widely distributed across various ecosystems where they establish a symbiotic association with the roots of the host plant species to simulate the nutrient and water acquisition of the host plants. AMF are important in the early-stage establishment of grass plantations in poor soil conditions as it significantly decreases the plant mortality and increases fitness in unsuitable environments (Pfleger et al. 1994, Vosatka et al. 1999). The association also strengthens soil stability and controls erosion through their extended fungal shared extraradical mycelium network in the region (Tisdall, 1994).

Generally, AMF is available in the market and can be easily bought (Table 4). Commercial availability of AMF as seed coatings, encapsulation and suspended carriers is generally done for larger row cropping systems.

Table 4: List of suppliers for commercial AMF inoculants in India. Source: Bharti et al, 2017.

Sl No	Name of the Company	Address
1	KCP Sugar and Industries Corporation Ltd	Andhra Pradesh, India
2	Cadila Pharmaceuticals Ltd	Gujarat, India
3	Symbiotic Sciences Pvt Ltd	Haryana, India

b. Establishment and After care

Establishment of grasses takes a short time period (between 10-30 days). However, this will vary depending on competitive pressure, soil moisture and climate conditions. Early management (aftercare) is critical in order to reduce competition from any existing vegetation and prevent reinvasion of invasive perennial weeds.

Addressing Invasive Plants: Weed regeneration and spread of invasive species need to be checked in the early stages of grass establishment at the restoration sites. Forest Department can take support from the local community, especially the Mahila Mandals in carrying out weed control measures. Some of the Mahila Mandals as well as farmers expressed their willingness to carry out these activities in the degraded high altitude pasturelands that they use. Local parataxonomists can also be involved in this process. This activity needs to be carried out every year.

Hydration regime: Initial phases of establishment require sufficient water. The terrain, being highly slopy, most of the water flows down due to gravity. It will be ideal to develop a mechanism to tap glacial water. Harvesting glacial water will help to ensure that there is adequate moisture available in the soil in the summers, which will support, both seed germination as well establishment of the planted saplings/seedlings. Studies and initiation programmes on cryosphere-based water solutions in these upper elevation areas of Himalayas have been proved efficient before (Mukherji et al, 2019).. In lower elevations drip irrigation can also be used during the establishment phase of the restoration programme.

- ***Glacier Tapping for watering the plantation areas***: Water tapping from the nearby glaciers has been used in several parts of Himalayas before (Vaidya, 2015; Dar et al, 2017; Nusser et al, 2019). Suitable plantation areas require adequate water to grow and

establish the newly broadcasted seeds. In the glacial tapping method, a trench from glacier to the plantation sites can direct snow melt to support grass germination. The trench can be dug manually. On an average the per metre cost of such a trench (0.5m*0.5m*0.5m) ranges around Rs 17/-. Convergence from schemes like MGNREGA can be sourced for financing such activities.

Protection of Restoration project sites: The area under restoration needs to be protected from grazing and any other anthropogenic disturbance. The practice of rotational grazing needs to be followed for the same (with a cycle of 4 years). In order to mark out area for rotational grazing, it will not be possible to cordon off the entire pastureland. However, the total area where each Gaddi grazes his livestock, needs to be re-divided into smaller blocks and then the more degraded blocks (based on the degradation map developed for the pasturelands in Miya sub-river basin by ICLEI South Asia and submitted in the 6th report) need to be cordoned off in the initial year for 4 years. Once these blocks rejuvenate in 4 years, these can be opened up for grazing and the next set of blocks (with the next level of degradation) need to be cordoned off. Discussions with the officials of the Forest Department posted on-site, and the Gaddis have shown that the above suggested mechanism is possible and will see cooperation from all stakeholders. A detailed participatory action plan will need to be developed, which has to be facilitated by the Forest Department. Active involvement of the Gaddis, Village Panchayats and Mahila Mandals will be needed while formulating the action, identifying the land parcels and carrying out regular monitoring and surveillance in the cordoned off areas.

Each site that is cordoned off needs to be marked with sign boards. Chain linked fencing will need to be established around the entire site.

Recently the Jammu & Kashmir Forest Department has launched the “One Beat-Guard One Village Programme” with the target of covering 1000 villages through low-cost greening interventions. The programme has been proposed to be achieved by involving Panchayati Raj Institutions and other local institutions. Under this programme, one beat guard is responsible for distribution and planting of trees and grasses in one village, in collaboration with the village panchayat and the BMC. The area will be monitored by them for the next 3-5 years.

1.2 Ice Stupas

Data sourced from the India Water Resources Information System; Global Weather Data for SWAT, 2021 for Lahaul and Pangi across the time period of 2000 to 2020, showed that between the years 2005-2010 the region had the lowest mean precipitation over the entire temporal range and between the years 2016-2020 the region showed the most variation in the winter precipitation of the last two decades.

A decline in NPP highlighted that the decline in winter rain was one of the factors as winter rain is essential for germination of the grasses and other annual herbs in the grasslands. In order to overcome the decrease in precipitation i.e., winter rain, and to ensure moisture availability in the soil for germination, it is proposed that ice-stupas be built.

Ice stupas are a mechanism of creating artificial glaciers through a glacier grafting technique, used to store winter water in the form of conical shaped ice heaps. Traditional artificial glaciers

are generally established in the high altitudes (4000 m) on the leeward side or the North facing side of the mountain to provide adequate shade from the sun. These also require regular maintenance. Ice stupas on the other hand are free from these criteria. Only two matters need to be kept in mind while developing an ice stupa- the parent mountain or the water source (flowing river) and the destination point. The source is at the higher altitude and destination at the lower. The water flows in accordance with gravity, through the pipelines. The tendency of the water flow is in this mechanism is to maintain the similar water level as its origin. The water thus flows to the destination and comes out of a vertical pipeline, at a height of 7-10 meters from the ground. Having the source of the water at a higher altitude, ensures enough water pressure at the outlet, so that the water ca spread 3-4 m from the pipe on the ground. This is usually a winter night procedure. The water starts freezing in the winter nights (-30 to -50°C) after hitting the ground from the pipes and starts building as ice cones as it continues to flow out of the pipe. As more the ice builds up, the vertical pipe height needs to be adjusted to a higher height. The ice cone slowly grows up to the height of 50 meters. Since the structure is vertical it receives less solar radiations per volume of the water and slowly continues melting until spring. These structures help to maintain humidity in the area and and slow melting keeps the ground moist during the spring and summer time. The flow of water can also be controlled as per the need, time of the day, climatic conditions etc. by attaching regulators on the pipe. Ice Stupas have been extensively used in several villages in Leh and other villages of Ladakh since 2016. These structures require minimal monitoring and financial support, which has led to wide scale use of the same in Ladakh.

1.3 Landslide Mitigation

Landslides occur in the upper mountains of the Himalayas at a higher in frequency than any other areas of the world (Froude and Petley, 2018). Of the 580 landslides that occurred between the year 2004- 2017, 477 landslides were due to abrupt or high density short duration rainfall (Froude and Petley, 2018). Steep slopes, high topographic roughness and fragile lithology makes the region one of the most landslide prone in the world. In addition, the effects of climate change and increased anthropogenic activities have made the situation worse than before (Dubey et al, 2005).

The present study identified approximately 292 hectares of highly vulnerable landslide prone areas within the Miyar sub river Basin. These highly vulnerable regions are present mostly around the villages and along the Miyar river (Figure 4). Steep slopes coupled with heavy rainfall are trigger landslides in the region. This is further exacerbated by anthropogenic activities such as house, road and bridge construction which require cutting hill slopes and vegetation removal.

It is a well-known fact that the root systems of plants bind the soil, protecting against erosion and landslides. In order to address landslides in the area, tussock grasses need to be planted in the landslide vulnerable areas. (*Chrysopogon sp. Danthonia cachemyriana*, *Heteropogon contortus*, *Festuca gigantea* are examples of the same. In addition sea buckthorn (*Hippophae rhamnoides*) can also be planted to stabilise the denuded slopes. In addition application of bio-engineering techniques as detailed below, can also be practiced. These methods have been applied in the Ladakh landscape with great success (Tundup et al, 2017).

A) *Revegetating Slopes*: Revegetation is a widely used technique for controlling erosion and stabilization of slopes (Akers and Muter 1974). The root system of the vegetation supports slope stability by intercepting precipitation, controlling soil moisture, thereby decreasing pore water pressure and in turn increasing the cohesion of the soil (Bierbaß et al., 2014; Saifuddin and Osman, 2014). It also strengthens the mechanical stability of the soil, protecting against gravitational stresses (Caviezel et al., 2014; Zhu and Zhang, 2016; Löbmann et al., 2020a, Löbmann et al., 2020b). Generally, vegetation with a higher fine root density and rooting depth leads to higher near surface slope stability.

Some common practices for revegetation of slopes include

- The addition of plant material containing seeds over the disturbed areas, e.g., fresh-cut or dried hay (Florineth, 2004; Kiehl et al., 2010; Le Stradic et al., 2014)
- Sowing of seed mixtures (Bayfield, 1996), followed by the application of mulch (fertilize) and a protection measure keeping soil and seeds in place (Chambers et al., 1990; Florineth, 1995; Kiehl et al., 2010; Dietterich and Casper, 2017)
- Transplantation to overcome the fragile germination stage (Urbanska, 1995; Bruelheide and Flintrop, 2000; Fattorini, 2001; Bruelheide, 2003).

Water availability is crucial for seedling emergence and hence planting should be done during times of the year when natural precipitation is guaranteed such as the presence of melting snowpack in spring, or monsoon precipitation. However, artificial watering can enhance water availability especially during germination. Tussock forming species such as *Chrysopogon sp., Heteropogon sp., Kobresia sp. Carex sp.* can be considered for plantation along slopes.

B) *Bioengineering methods*

i. *Wattling and staking method:* Contour wattling, also called "wattling and staking", is a bioengineering approach that uses live vegetation to control erosion of soil. Branches of local woody Himalayan species such as Salix (*Salix tetrasperma, Salix disperma)*, *Baccharis pilularis, Tamarix gallica* etc. can be used for this method. This method can be used where grass cover is not strong enough to stabilize slopes. In this technique, bundles of live branches or fascines are laid in shallow trenches. These sprout shoots and roots, forming a strong line of vegetation. It is sometimes called live contour wattling. They reduce water velocity, trap sediment, and hold soil in place. Each wattle bunch is tied perpendicular to the main bunch. They are then placed in shallow trenches at regular spatial intervals from each other along the slopes. These are then covered with soil so that about 10% of the fascine is exposed, and pegged to the slope using wooden stakes driven vertically into the ground. Grasses (tussock) and shrubs can be planted between the wattles. Both live stakes and wattles will sprout and grow, forming a living stabilization system. Refer Annexure 6 for more details.

***Figure 5: A representative image of wattling and staking method** (Tundup et al, 2017).*

- *Brush layering:* Brush layering involves planting live woody material (live cut branches and rooted plants) into the slope face along trenches/terraces excavated in slope contours. It differs from fascine laying in that it provides a deeper soil stabilization. Brush layers, being linear structures, are supplemented with plantation or seeding. It is ideal for steep slopes that are highly disturbed or eroded cut and fill situations and provides protection within the first vegetative year. The part of the brush layers that exits the face of the slope, helps to capture debris, rainwater runoff moving down slope while the part that enters the slopes reinforces the soil. Refer Annexure 7 for more details.

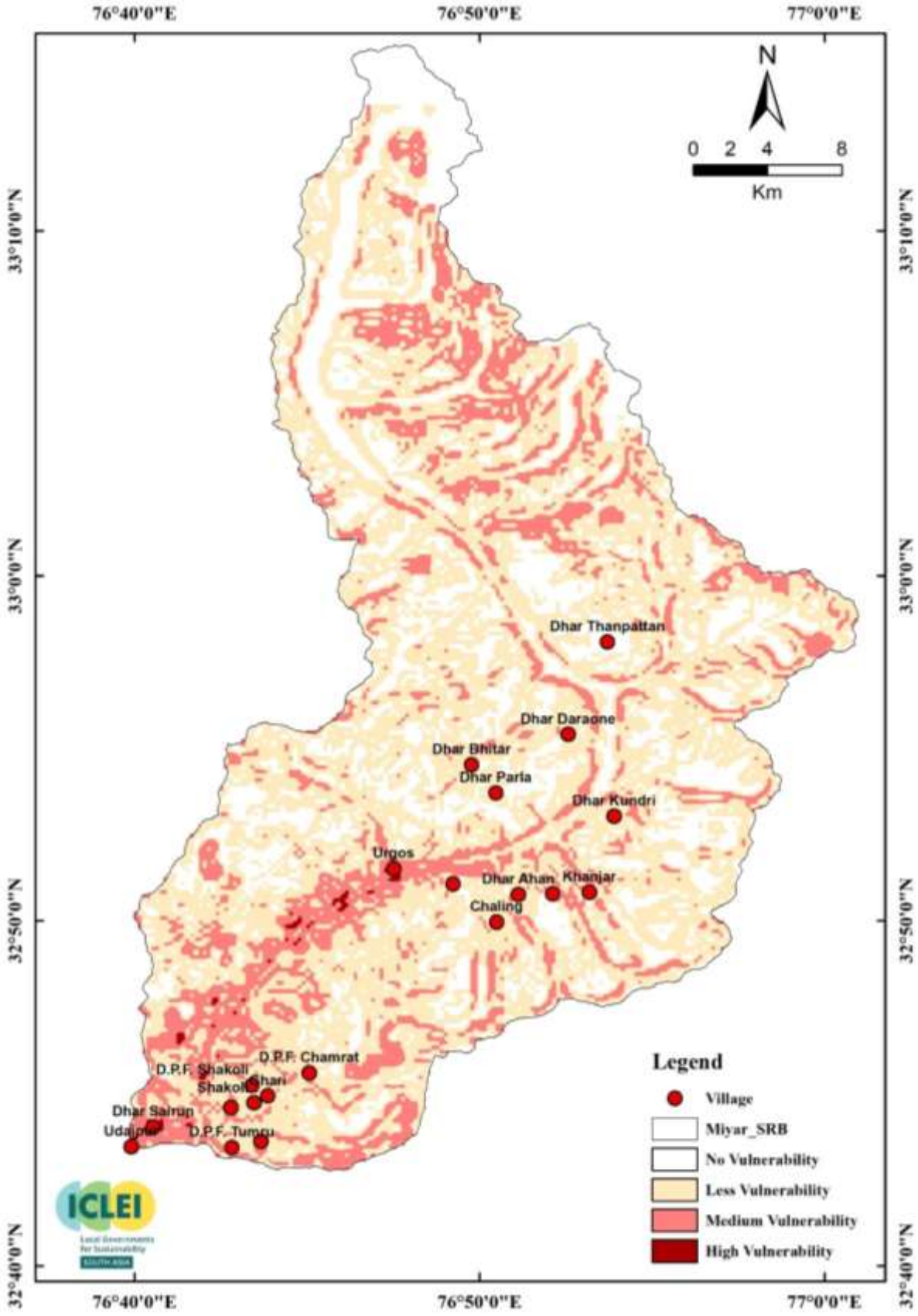

Figure 6: Landslide vulnerability map of Miyar Subriver Basin.

2 Low Altitude (2600– 3800 msl)

The low altitude region of the Miyar SRB is the smallest in size and comprises only around 10% (105 km^2) of the total area of the basin (refer Part A for more details). More than 60% of the total area in this region is dominated by the alpine pasturelands and around 22% of the region is barren land. The same has already been detailed in Part A of this report. The region also has sub-alpine and dry temperate forest. The presence of the river and other water bodies has led to concentration of majority of the human settlements of Miyar SRB in this altitudinal zone. Due to less rainfall, the vegetation is xeric dominated by *Eurotia ceratoides*, *Junipers wallichiana*, *Artemisia maritime*, *Lonicera* sp. and *Potentilla* sp.

The major factors driving degradation in grasslands at this altitude of the sub-river basin are primarily anthropogenic. This includes changes in cropping practices and patterns which has reduction in the availability of fodder, thereby increasing the pressure on the grasslands for fodder for stall feeding. Some natural factors such as landslides are also responsible of degradation at this altitude.

Interventions

2.1 Grassland Restoration

Low altitude grasslands face medium to low levels of degradation in this sub-river basin (refer details in Part A). While the primary reason for degradation of grasslands at this elevation is anthropogenic, undertaking plantations in the degraded sites will also support grassland restoration. The focus of the plantations needs to be on improving the density of the palatable species as well as legumes. The details of the method to follow for the same have already been provided in section 1.1.1. Additionally, plantation sites can be prepared through tillage for improving soil aeration.

Table 5: List of grass species recommended for plantation in the low-altitude degraded areas of Miyar sub river basin

S No	Species	Preferred by	Details
1.	*Lolium giganteum*	Livestock (Mishra et al, 2004)	Annexure 1
2.	*Alopecurus aequalis*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
3.	*Poa alpina*	Livestock & Wild Ungulates (Rawat, 1998; Han et al, 2019)	Annexure 1
4.	*Carex infuscata*	Livestock (Negi, 1993)	Annexure 1
5.	*Phleum alpinum*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
6.	*Alopecurus aequalis*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
7.	*Festuca ovina*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
8.	*Agropyron cristatum*	Livestock & Wild Ungulates (Bashir et al, 2020)	Annexure 1
9.	*Cynodon dactylon*	Livestock & Wild Ungulates (Syed & Ilyas, 2016)	Annexure 1
10.	*Danthonia cachemeriana*	Livestock & Wild Ungulates (Sathyakumar & Viswanath, 2003)	Annexure 1
11.	*Thamnocalamus spathiflorus*	Livestock & Wild Ungulates (Ashraf et al, 2017)	Annexure 1
12.	*Poa annua*	Livestock & Wild Ungulates (Ashraf et al, 2017)	Annexure 1
13.	*Themeda anathera*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
14.	*Elymus longe-aristatus*	Livestock (Dev et al, 2018)	Annexure 1

S No	Species	Preferred by	Details
15.	*Heteropogon contortus*	Livestock (Dev et al, 2018)	Annexure 1
16.	*Chrysopogon echinulatus*	Livestock & Wild Ungulates (Shi et al, 2016)	Annexure 1
17.	*Calamagrostis lahulensis*	Livestock (Shi et al, 2016)	Annexure 1
18.	*Stipa capillacea*	Livestock & Wild Ungulates (Harris & Miller, 1995; Shi et al, 2016)	Annexure 1
19.	*Deschampsia cespitosa*	Livestock (Negi, 1993; Dev et al, 2018)	Annexure 1
20.	*Cenchrus orientalis*	Livestock (Negi, 1993)	Annexure 1
21.	*Panicum antidotale*	Livestock (Mishra et al, 2004)	Annexure 1

Table 6: List of Legume species recommended for plantation in the low-altitude degraded areas of Miyar sub river basin.

Sl No	Species	Preferred by	Details
1.	*Desmodium elegans*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1
2.	*Indigofera heterantha*	Livestock (Singh, 1986)	Annexure 1
3.	*Lotus corniculatis*	Livestock (Singh, 1986)	Annexure 1
4.	*Trifolium repens*	Livestock (Rajasekaran et al, 2017)	Annexure 1
5.	*Indigofera geradiana*	Livestock & Wild Ungulates (Namgail et al, 2010)	Annexure 1
6.	*Caragana sukiensis*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1

i. *Establishment of nurseries*

Site selection for development of the nursery is one of the factors that defines the success of the nursery. The area should be easily accessible and preferably be established on community land. Establishment of community nurseries on private land should be avoided.. Water supply to the nursery should be ensured. In addition south facing slopes are better for nursery preparation as those slopes are warmer. The selected sites should not be in landslide prone zones. Some of the sites for establishment of nurseries have been identified by the community during the discussions. The community members in Udaipur stated that the area on top of Mrikula Mata Temple and the area behind the PWD Rest House would be ideal locations for the establishment of the nursery. Similarly community members in Urgos, Khanjar and Tingrit identified land on the hill facing the Tingrit Panchayta office as one of the possible sites for establishment of a nursery. More such areas will need to be identified in the other villages, after extensive community consultations by the Forest Department. It should be targeted to establish atleast one community nursery in each village in Miyar sub-river basin.

Nursery beds must be prepared carefully and should be cleaned of any unwanted plants and weeds. Nursery beds (6 m*6 m) can be raised in April. These beds should be well tilled and about 30 kg of organic manure mixed as bed base preparation for each bed. Watering must be done for four to six days, following which weeds will grow and should be removed immediately from the root. Sundried grass seeds should be hydrated and then sowed. Sowing should be done in a line

with a sand and seed mixture in a 5-6 mm depth. The distance from each line to another should be 10 cm. Post sowing, the seeds should be covered with a thin layer of soil immediately and the beds should be mulched with straw or any locally available material for a continuous period of four to six days to let the seeds germinate. Watering should be done twice a day (morning and evening). Usually, the germination will start from the third day after the sowing and will be completed by the seventh day. After the full germination, the mulch/gunny bags should be removed. Stored seeds will germinate better than the freshly collected seeds. In a seed bed size of 6m x 6m, it is advised to use 40 g -50 g of grass seeds per bed. One hectare of land can accommodate a minimum of 12 similar seed beds. Each grass seedling can be transplanted to the plantation area from the seed beds once they achieve a height of 15 to 25 cm, which usually takes four to six weeks.

Irrigation of the bed soils is required daily and a minimum of twice a day. After germination, the watering should be done lightly and the bed soil should be allowed for a slight dry condition before the next watering.

When the grass seedlings have grown to couple of inches, watering should be reduced and set to once every two to three days.

Seedlings should be transplanted to the prepared plantation sites right after the beginning of monsoon. Nursery beds should be watered well at this stage before pulling out the seedlings. Seedlings should be pulled out with caution as the root system can get damaged which will result in the death of those individuals after transplantation.

Plug tray method can also be used to develop the grass seedlings instead of directly raising them in the soil in the nursery beds.

AMF: Mulching is the simplest way to achieve natural and native AMF in the planting areas. In this process, each plant is mulched with hay or straw of local species of grass or other plants in plantation beds before planting. The degradation of the organic mulch will also add humus and will improve the water retaining capacity of the beds, which in turn will provide ideal site for AMF growth (Bharti et al, 2017).

The produced AMF should be stored in cold conditions. The lower temperature the better.

Use of on-farm AMFs and their inclusion in nurseries for grasses can be conducted manually by hand.

2.2 Landslide Mitigation

As detailed in section 1.1.3, the present study identified approximately 292 hectares of highly vulnerable landslide prone areas within the Miyar sub river Basin which are situated mostly around the villages and along the Miyar river (Figure 3). Areas in the lower elevation, which are prone to landslides can be stabilised with tussock forming grasses as well as sea buckthorn (*Hippophae rhamnoides; Hippophae salicifolia*),

Sea buckthorn can stabilise the slope and reduce erosion while also providing an alternate livelihood option to the locals.

Cultivation protocol for Sea buckthorn is provided in Annexure 3.

These provide both nutritional fruits as well as livestock feed as green and dry fodder. Harvesting of Sea buckthorn fruits and leaves is in general conducted manually by hand picking or branch shaking, stick beating etc. These procedures can lead to the harvest of 2-3kg of fruit per hour. Few harvesting tools have been developed such as wire clips, clippers etc. by the CSK Himachal Pradesh Agricultural University help in non-destructive harvest of the fruits and should be used. These tools can boost the harvest to up to 6kg/hour. After harvesting the fruits can be sent to the product manufacturers directly for further processing.

A) *Installing early-warning systems*

Most of the villages in the Miyar sub river basin are located at low altitudes and therefore alongside bio-engineering methods, in the interest of protecting human lives, it is wise to install early warning systems in and around these villages and along the roadways. An analysis of landslide vulnerability (Figure 3) indicated that most of the high landslide prone areas are in close proximity to villages (Table 8). Our surveys recorded several places around the villages which are landslide prone and face such issues every year. For instance, the villages of Tingrat, Urgos and Khanjar face landslides almost every year during the monsoons. Some locals have tried prevent it by building walls around the roads but have not been able to achieve success through the same.

Detailed documentation of the areas where present and past incidences of landslides have occurred need to be carried out. This will help to clearly delinate the areas that are highly prone to landslides in the sub-river basin.

Early warning systems also need to be installed. The equipment that has been developed recently by a start-up called iIoTs, from Indian Institute of Technology (IIT) has been deployed on several roads like Mandi-Manali Highway, Mandi-Joginder Nagar Highway etc. in Himachal Pradesh. The equipment monitors climate and soil parameters and warns the nearby people through visual and audio warning systems. The same should be installed in the highly landslide prone areas in the sub-river basin. Though this will not directly address grassland degradation, it will help to save lives in the region.

2.3 Improvement in Availability of Fodder

Primary data collection and stakeholder interactions have indicated that anthropogenic pressures in the low-elevation grasslands of the Miyar sub river basin have increased due to an increase in dependence on the grasslands for grazing and fodder collection. This is primarily due to the fact that there has been a shift in cropping patterns from traditional crops (paddy, millets, etc) to cash crops such as peas, cauliflower, and cabbage. This has increased pressure on the grasslands for fodder since traditional crops were also a major source of fodder, in absence of which, the villagers have had to depend more on the grasslands.

In order to reduce this pressure, the following strategies have been proposed to be implemented in the agriculture fields and areas in close vicinity to the villages.

A) Promotion of traditional crop cultivation
B) Cultivation of grasses on field bunds
C) Agrisilviculture
D) Post harvest processing for value addition
E) Training and capacity building activities

2.3.1 Promotion of traditional crop cultivation

The residents of Miyar sub-river basin prefer cultivating cash crops due to their higher market value in comparison to the traditional crops that were once cultivated in these regions. Traditional crops provided for the stall feeding requirement of livestock in the winters and also helped to arrest soil erosion as their roots had greater soil binding capacity.

Some of the traditional crops that can be promoted include Buckwheat (*Fagopyrum esculentum),* Millets, Black Pea (*Vigna unguiculata*), and Barley (*Hordeum vulgare*). The post-harvest residues have been traditionally used for stall feeding and promoting cultivation of these crops will help reduce the pressure of stall feed collection from the low altitude grasslands. In order to promote the cultivation of traditional crops, value addition through post-harvest processing needs to be encouraged. This will help the community derive higher economic benefits from these traditional crops. Details of such measures for Buckwheat have been summarised in the sections on post-harvest processing and marketing strategies below.

2.3.2 Cultivation of grasses on field bunds

Another strategy that will reduce grazing pressure on the low-altitude grasslands is the cultivation of grasses along field bunds. Planting grasses along the field bunds will not reduce the land available for cultivation of food crops, but helps to produce grass that will support the stall feeding requirements.

Some of the grass species that have been identified for cultivation on bunds are *Festuca gigantea, Pennisetum orientale, Panicum antidotale, Desmodium intortum, Arthraxon lancifolius, Poa annua, Heteropogon contortus, Chrysopogon gryllus, Cynodon dactylon* and *Chrysopogon echinulatus*

2.3.3 Agrisilviculture

Trees grown in and around the villages through agrisilvicultural practices will help to address the fodder needs of the livestock and thus decrease the reliance on grasslands for stall feed collection.

Some multi-purpose trees (MPTs) that have been documented in Himachal Pradesh for agrisilviculture include *Celtis australis, Grewia optiva, Bauhinia variegata, Leucaena leucocephala, Morus alba, Ulmus laevigata, Albizia chinensis, Alnus nepalensis and Toona hexandra.*

Some of the species that have been identified for agrisilviculture in the Miyar sub river basin are *Salix alba*,*Salix fragilis* and Poplar Trees (*Populus nigra, P. alba and P. balsabifera*).

Cultivation protocols for these have been provided in Annexure 4.

2.3.4 Post Harvest Processing for Value Addition

Post harvest processing of buckwheat can help to increase the economic returns to the farmers by many folds.

One of the salient examples of this is Buckwheat (*Fagopyrum esculentum*). This traditional crop can be used to produce biscuits. An initiative of this kind has been successful in Manali (where the entrepreneur had a buy-back agreement with the local farmers who made the biscuits). Such small scale units for biscuit production cost within INR 50,000 and can be established at the panchayat level. Mahila Mandal members can be given training and can run the unit. The Forest Department, along with the district administration can help establish a market linkage for the product. With the opening of Atal Tunnel, tourist inflow into the sun-river basin will be on the rise. Sales of such local products will be boosted by this tourist inflow. Such local products should also be mandatory to be served in all the home stays (which are increasing steadily with the increase in opportunities for eco-tourism and adventure tourism).

Post harvest processing (as basic as drying and packing) of crops like *Saussurea lappa* and *Inula racemosa* will also increase the economic benefit derived by the local community who cultivate the same.

There are several government schemes (in Himachal Pradesh) that provide support to community groups for establishment of such facilities, the details of which are provided in Annexure 5.

2.3.5 Market support

Development of steady market linkage is the key factor that will determine the success of all post harvest value addition and enterprise based conservation initiatives. Some NGOs are working to support the local community to sell the local products through online and offline modes (refer Table 8). There is an urgent need for the Forest Department and the district administration to support such activities and support the activities of such NGOs.

Table 8: Manufacturing companies in India that sell traditional produces

Sl No	Company Name	Products	Address
1	CEVA	Black Cumin, Apricot, Black gram Lentils, Hazelnut, Walnut, Buckwheat, Rajma	Chamba, Himachal Pradesh
2	Tapasu	Morel Mushroom, Barley, Black Pea, Jatto	Kullu, Himachal Pradesh
3	Kinnaur Heights	Black Cumin, Guchchi, Chilgoza, Rajma, Morel Mushroom	Jangpura, New Delhi

Another approach to promote and sustain the cultivation of traditional crops is providing subsidy to farmers for the same. The Department of Agriculture can also look at providing micro-credits to the farmers for cultivating these crops.

3 Livelihood improvement activities

Community participation is critical for ensuring the success of any conservation initiative. Addressing livelihood issues and providing additional sources of income, as a trade-off for conservation is an age-old tried and tested model. Some of the initiatives that can be promoted in Miyar sub-river basin are summarised below.

3.1.1 Sustainable Tourism in Miyar sub river Basin

Eco-tourism and adventure tourism are fast catching up in Miyar sub- river basin. The opening of Atal Tunnel is further aiding the same. One of the models of eco-tourism that can be promoted is Gaddi tourism. This will need an agreement between the panchayat and the Gaddis present in the high altitude grasslands in the panchayat area. The Forest Department will need to play advisory and supervisory role. The revenue model for the same will be such that the economic benefits derived from tourists for activities like homestay, sale of local products, transportation services etc will go to the village panchayat. The economic benefits from trekking charges in the high altitude pasturelands will be the right of the Gaddis. Gaddis can bring the tourists to their own camps and tourists can experience the nomadic life of Gaddis for a day or two, can reside and eat with them, following which they will be brought back to the nearest village and the responsibility of the tourists will again shift back to the panchayat. The areas in the high altitude pasturelands where Gaddi tourism can be carried out needs to be demarcated by the Forest Department, in consultation with the panchayat, Mahila Mandal and other stakeholders. The number of tourists who can be allowed in one season also needs to be decided by the Forest Department. Strict implementation of these rules (as well as other issues like waste management etc) should be the coordinated through the Mahila Mandal. This concept has received support from the officials, community members and Gaddis, during the field discussions that have been carried out.

The increase in income from such activities will ensure that both, the local community as well as the Gaddis actively participate in pastureland restoration and monitoring activities and will ensure the success of the same. A region specific eco-tourism policy would be needed, which promotes the use of local goods and products (including traditional crops) for the tourists.

Figure 5: Schematic representation of income generation in the proposed pastoral tourism plan for the Miyar SRB.

3.1.2 Addressing local livelihoods through enterprise-based conservation

Enterprise –based conservation is a tried and tested model for community based conservation of natural resources. A co-benefit of revegetating slopes with sea buckthorn is the opportunity to use the plant in an enterprise-based conservation activity. Empowerment to the locals through this strategy boosts the local economy, morale and their will to protect their natural resources.

Sea buckthorn is one such plant species that grows well in Miyar sub-river basin and the leaves and fruits of the same can be processed in the villages itself. The Indian Council of Agricultural Research (ICAR) in 2014 under the scheme National Agricultural Innovation Project, with the CSK Himachal Pradesh Agriculture University, Palampur, conducted a value chain analysis of products derived from sea buckthorn. The fruits were processed to make jams, squash, syrup, toffees, and the leaves were processed for tea. The leaves also serve as livestock feed. Thus plantation of seabuckthorn will help to address pasturelands through addressing landslides and reducing the pressure from pasturelands for collection of fodder for stall feeding. Seabuckthorn is also being promoted by MoFPI, Government of India in this district under the one district one product scheme.

Small scale processing units can be established in the villages and the same can be managed by the Mahila Mandal. Forest Department, in coordination with the District Administration should support trainings for the Mahila Mandals in running these processing units. The same can be provided by experts from CSK Himachal Pradesh Agriculture University Palampur, ICAR and Krishi Vigyan Kendras.

Table 9: Companies involved in Sea buckthorn products

S. No	Name	Products taken	Final Products
1	Lahaul & Spiti Seabuckthorn Cooperative Society, Keylong, Lahaul, Himachal Pradesh	Fruits, Leaves, Seeds	Jam, Jelly, Tea, Oil
2	Lahaul Potato Society, Raison, Himachal Pradesh	Fruits, Leaves	Jam, Jelly, Tea
3	Shimla Hills Pvt. Ltd., Shimla, Himachal Pradesh	Fruits, Leaves	Jam, Jelly, Tea
4	Vital Herbs, Uttam Nagar, Delhi	Fruit, Seed	Powder, Oil
5	Ivm Healthcare, Connaught Place New Delhi	Fruit	Pulp
6	International Herbal Corporation, Haridwar, Uttarakhand	Fruit	Juice
7	Seabuckthorn Beverages LLP, Gurugram		Jam, Jelly. Juice

4 Addressing Livestock Issues

As already stated in the sixth report, the Gaddis give higher significance to herd quantity than quality. In addition, over the years the change in herd composition (more goat than sheep) is also a reason for degradation of the pasturelands. Extensive awareness generation activities need to be carried out to communicate the adverse impacts of these practices among the local community as well as the Gaddis.

Some of the suggested action points include

i. Awareness generation and discussions on the need to have reasonable herd size : These can be steered by the Mahila Mandals and Yuva Mandals with technical support from the Animal Husbandry department, coordinated by the district administration
ii. State-wide campaign promoting sheep meat which can be done along the lines of Australia's Lamb campaigns[4]
iii. IEC material should be developed with support from local NGOs and circulated by Forest Department and Department of Animal Husbandry to Gaddis and locals during permit applications, animal health care check-ups etc.
iv. Training programmes to raise awareness among Gaddis on the negative impacts of inbreeding depression and the need to reduce it through cross-breeding among herds should be conducted by the Animal Husbandry Department with support from the district administration

[4] https://www.mla.com.au/marketing-beef-and-lamb/domestic-marketing/lamb-campaigns/

5 Develop a Grazing Action Plan and other initiatives

In order to ensure long term sustenance, replicability and upscaling of the restoration activities some of the key actions will need to be undertaken. These range from financial support to addressing research needs. These include:

Restoration sites in the mid-altitude grasslands of the Miyar SRB needs to be monitored well and for a longer period. Establishment of grasses in the degraded sites and their continuity depends on the safety of these planted grasses. Long-term management should encompass the following

- Rotational grazing and restoration scheme (which should be detailed in a sub river level participatory grassland management plan) needs to follow the pre-decided and stakeholder approved work plan.
- Long term financial support for the initiative needs to be ensured. For the same convergence from other ongoing and proposed government schemes also needs to be mapped on regular basis.
- Sub-river basin level participatory grassland management plan needs to be developed and the same needs to be integrated with the working plan.
- Permanent plots (100 m*100 m) need to be established in the degraded area, an area which is under restoration and an area that has been restored (this will be after 4 years). Such comparative plots need to be established in the mid and low altitudes. These will serve as baseline for any restoration work that is planned for and undertaken in future.
- Development of seed banks in each village (coordinated by the BMCs) needs to be practiced.

The participatory grazing action plan should

- Describe present management and identify opportunities, issues, problems
- List resources available at hand i.e., land allotments, resources (physical resources, animal resources, plant resources, human resources), facilities
- Establish goals and objectives
- Outline animal needs and timing
- Outline plant needs and timing
- Select the correct stocking rate
- Detail management tools and techniques
- Detail actions
- Incorporate a contingency plan for disasters
- Determine monitoring design

The plan should be integrated with the system of Gaddi permits with regulations being imposed on the number of livestock that each Gaddi can bring. Checks on these numbers can be carried out through on site inspection by the Forest Department, with support from the BMCs.

Capacity building of all the stakeholders is critical to ensure the long term sustenance grassland restoration. Such activities need to be tailor made for specific groups of

stakeholders (political leadership, administrative leadership, Gaddis, local community, village panchayats, Biodiversity Management Committees, Mahila Mandals, Yuva Mandals). While the trainings for the political and administrative leadership need to focus on bringing forth the need to undertake restoration activities and the criticalness of keeping continuity of such work; the ones of the others need to have greater emphasis on providing hands on trainings on activities like plantation techniques, seed broadcasting techniques, glacier water tapping, maintenance, better forage management techniques etc. Easy to understand technical trainings for farmers, Gaddis, Mahila Mandals, and other stakeholders should be designed by relevant institutes and disseminated at an appropriate frequency. The community trainings should be aimed at a training the trainer (ToT) model wherein atleast 2-3 master trainers are developed in each village. A yearly roster for these capacity building activities needs to be drawn up. While the trainings can be provided by the experts from the Forest Department, Agriculture Department and academic institutions, the coordination of the same should be done by an NGO, under the supervision of the Forest Department. One of the most promising examples of the same is the work being carried out by Nature Conservation Foundation in Spiti.

6 Research Needs

Our work has led to identification of several areas of research, which will support long term grassland restoration and conservation (Figure 6).

The most pressing research need is on establishing permanent monitoring plots in the grasslands of the Miyar SRB. Detailed and long-term documentation of grass and legume species, invasive and alien species, composition across different elevations and phenology is necessary to maintain the existing grasslands. This would form the baseline data for future studies in this region.

Detailed research into the livelihood options and their market linkages for the locals is also essential. Value chain analysis of the local products and traditional crops should be developed to increase the market demand and to provide local farmers with more opportunities for cultivation in more sustainable way.

Detailed study on the topography of the landscape including land use pattern with ground truthing throughout the landscape is recommended to further monitor the grassland restoration and conservation in the region. Establishment of climate grids to monitor the micro climate change in the grassland regions is needed to record the effect of climate change in the landscape. Installation of data loggers for local climate in appropriate grassland areas are recommended for long term monitoring.

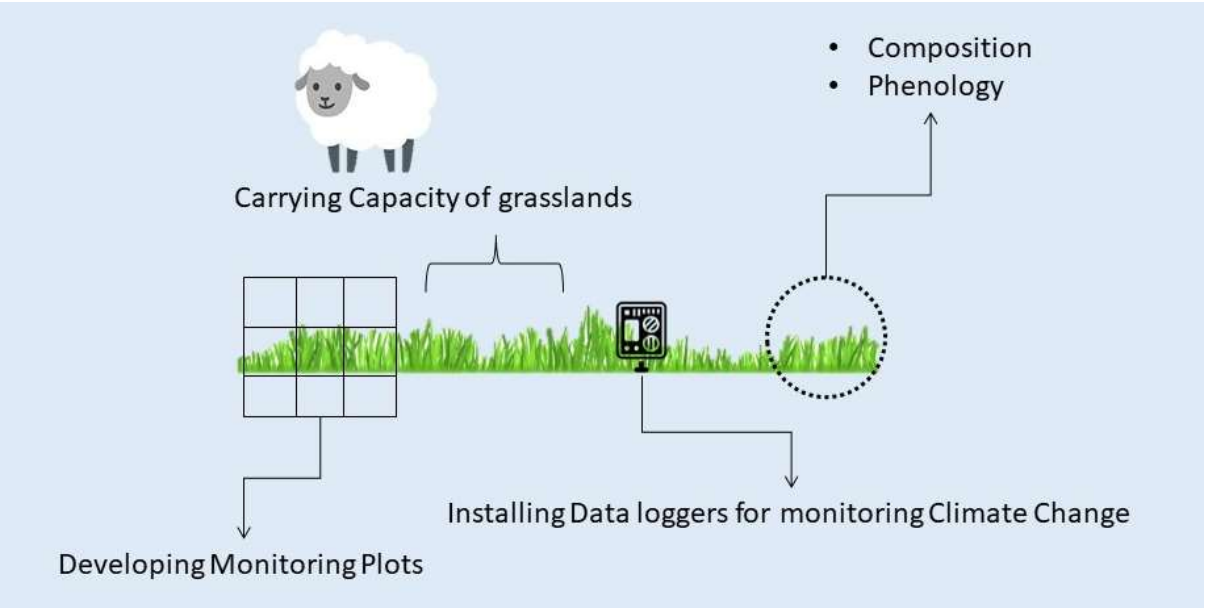

Figure 6: Schematic diagram pointing some of the key research needs for the grasslands of Miyar SRB for future monitoring and conservation.

The above interventions are summarised in Table 10 below.

Table 10: Activities proposed in the mitigation plan to address grassland degradation in Miyar Sub River Basin

Altitude	Issue addressed	Strategies/ Steps	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
Mid Altitude	Change in species composition	Seed broadcast	Thanpattan	30,000/ha	Forest Department, Mahila Mandal; Yuva Mandal; Biodiversity Management Committees, Village Panchayats, District Administration, Local NGOs; Gaddis	32, 37, 38, 41	3- 6 months (non-winter months) for 4 years in the cordoned off areas
		Seed balls		30,000/ha			
		Culm transplantation		1,30,000/ha			
		Trainings and capacity building		30,000/training of one day each	CSK HPKV Palampur; NGOs; ICAR; Forest Department; Agriculture Department; District Administration; Gaddis		Continuous, at regular frequency
	Deficiency in winter rain	Ice Stupas	Mid elevation Glaciers in close proximity to Thanpattan	50,000-1,00,000	Mahila Mandal; Yuva Mandal; Forest Department; Jal Shakti Vibhag; Irrigation and Public Health Department; Hydrogeologists; District Administration	32, 37, 38, 41	4-6 months (winter) for the stupa to rise to the appropriate height
		Glacial tapping		15000/ km trench (0.5m deep and 0.5 m broad)			Summer months
	Landslides	Revegetation of slopes using tussock grasses	Landslide prone areas in the Sub River Basin	1,30,000/ha	Forest Department; National Highways Authority of India; District Administration; Mahila Mandal; Yuva Mandal; NGOs	9,32, 35,37,38,41	3-6 months (non –winter months)
		Bioengineering methods- Wattling and Staking		30,000/km			A minimum of 6 months to develop appropriate rooting systems

Altitude	Issue addressed	Strategies/ Steps	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
		Bioengineering methods- Brush L	Landslide prone areas in the Sub-River Basin	150000/km	Forest Department; National Highways Authority of India; District Administration; Mahila Mandal; Yuva Mandal; NGOs	9,32, 35,37,38,41	6 months (non winter months)
Low Altitude	Change in species composition	Nurseries		3,00,000/ per nursery	Forest Department, Mahila Mandal; Yuva Mandal; Biodiversity Management Committees, Village Panchayats, District Administration, Local NGOs	32, 37,38,41	3- 6 months (non-winter months) for 4 years in the cordoned off areas
		Plug Planting		15,00,000/ha			
		Seed broadcast		30,000/ha			
		Culm transplantation		3,00,000/ha			
		Trainings and capacity building		30,000/training of one day each	CSK HPKV Palampur; NGOs; ICAR; Forest Department; Agriculture Department; District Administration		Continuous, at regular frequency
	Landslides	Revegetation using Sea buckthorn	Landslide prone areas in the Sub-River Basin	1,50,000/ha	Yuva Mandal; Mahila Mandal; BMC; Horticulture Department; Himachal Pradesh Forest Development Corporation; NGOs; Lahaul-Spiti Seabuckthorn Cooperative Society, CSK HPKV Palampur; Forest Department; ICAR	9,14,32,35,37,38, 41	Sea buckthorn needs a period of 4-6 years from seeding to begin to give fruit. Intensive training programs can be scheduled over a period of 3-6 months as to how to grow, harvest, process and market the plant.
		Bioengineering methods (Wattling and Staking)		30,000/km	Disaster Management Authority; SDO; Mahila Mandal; Yuva Mandal; National Highways Authority of India (NHAI)		One working season for plantation, at least 6 months for appropriate rooting system to develop

Altitude	Issue addressed	Strategies/ Steps	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
		Bioengineering methods (Brush Matting		150000/km			
		Installing early warning systems		1,00,000 per system	Intiots Technologies; Forest Department; District Administration; Village Panchayat		One working season (non winter months) to install the systems at select locations
	Changes in cropping practices and patterns	Promotion of traditional crop cultivation	In all villages in Miyar Sub-River Basin	Aided through schemes provided by State and Central Governments	Agriculture Department; Horticulture Department; District Administration; Mahila Mandal; Yuva Mandal; Sector experts; NGOs; Forest Department; Biodiversity Management Committees; Farmers	5,6,7,8,10,11,12, 13,14,16,17,18,1 9,25,26,28,30,31, 32,36,39,40,42	1 year to promote the various cultivation technologies, form farmers groups and develop market linkages
		Cultivation of grasses on field bunds		3500/ 10 kg seed	Forest Department; Animal Husbandry Department; District Administration; Mahila Mandal; Farmers; NGOs		3-6 months (non winter months)
		Agrisilviculture		200/ sapling	Forest Department; Animal Husbandry Department; District Administration; Mahila Mandal; Farmers; NGOs		3-6 months (non winter months)
		Enterprise-based Conservation Activities (Seabuckthorn and Buckwheat)		1,00,000 per unit for buckwheat processing; 30,00,000 per processing unit of Seabuckthorn	Forest Department; Agriculture Department; District Administration; Tourism Department; Mahila Mandal; Yuva Mandal; NGOs; Dept. of Agriculture; Mahila Mandal; Yuva Mandal; Himachal Pradesh Forest Development Corporation; Lahaul-Spiti		During non winter months

Altitude	Issue addressed	Strategies/ Steps	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
					Seabuckthorn Cooperative Society, CSK HPKV Palampur		
		Training and capacity building activities		30,000/training of one day each	NGOs; Sector experts; INVEST INDIA; Krishi Vigyan Kendras; ICAR; Forest Department; District Administration; Mahila Mandal; Yuva Mandal		Continuous, at regular frequency
All Altitudes	Addressing livelihood issues	Ecotourism model	Villages in Miyar Sub River Basin along with Thanpattan	30,00,000 per village	Tourism Department; Mahila Mandal; Yuva Mandal; Forest Department; Local NGOs; District Administration; Gaddis; Biodiversity Management Committee	1,3,7,32,40	1 year to develop plan in consultation with all stakeholders and beneficiaries and infrastructure establishment; execution of the same from next year
	Livestock Issues	IEC campaigns on herd size	Villages in Miyar Sub River Basin, Animal Husbandry clinics, Forest Department Permit issuance offices	10,000/per campaign	Mahila Mandal; Yuva Mandal, Gaddis; Biodiversity Management Committee; Forest Department; Animal Husbandry Department; District Administration	21,22,23,32	3 months to develop the material; Regular campaigns in the Sub River Basin
		Development of a	Miyar Sub River Basin	10,00,000	Forest Department; NGOs; Grassland research institutes;		1 year

Altitude	Issue addressed	Strategies/ Steps	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
		Grazing action plan			ICAR; District Administration; Mahila Mandal; Gaddis; Village Panchayat; Subject Matter Experts; ICAR		
	Addressing Research Needs	Long term studies to document Grassland species composition and phenology	Across grasslands of Miyar Sub River Basin	50,00,000	Research Organisations; Forest Department; District Department; ICAR; Yuva Mandal; Parataxonomists; NGOs; Mahila Mandal; Biodiversity Management Committee	38	Continuous
		Estimating carrying capacity for livestock					
		Monitoring climate change					

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Annexure 1

Grass Species

1. ***Festuca giganteum* or Giant Fescue**[5]

It is a perennial species of tussock grass that can reach upto a height of 1.5-1.8 meter. Foliage of the species are shiny and flat. Flowers are green in colour. It generally ranges between the altitude of 1000 – 3800 meters. Species grows in wet soils well and can grow in sun or shade.

2. ***Poa alpina* or Alpine Bluegrass**[6]

It is a perennial grass species that can grow to a height of 0.15 meters. Leaf blades can grow up to 3-12 cm long and 2-5 cm wide in mature plants. Except for high acidic soil, this plant species is an important pioneer species in restoration of degraded lands. It has very hard rooting system that helps in soil binding and conservation and prevents landslides. High nutrient content, strong resistance to wind and livestock grazing makes this species as one of the valuable forage species of high-altitude grasslands. The species can be found between the altitudes of 2700-5500m.

3. ***Stipa capillacea***[7]

It is an alpine grass species that is native to the Himalayas and is distributed between the altitudes of 2900 – 5000 m. It is perennial and mostly grows in the open grasslands. The species is highly tolerant to temperature variations and soil nutrients. In the Himalayas, soil begins to thaw and snow melts in the month of April. During this time the seeds of this plant absorbs water and gathers heat for germination. The plant has very high germination potential in low temperatures of higher altitudes, making it one of the ideal grasses for use in the restoration of the high-altitude grasslands in the Himalayas.

[5] Image Source: https://species.wikimedia.org/wiki/Festuca_gigantea Date Accessed: 28.10.2021
[6] Image Source: https://commons.wikimedia.org/wiki/File:Poa_alpina_(3987334209).jpg Date Accessed: 28.10.2021
[7] Image Source: https://ukrbin.com/compare.php?imageid=69215&category=75657 Date Accessed: 28.10.2021

4. ***Deschampsia cespitosa or* Tufted Hairgrass[8]**

This species occurs in the temperate region through out the world. It can be found up at altitudes of 2900 m-4000 m. It is a perennial grass, that can grow up to 1.4 meters. Culm size ranges between 20-150 cm in height. Leaves are flat and can grow up to a length between 10-60 cm, and width of 2-5 mm. The plant has deep root system and thus can survive in less wet soils and helps in soil binding It has a pH tolerance of 5 to 7.5. It is a hardy plant and can tolerate strong frosts. It can also tolerate high nutrient variations.

5. Kobresia pygmaea[9]

It is an extremely densely tufted grass species. The plant height reaches 2.5 cm- 3 cm and on rare occasions up to 4 cm. It can be found between the altitudes of 3000 –6000 m. The species is endemic to the Himalayas. The species can survive extreme temperature shifts, high UV radiation exposure with low oxygen availability in the higher mountains.

6. *Carex infuscata*[10]

It is very similar in looks with *Kobresia* sp except in *C. infuscata* the perigynium has a false abaxial suture where as in *Kobresia* sp, it is completely closed. It is generally found around moist grassy slopes, mostly along alpine water channels and streams. The species is known to be distributed between the altitudinal range of 1700-4000m in the Himalayas.

7. *Phleum alpinum* or Mountain Timothy[11]

This is a perennial grass species. Clumps are usually in size of 20-60 centimetres. The inflorescence of the plant can reach up to the height of 6 centimetres and as wide as 1.2 centimetres. The species can be generally found at the wet alpine meadows, damp soil around bushes of streambanks, conifer forest etc. The elevational range for this species 2500-3900 meters.

[8] Image source: https://www.gardens4you.eu/deschampsia-cespitosa-goldschleier-eu-en.html Date Accessed: 28.10.2021
[9] Image source: https://alchetron.com/Kobresia Date Accessed: 28.10.2021

[11] Image Source: https://en.wikipedia.org/wiki/Phleum_alpinum Date Accessed: 28.10.2021

8. ***Alopecurus aequalis* or Orange Foxtail**[12]

It is a perennial grass species with a broad distribution throughout the world. The species can reach up to the height of 70 centimetres with leaves as long as 15 centimetres and a narrow leaf breadth of 8 millimetre. The species generally flourishes in open, wet places that might get dry in summers. Altitudinal range of the species is from 500 – 3500m.

9. ***Festuca ovina* or Blue Fescue**[13]

It is a perennial grass species and usually considered as less susceptible to disease or pests. It can grow up to 30 centimetres. The species grows in the spring and fall while in summer it hardly shows any growth at all, depending on the availability of rainfall. It is also a highly cold and drought tolerant species. It has a deep rooting system that also helps in mitigation of soil erosion. Altitudinal range of the species is between 1600 m-4400 m.

***Koeleria pyramidata* or June Grass**[14]

It is a perennial grass species and highly drought tolerant. It is a cool-season grass which stays dormant during the late summer. It grows easily in dry to medium, well-drained soils in full sun. The plant in general thrives in rocky or gritty soils. The plant can grow as long as 20 inches. Leaves are around 6 inches long and 1-4 mm wide. Altitudinal range of the species is between 1800-5300 m.

10. ***Agropyron cristatum* or Crested Wheatgrass**[15]

The species is generally found in dry grasslands. It is frequently found on carbonate slopes in the forest steppe, on dry terraces, and in steppe woodlands. Plants of these species mostly prefers rainfall between 230-380 mm and altitudinal distribution ranges between 1500 to 3700 m. It is highly valuable forage species and is often used to control soil erosion.

[12] Image Source: https://en.wikipedia.org/wiki/Alopecurus_aequalis Date Accessed: 28.10.2021
[13] Image Source: http://antropocene.it/en/2019/06/05/festuca-ovina/ Date Accessed: 28.10.2021
[14] Image Source: https://swbiodiversity.org/seinet/taxa/index.php?taxon=Koeleria%20pyramidata Date Accessed: 28.10.2021
[15] Image Source: http://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:7365-2 Date Accessed: 28.10.2021

11. Cynodon dactylon or Burmuda Grass[16]

It is one of the wide spread, highly adaptive and drought tolerant annual grass species. The plant can survive for as long as seven months in drought induced dormancy and can regenerate easily again when the favourable condition comes. The species is also susceptible to hard or prolonged frost. The annual growth-form of this plant becomes dormant and turns brown when night temperature falls below freezing or average daytime temperatures are below 10° C. Altitudinal range of the species is between 700-2800m.

12. *Tenaxia cachemyriana*[17]

It is a perennial grass species. Culms are 10-25 cm long. Leaves of this plant are 3-6 cm long and 0.5-1 mm wide. Inflorescence are 1-3 cm long. These plants are well adapted for rough mountain habitats with deep root system that also helps in soil conservation. Altitudinal range of the species is up to 4500m.

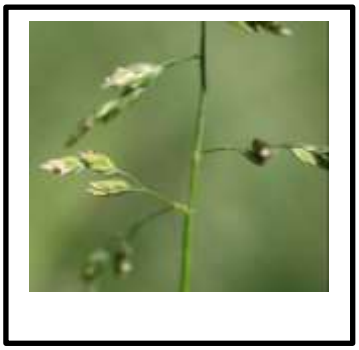
13. *Thamnocalamus spathiflorus*[18]

It is a culms-forming bamboo species. The plant can be found distributed between the elevations of 2500-3600 m in the Himalayas. Individuals of this species can grow up to 6 m in height with a diameter of up to 20mm. The species forms thickets in the wet areas of forests together with Oak, Cedar and Fir forests. Although the plant can not survive prolonged low temperatures but records suggest the plant to survive up to the temperatures as low as -20°C.

[16] Image Source: https://gobotany.nativeplanttrust.org/species/cynodon/dactylon/ Date Accessed: 28.10.2021
[17] Image Source: https://efloraofindia.com/2013/01/06/danthonia-cachemyriana/ Date Accessed: 28.10.2021
[18] Image Source: http://www.bamboogarden.com/Thamnocalamus%20spathiflorus%20%27Nyalam%27.htm Date Accessed: 28.10.2021

14. *Poa annua* or Annual Meadowgrass[19]

The species grows as densely clumped populations with very shallow rooting system. These plants have larger environmental elasticity and can adapt quickly to the climate. Less rain, dry winter to temperature below frozen points have also been reported for this species to survive and germinate at favourable conditions. Plants have rapid flowering and profuse seeding capability that makes it easier for survival in the adverse conditions. Individuals of this species can grow up to 30 cm with flat and hairless blades of leaves. Altitudinal range of the species is between 1000-4000m.



15. *Themeda anathera* or Loonder Grass[20]

It is a perennial grass species. Culms of the plants can usually reach up to the height of 120 cm with leaves as long as 30 cm. It is well known as fodder grass species. Altitudinal range of the species is up to 4000m.

16. *Elymus duthiei*[21]

It is a Himalayan native perennial grass species. Culms of these grasses can grow as long as 40-70 cm. Leaf blades have been recorded to grow up to a length of 30 cm with a width of up to 3mm. Inflorescence of these grasses are composed of racemes. These grasses are distributed up to the altitudes of 2400 m in the Himalayas.

17. *Heteropogon contortus* or Black Speargrass[22]

It is a perennial tussock grass. Individuals of this species can grow up to a height of 1.5 metres. The species can not tolerate prolonged flooding or waterlogging. Generally, the species prefers to grow on the heavy clay soils to rocky surfaces of mountains. It has a pH tolerance of 5.0-6.0 . The species can survive long, harsh, dry and cold weathers. Altitudinal range of the species is between 1000-3000m.

[19] Image Source: https://en.wikipedia.org/wiki/Poa_annua Date Accessed: 28.10.2021
[20] Image Source: https://en.wikipedia.org/wiki/Themeda Date Accessed: 28.10.2021
[21] Image Source: https://en.wikipedia.org/wiki/Elymus_(plant) Date Accessed: 28.10.2021
[22] Image Source: https://swbiodiversity.org/seinet/taxa/index.php?taxauthid=1&taxon=551&clid=15 Date Accessed: 28.10.2021

18. *Chrysopogon gryllus* or Scented Grass[23]

It is a perennial grass species with a wide distribution. It is a dense clump-forming species. Individuals can grow up to a hight of 150 cm. Leaf blades can reach up to the length of 30 cm and a width of 5mm. It grows well on the drained soils. Altitudinal range of the species is between 800 m-2900 m.

19. *Bothriochloa bladhii* or Forest Bluegrass[24]

It is a wide spread perennial species. It is known to be used highly as a fodder species for local livestock and as a grazing plant throughout its distribution. The species is also known to respond well when planted in disturbed or degraded areas for restoration. The species is known to tolerate a broad range of temperature with as cold as -8 degree centigrade and rainfall. The species has been recorded from altitudes upto 2800 m in the higher mountains.

20. *Elymus longe-aristatus*[25]

It is a perennial grass. Leaf blades are convoluted and 5-15cm long and 2-3cm wide. The species is predominant in alpine and trans Himalayan region. The species is generally found up to the altitude of 4000 m. The species has a high fodder value and is consumed by wild ungulates too, especially in the summer.

21. *Calamagrostis lahulensis*[26]

It is a perennial grass species. Leaf blades are flat, around 13.5 cm long and 2-3.5 cm long. The plant is generally 40 cm tall. The species is native Himalayan grass species. The altitudinal range for the species is between 2700m-5200m.

[23] Image Source: https://www.flowersofindia.net/catalog/slides/Scented%20Grass.html Date Accessed: 28.10.2021
[24] Image Source: http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:392701-1 Date Accessed: 28.10.2021
[25] Image Source: http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:328322-2 Date Accessed: 28.10.2021
[26] Image Source: https://www.earth.com/plant-encyclopedia/angiosperms/poaceae/calamagrostis-lahulensis/tl/ Date Accessed: 28.10.2021

22. *Cenchrus orientalis* or Oriental Fountain Grass[27]

It is a clump forming perennial species. Flowers are white to light pink in colour. Height can reach upto 40 cm. Leaf blades are 30cm-60cm long and 7.15 mm wide. It is a widely distributed species and known for its fodder value, grazing resistance and drought tolerance. The species is distributed with in the altitudinal range of 300m to over 5000m.

23. *Panicum antidotale* or Blue Panic Grass[28]

It is a perennial tufted grass species. The plant can reach a height of 3 meter. It has deep root system. Stems are hard and almost woody. The leaves are smooth, 15-30 cm long and upto 12mm wide. It has high fodder value. The species is native to India. Flowering is between July to October. The species is distributed at the height of more than 4500 m in altitude.

24. *Arthraxon lancifolius* or Lanceleaf Carpetgrass[29]

It is a perennial grass with a slender stem. Leaf blades are lance shaped. Each leaf blade is 1-4 cm long and 3-10mm wide. Flowers are in cluster. Flowering is between July and October. The species can be found up to the altitude of 2700m.

[27] Image Source: https://garden.org/plants/view/165264/Oriental-Fountain-Grass-Cenchrus-orientalis/ Date Accessed: 28.10.2021
[28] Image Source: https://www.floraofqatar.com/panicum_antidotale.htm Date Accessed: 28.10.2021
[29] Image Source: https://species.wikimedia.org/wiki/Arthraxon Date Accessed: 28.10.2021

Legume Species

1. ***Desmodium elegans***[30]
   It is a deciduous shrub. Normally it reaches to the height of 3 metres. Its leaves are trifoliated. The plant has pink to dark purple flowers. Petals of the flowers are rounded in shape. The flowering time of the plants is June-September. This plant is common in Himalayas. Altitudinal distribution is restricted between 1200-3000 m.

2. ***Indigofera heterantha***[31]
   It is commonly known as Himalayan Indigo. It is a deciduous shrub . It is native and widely distributed in Himalaya. The plant can reach the height of up to 3 metres. Each leaf of the plant can carry up to 21 leaflets which are grey-green in colour. It is a drought tolerant and hardy plant that can survive up to -15 °C. In colder areas the plant dies out at the end of the season and regrows again the following year.

3. ***Lotus corniculatis***[32]
   It is commonly known as Bird's-foot trefoil. It is a perennial herbaceous plant that has a wide distribution range. Each leaf has five leaflets. Flowers are yellow in colour. It is very widely used as livestock forage. It is highly tolerant to grazing and flowers between June to September.

4. ***Trifolium repens***[33]
   It is commonly known a White Clover. It is a perennial herbaceous plant. It has been used widely as a forage plant widely for the livestock. It has white flowers and honeybees and bumble bees are known to visit this plant very actively. These plants are known to fix nitrogen in temperate pasturelands very well and is often used due to this purpose.

[30] Image Source: https://en.m.wikipedia.org/wiki/File:Desmodium_elegans_(15131977732).jpg Date Accessed: 28.10.2021
[31] Image Source: https://www.gardenersworld.com/plants/indigofera-heterantha/ Date Accessed: 28.10.2021
[32] Image Source: https://sco.wikipedia.org/wiki/Lotus_corniculatus Date Accessed: 28.10.2021
[33] Image Source: http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:523626-1 Date Accessed: 28.10.2021

5. ***Indigofera geradiana***[34]
It is a deciduous herbaceous plant usually found in the high temperate regions. It has pink flowers. Flowering time of this plant is between June to September. The plant can reach to the height of up to 3 feet and can spread 2 feet.

6. ***Caragana sukiensis***[35]
The plant can grow upto 4 m in height. The species is native to the Himalayas. It is found in Western Himalayas to Bhutan. Altitudinal distribution of the species ranges from 3000 m to 3700 m.

7. ***Astragalus himalayanus* or Himalayan Milk Vetch**[36]
It is perennial herb species with dense rounded flower clusters. Each flowers are 1-1.5 cm long. Leaves are generally 3-4 cm long. The species is distributed from the Kashmir in India to the Eastern Nepal. Its altitudinal range is 3200 m-4400 m. The plant flowers between the months of June to September.

8. ***Astragalus himachalensis*** [37]
It is a perennial herb with a rhizomatous stock. Leaves are usually 3.5-4 cm long with faint grooves above. Flowers are 8-9 cm long and purple or blueish purple is in colour. Flowers bloom between July to September. It grows well in hard rock soil, mountain slopes and can easily be found between the altitude of 3300 m-4400 m. This species has been described new and the type specimens are from Keylong, Lahaul, Himachal Pradesh.

[34] Image Source: https://www.flickr.com/photos/24160994@N03/2340757860 Date Accessed: 28.10.2021
[35] Image Source: https://en.wikipedia.org/wiki/Caragana Date Accessed: 28.10.2021
[36] Image Source: https://uk.inaturalist.org/taxa/939807-Astragalus-himalayanus Date Accessed: 28.10.2021

9. ***Astragalus oxyodon***[38]
   This legume usually grows up to 18 cm. Leaves are 4-7 cm long. The species is native to the Himalayas. Altitudinal range for the species is between 3500 m to 4600 m. Flowers can be light blue to purple in colour. Flowering season is from June to September.

10. ***Hedysarum astragaloides*** **or Lahaul Sweetvetch**[39]
    It usually grows 2 feet in height. Stems have dense hair giving it a velvet like appearance. Compound leaves. Each leaf is 10-20 cm long. Flowers are light to dark purple at the tip, 5-7.5 cm long and grows in a bunch. Flowering is in June. It is easily found between the altitude of 3000m-4000m. It is well distributed in Kashmir and Himachal Pradesh.

11. ***Astragalus rhizanthus*** **or Candolle's Milk-Vetch**[40]
    It is a spiny rounded stalkless cluster shaped plant with yellow flowers. Leaves are compound and old leaves turns in to long spines. Flowers are usually 1.5-2.5 cm long. Leaves size varies between 5-10 cm. It is native to the Himalayas. Flowers between May and August. The species has higher altitudinal gradient between 1800 m-5000 m.

[40] Image Source: https://sites.google.com/site/efloraofindia/species/a---l/f/fabaceae/astragalus/astragalus-rhizanthus-1 Date Accessed: 28.10.2021

Annexure 2

Method for Selection of Plantation sites

Selection of plantation sites in the present study was conducted on the basis of multi-criteria evaluation method (MCE). It is a supportive decision-making procedure that uses a set of parameters or set of events and results in a single composite output (Malczewski, 1999). Each of the required parameters are assigned weighted values. These values are assigned based on the expert opinions, field scenarios, geological structure, climate, topology, land cover and land use etc. MCE is considered through multiple qualitative techniques viz. Analytical Hierarchy Process (AHP), Bivariate Statistical Analysis (BSA), Multivariate Statistical Approach (MSA) and Weighted Overlay Linear Combination (WLC) (Saaty, 1990; Ayalew et al, 2004; Basharat et al, 2016). In the present study we used Weighted Overlay Linear Combination as it is one of the most reliable techniques of MCE for determining the required results in the landscape ecology studies and site selection scenarios (Saaty, 1990; Basharat et al, 2016).

In the present spatial analysis, we used Spatial Multicriteria Decision Analysis (MCDA) through geospatial software which is more advanced calculation of the MCE method through Geo-spatial analytics (Malcewski, 2004; Nyerges and Jankowski, 2010; Tenerelli and Carver, 2012). For the present model, parameters were chosen based on literature and past studies for evaluating suitable plantation areas though GIS (Aguirre-Salado et al, 2015; Zaini et al, 2021) (Table 1). The Spatial Weighted Overlay Analysis therefore, combined each of these spatial rasters and calculated the suitable areas for the plantations based on the Boolean Algebra and provided a final raster output that indicates the calculated suitable areas within the landscape (Aliki and Hatzichristos, 2019). All the analysis was based on the rasters of 30 arc second (~ 1 km) resolution.

We used river flows and stream order as a parameter to evaluate the suitable site for grassland plantation. River flows and stream orders are necessary as presence of water source is one of the crucial elements. Also flow of the river and direction indicates the probability of unforeseen disasters such as, flash floods or landslides, which are essential in selection of this suitable site for plantation. We used area less than 7 km from the low stream order 1st, 2nd and 3rd as the ideal for the selection of the suitable restoration areas. Higher stream orders were deemed unfit for the restoration area as they contain higher flow velocity which is not suitable for water harvesting or any irrigation purpose and provides increased chances of natural disasters (Zaini et al, 2021). Slope of a mountain is important and we included it in the present model as the angel represents the monsoon waterflow or summer snow melts and provides us insight of the soil moisture and stability. Up to 45 degrees of slope has been found suitable for plantation in the Himalayas and we therefore selected 45 degrees as the highest slope angel for the present study in selection of suitable grassland restoration areas (Singh et al, 1989; Rawat and Everson, 2012). Influence of human habitations are important to safe guard the planted site and hence it was kept as representative parameter for the present study for anthropogenic influence in detection of the suitable site. As field study and FGD results, majority of the locals in Miyar SRB uses grasses that are available nearby their houses and doesn't utilise the grasslands in the upper mountains. Hence, we kept the safe distance for the present study at 2 km from the village as not suitable for plantation. Integrated parameters

evaluated suitable areas based on the calculation of WLC where each pixel calculations were evaluated using the following formula;

$$S = \sum_{i=1}^{n} w_i x_i \; X \; \prod_{j=1}^{k} C_j \quad \text{where,}$$

S = Land Suitability for planting grasses; w_i = importance of factor i; x_i = score of factor I; $\prod_{i=1}^{k} C_j$ = products of the j constraint.

Scores for each of the factors (x_i) were generated from the standardised variables used in the present model. Estimated importance of factors (w_i) were generated through pairwise comparisons as part of the analytical hierarchy process through the GIS software (Saaty and Vargas, 2002).

Table 1: Following table details of the parameters used in the Spatially Weighted Overlay Model for the development of most suitable plantation areas within the Miyar Subriver Basin in the present study (2018-2021)

Parameters	Source	Criteria Values
Slope	Developed using Digital Elevation Model	$<45^0$
Stream Order and Flow direction	Developed using Digital Elevation Model	Euclidean distance from the rivers. Suitable <7 km.
Landslide Zones	Developed in the present study	Vulnerability>50%
Human Habitation	Field Data	< 2 km
Grassland Degradation	Developed in the present study	Mid and Highly Degraded Areas

Method for identification of landslide prone sites:

Landslide vulnerable areas in the present study were demarcated using the GIS models following the Spatial Weighted Overlay Analysis. The methodology has been discussed in detail in the section above. We used slope, road network, river, annual rainfall. Each of the variables were assigned a vulnerability contribution to the present study area based on literatures and through AHP calculations (Table 2). Slope was kept as the 35 degrees and beyond this it is considered highly prone to landslide events. 35 degrees has been accepted as safe angle globally and for the Himalayas, based on the landslide record studies in the past (Prakasam et al, 2020). Mountain roads are mostly constructed around the mountains and generally steep slopes above the road are more than 35 degrees. Including the average road to valley distance on one hand and closeness to the other side of the road, 2 km in the vicinity of roads in mountains are considered to be vulnerable to landslides. Another reason for this

distance is often the debris from the landslides skid further away from the roads and mountain road systems being spiral in configuration, lower road segments are also considered to be vulnerable (Ahmed et al, 2015). Less than 200 m distance from rivers is considered as landslide prone as often the banks of the rivers get eroded due to landslides and river water velocity. Distance has been kept optimum based on the past studies of landslides in the Himalayas (Prakasam et al, 2020). Winter rainfall of more than 1500 mm is considered as trigger to landslides, based on the past studies in the Himalayas (Prakasam et al, 2020).

Table 2: Variables used in the weighted overlay model for estimation of landslide prone areas in the Miyar subriver basin during the present study

Triggering Variables	Vulnerable	Source
Slope	>35°	Ahmed et al, 2015; Prakasam et al, 2020; Koley et al, 2020
Euclidian Distance to Road	< 2km	Ahmed et al, 2015; Prakasam et al, 2020; Koley et al, 2020
Euclidian Distance to River	<200 m	Ahmed et al, 2015; Prakasam et al, 2020; Koley et al, 2020
Annual Rainfall	>1500mm	Koley et al, 2020; Bera et al, 2019

The model result was naturally broken in to four categories, viz., No vulnerability, Low Vulnerability, Medium Vulnerability and Highly Vulnerable areas within the Miyar Subriver Basin (Table 3). Highly vulnerable areas were significantly low in the region (around 3 km^2). Low vulnerable areas were highest in Miyar SRB (~485 km^2), followed by medium vulnerable areas (approximately 199 km^2) and not vulnerable (252 km^2).

Table 3: Landslide vulnerability analysis of Miyar SRB

S. No	Vulnerability	Area (km^2)	Area (ha)
1	Not Vulnerable	252.0588	25205.88
2	Low Vulnerability	485.4567	48545.67
3	Medium Vulnerability	198.6211	19862.11
4	High Vulnerability	2.929886	292.9886

Higher vulnerable regions were located mostly near the human habitations which can be due to the landscape alterations through anthropogenic activities in the area (Figure 1). Road and house development and reshaping of mountains for human use have been noted as the major factors that have increased vulnerability to landslides (Prakasam et al, 2020; Koley et al, 2020). Recent developmental activities in Miyar SRB, along with increased human population and demand for spatial resource for agriculture and housing (Prakash et al, 2019) has resulted in these areas being more prone to landslides.

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Annexure 3

Cultivation Protocol of Sea buckthorn

While undertaking plantation, sea buckthorn saplings are usually placed at 4 x 2m apart, which results in high canopy volumes. Planting less than 1.5m apart can create canopy overlapping and occasional trimming may be required. Pits are often placed around the plants with usual diameter of 2 x 2 x 2 metres. These pits get covered in the snow during the winter and provides extra humidity and water to soil during the summers. Weed control is done by polythene mulching or mulching with *Artemisia* sp. . Both have resulted in more than 94% of success in weed control in the region for Sea buckthorn. For nutritional requirements organic manures with high nitrogen load (50kg/hectare) is recommended during the early establishment period of the plants. Rest of the nutrients are generally supplemented from the soil by the plant itself. It is recommended to plant the Sea buckthorn as mixed species plantation. Mixed plantations have recorded better growth and yield for all the species which are planted together. The best combination is Sea buckthorn with Fescues (*Festuca sp*.) or Orchard grass (*Dactylis glomerata*) and Red Clover (*Trifolium pratense*) together. More than a 37% increase has been noted in their total yield and production in comparison to the same from monoculture.

Reference

A value chain on Seabuckthorn (Hippophae L.). 2014. National Agricultural Innovation Project. Indian Council of Agricultural Research. Final Report. CSK Himachal Pradesh Agricultural University. Palampur, Himachal Pradesh.

Annexure 4

Cultivation Protocols

Poa alpina

This grass species has low competitive capacity in juvenile period; hence, weeding is absolutely necessary before sowing as well as during the growth of the species. Seeding in plantation area should be done in early monsoon. The species has surface germination and therefore should not be sowed at more than 0.5 cm depth and spacing between the seeds must be adequate and minimum of 12 to 15 cm. Minimum of 8 kg/ha of seeding is required for successful germination.

Reference

Krautzer, B., Peratoner, G., & Bozzo, F. (2004). Site-Specific Grasses and Herbs: Seed production and use for restoration of mountain environments. Food and Agriculture Organization of the United Nations, Rome.

Deschampsia cespitosa

Plantation of this species requires adequate hydration in soil and a pH range of 5 to 7.5. The species can tolerate strong frost. This species has surface germination and sowing is recommended at 0.5 cm depth from the above ground surface. Optimum time for plantation is early monsoon. 6-8 kg/ ha of seeds is generally used. Effective through seed broadcast. Weeding is recommended.

Reference

Krautzer, B., Peratoner, G., & Bozzo, F. (2004). Site-Specific Grasses and Herbs: Seed production and use for restoration of mountain environments. Food and Agriculture Organization of the United Nations, Rome.

Koeleria pyramidata

This species has a broad environmental tolerance. Optimum pH for growth is 6-7.5. Plants of this species can be sowed in early monsoon, however, well weeding is very essential from the early stages of growth. Seeds should not be sowed at more than 0.5 cm depth. 7-9 kg/ ha of seeding is recommended. Effective for seed broadcasting.

Reference

Krautzer, B., Peratoner, G., & Bozzo, F. (2004). Site-Specific Grasses and Herbs: Seed production and use for restoration of mountain environments. Food and Agriculture Organization of the United Nations, Rome.

Cynodon dactylon

This species has the broadest environmental tolerance among the grasses in the world. C. dactylon is known to have well growth condition in diverse soil and moisture regimes, can

withstand drought and survives in as low as -10°C. Optimum pH range for growth in soil is generally between 4.3 to 8.4. Seeds are generally sowed in early summer and little soil cover is needed. Effective through seed broadcasting. Germination is fast and completes within 2 weeks. Saplings, seeds or even rooted side-shoots can simply be used for plantation.

Reference

https://pfaf.org/user/Plant.aspx?LatinName=Cynodon+dactylon

Astragalus rhizanthus

Cultivation of this species is primarily through seeds. Winter (February to March) is the best time for the species for sowing the seeds. Seed treatment is generally done by soaking in hot water for 24 hours, which increases the chances of successful germination. After soaking for 24 hours in hot water, the seeds are allowed to come to room temperature. The non-swollen seeds are picked up after 24 hours and the process is repeated till they germinate. Germination has been found to be successful within 4-9 weeks for the species in as low as 13°C but might require more time if the temperature is low. Once the seedlings are grown enough to be handled, they can be transplanted to pots and then to the planting site in early summer.

Reference

Temperate Plants Database, Ken Fern. temperate.theferns.info. 2021-11-02. <temperate.theferns.info/plant/Astragalus+rhizanthus>.

Indigofera gerardiana

It is a hardy cold tolerant species. Plants of this species can have slow growth at temperatures between -5 to -10°C, however the rooting system works fine underground and helps in the survival in harsh conditions. Plants will resume growing during the summer times with warmer temperature and sunshine. Soil at the planting sites should be well drained. The species is tolerant to common fungal diseases like Honey fungus.

Reference

Sheat, W. G. (1948). Propagation of trees, shrubs and conifers. Mcmillan & Co. London. 479pp.

Trifolium repens

This species grows well on soil that have good number of nutritional elements such as, P, N, S, and Mb. Soil pH for the species ideally ranges around 4.5 for optimum growth. Soil should also have a good water holding capacity, however, at the plantation site the soil should be well drained. Plants of this species can be seeded at the target sites through surface sowing. For degraded areas and pasturelands, over sowing is recommended for this species. Dense sowing is recommended usually with 0.5-3 kg/ha. However, the number of seeds for sowing might vary based on the climate, elevation and geographic locations. The species requires surface sowing for successful germination with soil dug up to 15 cm for each seed sowing. The species has a good amount of tolerance to rotational grazing. Once it reaches the

optimum height, the pastureland with this species can be grazed for spring and early summer. However, the plants must reach the height of 15-20 cm, before grazing should begin.

Reference

The Biology of Trifolium repens L. (White Clover). 2008. Department of Health & Aging Office of the Gene Technology Regulator, Government of Australia. Version 2.

Lotus corniculatis

This species is sown in early summer and seed treatment in hot water usually improves germination. Seeds can be directly sowed in the surface, however, ground must be cleared well before sowing the seeds. Usually the seeds take 2-4 weeks to germinate. This species shows rapid growth and is an ideal choice for improving degraded pastures. The plant grows well even in poor soil condition and decomposed plants of this species work very effectively in supressing weeds in the planted areas. Seeds should be planted around 3kg/ha. Within 3 to 6 months the plants become good forage for livestock and can be allowed to graze.

Reference

https://www.seedaholic.com/lotus-corniculatus-bird-s-foot-trefoil.html

Desmodium elegans

This species is in general a cold resistant species and can tolerate dormant temperatures between -15 to -20°C. The species requires well drained soil for optimum growth. Plantation must be done in late winter or early summer. Best grown methods for this species is in nursery. Seeds are generally recommended for hot water treatment for 5 hours before sowing. Germination usually occurs within 1-4 months but can vary according to locations. Plants must be kept in nursery for the first winter for seedlings to protect from frosts and snow.

Reference

Temperate Plants Database, Ken Fern. temperate.theferns.info. 2021-11-02. <temperate.theferns.info/plant/Desmodium+elegans>

Grewia optiva

Nursery beds are ideal for germination of seeds of this plant. The size of the bed is usually kept at 10 m x1 m but can be adjusted as per the requirements. Good drainage needs to be ensured in the beds.

The seeds can also be germinated in polythene bags. Bags with dimensions of 22.5 cm x 15 cm are filled up with by mixing soil, sand and compost in the ratio of 1:1:1 leaving 2-3 cm of free space at the top of the bag. Each bag is sowed with 3-4 seeds and kept under shade and watered daily.

Germination success is very low for this species. To have an effective germination it is suggested to treat the plant seeds in hot water. In this case, water is heated to its boiling point and then kept for cooling. After cooling for 5 minutes the seeds are kept in the water and

allowed to soak overnight. The following day, the seeds are packed in gunny bags and hung in shade for 2 hours and then used for sowing. Sowing of seeds are done in a line and is watered regularly.

Seedlings emerge within 30-35 days and can reach up to 15-20 cm in just 60 days. Within a year these saplings may reach up to the height of up to 150 cm.

Planting of Seed: Seeds are sowed generally in summer or just before monsoon in pits of dimensions 45 x 45 x 45 cm. Fallen logs, boulders, rocks etc should be removed, otherwise they can hinder the growth of the sapling. Dug up soil should be kept aside and pits should be left open for 15-20 hours for aeration. 5kg compost with soil mixed well is added to the pits first and the rest of the pit is then filled with soil.

Planting of Sapling: One year old saplings can be planted in the monsoon in the pits. 15 cm of soil is scooped and then sapling is planted gently and then the pit is covered with soil, keeping the plant straight. Pits should be watered adequately.

Reference

Harsh, M., Tyagi, P. C., & Dadhwal, K. S. (2011). High-yielding provenances of bhimal (*Grewia optiva*) for fodder and fuelwood production in north-western Himalayas. Indian Journal of Agricultural Sciences, 81(8), 717-722.

Bauhinia variegata

Plants of *Bauhinia variegate* are cultivated for fodder and fuel. Seeds of this plant are generally collected via pod collection. Pod collection is done before they burst open. Usually this plant contains 2000-3000 seeds/kg, which may remain viable for up to a year with 90% of germination success. Seeds are generally treated in cold water for 4-8 hours, before sowing.

Sowing of seeds is done during the month of May-June. Within 6-7 days of sowing the germination starts and completes within 15 days. Seedlings are then transplanted to transplant beds, where they are allowed to grow for another year. The roots are pruned and planted after that.

Reference

The Tamil Nadu Agricultural University (TNAU). TNAU Agritech Portal. https://agritech.tnau.ac.in/forestry/forestry_nursery_bauhinia_variegata.html

Alnus nepalensis

Cultivation of *Alnus nepalensis* requires usually a spacing of 2.5 x 2.5 m, however, much closer plantation can be done in case for the purpose of fodder plantations.

The species is generally grown from seeds. Each kilogram contains around 2 million seeds and the viability of the seeds can reach up to a year. Seeds require no treatment. After sowing, the seeds start to germinate after one to two weeks. If seedlings are grown in nursery, then the transplantation to sapling containers can be made 4-5 weeks after germination. Plantation of saplings can be done at the age of 4-5 months, when the plants reach the height of around

30 cm. The growth rate of *A. nepalensis* depends on the geographic location, light intensity and the available soil moisture. Pollination and seed dispersal of this tree species are generally done by wind. Slopes with northern aspects are preferable to this species for establish as the soil moistures remain high.

When the tree circumference is about 70 to 80 cm, each tree is then pollarded. Bark of the tree usually starts developing rough fissures by 6 to 10 years. However, care should be taken in the time of pollarding. Pollarding should be done during the months of December and January. First time pollarding is done in a horizontal manner across the main trunk and the stump height is kept at 7-8 feet from the ground. Auxiliary branches are all cut off.

After the completion of pollarding, the freshly cut area is plastered with mud for prevention of air drying and stone slab is placed on top of the stump. The placed stone also protects the tree from frost and promotes rejuvenation of the new branches for a more horizontal spread, leading to a larger canopy.

Reference

Ghimire, M.P. 1985. Growing Alnus trees over cardamom plantations for fuetwood in Ilam District. Community For" Development Project, occasional Paper No. 9, FAO/UNDP/HMG, Nepal.

Cairns, M., Keitzar, S., & Yaden, T. A. (2010). Shifting forests in Northeast India: Management of Alnus nepalensis as an improved fallow in Nagaland (pp. 362-399). Routledge.

Salix alba* and *Salix fragilis

Shoot Cutting Method is usually followed for the species in cold regions. 3-5 willow shoots are planted depending upon the altitude. Higher altitude requires plantation of higher number of shoots subject to survival. Shoots of similar height, breadth and age are tied together in this process as a bunch. Such bunching of shoots provide protection to the inner tissues from grazing animals and high-speed winds in the region. Alternatively, local plants like Sea buckthorn or wild roses can also be tied up together to save the bunch from the grazing animals. Bunches are planted around March and April as the snow melting water hydrates the soil with optimum moisture. Planting is done usually in a 75 cm deep and 45 cm wide pit for each bunch. Rocks are kept at the downhill side of the plants to protect from snow slides. Watering is important after plantation. During the early development stages, the shoots are trimmed twice every month from the main body. After 4 years, pollarding can be started for the plants. It should be done at 2.5 m height minimum to prevent new shoots from predation of grazing animals. November and December are ideal for pollarding of this plant in the region and the branches can be used as fodder and fuel wood. During the summer, annual pruning should be continued in the lower trunks of the tree. Each of the plants can survive in the region for 150 years however, the trunk becomes hollow after 80 years and the tree start producing less branches.

Reference:

Rawat, Y. S., Oinam, S. S., Vishvakarma, S. C., Kuniyal, C. P., & Kuniyal, J. C. (2006). Willow (Salix fragilis Linn.): a multipurpose tree species under pest attack in the cold desert

of Lahaul valley, northwestern Himalaya, India. AMBIO: A Journal of the Human Environment, 35(1), 43-48.

Poplar Trees (*Populus nigra, P. alba and P. balsabifera*)

Poplar is usually propagated in nurseries by stem cutting method. Nursery beds are first weeded and irrigated. Cuttings are generally planted in late winter or in early summer. By the next early summer, the saplings can grow up to 3-8 meter in height. Approximately 20,000 saplings can be grown in a one-hectare nursery area. Saplings are then transferred to the field and planted. Plantation is done in a pit with a diameter of 7-10 cm and at a depth of 60-90 cm. After putting the sapling inside the pit, it is filled with soil and water is added. A week later the pit is covered with soil to resettle and watered again. Spacing of the plantation can vary depending on the location. General spacing used for poplar plantations are 5x5m, 7x3m, and 8x3m. Each plantation line is kept at a distance of 2-3m apart from each other. Wider spacing in lines however, has been found to produce good quality timber. Pruning is an essential part also for producing good quality timber and higher longevity of the planted trees. Poplar roots also grows near the ground and is thus vulnerable to strong winds, especially during the early ages (1-2 years) and in old ages. Pruning also helps facing the strong winds of the mountain for these trees. Lateral pruning is done in the early ages of plantations (2-3 years). In this method, lower side branches are cut down that helps in the faster growth in the early growing stages. Vertical pruning is done at more later stage of the growth (usually after 3 years of planting). In this method, larger stems towards the crown are cut down to reduce the crown size. Both pruning mechanisms are performed in the winters. Vertical pruning is done in alternative years while lateral pruning continues every year. Poplars are fast growing and can be harvested and sold between 8 to 12 years.

Reference: Dhiman, R. C. (2012). Status of Poplar culture in India. *Forestry Bulletin*, *12*(1), 15-32.

Annexure 5

Mapping Convergence

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
1	HP Single Use Plastic Buyback Scheme	Buy-back of Non-recyclable and Single Use Plastic Waste including plastic bags in the Himachal Pradesh from the informal sector and households, providing Minimum Support Price of Rs. 75/- (Rupees Seventy-five) per kg, for its collection and deposit in the collection centres of the Urban Local Bodies.	The Departments of Environment, Science & Technology, Urban Development, Public Works, Rural Development, State Pollution Control Board and Cement Companies	Environment Science & Technology Department, Himachal Pradesh	Nearest Designated Collection towns are Chamba & Dalhousie	http://dest.hp.gov.in/sites/default/files/Notification_01102019_0.pdf
2	Himachal Grihini Suvidha Yojana 2021	Provision of security amount for domestic Liquefied Petroleum Gas (LPG) connection and a gas stove to poor families. Families in the state without LPG Gas Connections and who are not covered under Pradhan Mantri Ujjwala Yojana (PMUY) are covered under this scheme 2021 for at least 2 years.	Rural Development	Food, Civil Supplies and Consumer Affairs Department, Himachal Pradesh		https://sarkariyojana.com/grihini-suvidha-yojana/
3	Sashkat Mahila Yojana	All SHGs/Mahila Mandals having bank accounts/bank linkage will receive need-based training for income generation activities like soft toys, pickle and preserve making, jute bag, recycling of waste material, knitting and embroidery	Women & Child Development	Department of Social Justice & Empowerment	Age Group to avail this scheme is 19-45 years	https://himachal.nic.in/WriteReadData/l892s/176_l892s/Sashakt%20Mahila%20Yojna-30901215.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		products etc. with the view to promote micro enterprise at village level. A one-time seed fund worth Rs 50,000 will be distributed to the state's self-help group for income-generating activities. Women will be also provided with information about their rights.				
4	Van Samridhi Jan Samridhi Yojana	Economic returns to rural households engaged in collecting and sale of Non- Timber Forest Produce, including medicinal plants. This will be done through strengthening of the wild resource base, post-harvest handling, value addition and marketing. A 25% subsidy will be given to those who grow medicinal plants on their land. The main objective is to provide appropriate prices for medicinal plants which grow in the forests of the state.	Rural Development	Jari-Buti Cell under Zaika Project, Department of Forest, Himachal Pradesh	The scheme will be implemented through Community User Groups in these districts for the Phase 1 (April, 2018-March 2038) who will be reporting to Biodiversity Management Committees.	https://hpforest.nic.in/files/Van%20Samridhi%20Jan%20Samridhi%2010.pdf
5	Saur Sinchai Yojana	The scheme (Solar Irrigation Scheme) will provide solar pump sets to farmers for agricultural/irrigation purposes. Under this scheme, the state govt. will provide 90% financial assistance to small and marginal farmers for purchase of pump-sets	Agriculture & Horticulture	Soil & Water Conservation wing, Dept. of Agriculture, Govt. of H.P.	Preference for small farmers, Crop cultivation through rain fed conditions, Neo-Youth, Organic farming, Zero Budget Natural farming etc.	http://www.hpagriculture.com/Guidelines%20of%20Saur%20Sinchayee%20Yojana.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		and 80% subsidy to all individual medium and big farmers.				
6	Mukhya Mantri Swavalamban Yojana	In order to provide employment opportunities to jobless youths, widow and women candidates, Himachal Pradesh government will take the guarantee of loans provided to the unemployed. Residents eligible can set up manufacturing unit, service sector and businesses at a cost of 60 lakh rupees. The state govt. will provide capital investment subsidy at the rate of 25 to 35 percent, interest subsidy at the rate of 5 percent and other incentives provided by the industry centre in the district.	Livelihood Development	Department of Industries	**Eligibility** Applicant must be a permanent resident of Himachal Pradesh. Applicants must be between 18 to 45 years of age. The applicant youth, widow or women must be unemployed. Unemployed youth will get a 25% subsidy on machinery with an investment of Rs. 40 lakh in the industry. Jobless women will get 30% subsidy with an investment of Rs. 40 lakhs on machinery in the industry. Jobless widow will get 35% subsidy with an investment of Rs. 40 lakh on machinery in the industry. The state government will provide an interest subsidy of 5% for 3 years at Rs 40 lakh.	http://mmsy.hp.gov.in/documents/Mukhya_Mantri_Swavlamban_Yojana_2019.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					Apart from this, the government will also provide land on rent to the youth at a rate of just 1%. With this, the government will reduce the stamp duty on the purchase of land from 6% to 3%	
7	Nai Raahein Nai Manzilien Scheme	Under this scheme, unexplored and untapped tourist destinations will be identified to promote tourism in. The total budgetary allocation of Nai Rahen Nai Manzil Scheme is Rs. 50 crore.	Tourism Development	Department of Tourism, Got. Of H.P.	Tourism Dept. has prepared 9 circuits under Nai Rahen Nai Manzil Scheme 2018 which are as follows • Jogindernagar-Barot-Kothi Kohar-Rajgungja-Bir-Billing • Sundernagar-Chail Chowk-Kamru Nag-Shikari Devi-Janjheli • Shimla-Khara Pathar-Rohru-Sandasu-Larot-Chanshal-Dodra Kwar • Dhauladhar Circuit • Buddhist Circuit • Bhakra-Bilaspur-Sundernagar-Jogindernagar-Pong Dam • Solan-Habban-Rajgarh-Shillai • Manali-Rohtan-Tandi-Udaipur-Killar	https://sarkariyojana.com/nai-raahein-nai-manzilien-scheme-hp-identify-tourist-places/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					• Narkanda-Baghi-Khadrala-Chini (Kalpa)-Pangi Circuit A committee of Tourism, PWD, Forests, Language, Art and Culture Officers will make a visit to the selected circuits. This committee will propose the activities which needs to be carried out in these circuits after consulting the local panchayats and other stakeholders.	
8	Cm Startup Scheme	This scheme will support startups and Innovation Projects in the state and will provide skills to the youth and potential investors to develop entrepreneurship. Besides this, the government is providing facility of hand holding and mentorship to innovative enterprises from the initial stage to setting up of the industry.	Industry Development	Dept. of Industries, Govt. of H.P.	Sectors supported include • Technology driven innovation in any sector • Rural infrastructure and facilities, crafts, arts, water and sanitation, renewable energy, healthcare, etc. • Clean technology • Agriculture, Horticulture and the related areas • Food Processing • Retail • Tourism and Hospitality • Mobile, IT and ITes including hardware • Biotechnology	https://sarkariyojana.com/cm-startup-scheme-himachal-pradesh/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
9	Mukhya Mantri Gram Sadak Yojana	The state government will develop road connectivity between villages/habitations and cities through this scheme.	Transport	Department of transport, Govt. of H.P.	• -	https://sarkariyojana.com/mukhya-mantri-gram-sadak-yojana-himachal-pradesh/
10	Mahila Vikas Nigam	Focussing on the welfare of the women of its state, the scheme will support women entrepreneurs and the women workforce through no to low interest rate loans.	Women Empowerment	Ministry of Social Justice and Empowerment, Govt. of H.P.	Types of loans provided include • Interest-free loan up to Rs. 3000. • 5% interest rate for a loan of Rs. 20,000. • 7% interest for a loan over Rs. 20,000. • Interest-free loan is sanctioned to study in selected courses up to Rs. 75000.	https://www.indiafilings.com/learn/mahila-vikas-nigam-loan-yojana/
11	Revamped Restructured Weather Based Crop Insurance	The scheme intends to provide Insurance protection to the cultivators against weather incidence, such as High mean temperature & Low mean temperature, Deficit rainfall and Excess/Unseasonal rainfall, Temperature fluctuation, Maximum temperature & Minimum temperature, Dry Spell and Disease Congenial Days cover etc. which may adversely affect the Kharif & Rabi Crops during its cultivation period.	Agriculture	Dept. of Agriculture, Govt. of H.P.	During Kharif seasons, Tomato, Potato, Ginger, Peas, Cabbage & Cauliflower crops will be covered and during Rabi seasons, Tomato, Potato, Garlic & Capsicum crops will be covered under the Scheme. In Chamba (Chamba, Mehla, Salooni, Tissa, Bharmour, Salooni, Tissa): Potato & Peas are covered, in Lahaul & Spiti:	http://www.hpagriculture.com/Revamped__RWBCIS_from_Kharif_2020_to_Rabi_2022-23.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					Potato, Pea, Cauliflower are covered	
12	Quality Seed Multiplication And Distribution	Under this scheme, expenditure on seed multiplication farms, seed stores, seed testing and certification, subsidy on cost of seeds and cost on demonstrations etc, are met to improve production and area of crops and raise income of small and marginal farmers. This will be done through the creation of various infrastructure, promotion of organic farming and training and capacity building.	Agriculture	Dept. of Agriculture, Govt. of H.P.	Department owns 21 Seed Multiplication Farms where foundation seeds of Kharif and Rabi crops are produced. Annually about 3500 to 4000 quintals seed of cereals, pulses and vegetables are produced in these farms. Further about 90,000 quintals of certified seeds of various crops are distributed to the farmers in the state.	http://hpagrisnet.gov.in/hpagris/agriculture/PDF/State%20%20Sponsored%20Schemes%20%282%29.pdf
13	Rashtriya Krishi Vikas Yojna	The department is providing financial assistance for community owned water harvesting structures, farm ponds and tanks on community based schemes. 100% expenditure is borne by the Govt. of India with an objective to achieve 4% growth in agriculture sector.	Agriculture	Dept. of Agriculture, Govt. of H.P.	1. Recharging of ground water. 2. Reduction in soil loss. 3. Production of Fish Culture. 4. Reduction in flush floods. 5. Mitigation of draught. 6. Better environment conditions in the catchment. 7. Reduction in drainage density.	http://hpagrisnet.gov.in/hpagris/Agriculture/Default.aspx?SiteID=2&PageID=140

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					8. Higher availability of water for drinking and other domestic needs. 9. Higher availability of other needs like fuel and fodder	
14	Deen Dayal Kisan Bagwan Samridhi Yojna	Assist farmers in their own farm land who intend to install micro irrigation system (sprinkler or drip) on their farm lands. The scheme will promote more efficient irrigation systems, rainwater harvesting structures in order to conserve natural resources, improve food crop yield and strengthen existing integrated farming systems.	Agriculture	Dept. of Agriculture, Govt. of H.P.	Preference would be given to farmers growing crops under rain fed situations, Small and marginal farmers, farmers whose livelihood source is Agriculture sector only and neo-literate youths having farm land.	http://hpagrisnet.gov.in/hpagris/Agriculture/Default.aspx?SiteID=2&PageID=142
15	Manures And Fertilizers	**Distribution of Fertilizers**: The State Govt. has allowed cost subsidy on complex fertilizers DAP 18:46,NPK 12:32:16, NPK 10:26:26 and NPK 15:15:15 @ Rs.1000/-per MT. Apart from this cost subsidy @25% is also being provided on 100% water soluble complex fertilizers to the farmers (limited to Rs. 2500 per farmer). **Soil Testing Centres:** Soil testing has great importance for raising agriculture production. The department is providing free soil testing facilities to the farmers.		Govt. of H.P.	-	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		Department has 11 Soil Testing Laboratories besides seven mobile soil testing labs to provide free soil testing facilities to the farmers.				
16	Rajiv Gandhi Micro-Irrigation Scheme	To promote Agriculture in the State by increasing the productivity of crops, 80% assistance shall be provided to individual farmer for Micro- irrigation Systems	Agriculture	Dept. of Agriculture, Govt. of H.P.	Outlay of Rs.154 Crore over a period of 4 years. Through this Project, 8,500-hectare area will be brought under Drip/ Sprinkler Irrigation System benefitting 14,000 farmers. Farmers will get a subsidy of Rs.113 Crore during the project period. The project is under appraisal with NABARD under RIDF funding.	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
17	Uttam Chaara Utpadan Yojna	To increase fodder production in the State, the scheme will supply quality Seed of Fodder Grasses, Cuttings, Seedlings of Improved Fodder Varieties at subsidised rates to the farmers.	Agriculture	Dept. of Agriculture, Govt. of H.P.		http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
18	Mukhya Mantri Khet Sanrakshan Yojna	Under this scheme the Government has enhanced the subsidy from existing 60% to 80% for wildlife conflict measures. The farmers will be given option for installation of solar fencing by themselves	Agriculture	Dept. of Agriculture, Govt. of H.P.	This scheme is being executed through 5 empanelled firms and the department has approved costs per running meter for Regular Electric	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		provided that the technical specifications are fulfilled.			powered and Solar Electric Powered fencing.	
19	Mukhya Mantri Green House Renovation Scheme	Under this scheme, 50 % subsidy will be provided to the farmers for the replacement of poly sheets after 5 years of setting up of polyhouse or from damage due to natural calamities.	Agriculture	Dept. of Agriculture, Govt. of H.P.	-	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
20	Angora Wool Development Scheme	Improve scientific rearing of Angora rabbits through training, employment opportunities and improve existing small scale, cottage & handloom set up for production of the Angora wool.	Animal Husbandry	Sheep and Wool Boards, Govt. of H.P.	In India, Angora Rabbit Wool is reared in hilly areas of Uttaranchal, Himachal Pradesh and in some other states where climatic conditions are suitable for its rearing. The total Angora population in the country is around 50,000 and nearly 30,000 Kg. wool is produced annually. With the assistance of UNDP, the Department has established a germ plasm centre at Nagwain (District Mandi) where pure breed German Angora rabbits are being bred on scientific lines.	http://woolboard.nic.in/download/I.C.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
21	Uttam Pashu Puraskar Yojna	Provides incentive and encouragement to livestock owners for rearing good quality high yielding animals	Animal Husbandry	Animal Husbandry Department, Govt. of Himachal Pradesh		http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/Dept_Activities__July_2017.PDF
22	Scheme For Provision Of Subsidized Rams To Sheep Breeders	Improve quality and quantity of Wool being produced in the state, thereby ensuring better economic returns to the Sheep Breeders.	Animal Husbandry	Animal Husbandry Department, Govt. of Himachal Pradesh	Breeding Ram will be provided on 60% subsidy.	http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/Dept_Activities__July_2017.PDF
23	Bpl Krishak Bakri Palan Yojna	Increase income generation opportunities for economically weaker segments of the society as well as meat production through provisions of subsidies for goats	Animal Husbandry	Animal Husbandry Department, Govt. of Himachal Pradesh	Goat units of (10 female +1 male/ 4 female +1 male /2 female +1 male) will be provided on 60% subsidy.	http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/Dept_Activities__July_2017.PDF
24	Mukhyamantri Madhu Vikas Yojana	Under the scheme, beekeeping and honey production is given a boost through subsidies, training, assistance with infrastructure.	Horticulture	Department of Horticulture, Govt of India	Beekeepers will be given 80 per cent cost amount or Rs 1,600 per bee colony to raise 50 bee colonies. In each district, a bee-breeder of 300 bee colonies will be given an amount of Rs 3 lakh. They will be given 50 per cent subsidies on the	https://hpkangra.nic.in/scheme/the-mukhyamantri-madhu-vikas-yojana/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					transportation per year. To establish a honey processing unit, 100 per cent of the cost of the project will be provided for the plantation of bee flora in two bighas. The farmers will also get 50 per cent subsidies on honey extractor, food grade container in which Rs 7,000 per set will be provided. Under the Horticulture Mission, there is a provision of providing 50 per cent subsidy on the production of bee colonies to the beekeepers	
25	Pushp Kranti Yojana	Under this scheme, farmers are provided with high-tech poly houses, training and other means of flower production. The scheme also provides loans to unemployed youth to take up flower production.	Horticulture	Department of Horticulture, Govt of India	Farmers are also offered around 25% discount while sending their cultivated flowers via state owned transportation service provider HRTC buses.	http://www.eudyan.hp.gov.in/UploadedImages/Document/guiudelines%20of%20Himachal%20Pushp%20Kranti%20Yojna.pdf
26	Anti-Hail Net (Bagwani Surksha Yojna)	The state government has extended the subsidy scheme on anti-hail nets to agriculture. Until now, the scheme was available	Agriculture/Horticulture	Department of Horticulture, Govt of India	The farmers involved in multi-cropping, including both horticulture and	http://eudyan.hp.gov.in/UploadedImages/Document/A

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		only for horticulture. Under this scheme, the farmers will get 80 per cent subsidy on hail nets for 5,000 square meter area.			agriculture, too, can avail the scheme. In the absence of anti-hail nets, many crops such as peas, cabbage, tomatoes and cauliflower etc suffer huge losses in the event of inclement weather. The farmers would need to apply to the department along with documents related to land and their Aadhaar Card.	nti%20Hail%20Net%201.pdf
27	Khumb Vikas Yojna	This scheme enables increased production of khumb/mushroom in the state. Under the scheme, training and assistance is provided to the farmers starting from production of khumb to its marketing the produce through proper channels.	Agriculture/ Horticulture	Department of Horticulture, Govt of India	Allowances and subsidies are also provided to the farmers for purchasing manure, compost, farm tools, etc. Technical guidance and disease control activities are also conducted for the farmers by the Horticulture department.	http://eudyan.hp.gov.in/UploadedImages/Document/Himachal%20khumb%20vikas%20yojna%202019-20.pdf
28	State Mission on Food Processing (SMFP)	The centrally sponsored mission intends to promote facilities for post-harvest operations including setting up of food processing industries, improve the capacity of food processors, support SHGs in the food-processing sector and capacitate/upskill manpower in the	Food processing	Department of Industries, Govt. of H.P.		https://emerginghimachal.hp.gov.in/themes/backend/uploads/notification/SMFP.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		industry. This can be done through augmenting farm gate infrastructure, supply chain logistics, storage and processing capacity. The mission also aims to raise the standards of food safety and hygiene in order to meet the norms setup by FSSAI, and facilitate food processing industries to adopt HACCP and ISO certification norms.				
29	Vidyarthi Van Mitra Yojna	The scheme aims at sensitising students and the school administration about forests and their importance by involving them in plantation of saplings/afforestation in various degraded forest areas.	Forests	Department of Forests, Govt. of H.P.		https://hpforest.nic.in/files/Vidyarthi%20Van%20Mittar%20Yojna.pdf
30	Samudayik Van Samvardhan Yojna	The scheme intends to provide maximum economic benefits to the members of JFM/VFDSs in the form of valuable Forest Products and other usufruct yielding high economic returns in the market as well as productive usage water. The overall outcomes expected from this is the improvement of local ecosystem services, enhancement of forest cover and rejuvenation of village level	Forests	Department of Forests, Govt. of H.P.		https://hpforest.nic.in/files/SAMUDAYIK%20VAN%20SAMVARDHAN%20YOJNA.docx

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		institutions related to conservation and sustainable use of natural resources through awareness, education and organization of village communities.				
31	Prakritik Kheti-Khushhal Kisan	The scheme aims to promote natural farming/zero-budget farming in the state through subsidies, financial assistance and training. Natural farming requires minimal cost inputs and depends on the natural resources for crops.	Agriculture	Department of Agriculture	75% subsidy on drums which are required to make inputs for natural farming Financial assistance of Rs. 50,000 to open natural resources store in village Training and workshop to create awareness about natural farming for farmers	http://himachalpr.gov.in/PressReleaseByYear.aspx?Language=1&ID=11892&Type=2&Date=25%2f04%2f2018
32	Mahila Mandal Protsahan Yojana	To encourage women groups and to strengthen the Mahila Mandals the Government has instituted this Award scheme. The awards are given through Development Blocks for providing incentives to the Mahila Mandals, which excel in the field of Rural Development.		Rural Development Department, Govt. of H.P.		http://www.hprural.nic.in/RFPMM.pdf
33	Maharishi Valmiki Sampoorna Swachhta Puraskar	To motivate rural communities to adopt safe sanitation practices and end open defecation, this award was instituted. The award is won by the cleanest gram panchayat, at the block, district, division and state	Sanitation	Rural Development Department, Govt. of H.P	Any Gram Panchayat that satisfies the following conditions is eligible to participate in the MVSSP competition	https://hprural.nic.in/MVSSP_2009_Guidelines.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		level based on an annual competition.			• The Gram Panchayat should have become open defecation free. • Winning Gram Panchayats at any level are excluded from participating for the Award for that level for the next three years. However, it can participate in this competition at a higher level e.g. Panchayats having won the Block level award in the previous year, would be eligible to compete only for District, Division and State Award in the next year's competition. • State level winner is not eligible to participate in the competition for 3 years after the year of winning.	
34	Vikas Mein Jan Sahyog	Under this programme, an open offer was given to the public that if they come forward with a public share of 30% of the project cost, Govt. will provide them the rest and sanction them a developmental scheme benefiting the community.	Infrastructure	Since the works under this scheme would be implemented by different State Government agencies such as PWD, Rural	According to Govt. decision, the public share for the sanction a particular scheme in rural areas was raised to 75% of the estimated cost of the project, thereby reducing the public share	https://himachal.nic.in/contprintcont.php?lid=7931&cont=70&lang=1&dpt_id=198&level=1&sublinkid=7656

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
				Development, Irrigation, Agriculture, Health, Education, Area Development Authorities, Water Supply and Sewerage Boards, Housing Corporation etc. the Heads of the respective districts would be responsible for the coordination and overall supervision of the works under this scheme at the district level.	to 25%. The limit for the sanction of project was also raised to Rs. 1.00 lakh. Subsequently, in the year 1997 the limit for the scheme to be sanctioned by the Deputy Commissioners was raised to Rs. 3.00 lakh and now it has been raised to Rs. 5.00 lakh. i) Construction of buildings of Government education institutions. ii) Construction of multipurpose community/public assets. iii)Construction of motor able roads and ropeways. iv)Construction of irrigation schemes/drinking water schemes/installation of hand-pumps. v) Construction of buildings of public health services. vi)Provision of important missing links; such as, three-phase transmission lines, transformers, X-ray plants, ambulances etc.	

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					vii)Provision of consumable items like lab. equipment & furniture etc.	
35	Border Area Development Programme	The main objective of the programme is to meet the special needs of the people living in remote, inaccessible areas situated near the border with an emphasis on the schemes for employment promotion, production-oriented activities which provide critical inputs to the social sectors, infrastructure and economic development activities.	Infrastructure		Border Area Development Programme in Kalpa and Pooh Blocks of the Kinnaur district and Spiti Block of the District Lahaul & Spiti.	http://himachalservices.nic.in/tribal/pdf/ComprehensiveDev.pdf
36	Green Gold	The Government of India the Green Gold project for the District Chamba under SGSY Special Project Component with a total Project Cost of Rs.1488.73 lacs which includes subsidy of Rs.1361.23 lacs, Rs. 127.50 lacs as loan component and beneficiaries share. Centre and State Government will share the subsidy component on 75:25 sharing basis.	Agriculture/Horticulture	Rural Development Department, Govt. of H.P	Under this Project the following activities will be taken: - • Cultivation of Medicinal plants, Aromatic plants, Flowers and Orchids • Cultivation of Off-Season vegetables. • Cultivation of Mushroom • Improved Dairy Management	https://hprural.nic.in/Schemes.htm
37	National Rural Employment Guarantee	The scheme grants an entitlement of 100 days of guaranteed employment in a financial year per		Rural Development	As per schedule 1 of the Act the focus of the scheme is on the following	http://www.hprural.nic.in/nre.htm

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
	Scheme (MGNREGA)	household. This entitlement of 100 days per year can be shared within the household. All adult members of the household who registered can apply for work. To register, they have to:- a) Be local residents i.e. those residing within the gram panchayat. b) Be willing to do un-skilled manual work. c) Apply as a household at the local gram panchayat.		Department, Govt. of H.P	works in their order of priority:- (i) Water Conservation and Water Harvesting works; (ii) Drought proofing works (including afforestation and tree plantation) (iii) Irrigation canals including micro and minor irrigation works; (iv) Provision of irrigation facility, horticulture plantation and land development facilities on land owned by the households belonging to the Scheduled Caste and Scheduled Tribes or to BPL families or to beneficiaries of land reforms or to the beneficiaries under the Indira Awas Yojana of the Government of India; (v) Renovation of traditional water bodies including desiliting of tanks ; (vi) Land developments works;	

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					(vii) Flood control and protection works including drainage in water logged areas; (viii) Rural connectivity to provide all-weather access; and (ix) Any other work which may be notified by the Government of India in consultation with the State Government.	
38	State Compensatory Afforestation Fund Management and Planning Authority (State CAMPA)	The fund allows for afforestation, Soil & Water conservation strategies that are suitable for a mountain state like Himachal Pradesh. This may include (a) Conservation, protection, regeneration and management of existing natural forests; (b) Compensatory afforestation and Catchment area treatment activities; (c) Environmental services (d) Research, training and capacity building.	Forests	Dept. of Forests, Govt. of India		https://hpforest.nic.in/files/State%20Compensatory%20Afforstation%20Fund%20Management%20and%20Planning%20Authority.pdf
39	One District One Product (ODOP)	The scheme adopts the approach to reap the benefit of scale in terms of procurement of inputs, availing common services and marketing of products. ODOP for the scheme	Food processing	Ministry of Food processing industries, Govt. of India	There may be more than one cluster of ODOP products in one district. There may be a cluster of ODOP products consisting	https://mofpi.nic.in/pmfme/one-district-one-product

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		will provide the framework for value chain development and alignment of support infrastructure.			of more than one adjacent district in a State. The ODOP product could be a perishable Agri produce, cereal-based product, or a food product widely produced in a district and their allied sectors. Besides, certain other traditional and innovative products including waste to wealth products could be supported under the Scheme. For example, honey, minor forest products in tribal areas, traditional Indian herbal edible items like turmeric, amla, haldi, etc.	
40	Prime Minister's Employment Generation Programme (PMEGP)	The programme is concerned with generating employment opportunities in rural as well as urban areas of the country through setting up of new self-employment ventures/projects/micro enterprises.	Industry	Ministry of Micro, Small and Medium Enterprises (MoMSME), Govt. of India	The main focus of this programme is on traditional artisans and unemployed youth to arrest put migration from rural to urban areas. SHGs are also eligible to apply.	https://cdn.s3waas.gov.in/s368d30a9594728bc39aa24be94b319d21/uploads/2020/08/2020082731.pdf
41	Soil Health Management (SHM)	SHM aims at promoting location as well as crop specific sustainable soil health management and judicious application of fertilizers.	Agriculture/Horticulture	National Level Advisory Committee, Executive	Main objectives are i. Employment generation for rural youth.	https://soilhealth.dac.gov.in/Content/Guideline_Soil

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		Under the SHM, soil testing labs can be established at district / block level.		Committee and State Level Committee under the National Mission for Sustainable Agriculture (NMSA), District Level Executive Committee (DLEC)	ii. To improve timeliness in analysis of soil samples. iii. Introduction of the Single Window approach from collection to issue of SHC so as to minimize delays and maximize convenience to farmers iv. Online delivery of soil health cards to the farmers using Soil Health Card Portal. v. Provide soil testing facilities to farmers at their door step.	TestingLab_Project.pdf
42	Pradhan Mantri Kisan Samman Nidhi	The scheme aims to supplement the financial needs of all landholding farmers' families in procuring various inputs to ensure proper crop health and appropriate yields, commensurate with the anticipated farm income as well as for domestic needs.	Directorate Of Land Records, Govt. of H.P.		Beneficiary: A landholder farmer's family is defined as "a family comprising of husband, wife and minor children who own cultivable land as per land records of the concerned State/UT". The existing land-ownership system will be used for identification of beneficiaries for calculation of benefit. Benefits:	https://cdn.s3waas.gov.in/s3577bcc914f9e55d5e4e4f82f9f00e7d4/uploads/2020/05/2020050119.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					Under the Scheme an income support of Rs.6000/- per year is provided to all farmer families across the country in three equal instalments of Rs.2000/- each, every four months.	

Annexure 6

Contour Wattling/Fascines

Sites

This method is preferable for consolidated debris or soft-cut slopes of 1.5' horizontal to 1' vertical or less. The maximum slope is about 45°.

Materials

• Woody cuttings of suitable species (see above), at least ½ to 1 ½ inches in diameter and 4 to 8 ft long

• Hessian and water to keep the cuttings moist until planting;

• Tools to dig trenches;

• (Optional) Jute or coir string or wire to bind the fascine as it is laid.

Individual branches create wattle bunches[41] of 8 to 10 inches wide. These bundles are tied together with twine until the length of the contour is covered. Within the fascines, there should be at least four but no more than eight cuttings.

Spacing

Spacing between fascines depends on the steepness of the slope.

Less than 30°	4 m interval;
30 to 45°	2 m interval.

Construction steps

1 Site Preparation: Slope preparatory work before planting should be carried out such as clearing of material, levelling of protrusions, or filling of small gullies.

2 Marking planting sites: The sections where fascines are to be installed must be marked at regular distances along the contour within the contour line. This needs to be supervised to ensure that the lines follow the contour or desired angle precisely.

3 Fascine construction: This must always begin from the bottom of the slope and progress upwards

4 Trench Digging and filling: Trenches (100mm deep and 200mm wide) must be dug about five metres at a time while simultaneously laying the cuttings together, to ensure that the soil has minimal exposure time to air (minimising residual soil moisture loss). This must be

[41] Wattles are a cigar-shaped bundle of alternating live branches that root easily, with slender tips extending 40 cm beyond the larger butt ends

followed with filling the trench such that the ends of the fascines overlap, forming a single cable right across the slope. Four- eight cuttings per bundle can be used.

5 Wattling: The fascines can be tied every 30-40 cm during backfilling.

6 Backfill the trench: As soon as possible the wattles must be covered with soil, firmly compacting on the soil down around it leaving about 80% of the wattle buried below the soil surface.

7 Staking: On slopes of more than 25°, the wattles must be pegged by placing a large cutting at right angles into the slope immediately below the wattles. Use one peg per 500-mm run of fascines.

Maintenance

Since the spacing of plants resulting from fascines is very dense, there is unlikely to be a need for replacing failures, but some thinning of the shrubs may be required after a few years.

Although fascine laying is a good erosion control technique, there is a significant quantity of plant material required thus resulting in a labour crew of at least 3 to 4 people. On steep or long slope lengths, runoff can undercut wattlings and they can dry out if not properly installed, covered, or maintained.

Budget involved in fascine laying 1 km

Site preparation for fascine laying: earth works in excavation of trench to 20 cm depth 1060 m @ INR 7.11 =7,536.60

Laying of live fascines, using live hardwood cuttings of selected species of minimum 1 m length, placed in bundles to give 4 running meters of cuttings per metre of fascine, including backfilling of trench and careful compaction 1060 m @ INR 20.14= INR 21,348.40

A ten-man crew may be able to carry out contour wattling work on an area at a rate of up to 250 m^2 per day. Within the working crew, six labourers will stake, two labourers will dig trenches and cover wattles, and two labourers will carry out transportation and other duties.

Reference

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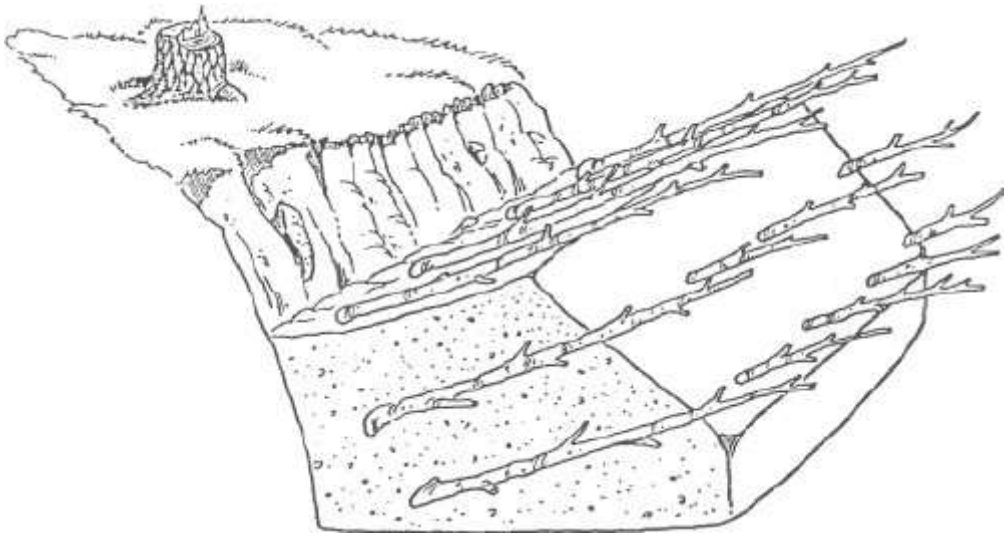
Annexure 7

Brush Layering



Cross section of a slope with Brush Layering Source: David F. Polster

Materials

· Live Cuttings from woody material (capable of adventitious root growth such as *Salix tetrasperma*) that is 6 to 18 months old with a diameter of 2 to 4 cm and length of at least 50 cm. The top of the wood branches should be cut at right angles to the stem and the bottom at 45° to make it clear as to which way it should be inserted. It is preferable to take the cuttings the same day that they are to be planted.

- Hessian and water to keep the cuttings moist until planting.
- Shovels and pick axes to make the trenches for planting.
- Line string.
- Tape measure (30 metres).
- For brush layering on gravel fill embankments, a supply of forest topsoil at the rate of 1 cu. m per 20 metres of layering.

Spacing

Spacing between brush layers depends on the steepness of the slope.

Slope less than 30° 2 m interval;
Slope 30 to 45° 1 m interval.

Within the brush layers, cuttings should be at 50 mm centres, in the double layer described above. A wider gap than this is acceptable on gentle slopes, but on steep slopes this spacing is required to give adequate protection.

Construction steps

1 Marking terrace locations: Starting 500 mm from the base of the slope, the locations of the terraces should be marked. As with Fascines, brush layers must be constructed from the bottom of the slope, working upwards.

2 Digging terraces: A small terrace, with a 20 percent fall back into the slope, should be made. Terrace widths of 0.5 to 1.5 m, with a spacing distance depending on the slope angle and varying from 1 to 2 m should be dug.

3 Layering the brush layers: The first layer of cuttings should be along the terrace, with a 50 mm interval between the cuttings. At least one bud and up to one-third of the cuttings should stick out beyond the terrace edge and the rest inside at an angle of at least 10°. The branch growing tips should point towards the outside of the terrace. A 20 mm-thick layer of soil must be filled in between the cuttings to provide a loose cushion after which a second layer of cuttings be added on top of this, staggered with the first layer.

4 Backfilling: The terrace must then be partially backfilled upto 50 mm with the excavated materials.

Once complete, the next trench must be marked 1 metre above the first brush layer and steps 1-4 repeated. As the next terrace is cut, the lower bench must always be filled with the material excavated from above and compacted well by gentle foot pressure. Interplanting with grasses and herbs can be done for additional stability.

Good site supervision is essential to ensure that lines run along the contours and do not concentrate runoff; also to make sure that cuttings are not allowed to dry in the sun. Well-buried cuttings have a higher survival rate.

Maintenance

Since the spacing of plants recommended here is very dense, there is unlikely to be a need for replacing failures, but some thinning of the trees or shrubs may be required after a few years.

Brush layering is not good for dense soil structures and should only be used on gully erosion in specific situations. This technique is labour intensive and is intolerant to development of water channels

Budget involved in Brush layering 1 km area
Collection of hardwood cuttings for planting materials from sources within 1 km of road. Material to be approximately 1 m in length and minimum 5 cm in diameter- 520 nos x INR 112.41= INR 58,453.24
Preparation and planting of live pegs of selected species of minimum 1 m length to 0.5 depth into hard ground. Pegs spaced at 5 cm centres within rows, with 5 - 20 cm between rows, and interwoven with vegetation 4420m x INR 20.14= 89,018.80

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PART C: RESTORATION PLAN FOR KUNDAL SUB-RIVER BASIN

Restoration Plan for Kundal Sub- River Basin

The Kundal sub river basin is located between 76^0 24'52'' to 76^0 32' 18'' East longitude and 32^0 39'3'' to 32^0 45'44'' North latitude, between an elevation of 2398 m to 5947 m asl. The total area of the sub river basin is 86.56 km^2. An elevation-wise analysis of the land use of Kundal sub-river basin shows that the grasslands primarily fall in the medium elevation (1835. 85ha), followed by low elevation (1056.17 ha). Only a very small area of grasslands falls in high elevation e (0.02 ha) (refer Part A of this report).

As has been detailed in the sixth report, around 47.71% of grasslands in Kundal sub-river basin face varying intensities of degradation due to change in species composition, legume deficiency, anthropogenic pressures, landslides, livestock issues, conflicts with gaddis and livelihood issues.

The sixth report also highlights that the factors causing degradation differ with altitude. The restoration plan for Kundal sub-river basin is also thus formulated altitude wise. As the present study has found no significant degradation in the high-altitude areas of this sub river basin, the restoration plan does not propose specific interventions for the same. Majority of the degradation has taken place at the low elevation areas, followed by the middle elevation areas and therefore the plan accounts for these areas.

1 Mid Altitude Grasslands (3500 – 4700 m asl)

The mid altitude region of Kundal occupies the largest area within the entire SRB, covering more than 60% (approx. 5067 ha) of the total sub-river basin. A majority of the region is covered with alpine grasslands (36.2%) followed by snow cover (36.1%) and barren land (26.9%) (refer sixth report). Most of the water the grasslands receive is through the snow melt in the summer. Plants like *Juniperus macropoda*, *Fraxinus xanthoxyloides*, *Rosa webbina*, *R. sericea*, *Ribes grossularia* are known to be predominant in the region (Champion & Seth, 1968).

Interventions

1.1 Grassland Restoration

26% of the grasslands in the mid-altitude of Kundal SRB are degraded (as detailed in Part A of this report). This has been attributed to change in species composition due to a decline in the palatable grass species, as well as legumes (refer Part A). In order to address this, the following restoration activities are proposed

A) Restoration- Plantation of grasses and legumes to restore the species composition

The steps required to restore grasses and legumes within grasslands are the following

f. Species selection
g. Selection and preparation of planting sites
h. Planting
    i. Seed balls

ii. Culms

i. Establishment and Aftercare

j. Long-term management

1.1.1 Species selection

Native grass species are the most naturally adapted to the regional climatic and topographic conditions of the area. Collection of culms or seeds from natural local sources needs to be carried out in order to ensure that local grasses are used.

Based on quadrat analysis, stakeholder consultations and expert committee consultations, the following species (Table 2) are recommended for plantation in the mid-altitude elevation gradient of Kundal SRB.

Table 7: List of grass species selected for plantation in the mid-elevational zone of Kundal SRB

S.No	Species	Preferred by	Details
1	*Lolium giganteum*	Livestock (Mishra et al, 2004)	Annexure 1
2	*Tenaxia cachemyriana*	Livestock & Wild Ungulates (Syed & Ilyas, 2016)	Annexure 1
3	*Poa annua*	Livestock & Wild Ungulates (Ashraf et al, 2017)	Annexure 1
4	*Elymus longe-aristatus*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
5	*Themeda anaethera*	Livestock & Wild Ungulates (Mishra et al, 2004)	Annexure 1
6	*Elymus dahuricus*	Livestock (Zhou et al, 2009)	Annexure 1
7	*Poa alpina*	Livestock & Wild Ungulates (Rawat, 1998; Han et al, 2019)	Annexure 1
8	*Phleum alpinum*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
9	*Festuca ovina*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
10	*Koeleria pyramidata*	Livestock & Wild Ungulates (Wingard, 2005)	Annexure 1

In landslide-prone mid-altitude grasslands, the species focus should preferably be on native, tussock forming grasses like *Poa alpina*, *Koeleria pyramidata*, *Cenchrus orientalis* etc. Tussock grasses have good soil holding capacities, thus support in protecting against landslides.

Legume species selection

Legumes are important components of grasslands. They provide high quality forage due to their high fibre and protein content (Mortenson et al. 2004) and thereby have an important fodder value. They also promote symbiotic nitrogen fixation thereby contributing to grass regeneration (Suter et al. 2015). Based on primary data collection (through quadrat studies, stakeholder meetings and expert consultations) and secondary literature review, the legume species that have been identified are summarised in Table 2.

Table 8: List of legume species selected for plantation in the mid-elevational zone of Kundal SRB

S. No	Species	Preferred by	Details
7.	*Desmodium elegans*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1
8.	*Astragalus himalayanus*	Livestock & Wild Ungulates (Harris & Miller, 1995; Ashraf et al, 2014)	Annexure 1
9.	*Astragalus himachalensis*	Livestock (Ashraf et al, 2014)	Annexure 1
10.	*Astragalus oxyodon*	Livestock (Jishtu & Goraya, 2020)	Annexure 1
11.	*Hedysarum astragaloides*	Livestock (Lal et al, 2014)	Annexure 1
12.	*Astragalus candolleanus*	Livestock & Wild Ungulates (Harris & Miller, 1995; Ashraf et al, 2014)	Annexure 1

Seed sourcing collection and storage

It is recommended that seeds be collected within the 30-mile radius of the proposed restoration site to preserve and utilize the ecotype. Collected seeds must be cleaned and stored up to the time of seeding in the restoration plots. Careful storage is essential in order to avoid damage by insects or predation by other animals. Seeds must be kept dry to reduce moisture related fungal infections. Grass planting material may also be sourced from seed banks or grassland research institutions like ICAR-Indian Grassland and Fodder Research Institute (IGFRI) situated in Jhansi, Uttar Pradesh. The institute has a grass seed bank. Himachal Pradesh Forest Department also maintains nurseries. The above listed grass species need to be cultivated there as well. In addition, nurseries for the same need to be developed. The nurseries should maintain stocks of all needed plants (grasses and legumes) in ample quantities. Collection of seeds and stocks from the wild for raising in the nurseries is also needed to be practiced. The nurseries can be jointly managed by the Himachal Pradesh Forest Department and Mahila Mandals. Trainings for the same can be provided by experts from IGFRI. Agencies like Navdanya a Dehradun based NGO, that has been working for over 30 years on storing wild agricultural/crop/fodder seeds can be approached with regard to seed sourcing, as well as for community trainings on development and maintenance of community seed banks.

As a rule of thumb, four to nine kilogram of seed mix is generally used per acre for restoration. Of this amount, one to three kilogram per acre should comprise fast growing species (legumes) while two and a half to four and a half kilograms per acre should comprise slow growing species (perennial grasses). Large seeds should be higher in proportion than the small seeded plants.

Whether it is a culms or seed, the chosen plants can also be collected from local areas that are undisturbed and cultivated in adequate numbers in local nurseries beforehand, prior to initiating the plantation at the restoration sites.

1.1.2 Selection and preparation of planting sites

Grassland restoration sites in the mountains generally depend on physical, climatic and biological factors of the area. Mountain slopes and elevations play a crucial role in the distribution of grass species and compositions. Higher altitude areas usually have small summers and long snow cover. Climatic and seasonal factors such as winter rain and summer length are important for the grass seed germination. Apart from these factors there always remains some factors like flash floods and landslides that impacts the landscape thus affecting the grassland distribution in the upper mountains. Human factors such as grazing livestock and fodder collection should also be taken in to account in determining the most suitable areas for restoration.

Selection of the sites

Using a multi-criteria evaluation method (MCE)[42], specifically Weighted Overlay Linear Combination[43], planting sites were identified within the Kundal sub-river basin (Figure 1). Details of the process can be found in Annexure 2. Parameters that considered included river flow and stream orders as a water source is crucial for plant growth and landscape restoration. The river flow and direction also indicate the probability of unforeseen disasters such as, flash floods or landslides. The other parameters considered were slope which indicates the monsoon waterflow or summer snow melts and provides insight into the soil moisture and stability of the area, and influence of human habitations since this is important to safeguard the planted site. The final parameter considered was landslide vulnerability. The various parameters considered have been summarised in Table 3.

[42] MCE is a supportive decision-making procedure that uses a set of parameters or set of events and results in a single composite output (Malczewski, 1999). Each of the required parameters are assigned weighted values. These values are assigned based on the expert opinions, field scenarios, geological structure, climate, topology, land cover and land use etc. MCE is considered through multiple qualitative techniques viz. Analytical Hierarchy Process (AHP), Bivariate Statistical Analysis (BSA), Multivariate Statistical Approach (MSA) and Weighted Overlay Linear Combination (WLC) (Saaty, 1990; Ayalew et al, 2004; Basharat et al, 2016).

[43] The Weighted Overlay Linear Combination is one of the most reliable techniques of MCE for determining the required results in landscape ecology studies and for site selection (Saaty, 1990; Basharat et al, 2016).

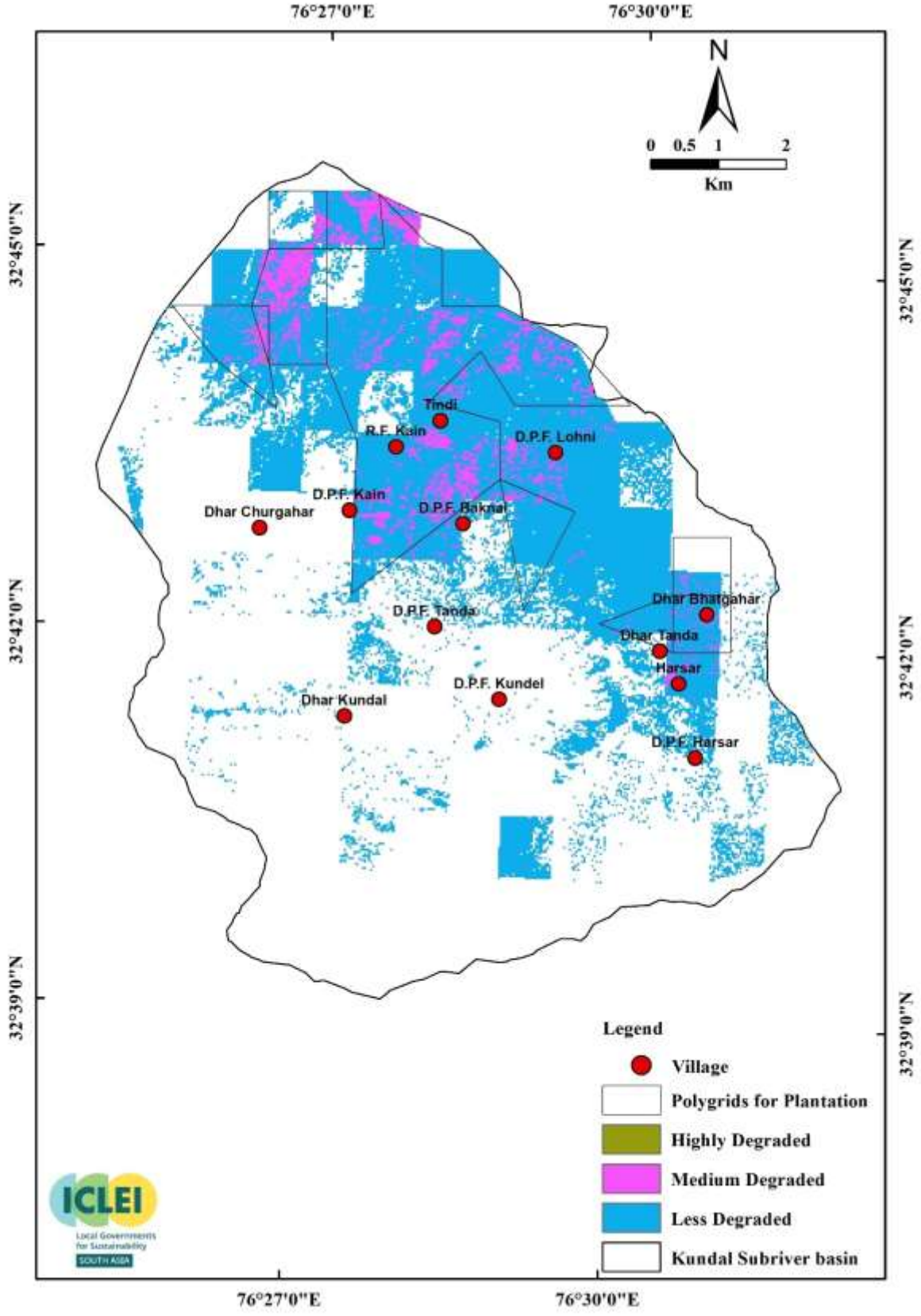

Figure 7: Map of Kundal SRB with suitable polygrids for plantation.

Table 9: Details of the parameters used in the Spatially Weighted Overlay Model for the development of most suitable plantation areas within the Kundal SRB in the present study (2018-2021).

Parameters	**Source**	**Criteria Values (for details refer Appendix 2)**
Slope	Developed using Digital Elevation Model	<45 Degree
Stream Order and Flow direction	Developed using Digital Elevation Model	Euclidean distance from the rivers. Suitable <7 Km.
Landslide Zones	Developed in the present study	Vulnerability>50%
Human Habitation	Field Data	< 2 km
Grassland Degradation	Developed in the present study	Mid & Highly Degraded Areas

The weighted model estimated around 3097 ha area in the entire mid elevation Kundal SRB as the suitable plantation sites for the grassland restoration in the present study out of the total area of 8656 ha of the sub river basin. A total of 17 polygrids (polygonal grids) ranging between an area of 46 ha to 1075 ha with an average size of 238 ha were found to be suitable. Gridding helps to identify more robust, easier to maintain restoration sites, which can also be easily monitored and safeguarded by the respective authorities.

Within the identified grids for restoration, sites need to be demarcated for undertaking restoration and plantation. The grid needs to be sub-divided into smaller sites as the entire grid cannot be closed for grazing (Figure 2). Smaller sites, within the grid can however be closed for grazing for 1-3 years in order to ensure the growth of the planted grass and legume species. This will not hinder the grazing of livestock by Gaddis as well. The same was also discussed with the forest officials at the landscape and was acceptable to them as well. Some of the proposed sites in Kundal SRB are depicted in Figure 2. These marked sites within the grids should be protected from grazing for at least three years to allow grasses and legumes to establish. Chain link fencing will need to be carried out at the restoration site to prevent trespassing of wild ungulates and livestock in the region. Restoration grids should be monitored very closely.

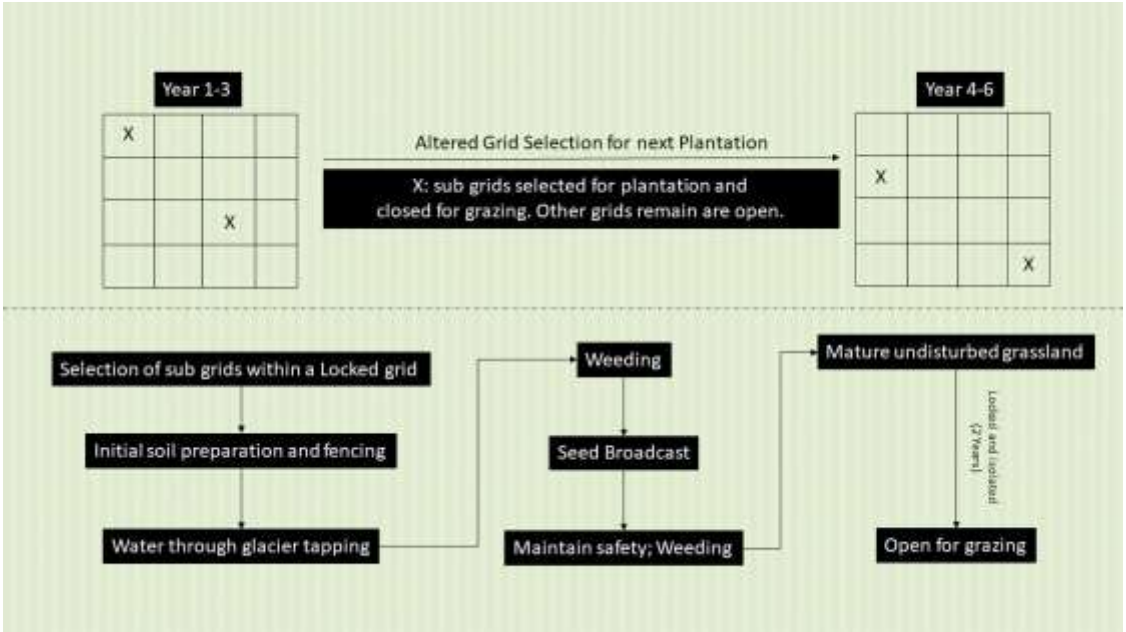

Figure 8: Representative image of the grid lock system in Kundal SRB. Marked grids are depicted as closed within which restoration sites will be fenced and guarded from trespassing of wild ungulates and livestock grazing by Gaddis. Rest of the grasslands will be open for grazing for the tentative year. Each restoration grid should be closed strictly from grazing for up to 4 years, after which they will be opened and new grids will be closed for restoration.

Preparation of the sites

Soil analyses of selected sites in Kundal SRB revealed low levels of Organic carbon, Nitrogen, Phosphate, and Potassium when compared with the control site. Organic carbon is almost half of that recorded from the control sites (refer Part A of this report). To facilitate survival of the planted grasses, the following steps are recommended within selected sites:

Keep plantation sites undisturbed: Most of the selected plantation sites must be kept as undisturbed as possible,and free from anthropogenic activities. Rocky mountain areas have lower soil fertility, lower decomposition rate and fewer nutrients. Therefore, dead organic matter such as dead plants, leaves or excreta of wild animals which are a major source of required minerals, must be retained for at least a year before the commencement of the plantation.

Soil adjustments: Soil from nearby healthy areas can also be brought back to Kundal and spread over the selected plantation areas to improve the soil conditions before plantation. Such activities can ensure higher levels of success of the restoration programme.

Invasive Plant/Weed Control: Weed control is a key aspect for the success of any restoration programme. The present study has recorded widespread distribution of weeds *Artemesia annua and Cynoglossum zeyanicum.* These species will outcompete the planted grass and legumes. It is thus highly recommended that weeding is performed at the plantation sites before seeding or culm/plug plantations. Weed removal in early summer is recommended and constant monitoring and weed removal again after plantation should be followed at regular intervals. There must be community involvement through Yuva Mandal and Mahila Mandal.

Trained para- taxonomists (under the Green Skill Development Programme of Ministry of Environment, Forests and Climate Change, Government of India) can provide guidance on what plants need to be weeded from plantation sites.

Figure 9: Image depicts the spread of Artemisia annua, a weed species in Kundal SRB.

1.1.3 Planting

Selected plant species need to be collected in the form of clumps or seeds for plantation. While clumps are readily usable, can establish and grow faster, seed plantation requires time to establish. Transplantation must be done in a circular and clumpy manner. This technique reduces the chances of weed invasion due to a lower edge to area ratio.

Timing of undertaking the plantation is critical. The Kundal SRB harbors short summers and the sub river basin stays snow covered even in the lower elevation zones, for a significant portion of the year. Plant species chosen need to be able to establish themselves fast in the early summer. Initial summer snow melt can help establish the seeds/plugs efficiently.

In areas where watering is not possible, seeding just before winter can be considered as the snow cover will help the seed to over winter and the snow melt in early summer will help the see to germinate.

In the case of the mid-altitude region of the Kundal SRB, human accessibility and mobility is low and therefore, seed broadcast and seed balls are recommended within the selected poly grids for planting.

i. *Seed broadcasting*

For seed broadcasting, the seed bed must be prepared with care as it is one of the crucial success factors. Broadcasting using the seed-mix procedure is considered the most successful technique. Seed mixed with moist saw dust or moss keeps the seed protected and hydrated for a good amount of time. Soil in the seed bed must be tilled or raked before planting the seeds. Manual broadcast of seeds is the most cost effective and successful of methods which is recommended to follow in such a mountainous terrain. Mechanical methods of broadcasting might not be suitable due to adverse environmental, topographical and weather conditions in the region.

Once the seeds are planted, the seed bed should be lightly tilled to improve the seed to soil contact, which helps to improve the germination rate. One of the basic principles of the broadcasting is the usage of centrifugal force to establish the seed into the ground. The weight of the seed mix is very important and must be considered during the broadcasting. Seeds of grass species are light in weight and thus require a carrier object to help settle the seeds in the seed bed properly. Rice hulls, pelletized lime, etc. can be used as the grass seed carriers. Watering is important after seeding. Weed control should be performed in the first year as they can out compete the seedlings and deprive them of nutrients, water, light or space.

It should be noted that seed broadcasting is recommended in areas which show significant degradation and have low diversity of grasses. In cases with an appropriate or healthy density of existing vegetation, minimal seedbed preparation is recommended. This avoids disturbing the established natives or bringing additional weed seeds and rhizomes to the soil surface.

ii. *Seed Balls*

Seed balls are a low-cost, direct seeding process where varieties of seeds are mixed together (grasses and legumes) with soil and water, and made into small round balls of half inch. These are stored and dried for optimum plantation time. During plantation these balls can be randomly distributed at the restoration sites. Distribution before winter is advisable in the present study areas as these seed balls will be covered in snow during the winter. In summer the snow will melt and being made of clay, the balls will retain water sufficient enough to germinate and establish the seeds. Another benefit of using seed balls is that the seeds residing inside the soil are safe from any type of predation or insect attacks during the initial establishment period.

The preparation of seed balls includes native grass and legume seeds being mixed together in local soil (with reasonable clay content), which also helps to promote

establishment of AMF present in the soil, with the roots of the plants, some husk or coco peat as binding material, manure, and water. AMF can also be purchased and added additionally to the seed ball.

One portion of the soil must be mixed with half portion of manure/compost and some husk/coco peat. To this, one or two parts of water needs to be added. This should be mixed to form a cohesive dough like ball. The soil and manure should be sieved to minimize and remove rocks and other plant parts that may be present. Also, the soil should be dried and powdered beforehand as large chunks will reduce the seed carrying capacity in the seed balls. The clay content also should be monitored as if it is too high, the ball will not split open. In the center of the ball, 5-7 grass seeds should be place and then rolled/compacted such that it binds the seeds and mixture. The seed balls should then be dried in the shade for at least 48 hours. The seed balls should have a dimeter of 2-3 cm. This technique has been successfully used by the Jammu and Kashmir Forest Department in high altitude degraded grasslands.

Students, para-taxonomists trained under the MoEFCC Green Skill Development programme, youth from Yuva Mandals and women from Mahila Mandals can be involved in the preparation of the seed balls. The dispersal of the seed balls requires lesser manpower and costs, in relation to other methods such as seed broadcast or culm transplantations. Generally, seed balls need to be placed in a shallow hole/cavity or in the case of steep slopes, be broadcasted aerially. The number of seed balls to be used will depend on the nature of the site, its condition and the topography. General estimates vary between 2000-4000 balls per hectare. Seed balls of grasses and legumes (species lists have been provided in the relevant sections) can be used in pasturelands within the higher altitudes. The per hectare costs range between INR 7,500 to INR 25,000.

iii. *Culm Planting*

It is a type of propagation where grass rhizomes with buds are used for plantation in degraded areas for early establishment. Generally, a mix of grass species or single species as a clump with an age of more than 3 months are used in this process. The stems are cut at the height of 100-150mm above the ground and the whole clump is then uprooted carefully without harming the root system. This method is most successful for tussock forming grasses. The culms, once removed from the soil, ideally need to be brought back to the nurseries and grown in the soil with some mulching and if needed with indole acetic acid (IAA). Once, these culms develop more rooting systems, they can be transplanted to the degraded sites. At the plantation sites, these culms are planted at a minimum depth of 20 cm. AMF is added with mulching, to provide enough nutrition and water for their establishment. Once planted in the degraded areas, these culms grow shoots rapidly, revegetating the degraded areas.

AMF: AMF are widely distributed across various ecosystems where they establish a symbiotic association with the roots of the host plant species to simulate the nutrient and water acquisition of the host plants. AMF are important in the early-stage establishment of grass plantations in poor soil conditions as it significantly decreases the plant mortality and increases fitness in unsuitable environments (Pfleger et al. 1994, Vosatka et al. 1999). The association also strengthens soil stability and controls erosion through their extended fungal shared

extraradical mycelium network in the region (Tisdall, 1994). Generally, AMF is available in the market and can be easily bought (Table 4). Commercial availability of AMF as seed coatings, encapsulation and suspended carriers is generally done for larger row cropping systems.

Table 4: List of suppliers for commercial AMF inoculants in India. (Source: Bharti et al, 2017)

Sl No	Name of the Company	Address
1	KCP Sugar and Industries Corporation Ltd	Andhra Pradesh, India
2	Cadila Pharmaceuticals Ltd	Gujarat, India
3	Symbiotic Sciences Pvt Ltd	Haryana, India

1.1.4 Establishment and after care

Protection of Restoration project sites: The area under restoration needs to be protected from grazing and any other anthropogenic disturbance. The practice of rotational grazing should be followed for the same (with a cycle of four years). In order to mark out area for rotational grazing, it will not be possible to cordon off the entire pastureland. However, the total area where livestock grazing by Gaddis and local community members takes place needs to be re-divided into smaller blocks wherein the more degraded blocks (based on the degradation map developed for the pasturelands in Kundal sub-river basin by ICLEI South Asia and submitted in the 6th report) need to be cordoned off for four years. Once these blocks rejuvenate in four years, they can be opened up for grazing and the next set of blocks (with the next level of degradation) be cordoned off. Discussions with the officials of the Forest Department posted on-site, local community and the Gaddis have shown that the above suggested mechanism is possible and will see cooperation from all stakeholders. A detailed participatory action plan will need to be developed, which has to be facilitated by the Forest Department. Active involvement of the Gaddis, Village Panchayats and Mahila Mandals will be required while formulating the actions, identifying the land parcels and carrying out regular monitoring and surveillance in the cordoned off areas. Each site that is cordoned off must be marked with sign boards. Chain linked fencing will need to be established around the entire site.

1.2 Landslide Mitigation

The present study identified approximately 279 hectares of highly vulnerable landslide prone areas within the Kundal sub-river basin. These highly vulnerable regions are present mostly at the mid-elevational grassland areas (Figure 4). Steep slopes coupled with heavy rainfall trigger landslides in the region. This is further exacerbated by anthropogenic activities such as house, road and bridge construction which require cutting hill slopes and vegetation removal.

It is a well-known fact that the root systems of plants bind the soil, protecting against erosion and landslides. In order to address landslides in the area, tussock grasses, such as *Chrysopogon sp. Danthonia cachemyriana*, *Heteropogon contortus*, *Festuca gigantea,* can be planted in the landslide vulnerable areas. Sea buckthorn (*Hippophae rhamnoides*) can also be planted to stabilise the denuded slopes. In addition, bio-engineering techniques as detailed

below, can also be practiced. These methods have been applied in the Ladakh landscape with great success (Tundup et al, 2017).

1.2.1 Bioengineering methods as mitigation against landslides

v. *Wattling and staking method:* Contour wattling, also called "wattling and staking", is a bioengineering approach that uses live vegetation to control erosion of soil. Branches of local woody Himalayan species such as Salix (*Salix tetrasperma, Salix disperma)*, *Baccharis pilularis, Tamarix gallica* etc. can be used for this method. This method can be used where grass cover is not strong enough to stabilize slopes. In this technique, bundles of live branches or fascines are laid in shallow trenches. These sprout shoots and roots, forming a strong line of vegetation. It is sometimes called live contour wattling. They reduce water velocity, trap sediment, and hold soil in place. Each wattle bunch is tied perpendicular to the main bunch. They are then placed in shallow trenches at regular spatial intervals from each other along the slopes. These are then covered with soil so that about 10% of the fascine is exposed, and pegged to the slope using wooden stakes driven vertically into the ground. Grasses (tussock) and shrubs can be planted between the wattles. Both live stakes and wattles will sprout and grow, forming a living stabilization system. Refer Annexure 6 for more details.

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vi. *Brush layering:* Brush layering involves planting live woody material (live cut branches and rooted plants) into the slope face along trenches/terraces excavated in slope contours. It differs from fascine laying in that it provides a deeper soil stabilization. Brush layers, being linear structures, are supplemented with plantation or seeding. It is ideal for steep slopes that are highly disturbed or eroded cut and fill situations and provides protection within the first vegetative year. The part of the brush layers that exits the face of the slope, helps to capture debris, rainwater runoff moving down slope while the part that enters the slopes reinforces the soil.

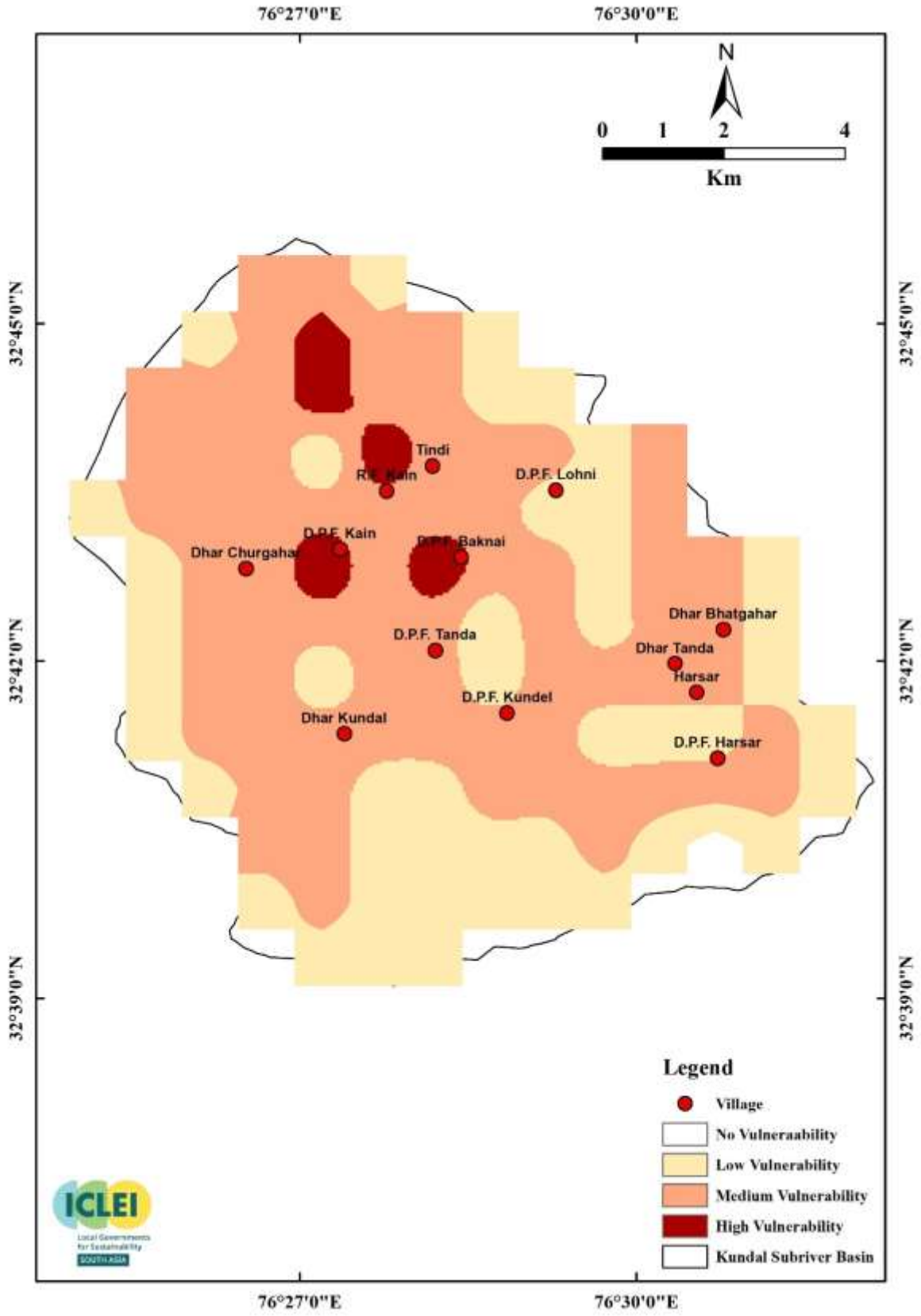


Figure 10: Landslide vulnerability map of Kundal Subriver Basin.

1.3 Improving soil moisture content:

The pasturelands have been seen to face degradation due to decline in winter rain (refer 6th report). In order to ensure availability of soil moisture for seed germination, minor checkdams are proposed. These will also help to rejuvenate rivers and streams in the sub river basin and address water scarcity in villages like Lohni (has been detailed in the section on low altitude) .

Check dams can be constructed by following the steps mentioned below:

- First step of preparing a check dam is laying the foundation. For this, ground is excavated and soil is kept on the bank at the downstream side of the check dam. Depth should be 0.5m, length should be width of the river + 0.5m in each side of the bank, and width should be 1.5m.
- Preparation of the gabion is the next step where a steel mesh is folded like a box cage and placed on the excavated site.
- Wooden logs with a diameter between 5 to 15 cm are bundled up and placed at the downstream and upstream side of the cage to form two rows.
- Space between the rows is then filled with rocks and stones. Larger rocks should be placed at the bottom and small rocks in between them. Add soil to fill the rest of the gaps. Once it is completely filled, close the cage top and stabilize the structure using iron wires.
- Next place big and heavy stones on top of the foundation and make a top view “U” shape at both sides to pass the water from between. To protect the bank, the height of the rock covers should be kept higher than the middle of the dam. Leave a small place of around 50-80 cm wide in the middle as a water passage.
- Next cover this rock structure with another steel mesh sheet and put rock and stones over it. Then lock the sheet to the bank using iron wire and hooks.

Usually for building check dams over small rivulets, the following materials, equipment and labour force are required.

- One gabion (steel mesh) with dimensions of (2m x 1m x 1m), rocks and stones of different sizes (can be taken from the preparation site itself), Iron wire and Iron hooks. For equipment, shovels, pliers, working gloves will be required. At least 6 workers and one supervisor will be needed for one check dam. The exact number of these materials, tools and labour force will depend on the width of the stream bed.

2 Low Altitude (2300 – 3500 msl)

The low altitude region of the Kundal SRB spreads over 30% (2635 ha) of the total area of the basin (refer Part A for more details). More than 40% of the total area in this region is dominated by the alpine pasturelands and around 38% of the region harbours Himalayan dry temperate forest. The same has already been detailed in Part A. The population concentration is in this altitudinal zone and the villages of this sub-river basin are all situated here. Due to low rainfall, the vegetation is xeric dominated by *Eurotia ceratoides*, *Junipers wallichiana*, *Artemisia maritime*, *Lonicera* sp. and *Potentilla* sp.

The major factors driving degradation in grasslands at this altitude of the sub-river basin are primarily anthropogenic. This includes changes in cropping practices and patterns which has reduction in the availability of fodder, thereby increasing the pressure on the grasslands. Removal of forest cover leading to water scarcity and Natural factors such as landslides are also responsible for degradation in this altitude.

Interventions

2.1 Grassland Restoration

Low-altitude grasslands face medium to low levels of degradation in this sub-river basin (refer details in Part A). Undertaking plantation in the degraded sites will support grassland restoration. The focus of the plantation needs to be on improving the availability of the palatable species as well as legumes. The details of the method to follow for the same have already been provided in section 1.1.1. Additionally, plantation sites can be prepared through tillage for improving soil aeration.

Table 10: List of grass species recommended for the degraded low elevation of Kundal SRB

S. No	Species	Preferred by	Details
1	*Cynodon dactylon*	Livestock & Wild Ungulates (Syed & Ilyas, 2016)	Annexure 1
2	*Thamnocalamus spathiflora*	Livestock & Wild Ungulates (Ashraf et al, 2017)	Annexure 1
3	*Heteropogon contortus*	Livestock (Dev et al, 2018)	Annexure 1
4	*Chrysopogon echinulatus*	Livestock & Wild Ungulates (Shi et al, 2016)	Annexure 1
5	*Bothriochloa pertusa*	Livestock (Kutt & Fisher, 2011)	Annexure 1
6	*Alopecurus aequalis*	Livestock & Wild Ungulates (Han et al, 2019)	Annexure 1
7	*Agropyron cristatum*	Livestock & Wild Ungulates (Bashir et al, 2020)	Annexure 1

Table 11: List of legume species recommended for plantation in degraded low elevations of Kundal SRB.

S. No	Species	Preferred by	Details
1.	*Desmodium elegans*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1
2.	*Indigofera heterantha*	Livestock (Singh, 1986)	Annexure 1
3	*Lotus corniculatis*	Livestock (Singh, 1986)	Annexure 1
4	*Trifolium repens*	Livestock (Rajasekaran et al, 2017)	Annexure 1
5	*Indigofera geradiana*	Livestock & Wild Ungulates (Namgail et al, 2010)	Annexure 1
6	*Caragana sukiensis*	Livestock & Wild Ungulates (Samant et al, 2007)	Annexure 1

i. Establishment of nurseries

Site selection for development of the nursery is one of the factors that defines the success of the nursery. The area should be easily accessible and preferably be established on community land. Establishment of community nurseries on private land should be avoided. Water supply to the nursery should be ensured. In addition, south facing slopes are better for nursery preparation as those slopes are warmer. The selected sites should not be in landslide prone zones.

Nursery beds must be prepared carefully and should be cleaned of any unwanted plants and weeds. Nursery beds (6 m*6 m*6 m) can be raised in April. These beds should be well tilled and about 30 kg of organic manure mixed as bed base preparation for each bed. Watering must be done for four to six days, following which weeds will grow and should be removed immediately from the root. Sundried grass seeds should be hydrated and then sowed. Sowing should be done in a line with a sand and seed mixture in a 5-6 mm depth. The distance from each line to another should be 10 cm. Post sowing, the seeds should be covered with a thin layer of soil immediately and the beds should be mulched with straw or any locally available material for a continuous period of four to six days to let the seeds germinate. Watering should be done twice a day (morning and evening). Usually, the germination will start from the third day after the sowing and will be completed by the seventh day. After the full germination, the mulch should be removed. Stored seeds will germinate better than the freshly collected seeds. In a seed bed size of 6m x 6m, it is advised to use 40 g -50 g of grass seeds per bed. One hectare of land can accommodate a minimum of 12 similar seed beds. Each grass seedlings can be transplanted to the plantation area from the seed beds once they achieve a height of 15 to 25 cm, which usually takes four to six weeks.

Irrigation of the bed soils is required daily and a minimum of twice a day. After germination, the watering should be done lightly and the bed soil should be allowed for a slight dry condition before the next watering.

When the grass seedlings have grown to couple of inches, watering should be reduced and set to once every two to three days.

Seedlings should be transplanted to the prepared plantation sites right after the beginning of monsoon. Nursery beds should be watered well at this stage before pulling out the

seedlings. Seedlings should be pulled out with caution as the root system can get damaged which will result in the death of those individuals after transplantation.

Plug tray method can also be used to develop the grass seedlings instead of directly raising them in the soil in the nursery beds.

AMF: Mulching is the simplest way to achieve natural and native AMF in the planting areas. In this process, each plant is mulched with hay or straw of local species of grass or other plants in plantation beds before planting. The degradation of the organic mulch will also add humus and will improve the water retaining capacity of the beds, which in turn will provide ideal site for AMF growth (Bharti et al, 2017).

The produced AMF should be stored in cold conditions. The lower temperature the better. Use of on-farm AMFs and their inclusion in nurseries for grasses can be conducted manually by hand.

2.2 Landslide Mitigation

As detailed in section 1.2, most of the landslide prone areas have been identified in the mid-altitudes. Areas in the lower elevation, which are prone to landslides can be stabilised with tussock forming grasses as well as sea buckthorn (*Hippophae rhamnoides; Hippophae salicifolia*),

Sea buckthorn can stabilise the slope and reduce erosion while also providing an alternate livelihood option to the locals.

Cultivation protocol for Sea buckthorn is provided in Annexure 3.

These provide both nutritional fruits as well as livestock feed as green and dry fodder. Harvesting of Sea buckthorn fruits and leaves is in general conducted manually by hand picking or branch shaking, stick beating etc. These procedures can lead to the harvest of 2-3kg of fruit per hour. Few harvesting tools have been developed such as wire clips, clippers etc. by the CSK Himachal Pradesh Agricultural University help in non-destructive harvest of the fruits and should be used. These tools can boost the harvest to up to 6kg/hour. After harvesting the fruits can be sent to the product manufacturers directly for further processing.

A. Installing early-warning systems

Though the low altitudes in the sub river basin are not highly vulnerable to landslides, installing early warning systems will help to reduce the loss in case of any such incident.

Early warning system that has been developed recently by a start-up called iIoTs, from Indian Institute of Technology (IIT) has been deployed on several roads like Mandi-Manali Highway, Mandi-Joginder Nagar Highway etc. in Himachal Pradesh. The equipment monitors climate and soil parameters and warns the nearby people through visual and audio warning systems. The same should be installed in the sub-river basin. Though this will not directly address grassland degradation, it will help to save lives in the region.

2.3 Improvement in Availability of Fodder

Primary data collection and stakeholder interactions have indicated that anthropogenic pressures in the grasslands of the Kundal sub river basin have increased due to an increase in dependence on the grasslands for grazing and fodder collection. This is primarily due to the fact that there has been a shift in cropping patterns from traditional crops (paddy, millets, etc) to cash crops such as peas, cauliflower, and cabbage. This has increased pressure on the grasslands for fodder since traditional crops were also a major source of fodder, in absence of which, the villagers have had to depend more on the grasslands. In addition, due to degradation of the low attitude grasslands, the local community has also been taking their livestock to the mid altitude grasslands, leading to resource conflicts with the livestock of Gaddis.

In order to reduce this pressure, apart from restoration of the low altitude grasslands (which has been detailed in the section on the same), the following strategies have been proposed to be implemented in the agriculture fields and areas in close vicinity to the villages.

F) Promotion of traditional crop cultivation
G) Cultivation of grasses on field bunds
H) Agrisilviculture
I) Post-harvest processing for value addition
J) Training and capacity building activities

2.3.1 Promotion of traditional crop cultivation

Agricultural lands are situated at lower elevations and are mostly adjacent to the villages, comprising of more than 3% (approximately 90 ha) of the total area.The last couple of decades have seen major shifts in the choice of crops for cultivation in the region. Traditional and local wheat, maize and paddy have been replaced with profitable cash crops.

Traditional crops in the past, provided for the stall-feeding requirement of livestock in the winters and also helped to arrest soil erosion, as their roots had greater soil binding capacity. Therefore, shifting the focus back on traditional crop cultivation has several benefits. Some of the traditional crops that can be promoted include Buckwheat (*Fagopyrum esculentum),* Millets, Black Pea (*Vigna unguiculata*), and Barley (*Hordeum vulgare*). The post-harvest residues have been traditionally used for stall feeding and promoting cultivation of these crops will help reduce the pressure of stall feed collection from the grasslands. In order to promote the cultivation of traditional crops, value addition through post- harvest processing needs to be encouraged. This will help the community derive higher economic benefits from these traditional crops. Details of such measures for Buckwheat have been summarised in the sections on post-harvest processing and marketing strategies below.

2.3.2 Cultivation of grasses on field bunds

Another strategy that will reduce grazing pressure on the grasslands is the cultivation of grasses along field bunds. Planting grasses along the field bunds will not reduce the land available for cultivation of food crops, but will help to produce fodder that will support the stall-feeding requirements.

Some of the grass species that have been identified for cultivation on bunds are *Festuca gigantea, Pennisetum orientale, Panicum antidotale, Desmodium intortum, Arthraxon lancifolius, Poa annua, Heteropogon contortus, Chrysopogon gryllus, Cynodon dactylon* and *Chrysopogon echinulatus.*

2.3.3 Agrisilviculture

Trees grown in and around the villages through agrisilvicultural practices will help to address the fodder needs of the livestock and thus decrease the reliance on grasslands for stall feed collection.

Some multi-purpose trees (MPTs) that have been documented in Himachal Pradesh for agrisilviculture include *Celtis australis, Grewia optiva, Bauhinia variegata, Leucaena leucocephala, Morus alba, Ulmus laevigata, Albizia chinensis, Alnus nepalensis and Toona hexandra.*

Some of the species that have been identified for agrisilviculture in the Kundal sub river basin are *Salix fragilis, Salix alba, Juglans regia, Populus nigra, Populus armeniaca, Populus cornuta and Populus. communis*. Cultivation protocols for these have been provided in Annexure 4.

2.3.4 Post-Harvest Processing for Value Addition

Post-harvest processing of traditional crops can help to increase the economic returns to the farmers.

One of the salient examples of this is Buckwheat (*Fagopyrum esculentum*). This traditional crop can be used to produce biscuits. An initiative of this kind has been successful in Manali (where the entrepreneur had a buy-back agreement with the local farmers who made the biscuits). Such small-scale units for biscuit production cost within INR 50,000 and can be established at the panchayat level. Mahila Mandal members can be given training and can run the unit. The Forest Department, along with the district administration can help establish a market linkage for the product. With the opening of Atal Tunnel, tourist inflow into the sun-river basin will be on the rise. Sales of such local products will be boosted by this tourist inflow. Such local products should also be mandatory to be served in all the home stays (which are increasing steadily with the increase in opportunities for eco-tourism and adventure tourism).

There are several government schemes (in Himachal Pradesh) that provide support to community groups for establishment of such facilities, the details of which are provided in Annexure 5.

2.3.5 Market support

Development of steady market linkage is the key factor that will determine the success of all post-harvest value addition and enterprise-based conservation initiatives. Some NGOs are working to support the local community to sell the local products through online and offline modes (refer Table 7). There is an urgent need for the Forest Department and the district administration to support such activities and support the activities of such NGOs.

Table 12: Manufacturing companies in India that sell traditional produce

S. No	Company Name	Products	Address
1	CEVA	Black Cumin, Apricot, Black gram Lentils, Hazelnut, Walnut, Buckwheat, Rajma	Chamba, Himachal Pradesh
2	Tapasu	Morel Mushroom, Barley, Black Pea, Jatto	Kullu, Himachal Pradesh
3	Kinnaur Heights	Black Cumin, Guchchi, Chilgoza, Rajma, Morel Mushroom	Jangpura, New Delhi

Another approach to promote and sustain the cultivation of traditional crops is providing subsidy to farmers for the same. The Department of Agriculture can also look at providing micro-credits to the farmers for cultivating these crops.

6.1 Spring-shed Development

The present study has recorded water scarcity as one of most pressing concerns in Lohni village in Kundal SRB. The only source of drinking water at present is the IPH connection from Lohni Nala and the irrigation water comes from Brakhdi Nala. t. Both these streams have limited water flow and nearly dry up in winters and are rejuvenated with glacier melt in the next summer. dry up from November until spring melt replenish them in summer again (Figure 5).

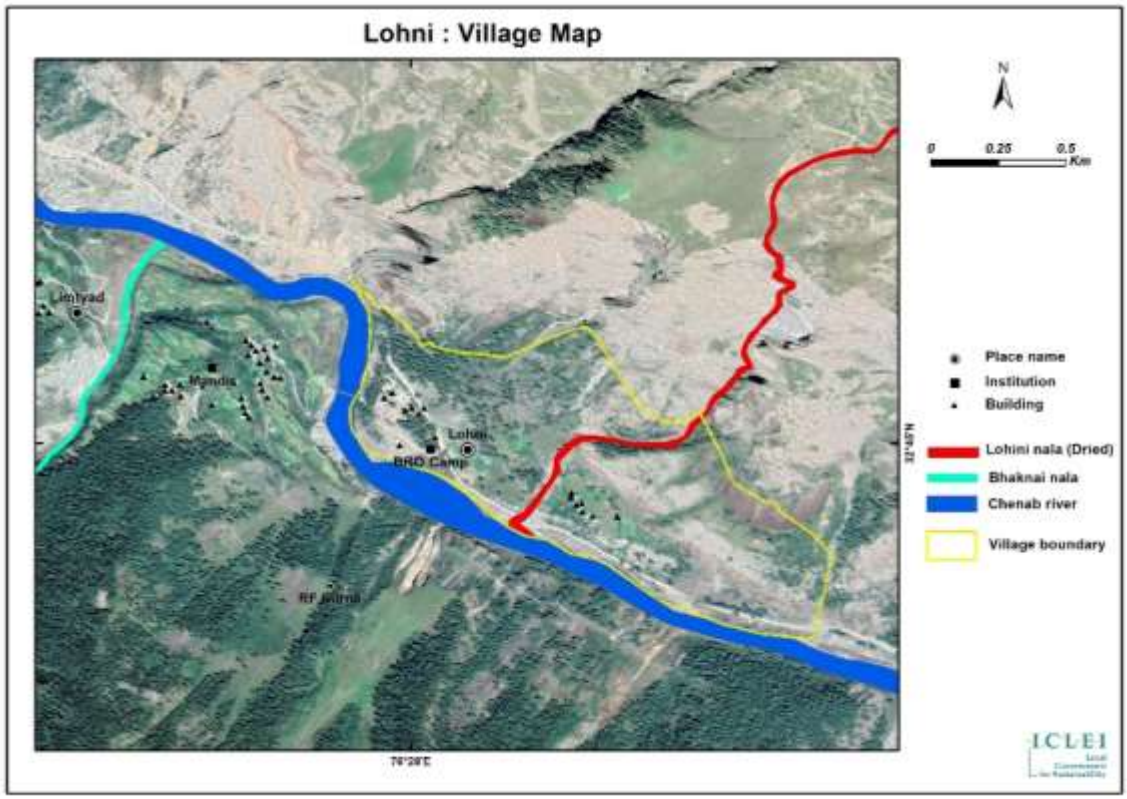


Figure 11: Image depicting the Nalas on which Lohni village relies for drinking and irrigation water

Satellite images of the area clearly show the reduction in tree cover in the catchment area of the streams closer to the village. This has led to the stream drying up (this used to be the main water source for the village several decades back).

In addition the snow cover in the region has also decreased, thus aggravating the water crisis in the village (refer Figure 6).

It is thus essential to rejuvenate the streams and restore the catchment areas of the same. This will also help to improve the health of the grasslands.

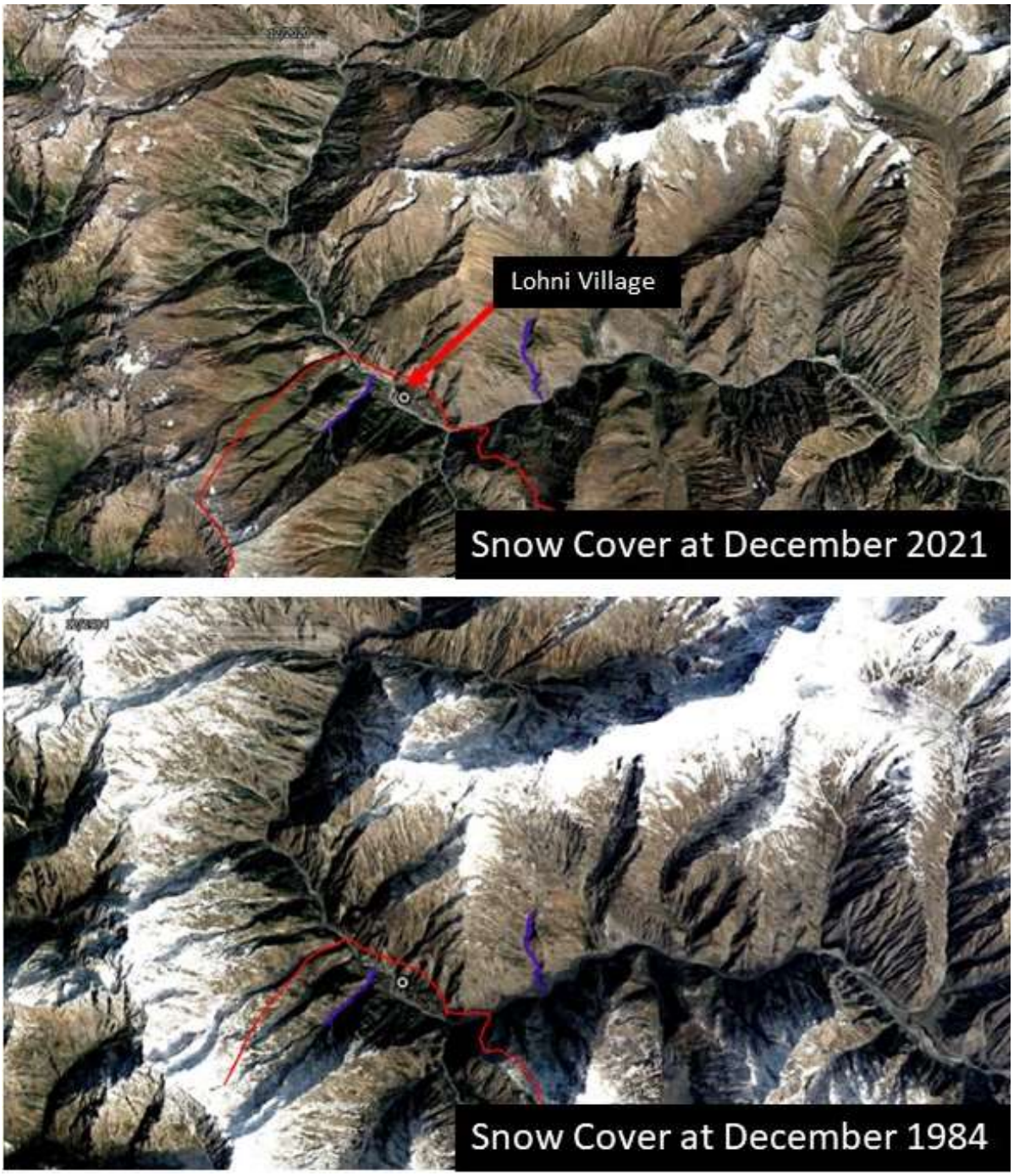


Figure 12: Image showing the decrease in snow cover area around the Lohni village from December 1984 to December 2020.

Dhara Vikas initiative- Sikkim State, 2008

This initiative to revive springs, streams and lakes was undertaken in drought-prone areas of Sikkim. This was done through spring-shed development under the MGNREGS with convergence of various government line departments and non-government organizations (NGOs). The initiative combined capacity building, scientific recharge and conservation of springs and community participation which resulted in recharge of 1035 million litres of groundwater annually covering 637 ha and revival of 60 springs and 4 lakes in 20 drought-prone Gram Panchayats. The main approaches followed by the programme were

1. Trained para-geohydrologists were developed to bridge the knowledge gap on geo-hydrology and revival of springs at the village level

2. A landscape-level approach was adopted by reviving springs, streams and lakes

3. A community-driven initiative was built that created grassroots demand by successfully carrying out pilot projects on spring-shed development

4. Linked with the MGNREGS national scheme for sustainable funding support

Within the first year of the programme in Sikkim, several capacity building programmes were organised with various NGO stakeholders to develop a cadre of para-hydrogeologists with specialised knowledge and skills in areas such as rainwater harvesting, geohydrology, and spring discharge measurement; use of GPS; and laying of contour trenches.

At the same time, a climate change vulnerability assessment of villages was conducted and the Rural Management and Development Department of Sikkim (RMDD) identified the recharge areas of various springs and streams based on the varying structure, weathering and fracture pattern of rocks. This resulted in the preparation of a village spring atlas.

Finally, after the selection of pilot villages (facing acute water shortage), contour trenches, rainwater harvesting structures, ponds were created. These activities were taken up under the national flagship MGNREGA programme.

Dhara Vikas achieved remarkable convergence of expertise from various departments like forest, mines and science and technology, who provided their specialised knowledge on relevant subjects. Public awareness was high in the areas where the pilot was conducted. Microlevel planning invariably involved discussion with the local populace. As the initiative was being implemented through MGNREGS, the locals were also kept updated on aspects of implementation. As a co-benefit of the programme, sanitation in the pilot areas also improved.

Since streams and nalas are common pool resources, community capacity building and participation is essential. The science behind the techniques must be explained to locals so as to allow local management of the resources. Therefore, the implementation of such an initiative focussed on executing a scientifically robust strategy and generating awareness.

Spring-shed development applies the principles of geohydrology, watershed and Geographical Information Systems (GIS) to recharge natural groundwater. This involved identifying recharge areas of the spring aquifers, then carrying out artificial recharge (on sloping lands not affected by landslides) through contour trenches, ponds, percolation pits, check dams which allow capture and infiltration of rainwater.

The steps involved in reviving springs, are eight-fold as given below,

1. Comprehensive mapping of springs and spring sheds.
2. Setting up of a data monitoring system.
3. Understanding socio-economic and governance systems of springs.
4. Hydrogeological mapping.
5. Creating a conceptual hydrogeological layout of the spring-shed.
6. Classification of spring type, identifying mountain aquifer and demarcating recharge area.
7. Developing spring-shed management and governance protocols and
8. Impact assessment.

Using "Suttar" for Water conservation

Pinus wallichiana (Pine tree or Kyle tree) is a coniferous evergreen tree indigenous to the Himalayan region. This tree is of high significance for the local people of these tribal areas. The leaves of the tree is needle shaped with a length of 12 to 18 cm. Leaves collected can be tied in small bundles and spread on the field. Land in mountainous regions is generally sloped. So, while irrigating the field, runoff of water can take place leading to soil erosion. But, when suttar (leaves of Pine tree) are spread in fields, they slow down the velocity of water and allow more percolation into the soil. They also prevent water erosion and thus contribute to even spreading of irrigation water in the field. Suttar can be utilized as mulch, thus conserving soil moisture and as it decomposes, acts as a source of nutrients too.

3 Livelihood improvement activities

The success of any conservation initiative lies with community ownership of the same. Addressing livelihood issues and providing additional sources of income, as a trade-off for conservation is an age-old tried and tested model. Some of the initiatives that can be promoted in Kundal sub-river basin are summarised below.

3.1 Sustainable Tourism in Kundal sub river Basin

Eco-tourism and adventure tourism are fast catching up in Kundal sub- river basin. The opening of Atal Tunnel is further aiding the same. One of the models of eco-tourism that can be promoted is Gaddi tourism. This will need an agreement between the panchayat and the Gaddis present in the mid altitude grasslands in the panchayat area. The Forest Department will need to play advisory and supervisory role. The revenue model for the same will be such that the economic benefits derived from tourists for activities like homestay, sale of local products, transportation services etc will go to the village panchayat. The economic benefits from trekking charges in the mid altitude pasturelands will be the right of the Gaddis. Gaddis can bring the tourists to their own camps and tourists can experience the nomadic life of Gaddis for a day or two, can reside and eat with them, following which they will be brought back to the nearest village and the responsibility of the tourists will again shift back to the panchayat. The areas in the mid altitude pasturelands where Gaddi tourism can be carried out needs to be demarcated by the Forest Department, in consultation with the panchayat, Mahila Mandal and other stakeholders. The number of tourists who can be allowed in one season also needs to be decided by the Forest Department. Strict implementation of these rules (as well as other issues like waste management etc) should be the coordinated through the Mahila Mandal and the Biodiversity Management Committee. This concept has received support from the officials, community members and Gaddis, during the field discussions that have been carried out.

The increase in income from such activities will ensure that both, the local community as well as the Gaddis actively participate in pastureland restoration and monitoring activities and will ensure the success of the same. A region specific eco-tourism policy would be needed, which promotes the use of local goods and products (including traditional crops) for the tourists.

Figure 13: **Schematic representation of income generation in the proposed pastoral tourism plan for the Kundal SRB.**

3.2 Addressing local livelihoods through enterprise-based conservation

Enterprise –based conservation is a tried and tested model for community based conservation of natural resources. A co-benefit of revegetating slopes with sea buckthorn is the opportunity to use the plant in an enterprise-based conservation activity. Empowerment to the locals through this strategy boosts the local economy, morale and their will to protect their natural resources.

Sea buckthorn is one such plant species that grows well in Kundal sub-river basin and the leaves and fruits of the same can be processed in the villages itself. The Indian Council of Agricultural Research (ICAR) in 2014 under the scheme National Agricultural Innovation Project, with the CSK Himachal Pradesh Agriculture University, Palampur, conducted a value chain analysis of products derived from sea buckthorn. The fruits were processed to make jams, squash, syrup, toffees, and the leaves were processed for tea. The leaves also serve as livestock feed. Thus plantation of seabuckthorn will help to address pasturelands through addressing landslides and reducing the pressure from pasturelands for collection of fodder for stall feeding. Seabuckthorn is also being promoted by MoFPI, Government of India in this district under the one district one product scheme.

Small scale processing units can be established in the villages and the same can be managed by the Mahila Mandal. Forest Department, in coordination with the District Administration should support trainings for the Mahila Mandals in running these processing units. The same can be provided by experts from CSK Himachal Pradesh Agriculture University Palampur, ICAR and Krishi Vigyan Kendras.

Table 13: **Companies involved in Sea buckthorn products**

S. No	Name	Products taken	Final Products
1	Lahaul & Spiti Seabuckthorn Cooperative Society, Keylong, Lahaul, Himachal Pradesh	Fruits, Leaves, Seeds	Jam, Jelly, Tea, Oil
2	Lahaul Potato Society, Raison, Himachal Pradesh	Fruits, Leaves	Jam, Jelly, Tea
3	Shimla Hills Pvt. Ltd., Shimla, Himachal Pradesh	Fruits, Leaves	Jam, Jelly, Tea
4	Vital Herbs, Uttam Nagar, Delhi	Fruit, Seed	Powder, Oil
5	Ivm Healthcare, Connaught Place New Delhi	Fruit	Pulp
6	International Herbal Corporation, Haridwar, Uttarakhand	Fruit	Juice
7	Seabuckthorn Beverages LLP, Gurugram		Jam, Jelly. Juice

4 Addressing livestock issues

As already stated in the sixth report, the Gaddis give higher significance to herd quantity over quality. In addition, over the years the change in herd composition (more goat than sheep) is also a reason for degradation of the pasturelands. Extensive awareness generation activities need to be carried out to communicate the adverse impacts of these practices among the local community as well as the Gaddis.

Some of the suggested action points include

I. Awareness generation and discussions on the need to have reasonable herd size : These can be steered by the Mahila Mandals and Yuva Mandals with technical support from the Animal Husbandry department, coordinated by the district administration.
II. State-wide campaign promoting sheep meat which can be done along the lines of Australia's Lamb campaigns[44]
III. IEC material should be developed with support from local NGOs and circulated by Forest Department and Department of Animal Husbandry to Gaddis and locals during permit applications, animal health care check-ups etc.
IV. Training programmes to raise awareness among Gaddis on the negative impacts of inbreeding depression and the need to reduce it through cross-breeding among herds should be conducted by the Animal Husbandry Department with support from the district administration.

[44] https://www.mla.com.au/marketing-beef-and-lamb/domestic-marketing/lamb-campaigns/

5 Develop a Grazing Action Plan and other initiatives

In order to ensure long term sustenance, replicability and upscaling of the restoration activities some of the key actions will need to be undertaken. These range from financial support to addressing research needs. These include:

Restoration sites in the mid-altitude grasslands of the Kundal SRB needs to be monitored well and for a longer period. Establishment of grasses in the degraded sites and their continuity depends on the safety of these planted grasses. Long-term management should encompass the following

- Rotational grazing and restoration scheme (which should be detailed in a sub river level participatory grassland management plan) needs to follow the pre-decided and stakeholder approved work plan.
- Long term financial support for the initiative needs to be ensured. For the same convergence from other ongoing and proposed government schemes also needs to be mapped on regular basis.
- Sub-river basin level participatory grassland management plan needs to be developed and the same needs to be integrated with the working plan.
- Permanent plots (100 m*100 m) need to be established in the degraded area, an area which is under restoration and an area that has been restored (this will be after 4 years). Such comparative plots need to be established in the mid and low altitudes. These will serve as baseline for any restoration work that is planned for and undertaken in future.
- Development of seed banks in each village (coordinated by the BMCs) needs to be practiced.

The participatory grazing action plan should

- Describe present management and identify opportunities, issues, problems
- List resources available at hand i.e., land allotments, resources (physical resources, animal resources, plant resources, human resources), facilities
- Establish goals and objectives
- Outline animal needs and timing
- Outline plant needs and timing
- Define the correct stocking rate
- Detail management tools and techniques
- Detail actions
- Incorporate a contingency plan for disasters
- Determine monitoring design

The plan should be integrated with the system of Gaddi permits with regulations being imposed on the number of livestock that each Gaddi can bring. Checks on these numbers can be carried out through onsite inspection by the Forest Department, with support from the BMCs.

Capacity building of all the stakeholders is critical to ensure the long-term sustenance grassland restoration. Such activities need to be tailor made for specific groups of stakeholders (political leadership, administrative leadership, Gaddis, local community, village

panchayats, Biodiversity Management Committees, Mahila Mandals, Yuva Mandals). While the trainings for the political and administrative leadership need to focus on bringing forth the need to undertake restoration activities and the criticalness of keeping continuity of such work; the ones of the others need to have greater emphasis on providing hands on trainings on activities like plantation techniques, seed broadcasting techniques, glacier water tapping, maintenance, better forage management techniques etc. Easy to understand technical trainings for farmers, Gaddis, Mahila Mandals, and other stakeholders should be designed by relevant institutes and disseminated at an appropriate frequency. The community trainings should be aimed at a training the trainer (ToT) model wherein at least 2-3 master trainers are developed in each village. A yearly roster for these capacity building activities needs to be drawn up. While the trainings can be provided by the experts from the Forest Department, Agriculture Department and academic institutions, the coordination of the same should be done by an NGO, under the supervision of the Forest Department. One of the most promising examples of the same is the work being carried out by Nature Conservation Foundation in Spiti.

6 Research Needs

Our work has led to identification of several areas of research, which will support long term grassland restoration and conservation (Figure 7).

The most pressing research need the establishment of permanent monitoring plots in the grasslands of the Kundal SRB. Detailed and long-term documentation of grass and legume species, invasive and alien species, composition across different elevations and phenology is necessary to maintain the existing grasslands. This would form the baseline data for future studies in this region. Detailed research into livelihood options and their market linkages for the locals is also essential. Value chain analysis of the local products and traditional crops should be developed to increase the market demand and to provide local farmers with more opportunities for cultivation in more sustainable way. Detailed study on the topography of the landscape including land use pattern with ground truthing throughout the landscape is recommended to further improve grassland restoration and conservation in the region. Mapping of all the streams and springs is also essential for the Kundal SRB. Establishment of climate grids to monitor the micro climate change in the grassland regions is needed to record the effect of climate change in the landscape. Installation of data loggers for local climate in appropriate grassland areas are recommended for long term monitoring.

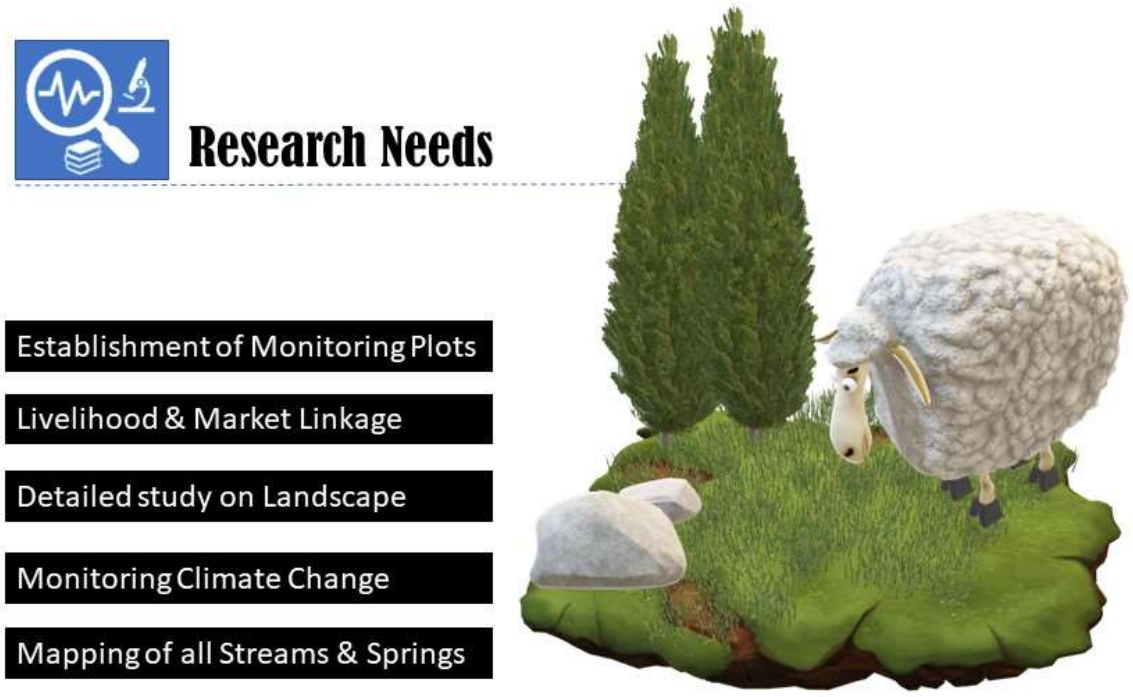


Figure 14: Schematic diagram highlighting key research needs for the grasslands of Kundal SRB

The interventions are summarised in Table 8 below.

Table 8: Activities proposed in the mitigation plan to address grassland degradation in Kundal Sub-River Basin

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
Mid Altitude	Change in Species Composition	Seed broadcast	Kundel Dhar	30,000/ha	Forest Department, Mahila Mandal; Yuva Mandal; Biodiversity Management Committees, Village Panchayats, District Administration, Local NGOs; Gaddis	17, 34, 37, 38, 40, 42	6 months (non-winter months) for 4 years in the cordoned off areas
		Seed balls		30,000/ha			
		Culm transplantation		1,30,000/ha			
		Trainings and capacity building for gaddis by forest		30,000/training of one day each	CSK HPKV Palampur; NGOs; ICAR; Forest Department; Agriculture Department; District Administration; Gaddis		Continuous, at regular frequency
	Landslides	Revegetation of slopes	Landslide prone areas in the Sub River Basin	1,30,000/ha	Forest Department; National Highways Authority of India; District Administration; Mahila Mandal; Yuva Mandal; NGOs	9.32, 35, 37, 38, 41	3-6 months (non-winter months)
		Bioengineering methods (Wattling and Staking; Brush Matting)		30,000/km		9, 37	6 months (Non winter months)

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
	Deficiency in soil moisture content due to decline in winter rain	Minor Check dams (Small structures)	Along stream flows	50,000/ check dam	Mahila Mandal; Yuva Mandal; Forest Department; Jal Shakti Vibhag; Irrigation and Public Health Department; Hydrogeologists; District Administration	13, 37, 38	Stone check dams of small structure (2m*1.5m*1.5m) can be made in a couple of days, with adequate manpower.
		Spring shed development		3,50,000/ spring			2 years
Low Elevation	Change in species composition	Seed broadcast	Villages of Kundal SRB	30,000/ha	Forest Department, Mahila Mandal; Yuva Mandal; Biodiversity Management Committees, Village Panchayats, District Administration, Local NGOs	13, 15, 17, 32, 37,38	3- 6 months (non-winter months) for 4 years in the cordoned off areas
		Nurseries		3,00,000/ per nursery			
		Plug planting		15,00,000/ha			
		Culm transplantation		3,00,000/ha			
		Trainings and capacity building		30,000/training of one day each	CSK HPKV Palampur; NGOs; ICAR; Forest Department; Agriculture Department; District Administration		Continuous, at regular intervals
	Landslide mitigation	Revegetation using Sea buckthorn	Landslide prone areas in the Sub-River Basin	1,50,000/ha	Yuva Mandal; Mahila Mandal; BMC; Horticulture Department; Himachal Pradesh Forest Development Corporation; NGOs; Lahaul-Spiti Seabuckthorn Cooperative Society, CSK HPKV	3, 4, 9, 28, 32, 34, 37,38	Sea buckthorn needs a period of 4 years from seeding to begin to give fruit

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
					Palampur; Forest Department; ICAR		
		Bioengineering methods (Wattling and Staking; Brush Matting)		30,000/km	Disaster Management Authority; SDO; Mahila Mandal; Yuva Mandal; National Highways Authority of India (NHAI)		6 months (non winter months)
		Installing early warning systems		1,00,000/ system	Intiots Technologies; Forest Department; District Administration; Village Panchayat		One working season (Non winter months) to install the systems at select locations
	Changes in cropping practices and patterns	Promotion of traditional crop cultivation	In all villages in Kundal Sub-River Basin	Aided through schemes provided by State and Central Governments	Agriculture Department; Horticulture Department; District Administration; Mahila Mandal; Yuva Mandal; Sector experts; NGOs; Forest Department; Biodiversity Management Committees; Farmers	5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 25, 26, 27, 28, 31, 32, 38, 39,40,41,42	1 year to promote the various cultivation technologies, form farmers groups and develop market linkages

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
		Cultivation of grasses on field bunds		3500/ 10 kg seed	Forest Department; Animal Husbandry Department; District Administration; Mahila Mandal; Farmers; NGOs		3-6 months (Non winter months)
		Agrisilviculture		200/ sapling	Forest Department; Animal Husbandry Department; District Administration; Mahila Mandal; Farmers; NGOs		3-6 months (Non winter months)
		Enterprise-based Conservation Activities (Seabuckthorn and Buckwheat)		1,00,000 per unit for buckwheat processing and ₹ 30,00,000 per processing unit of Seabuckthorn	Forest Department; Agriculture Department; District Administration; Tourism Department; Mahila Mandal; Yuva Mandal; NGOs; Dept. of Agriculture; Mahila Mandal; Yuva Mandal; Himachal Pradesh Forest Development Corporation; Lahaul-Spiti Seabuckthorn Cooperative Society, CSK HPKV Palampur		During non-winter months
		Training and capacity building activities		30,000/training of one day each	NGOs; Sector experts; INVEST INDIA; Krishi Vigyan Kendras; ICAR; Forest Department; District		Continuous, at regular intervals

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
					Administration; Mahila Mandal; Yuva Mandal		
	Water scarcity	Spring shed development	Lohni Village	3,50,000/ spring	Mahila Mandal; Yuva Mandal; Forest Department; Jal Shakti Vibhag; Irrigation and Public Health Department; Hydrogeologists; District Administration	13, 37, 38	2 years for implementation of activities
		Using Suttar for water conservation.		30,000/training	Mahila Mandal; Yuva Mandal; Forest Department; Jal Shakti Vibhag; Irrigation and Public Health Department, Farmers		Continuous, at regular frequency
	Addressing livelihood issues	Ecotourism model	Villages in Kundal Sub River	30,00,000 per village	Tourism Department; Mahila Mandal; Yuva Mandal; Forest Department; Local NGOs; District Administration; Gaddis; Biodiversity Management Committee	1. 3. 7. 32. 40	1 year to develop the plan in consultation with all stakeholders and beneficiaries and infrastructure establishment; execution of the same from the next year
	Livestock Issues	IEC Campaigns on herd size	Villages in Kundal Sub River Basin, Animal	10,000/per campaign	Mahila Mandal; Yuva Mandal, Gaddis; Biodiversity Management Committee; Forest	22, 23, 24, 37	1 year to develop training and IEC materials; Continuous engagement

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
			Husbandry clinics, Forest Department Permit issuance offices		Department; Animal Husbandry Department; District Administration		especially just before the start of the summer season.
		Development of a Grazing action plan	Kundal Sub River Basin	10,00,000	Forest Department; NGOs; Grassland research institutes; ICAR; District Administration; Mahila Mandal; Gaddis; Village Panchayat; Subject Matter Experts; ICAR		1 year
	Addressing Research Needs	Mapping of all streams and springs on GIS platform	Across grasslands of Kundal Sub River Basin	50,00,000	Research Organisations; Forest Department; District Department; ICAR; Yuva Mandal; Parataxonomists; NGOs; Mahila Mandal; Biodiversity Management Committee	38	Continuous
		Long term studies to document grassland species composition and phenology					
		Estimating carrying					

Altitude	Issue addressed	Actions	Location proposed	Estimated Budget (INR)	Actors	Schemes for possible convergence (refer Annexure 5 for details)	Time Frame to implement
		capacity of lgrassland Monitoring climate change					

Annexure 1

Grass Species

1. *Poa alpina* or Alpine Bluegrass[45]

It is a perennial grass species that can grow to a height of 0.15 meters. Leaf blades can grow up to 3-12 cm long and 2-5 cm wide in mature plants. Except for high acidic soil, this plant species is an important pioneer species in restoration of degraded lands. It has very hard rooting system that helps in soil binding and conservation and prevents landslides. High nutrient content, strong resistance to wind and livestock grazing makes this species as one of the valuable forage species of high-altitude grasslands. The species can be found between the altitudes of 2700-5500m.

25. *Phleum alpinum* or Mountain Timothy[46]

This is a perennial grass species. Clumps are usually in size of 20-60 centimetres. The inflorescence of the plant can reach up to the height of 6 centimetres and as wide as 1.2 centimetres. The species can be generally found at the wet alpine meadows, damp soil around bushes of streambanks, conifer forest etc. The elevational range for this species 2500-3900 m.

26. *Festuca ovina* or Blue Fescue[47]

It is a perennial grass species and usually considered as less susceptible to disease or pests. It can grow up to 30 centimetres. The species grows in the spring and fall while in summer it hardly shows any growth at all, depending on the availability of rainfall. It is also a highly cold and drought tolerant species. It has a deep rooting system that also helps in mitigation of soil erosion. Altitudinal range of the species is between 1600 m-4400 m.

[45] Image Source: https://commons.wikimedia.org/wiki/File:Poa_alpina_(3987334209).jpg Date Accessed: 28.10.2021
[46] Image Source: https://en.wikipedia.org/wiki/Phleum_alpinum Date Accessed: 28.10.2021
[47] Image Source: http://antropocene.it/en/2019/06/05/festuca-ovina/ Date Accessed: 28.10.2021

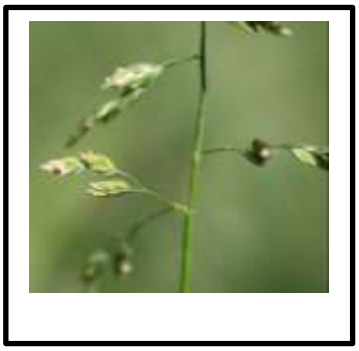
27. *Koeleria pyramidata* or June Grass[48]

It is a perennial grass species and highly drought tolerant. It is a cool-season grass which stays dormant during the late summer. It grows easily in dry to medium, well-drained soils in full sun. The plant in general thrives in rocky or gritty soils. The plant can grow as long as 20 inches. Leaves are around 6 inches long and 1-4 mm wide. Altitudinal range of the species is between 1800-5300 m.

28. *Tenaxia cachemyriana*[49]

It is a perennial grass species. Culms are 10-25 cm long. Leaves of this plant are 3-6 cm long and 0.5-1 mm wide. Inflorescence is 1-3 cm long. These plants are well adapted for rough mountain habitats with deep root system that also helps in soil conservation. Altitudinal range of the species is up to 4500m.

29. *Poa annua* or Annual Meadowgrass[50]



The species grows as densely clumped populations with very shallow rooting system. These plants have larger environmental elasticity and can adapt quickly to the climate. Less rain, dry winter to temperature below frozen points have also been reported for this species to survive and germinate at favourable conditions. Plants have rapid flowering and profuse seeding capability that makes it easier for survival in the adverse conditions. Individuals of this species can grow up to 30 cm with flat and hairless blades of leaves. Altitudinal range of the species is between 1000-4000m.

[48] Image Source: https://swbiodiversity.org/seinet/taxa/index.php?taxon=Koeleria%20pyramidata Date Accessed: 28.10.2021
[49] Image Source: https://efloraofindia.com/2013/01/06/danthonia-cachemyriana/ Date Accessed: 28.10.2021
[50] Image Source: https://en.wikipedia.org/wiki/Poa_annua Date Accessed: 28.10.2021

30. *Elymus longe-aristatus*[51]

It is a perennial grass. Leaf blades are convoluted and 5-15cm long and 2-3cm wide. The species is predominant in alpine and trans Himalayan region. The species is generally found up to the altitude of 4000 m. The species has a high fodder value and is consumed by wild ungulates too, especially in the summer.

[51] Image Source: http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:328322-2 Date Accessed: 28.10.2021

Legume Species

12. *Desmodium elegans*[52]

It is a deciduous shrub. Normally it reaches to the height of 3 metres. Its leaves are trifoliated. The plant has pink to dark purple flowers. Petals of the flowers are rounded in shape. The flowering time of the plants is June-September. This plant is common in Himalayas. Altitudinal distribution is restricted between 1200-3000 m.

13. *Indigofera heterantha*[53]

It is commonly known as Himalayan Indigo. It is a deciduous shrub . It is native and widely distributed in Himalaya. The plant can reach the height of up to 3 metres. Each leaf of the plant can carry up to 21 leaflets which are grey-green in colour. It is a drought tolerant and hardy plant that can survive up to -15 °C. In colder areas the plant dies out at the end of the season and regrows again the following year.

14. *Lotus corniculatis*[54]

It is commonly known as Bird's-foot trefoil. It is a perennial herbaceous plant that has a wide distribution range. Each leaf has five leaflets. Flowers are yellow in colour. It is very widely used as livestock forage. It is highly tolerant to grazing and flowers between June to September.

[52] Image Source: https://en.m.wikipedia.org/wiki/File:Desmodium_elegans_(15131977732).jpg Date Accessed: 28.10.2021
[53] Image Source: https://www.gardenersworld.com/plants/indigofera-heterantha/ Date Accessed: 28.10.2021
[54] Image Source: https://sco.wikipedia.org/wiki/Lotus_corniculatus Date Accessed: 28.10.2021

15. *Trifolium repens*[55]

It is commonly known a White Clover. It is a perennial herbaceous plant. It has been used widely as a forage plant widely for the livestock. It has white flowers and honeybees and bumble bees are known to visit this plant very actively. These plants are known to fix nitrogen in temperate pasturelands very well and is often used due to this purpose.

16. *Indigofera geradiana*[56]

It is a deciduous herbaceous plant usually found in the high temperate regions. It has pink flowers. Flowering time of this plant is between June to September. The plant can reach to the height of up to 3 feet and can spread 2 feet.

17. *Caragana sukiensis*[57]

The plant can grow upto 4 m in height. The species is native to the Himalayas. It is found in Western Himalayas to Bhutan. Altitudinal distribution of the species ranges from 3000 m to 3700 m.

18. *Astragalus himalayanus* or Himalayan Milk Vetch[58]

It is perennial herb species with dense rounded flower clusters. Each flowers are 1-1.5 cm long. Leaves are generally 3-4 cm long. The species is distributed from the Kashmir in India to the Eastern Nepal. Its altitudinal range is 3200 m-4400 m. The plant flowers between the months of June to September.

[55] Image Source: http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:523626-1 Date Accessed: 28.10.2021
[56] Image Source: https://www.flickr.com/photos/24160994@N03/2340757860 Date Accessed: 28.10.2021
[57] Image Source: https://en.wikipedia.org/wiki/Caragana Date Accessed: 28.10.2021
[58] Image Source: https://uk.inaturalist.org/taxa/939807-Astragalus-himalayanus Date Accessed: 28.10.2021

19. *Astragalus himachalensis* [59]

It is a perennial herb with a rhizomatous stock. Leaves are usually 3.5-4 cm long with faint grooves above. Flowers are 8-9 cm long and purple or blueish purple is in colour. Flowers bloom between July to September. It grows well in hard rock soil, mountain slopes and can easily be found between the altitude of 3300 m-4400 m. This species has been described new and the type specimens are from Keylong, Lahaul, Himachal Pradesh.

20. *Astragalus oxyodon*[60]

This legume usually grows up to 18 cm. Leaves are 4-7 cm long. The species is native to the Himalayas. Altitudinal range for the species is between 3500 m to 4600 m. Flowers can be light blue to purple in colour. Flowering season is from June to September.

21. *Hedysarum astragaloides* or Lahaul Sweetvetch[61]

It usually grows 2 feet in height. Stems have dense hair giving it a velvet like appearance. Compound leaves. Each leaf is 10-20 cm long. Flowers are light to dark purple at the tip, 5-7.5 cm long and grows in a bunch. Flowering is in June. It is easily found between the altitude of 3000m-4000m. It is well distributed in Kashmir and Himachal Pradesh.

22. *Astragalus candolleanus* or Candolle's Milk-Vetch[62]

It is a spiny rounded stalkless cluster shaped plant with yellow flowers. Leaves are compound and old leaves turns in to long spines. Flowers are usually 1.5-2.5 cm long. Leaves size varies between 5-10 cm. It is native to the Himalayas. Flowers between May and August. The species has higher altitudinal gradient between 1800 m-5000 m.

[62] Image Source: https://sites.google.com/site/efloraofindia/species/a---l/f/fabaceae/astragalus/astragalus-rhizanthus-1 Date Accessed: 28.10.2021

Annexure 2

Method for Selection of Plantation sites

Selection of plantation sites in the present study was conducted on the basis of multi-criteria evaluation method (MCE). It is a supportive decision-making procedure that uses a set of parameters or set of events and results in a single composite output (Malczewski, 1999). Each of the required parameters are assigned weighted values. These values are assigned based on the expert opinions, field scenarios, geological structure, climate, topology, land cover and land use etc. MCE is considered through multiple qualitative techniques viz. Analytical Hierarchy Process (AHP), Bivariate Statistical Analysis (BSA), Multivariate Statistical Approach (MSA) and Weighted Overlay Linear Combination (WLC) (Saaty, 1990; Ayalew et al, 2004; Basharat et al, 2016). In the present study we used Weighted Overlay Linear Combination as it is one of the most reliable techniques of MCE for determining the required results in the landscape ecology studies and site selection scenarios (Saaty, 1990; Basharat et al, 2016).

In the present spatial analysis, we used Spatial Multicriteria Decision Analysis (MCDA) through geospatial software which is more advanced calculation of the MCE method through Geo-spatial analytics (Malcewski, 2004; Nyerges and Jankowski, 2009; Tenerelli and Carver, 2012). For the present model, parameters were chosen based on literature and past studies for evaluating suitable plantation areas though GIS (Aguirre-Salado et al, 2015; Zaini et al, 2021) (Table 1). The Spatial Weighted Overlay Analysis therefore, combined each of these spatial rasters and calculated the suitable areas for the plantations based on the Boolean Algebra and provided a final raster output that indicates the calculated suitable areas within the landscape (Papadopoulou and Hatzichristos, 2020). All the analysis was based on the rasters of 30 arc second (~ 1 km) resolution.

We used river flows and stream order as a parameter to evaluate the suitable site for grassland plantation. River flows and stream orders are necessary as presence of water source is one of the crucial elements. Also flow of the river and direction indicates the probability of unforeseen disasters such as, flash floods or landslides, which are essential in selection of this suitable site for plantation. We used area less than 7 km from the low stream order 1st, 2nd and 3rd as the ideal for the selection of the suitable restoration areas. Higher stream orders were deemed unfit for the restoration area as they contain higher flow velocity which is not suitable for water harvesting or any irrigation purpose and provides increased chances of natural disasters (Zaini et al, 2021). Slope of a mountain is important and we included it in the present model as the angel represents the monsoon waterflow or summer snow melts and provides us insight of the soil moisture and stability. Up to 45 degrees of slope has been found suitable for plantation in the Himalayas and we therefore selected 45 degrees as the highest slope angel for the present study in selection of suitable grassland restoration areas (Singh et al, 1989; Bennie et al, 2006). Influence of human habitations are important to safe guard the planted site and hence it was kept as representative parameter for the present study for

anthropogenic influence in detection of the suitable site. As field study and FGD results, majority of the locals in Kundal SRB uses grasses that are available nearby their houses and doesn't utilise the grasslands in the upper mountains. Hence, we kept the safe distance for the present study at 2 km from the village as not suitable for plantation. Integrated parameters evaluated suitable areas based on the calculation of WLC where each pixel calculations were evaluated using the following formula;

$$S = \sum_{i=1}^{n} w_i x_i \; X \; \prod_{j=1}^{k} C_j \quad \text{where,}$$

Table 1: Following table details of the parameters used in the Spatially Weighted Overlay Model for the development of most suitable plantation areas within the Kundal Subriver Basin in the present study (2018-2021).

Parameters	Source	Criteria Values
Slope	Developed using Digital Elevation Model	$<45^0$
Stream Order and Flow direction	Developed using Digital Elevation Model	Euclidean distance from the rivers. Suitable <7 km.
Landslide Zones	Developed in the present study	Vulnerability>50%
Human Habitation	Field Data	< 2 km
Grassland Degradation	Developed in the present study	Medium Degraded Areas

S = Land Suitability for planting grasses; w_i = importance of factor i; x_i = score of factor I; $\prod_{i=1}^{k} C_j$ = products of the j constraint.

Scores for each of the factors (x_i) were generated from the standardised variables used in the present model. Estimated importance of factors (w_i) were generated through pairwise comparisons as part of the analytical hierarchy process through the GIS software (Saaty and Vargas, 2012).

Method for identification of landslide prone sites:

Landslide vulnerable areas in the present study were demarcated using the GIS models following the Spatial Weighted Overlay Analysis. The methodology has been discussed in detail in the section above. We used slope, road network, river, annual rainfall. Each of the variables were assigned a vulnerability contribution to the present study area based on literatures and through AHP calculations (Table 2). Slope was kept as the 35 degrees and beyond this it is considered highly prone to landslide events. 35 degrees has been accepted as safe angle globally and for the Himalayas, based on the landslide record studies in the past (Prakasam et al, 2020). Mountain roads are mostly constructed around the mountains and generally steep slopes above the road are more than 35 degrees. Including the average road to valley distance on one hand and closeness to the other side of the road, 2 km in the vicinity of roads in mountains are considered to be vulnerable to landslides. Another reason for this distance is often the debris from the landslides skid further away from the roads and mountain road systems being spiral in configuration, lower road segments are also considered to be vulnerable (Ahmed, 2015). Less than 200 m distance from rivers is considered as landslide prone as often the banks of the rivers get eroded due to landslides and river water velocity. Distance has been kept optimum based on the past studies of landslides in the Himalayas (Prakasam et al, 2020). Winter rainfall of more than 1500 mm is considered as trigger to landslides, based on the past studies in the Himalayas (Prakasam et al, 2020).

Table 2: Variables used in the weighted overlay model for estimation of landslide prone areas in the Kundal Subriver Basin during the present study.

Triggering Variables	Vulnerable	Source
Slope	>35°	Ahmed, 2015; Prakasam et al, 2020; Koley et al, 2020
Euclidian Distance to Road	< 2km	Ahmed, 2015; Prakasam et al, 2020; Koley et al, 2020
Euclidian Distance to River	<200 m	Ahmed, 2015; Prakasam et al, 2020; Koley et al, 2020
Annual Rainfall	>1500mm	Koley et al, 2020; Bera et al, 2019

The model result was naturally broken in to four categories, viz., No vulnerability, Low Vulnerability, Medium Vulnerability and Highly Vulnerable areas within the Kundal Subriver Basin (Table 3). Highly vulnerable areas were moderate in the region (around 3 km^2). Medium vulnerable areas were highest in Kundal SRB (~47 km^2), followed by low vulnerable areas (approximately 31 km^2) and not vulnerable (4.6 km^2).

Table 3: Landslide vulnerability analysis of Kundal SRB

SL No	Vulnerability	Area (km^2)	Area (ha)
1	Not Vulnerable	4.6	460
2	Low Vulnerability	31.2	3120
3	Medium Vulnerability	47.22	4722
4	High Vulnerability	2.77	277

Higher vulnerable regions were located mostly near the human habitations which can be due to the landscape alterations through anthropogenic activities in the area (Figure 1). Road and house development and reshaping of mountains for human use have been noted as the major factors that have increased vulnerability to landslides (Prakasam et al, 2020; Koley et al, 2020). Recent developmental activities in Kundal SRB, along with increased human population and demand for spatial resource for agriculture and housing (Prakash et al, 2019) has resulted in these areas being more prone to landslides.

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Annexure 3

Method for cultivation Seabuckthorn:

Sea buckthorn plants are usually placed at 4 x 2m apart, which results in high canopy volumes. Planting less than 1.5m apart can create canopy overlapping and occasional trimming may be required. Pits are often placed around the plants with usual diameter of 2 x 2 x 2 metres. These pits get covered in the snow during the winter and provides extra humidity and water to soil during the summers. Weed control is done by polythene mulching or mulching with Artemisia plants. Both have resulted in more than 94% of success in weed control in the region for Sea buckthorn. For nutritional requirements organic manures with high nitrogen load (50kg/hectare) is recommended during the early establishment period of the plants. Rest of the nutrients are generally supplemented from the soil by the plant itself. It is recommended to plant the Sea buckthorn as mixed species plantation. Mixed plantations have recorded better growth and yield for all the species which are planted together. The best combination is Sea buckthorn with Fescues (*Festuca sp*.) or Orchard grass (*Dactylis glomerata*) and Red Clover (*Trifolium pratense*) together. More than a 37% increase has been noted in their total yield and production in comparison to monocultures. These provide both nutritional fruits as well as livestock feed as green and dry fodder.

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Method for cultivation of *Salix fragilis*

Cultivation of Willow trees in Kundal sub river basin should be followed based on the local shoot propagation technique. In this method shoots with length of 2.4 to 3m in length and 5.6 to 6.3 diameter of cuttings from 3- to 4-year-old plants are used. Such 3 to 5 shoots are then bundled up and planted together in a pit of 75 cm depth and 45 cm width. Such plantings are generally done during March and April month of the year. These planted shoots start sprouting in the next month. Unsuccessful shoots are cleared from the plantation areas. Seabuckthorn plants are used as protection from grazing animals. Sprouts are watered weekly and for 2-4 hours. In summer, watering is done for 15-20 times. Snow pots are created 50 cm upslope from each of the planted pits. Such pots keep the soil moist for long times by harvesting the snow melting water. After 3-4 years pollarding is done for the first time. Usually, the pollarding is done at the height of 2.5 cm from the ground for each plant at the onset of winter or during the months of November and December. Such activity also provides the local the necessary fodder and fuel wood for the coming winter. Smaller branches are kept as fodder, and heavier branches are counted as fuelwood. After pollarding, barks from the heavier branches are also peeled off and kept for stall feeding the livestock during winter. Next summer new branches with more spreading and number emerges. Such pollarding continues for each tree for next 10 -15 years. After that the large head of the tree that produces less coppices are cut down for fodder and fuel wood. Each of such planted trees are viable for fodder and fuelwood for 60-80 years.

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Method for cultivation of *Salix alba*

This species is highly cold tolerant and can survive at the temperature of around -40°C. It grows usually in moist soil and sunny areas. Average age of each plant survival is around 100 years. Seeds of this plant are very small and lighter weight. Seeds have less viability in nature to germinate. Germination occurs on the surface of the soil so plantation requires to be sown at maximum depth of 5 cm. The species also grows well in nursery if kept in trays with moist soil and sunny areas. Germination, however, occurs in this species rapidly. Plantation of this species should be done by transplantation when seedlings are small for better establishment at the plantation site. Pollarding method is same as the *S. fragilis*.

Ref: http://temperate.theferns.info/plant/Salix+alba

Method for cultivation of *Juglans regia*

This species prefers well drained soil in general for plantation in a open sun facing areas. pH range of the soil can vary between 4.5 to 8 for this tree. Dormant seeds for this plant can tolerate surface temperature of about -27°C and can still germinate when summer comes. Care for the young seedlings is however recommended for this plant as they can be damaged easily in frost. Pollarding is suggested after 4 years for better amount of fodder and fuel wood. Seeds are generated after 5-7 years and can produce more than 200 kg of nuts per hectare in the cold regions. Plants can not tolerate any kind of root disturbance. Seedlings are hence suggested to plant in the planting sites at early age and rock supports should be used upslope and around the plant to protect from cold wind and snow for the first year. Pollarding should be done at the start of summer and at any other time can seriously damage the plant.

Ref: https://pfaf.org/user/plant.aspx?LatinName=Juglans+regia

Method for cultivation of *Prunus armeniaca*

It is a well-known fodder and fuelwood plant in the western Himalaya. Plant prefers well drained sunny positions for growth. pH of the soil can vary between 6.5 to 7.5. Roots of this species does not go deep in to the soil and pruning or pollarding should be restricted only to early summer. It gives the tree to recover new shoots before winter. Seeds should be planted at the site at the early winter. Germination process is very slow for this species and in the colder climate the species can take up to 18 months for germination to occur. Spacing at the plantation should be kept between 20-24 ft between each seed. Planting should be done in the early summer. Approximate diameter for planting seedlings are 80x80x80cm. After putting the plant in the pit, few gravel or crushed stones are usually kept at the bottom of the pit and then covered with mud. Such stones help the soil to retain water and hydrated for longer time and watering is very essential for this species during the early days after germination. Often

farm manure is used in 2:1 ratio with the local soil during plantation. An 8-10cm of mulching with straw, manure and mud is also recommended after plantation around the seedling. Pollarding is recommended after 3 years.

Ref: http://temperate.theferns.info/plant/Prunus+armeniaca

https://pfaf.org/user/Plant.aspx?LatinName=Prunus+armeniaca

https://www.fruit-crops.com/apricot-prunus-armeniaca/

https://floralife.com.ua/en/encyclopedia-of-plants-en/trees-enc-en/prunus-armeniaca-enc-en

Annexure 4

Cultivation Protocol – Grasses

Following are the suggested cultivation protocols for the grass species suggested in the present restoration plan. Implementation of the following protocols are however, subjective to Geographic position and climatic conditions. Necessary modifications to the under stated protocols are therefore recommended as per the needs.

1. *Poa alpina*

This grass species has low competitive capacity in juvenile period; hence, weeding is absolutely necessary before sowing as well as during the growth of the species. Seeding in plantation area should be done in early monsoon. The species has surface germination and therefore should not be sowed at more than 0.5 cm depth and spacing between the seeds must be adequate and minimum of 12 to 15 cm. Minimum of 8Kg/ha of seeding is required for successful germination.

Ref: Krautzer, B., Peratoner, G., & Bozzo, F. (2004). Site-Specific Grasses and Herbs: Seed production and use for restoration of mountain environments. Food and Agriculture Organization of the United Nations, Rome.

2. *Koeleria pyramidata*

This species has a broad environmental tolerance, however, plantation in mix with *Poa annua* is not recommended. Optimum pH for growth is 6-7.5. Plants of this species can be sowed in early monsoon, however, well weeding is very essential from the early stages of growth. Seeds should not be sowed at more than 0.5 cm depth. 7-9 kg/ ha of seeding is recommended. Effective for seed broadcasting.

Ref: Krautzer, B., Peratoner, G., & Bozzo, F. (2004). Site-Specific Grasses and Herbs: Seed production and use for restoration of mountain environments. Food and Agriculture Organization of the United Nations, Rome.

3. *Cynodon dactylum*

This prefer is well known for its growth in warm sunny condition, however, the species has one of the broadest environmental tolerance among the grasses in the world. C. dactylum is known to have well growth condition in diverse soil and moisture regimes, can withstand drought and survives in as low as -10°C. Optimum pH range for growth in soil is generally between 4.3 to 8.4. Seeds are generally sowed in early summer and little soil cover is needed. Effective through seed broadcasting. Germination is fast and completes within 2 weeks. Saplings, see`ds or even rooted side-shoots can simply be used for plantation.

Ref: https://pfaf.org/user/Plant.aspx?LatinName=Cynodon+dactylon

Cultivation Protocol – Legumes

Following are the suggested cultivation protocols for the legume species suggested in the present restoration plan. Implementation of the following protocols are however, subjective to Geographic position and climatic conditions. Necessary modifications to the under stated protocols are therefore recommended as per the needs.

1. *Indigofera gerardiana*

It is a hardy cold tolerant species. Plants of this species can have slow growth at temperatures between -5 to -10°C, however the rooting system works fine underground and helps in the survival in harsh conditions. Plants will resume growing during the summer times with warmer temperature and sunshine. Soil at the planting sites should be well drained. The species is tolerant to common fungal diseases like Honey fungus.

Ref: Sheat, W. G. (1948). Propagation of trees, shrubs and conifers. Mcmillan & Co. London. 479pp.

2. *Trifolium repens*

This species grows well on soil that have good number of nutritional elements such as, P, N, S, and Mb. Soil pH for the species ideally ranges around 4.5 for optimum growth. Soil should also have a good water holding capacity, however, at the plantation site the soil should be well drained. Plants of this species can be seeded at the target sites through surface sowing. For degraded areas and pasture lands, over sowing is recommended for this species. Dense sowing is recommended usually with 0.5-3 Kg/ha. However, the number of seed for sowing might vary based on the climate, elevation and geographic locations. The species requires surface sowing for successful germination with soil dug up to 15cm for each seed sowing. The species have a good amount of tolerance to rotational grazing. Once reach the optimum height, the pasture land with this species can be grazed for spring and early summer. However, the plants must reach the height of 15-20 cm, before grazing should begin.

Ref: The Biology of Trifolium repens L. (White Clover). 2008. Department of Health & Aging Office of the Gene Technology Regulator, Government of Australia. Version 2.

3. *Lotus corniculatis*

This species is sown in early summer and seed treatment in hot water usually improves germination. Seeds can be directly sowed in the surface, however, ground must be cleared well before sowing the seeds. Usually the seeds take 2-4 weeks to germinate. This plants have rapid growth and a well choice for improving degraded pastures. The plant grows well even in poor soil condition and decomposed plants of this species works very effectively in supressing weeds in the planted areas. Seeds should be planted around 3kg/ha. Within 3 to 6 months the plants become good forage for livestock and can be allowed to graze.

Ref: https://www.seedaholic.com/lotus-corniculatus-bird-s-foot-trefoil.html

4. Desmodium elegans

This species is in general a cold resistant species and can tolerate as dormant temperatures between -15 to -20°C. Species requires well drained soil for optimum growth. Plantations must be done in late winter or early summer. Best grown methods for this species is in Nursery. Seeds are generally recommended for hot water treatment for 5 hours before sowing. Germination usually occurs within 1-4 months but can vary according to locations. Plants must be kept in nursery for the first winter for seedlings to protect from frosts and snow.

Ref: Temperate Plants Database, Ken Fern. temperate.theferns.info. 2021-11-02. <temperate.theferns.info/plant/Desmodium+elegans>

Annexure 5

Mapping Convergence

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
1	HP Single Use Plastic Buyback Scheme	Buy-back of Non-recyclable and Single Use Plastic Waste including plastic bags in the Himachal Pradesh from the informal sector and households, providing Minimum Support Price of Rs. 75/- (Rupees Seventy-five) per kg, for its collection and deposit in the collection centres of the Urban Local Bodies.	The Departments of Environment, Science & Technology, Urban Development, Public Works, Rural Development, State Pollution Control Board and Cement Companies	Environment Science & Technology Department, Himachal Pradesh	Nearest Designated Collection towns are Chamba & Dalhousie	http://dest.hp.gov.in/sites/default/files/Notification_01102019_0.pdf
2	Himachal Grihini Suvidha Yojana 2021	Provision of security amount for domestic Liquefied Petroleum Gas (LPG) connection and a gas stove to poor families. Families in the state without LPG Gas Connections and who are not covered under Pradhan Mantri Ujjwala Yojana (PMUY) are covered under this scheme 2021 for at least 2 years.	Rural Development	Food, Civil Supplies and Consumer Affairs Department, Himachal Pradesh		https://sarkariyojana.com/grihini-suvidha-yojana/
3	Sashkat Mahila Yojana	All SHGs/Mahila Mandals having bank accounts/bank linkage will receive need-based training for income generation activities like soft toys, pickle and preserve making, jute bag, recycling of waste material, knitting and embroidery	Women & Child Development	Department of Social Justice & Empowerment	Age Group to avail this scheme is 19-45 years	https://himachal.nic.in/WriteReadData/l892s/176_l892s/Sashakt%20Mahila%20Yojna-30901215.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		products etc. with the view to promote micro enterprise at village level. A one-time seed fund worth Rs 50,000 will be distributed to the state's self-help group for income-generating activities. Women will be also provided with information about their rights.				
4	Van Samridhi Jan Samridhi Yojana	Economic returns to rural households engaged in collecting and sale of Non- Timber Forest Produce, including medicinal plants. This will be done through strengthening of the wild resource base, post-harvest handling, value addition and marketing. A 25% subsidy will be given to those who grow medicinal plants on their land. The main objective is to provide appropriate prices for medicinal plants which grow in the forests of the state.	Rural Development	Jari-Buti Cell under Zaika Project, Department of Forest, Himachal Pradesh	The scheme will be implemented through Community User Groups in these districts for the Phase 1 (April, 2018-March 2038) who will be reporting to Biodiversity Management Committees.	https://hpforest.nic.in/files/Van%20Samridhi%20Jan%20Samridhi%2010.pdf
5	Saur Sinchai Yojana	The scheme (Solar Irrigation Scheme) will provide solar pump sets to farmers for agricultural/irrigation purposes. Under this scheme, the state govt. will provide 90% financial assistance to small and marginal farmers for purchase of pump-sets	Agriculture & Horticulture	Soil & Water Conservation wing, Dept. of Agriculture, Govt. of H.P.	Preference for small farmers, Crop cultivation through rain fed conditions, Neo-Youth, Organic farming, Zero Budget Natural farming etc.	http://www.hpagriculture.com/Guidelines%20of%20Saur%20Sinchayee%20Yojana.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		and 80% subsidy to all individual medium and big farmers.				
6	Mukhya Mantri Swavalamban Yojana	In order to provide employment opportunities to jobless youths, widow and women candidates, Himachal Pradesh government will take the guarantee of loans provided to the unemployed. Residents eligible can set up manufacturing unit, service sector and businesses at a cost of 60 lakh rupees. The state govt. will provide capital investment subsidy at the rate of 25 to 35 percent, interest subsidy at the rate of 5 percent and other incentives provided by the industry centre in the district.	Livelihood Development	Department of Industries	**Eligibility** Applicant must be a permanent resident of Himachal Pradesh. Applicants must be between 18 to 45 years of age. The applicant youth, widow or women must be unemployed. Unemployed youth will get a 25% subsidy on machinery with an investment of Rs. 40 lakh in the industry. Jobless women will get 30% subsidy with an investment of Rs. 40 lakhs on machinery in the industry. Jobless widow will get 35% subsidy with an investment of Rs. 40 lakh on machinery in the industry. The state government will provide an interest subsidy of 5% for 3 years at Rs 40 lakh.	http://mmsy.hp.gov.in/documents/Mukhya_Mantri_Swavlamban_Yojana_2019.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					Apart from this, the government will also provide land on rent to the youth at a rate of just 1%. With this, the government will reduce the stamp duty on the purchase of land from 6% to 3%	
7	Nai Raahein Nai Manzilien Scheme	Under this scheme, unexplored and untapped tourist destinations will be identified to promote tourism in. The total budgetary allocation of Nai Rahen Nai Manzil Scheme is Rs. 50 crore.	Tourism Development	Department of Tourism, Got. Of H.P.	Tourism Dept. has prepared 9 circuits under Nai Rahen Nai Manzil Scheme 2018 which are as follows • Jogindernagar-Barot-Kothi Kohar-Rajgungja-Bir-Billing • Sundernagar-Chail Chowk-Kamru Nag-Shikari Devi-Janjheli • Shimla-Khara Pathar-Rohru-Sandasu-Larot-Chanshal-Dodra Kwar • Dhauladhar Circuit • Buddhist Circuit • Bhakra-Bilaspur-Sundernagar-Jogindernagar-Pong Dam • Solan-Habban-Rajgarh-Shillai • Manali-Rohtan-Tandi-Udaipur-Killar	https://sarkariyojana.com/nai-raahein-nai-manzilien-scheme-hp-identify-tourist-places/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					• Narkanda-Baghi-Khadrala-Chini (Kalpa)-Pangi Circuit A committee of Tourism, PWD, Forests, Language, Art and Culture Officers will make a visit to the selected circuits. This committee will propose the activities which needs to be carried out in these circuits after consulting the local panchayats and other stakeholders.	
8	Cm Startup Scheme	This scheme will support startups and Innovation Projects in the state and will provide skills to the youth and potential investors to develop entrepreneurship. Besides this, the government is providing facility of hand holding and mentorship to innovative enterprises from the initial stage to setting up of the industry.	Industry Development	Dept. of Industries, Govt. of H.P.	Sectors supported include • Technology driven innovation in any sector • Rural infrastructure and facilities, crafts, arts, water and sanitation, renewable energy, healthcare, etc. • Clean technology • Agriculture, Horticulture and the related areas • Food Processing • Retail • Tourism and Hospitality • Mobile, IT and ITes including hardware • Biotechnology	https://sarkariyojana.com/cm-startup-scheme-himachal-pradesh/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
9	Mukhya Mantri Gram Sadak Yojana	The state government will develop road connectivity between villages/habitations and cities through this scheme.	Transport	Department of transport, Govt. of H.P.		https://sarkariyojana.com/mukhya-mantri-gram-sadak-yojana-himachal-pradesh/
10	Mahila Vikas Nigam	Focussing on the welfare of the women of its state, the scheme will support women entrepreneurs and the women workforce through no to low interest rate loans.	Women Empowerment	Ministry of Social Justice and Empowerment, Govt. of H.P.	Types of loans provided include • Interest-free loan up to Rs. 3000. • 5% interest rate for a loan of Rs. 20,000. • 7% interest for a loan over Rs. 20,000. • Interest-free loan is sanctioned to study in selected courses up to Rs. 75000.	https://www.indiafilings.com/learn/mahila-vikas-nigam-loan-yojana/
11	Revamped Restructured Weather Based Crop Insurance	The scheme intends to provide Insurance protection to the cultivators against weather incidence, such as High mean temperature & Low mean temperature, Deficit rainfall and Excess/Unseasonal rainfall, Temperature fluctuation, Maximum temperature & Minimum temperature, Dry Spell and Disease Congenial Days cover etc. which may adversely affect the Kharif & Rabi Crops during its cultivation period.	Agriculture	Dept. of Agriculture, Govt. of H.P.	During Kharif seasons, Tomato, Potato, Ginger, Peas, Cabbage & Cauliflower crops will be covered and during Rabi seasons, Tomato, Potato, Garlic & Capsicum crops will be covered under the Scheme. In Chamba (Chamba, Mehla, Salooni, Tissa, Bharmour, Salooni, Tissa): Potato & Peas are covered, in Lahaul & Spiti:	http://www.hpagriculture.com/Revamped__RWBCIS_from_Kharif_2020_to_Rabi_2022-23.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					Potato, Pea, Cauliflower are covered	
12	Quality Seed Multiplication And Distribution	Under this scheme, expenditure on seed multiplication farms, seed stores, seed testing and certification, subsidy on cost of seeds and cost on demonstrations etc, are met to improve production and area of crops and raise income of small and marginal farmers. This will be done through the creation of various infrastructure, promotion of organic farming and training and capacity building.	Agriculture	Dept. of Agriculture, Govt. of H.P.	Department owns 21 Seed Multiplication Farms where foundation seeds of Kharif and Rabi crops are produced. Annually about 3500 to 4000 quintals seed of cereals, pulses and vegetables are produced in these farms. Further about 90,000 quintals of certified seeds of various crops are distributed to the farmers in the state.	http://hpagrisnet.gov.in/hpagris/agriculture/PDF/State%20%20Sponsored%20Schemes%20%282%29.pdf
13	Rashtriya Krishi Vikas Yojna	The department is providing financial assistance for community owned water harvesting structures, farm ponds and tanks on community based schemes. 100% expenditure is borne by the Govt. of India with an objective to achieve 4% growth in agriculture sector.	Agriculture	Dept. of Agriculture, Govt. of H.P.	1. Recharging of ground water. 2. Reduction in soil loss. 3. Production of Fish Culture. 4. Reduction in flush floods. 5. Mitigation of draught. 6. Better environment conditions in the catchment. 7. Reduction in drainage density.	http://hpagrisnet.gov.in/hpagris/Agriculture/Default.aspx?SiteID=2&PageID=140

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					8. Higher availability of water for drinking and other domestic needs. 9. Higher availability of other needs like fuel and fodder	
14	Deen Dayal Kisan Bagwan Samridhi Yojna	Assist farmers in their own farm land who intend to install micro irrigation system (sprinkler or drip) on their farm lands. The scheme will promote more efficient irrigation systems, rainwater harvesting structures in order to conserve natural resources, improve food crop yield and strengthen existing integrated farming systems.	Agriculture	Dept. of Agriculture, Govt. of H.P.	Preference would be given to farmers growing crops under rain fed situations, Small and marginal farmers, farmers whose livelihood source is Agriculture sector only and neo-literate youths having farm land.	http://hpagrisnet.gov.in/hpagris/Agriculture/Default.aspx?SiteID=2&PageID=142
15	Manures And Fertilizers	**Distribution of Fertilizers**: The State Govt. has allowed cost subsidy on complex fertilizers DAP 18:46,NPK 12:32:16, NPK 10:26:26 and NPK 15:15:15 @ Rs.1000/-per MT. Apart from this cost subsidy @25% is also being provided on 100% water soluble complex fertilizers to the farmers (limited to Rs. 2500 per farmer). **Soil Testing Centres:** Soil testing has great importance for raising agriculture production. The department is providing free soil testing facilities to the farmers.		Govt. of H.P.	-	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		Department has 11 Soil Testing Laboratories besides seven mobile soil testing labs to provide free soil testing facilities to the farmers.				
16	Rajiv Gandhi Micro-Irrigation Scheme	To promote Agriculture in the State by increasing the productivity of crops, 80% assistance shall be provided to individual farmer for Micro- irrigation Systems	Agriculture	Dept. of Agriculture, Govt. of H.P.	Outlay of Rs.154 Crore over a period of 4 years. Through this Project, 8,500-hectare area will be brought under Drip/ Sprinkler Irrigation System benefitting 14,000 farmers. Farmers will get a subsidy of Rs.113 Crore during the project period. The project is under appraisal with NABARD under RIDF funding.	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
17	Uttam Chaara Utpadan Yojna	To increase fodder production in the State, the scheme will supply quality Seed of Fodder Grasses, Cuttings, Seedlings of Improved Fodder Varieties at subsidised rates to the farmers.	Agriculture	Dept. of Agriculture, Govt. of H.P.		http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
18	Mukhya Mantri Khet Sanrakshan Yojna	Under this scheme the Government has enhanced the subsidy from existing 60% to 80% for wildlife conflict measures. The farmers will be given option for installation of solar fencing by themselves provided that the technical specifications are fulfilled.	Agriculture	Dept. of Agriculture, Govt. of H.P.	This scheme is being executed through 5 empanelled firms and the department has approved costs per running meter for Regular Electric powered and Solar Electric Powered fencing.	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
19	Mukhya Mantri Green House Renovation Scheme	Under this scheme, 50 % subsidy will be provided to the farmers for the replacement of poly sheets after 5 years of setting up of polyhouse or from damage due to natural calamities.	Agriculture	Dept. of Agriculture, Govt. of H.P.	-	http://farmer.gov.in/imagedefault/handbooks/FFH-2017HimachalPradesh-English.pdf
20	Angora Wool Development Scheme	Improve scientific rearing of Angora rabbits through training, employment opportunities and improve existing small scale, cottage & handloom set up for production of the Angora wool.	Animal Husbandry	Sheep and Wool Boards, Govt. of H.P.	In India, Angora Rabbit Wool is reared in hilly areas of Uttaranchal, Himachal Pradesh and in some other states where climatic conditions are suitable for its rearing. The total Angora population in the country is around 50,000 and nearly 30,000 Kg. wool is produced annually. With the assistance of UNDP, the Department has established a germ plasm centre at Nagwain (District Mandi) where pure breed German Angora rabbits are being bred on scientific lines.	http://woolboard.nic.in/download/I.C.pdf
21	Uttam Pashu Puraskar Yojna	Provides incentive and encouragement to livestock owners for rearing good quality high yielding animals	Animal Husbandry	Animal Husbandry Department, Govt. of		http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/D

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
				Himachal Pradesh		ept_Activities__July_2017.PDF
22	Scheme For Provision Of Subsidized Rams To Sheep Breeders	Improve quality and quantity of Wool being produced in the state, thereby ensuring better economic returns to the Sheep Breeders.	Animal Husbandry	Animal Husbandry Department, Govt. of Himachal Pradesh	Breeding Ram will be provided on 60% subsidy.	http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/Dept_Activities__July_2017.PDF
23	Bpl Krishak Bakri Palan Yojna	Increase income generation opportunities for economically weaker segments of the society as well as meat production through provisions of subsidies for goats	Animal Husbandry	Animal Husbandry Department, Govt. of Himachal Pradesh	Goat units of (10 female +1 male/ 4 female +1 male /2 female +1 male) will be provided on 60% subsidy.	http://www.hpagrisnet.gov.in/Agrisnet/AnimalHusbandry/pdf%20files/Dept_Activities__July_2017.PDF
24	Mukhyamantri Madhu Vikas Yojana	Under the scheme, beekeeping and honey production is given a boost through subsidies, training, assistance with infrastructure.	Horticulture	Department of Horticulture, Govt of India	Beekeepers will be given 80 per cent cost amount or Rs 1,600 per bee colony to raise 50 bee colonies. In each district, a bee-breeder of 300 bee colonies will be given an amount of Rs 3 lakh. They will be given 50 per cent subsidies on the transportation per year. To establish a honey processing unit, 100 per cent of the cost of the project will be provided for the plantation of bee flora in two bighas. The farmers	https://hpkangra.nic.in/scheme/the-mukhyamantri-madhu-vikas-yojana/

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					will also get 50 per cent subsidies on honey extractor, food grade container in which Rs 7,000 per set will be provided. Under the Horticulture Mission, there is a provision of providing 50 per cent subsidy on the production of bee colonies to the beekeepers	
25	Pushp Kranti Yojana	Under this scheme, farmers are provided with high-tech poly houses, training and other means of flower production. The scheme also provides loans to unemployed youth to take up flower production.	Horticulture	Department of Horticulture, Govt of India	Farmers are also offered around 25% discount while sending their cultivated flowers via state owned transportation service provider HRTC buses.	http://www.eudyan.hp.gov.in/UploadedImages/Document/guiudelines%20of%20Himachal%20Pushp%20Kranti%20Yojna.pdf
26	Anti-Hail Net (Bagwani Surksha Yojna)	The state government has extended the subsidy scheme on anti-hail nets to agriculture. Until now, the scheme was available only for horticulture. Under this scheme, the farmers will get 80 per cent subsidy on hail nets for 5,000 square meter area.	Agriculture/Horticulture	Department of Horticulture, Govt of India	The farmers involved in multi-cropping, including both horticulture and agriculture, too, can avail the scheme. In the absence of anti-hail nets, many crops such as peas, cabbage, tomatoes and cauliflower etc suffer huge losses in the event of inclement weather. The farmers would need to	http://eudyan.hp.gov.in/UploadedImages/Document/Anti%20Hail%20Net%201.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					apply to the department along with documents related to land and their Aadhaar Card.	
27	Khumb Vikas Yojna	This scheme enables increased production of khumb/mushroom in the state. Under the scheme, training and assistance is provided to the farmers starting from production of khumb to its marketing the produce through proper channels.	Agriculture/ Horticulture	Department of Horticulture, Govt of India	Allowances and subsidies are also provided to the farmers for purchasing manure, compost, farm tools, etc. Technical guidance and disease control activities are also conducted for the farmers by the Horticulture department.	http://eudyan.hp.gov.in/UploadedImages/Document/Himachal%20khumb%20vikas%20yojna%202019-20.pdf
28	State Mission on Food Processing (SMFP)	The centrally sponsored mission intends to promote facilities for post-harvest operations including setting up of food processing industries, improve the capacity of food processors, support SHGs in the food-processing sector and capacitate/upskill manpower in the industry. This can be done through augmenting farm gate infrastructure, supply chain logistics, storage and processing capacity. The mission also aims to raise the standards of food safety and hygiene in order to meet the norms setup by FSSAI, and facilitate food	Food processing	Department of Industries, Govt. of H.P.		https://emerginghimachal.hp.gov.in/themes/backend/uploads/notification/SMFP.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		processing industries to adopt HACCP and ISO certification norms.				
29	Vidyarthi Van Mitra Yojna	The scheme aims at sensitising students and the school administration about forests and their importance by involving them in plantation of saplings/afforestation in various degraded forest areas.	Forests	Department of Forests, Govt. of H.P.		https://hpforest.nic.in/files/Vidyarthi%20Van%20Mittar%20Yojna.pdf
30	Samudayik Van Samvardhan Yojna	The scheme intends to provide maximum economic benefits to the members of JFM/VFDSs in the form of valuable Forest Products and other usufruct yielding high economic returns in the market as well as productive usage water. The overall outcomes expected from this is the improvement of local ecosystem services, enhancement of forest cover and rejuvenation of village level institutions related to conservation and sustainable use of natural resources through awareness, education and organization of village communities.	Forests	Department of Forests, Govt. of H.P.		https://hpforest.nic.in/files/SAMUDAYIK%20VAN%20SAMVARDHAN%20YOJNA.docx
31	Prakritik Kheti-Khushhal Kisan	The scheme aims to promote natural farming/zero-budget farming in the state through subsidies, financial assistance and	Agriculture	Department of Agriculture	75% subsidy on drums which are required to make inputs for natural farming	http://himachalpr.gov.in/PressReleaseByYear.aspx?Language=1&ID=

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		training. Natural farming requires minimal cost inputs and depends on the natural resources for crops.			Financial assistance of Rs. 50,000 to open natural resources store in village Training and workshop to create awareness about natural farming for farmers	11892&Type=2&Date=25%2f04%2f2018
32	Mahila Mandal Protsahan Yojana	To encourage women groups and to strengthen the Mahila Mandals the Government has instituted this Award scheme. The awards are given through Development Blocks for providing incentives to the Mahila Mandals, which excel in the field of Rural Development.		Rural Development Department, Govt. of H.P.		http://www.hprural.nic.in/RFPMM.pdf
33	Maharishi Valmiki Sampoorna Swachhta Puraskar	To motivate rural communities to adopt safe sanitation practices and end open defecation, this award was instituted. The award is won by the cleanest gram panchayat, at the block, district, division and state level based on an annual competition.	Sanitation	Rural Development Department, Govt. of H.P	Any Gram Panchayat that satisfies the following conditions is eligible to participate in the MVSSP competition • The Gram Panchayat should have become open defecation free. • Winning Gram Panchayats at any level are excluded from participating for the Award for that level for the next three years. However, it can participate in this competition at a higher level e.g. Panchayats	https://hprural.nic.in/MVSSP_2009_Guidelines.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					having won the Block level award in the previous year, would be eligible to compete only for District, Division and State Award in the next year's competition. • State level winner is not eligible to participate in the competition for 3 years after the year of winning.	
34	Vikas Mein Jan Sahyog	Under this programme, an open offer was given to the public that if they come forward with a public share of 30% of the project cost, Govt. will provide them the rest and sanction them a developmental scheme benefiting the community.	Infrastructure	Since the works under this scheme would be implemented by different State Government agencies such as PWD, Rural Development, Irrigation, Agriculture, Health, Education, Area Development Authorities, Water Supply and Sewerage Boards, Housing Corporation etc. the Heads of the respective	According to Govt. decision, the public share for the sanction a particular scheme in rural areas was raised to 75% of the estimated cost of the project, thereby reducing the public share to 25%. The limit for the sanction of project was also raised to Rs. 1.00 lakh. Subsequently, in the year 1997 the limit for the scheme to be sanctioned by the Deputy Commissioners was raised to Rs. 3.00 lakh and now it has been raised to Rs. 5.00 lakh.	https://himachal.nic.in/contprintcont.php?lid=7931&cont=70&lang=1&dpt_id=198&level=1&sublinkid=7656

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
				districts would be responsible for the coordination and overall supervision of the works under this scheme at the district level.	i) Construction of buildings of Government education institutions. ii) Construction of multipurpose community/public assets. iii)Construction of motor able roads and ropeways. iv)Construction of irrigation schemes/drinking water schemes/installation of hand-pumps. v) Construction of buildings of public health services. vi)Provision of important missing links; such as, three-phase transmission lines, transformers, X-ray plants, ambulances etc. vii)Provision of consumable items like lab. equipment & furniture etc.	
35	Border Area Development Programme	The main objective of the programme is to meet the special needs of the people living in remote, inaccessible areas situated near the border with an emphasis on the schemes for employment promotion, production-oriented activities which provide critical inputs to the social sectors,	Infrastructure		Border Area Development Programme in Kalpa and Pooh Blocks of the Kinnaur district and Spiti Block of the District Lahaul & Spiti.	http://himachalservices.nic.in/tribal/pdf/ComprehensiveDev.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
		infrastructure and economic development activities.				
36	Green Gold	The Government of India the Green Gold project for the District Chamba under SGSY Special Project Component with a total Project Cost of Rs.1488.73 lacs which includes subsidy of Rs.1361.23 lacs, Rs. 127.50 lacs as loan component and beneficiaries share. Centre and State Government will share the subsidy component on 75:25 sharing basis.	Agriculture/Horticulture	Rural Development Department, Govt. of H.P	Under this Project the following activities will be taken: - • Cultivation of Medicinal plants, Aromatic plants, Flowers and Orchids • Cultivation of Off-Season vegetables. • Cultivation of Mushroom • Improved Dairy Management	https://hprural.nic.in/Schemes.htm
37	National Rural Employment Guarantee Scheme (MGNREGA)	The scheme grants an entitlement of 100 days of guaranteed employment in a financial year per household. This entitlement of 100 days per year can be shared within the household. All adult members of the household who registered can apply for work. To register, they have to:- a) Be local residents i.e. those residing within the gram panchayat. b) Be willing to do un-skilled manual work. c) Apply as a household at the local gram panchayat.		Rural Development Department, Govt. of H.P	As per schedule 1 of the Act the focus of the scheme is on the following works in their order of priority:- (i) Water Conservation and Water Harvesting works; (ii) Drought proofing works (including afforestation and tree plantation) (iii) Irrigation canals including micro and minor irrigation works; (iv) Provision of irrigation facility, horticulture	http://www.hprural.nic.in/nre.htm

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					plantation and land development facilities on land owned by the households belonging to the Scheduled Caste and Scheduled Tribes or to BPL families or to beneficiaries of land reforms or to the beneficiaries under the Indira Awas Yojana of the Government of India; (v) Renovation of traditional water bodies including desiliting of tanks ; (vi) Land developments works; (vii) Flood control and protection works including drainage in water logged areas; (viii) Rural connectivity to provide all-weather access; and (ix) Any other work which may be notified by the Government of India in consultation with the State Government.	
38	State	The fund allows for afforestation, Soil & Water conservation	Forests	Dept. of Forests, Govt. of India		https://hpforest.nic.in/files/State%2

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
	Compensatory Afforestation Fund Management and Planning Authority (State CAMPA)	strategies that are suitable for a mountain state like Himachal Pradesh. This may include (a) Conservation, protection, regeneration and management of existing natural forests; (b) Compensatory afforestation and Catchment area treatment activities; (c) Environmental services (d) Research, training and capacity building.				0Compensatory%20Afforstation%20Fund%20Management%20and%20Planning%20Authority.pdf
39	One District One Product (ODOP)	The scheme adopts the approach to reap the benefit of scale in terms of procurement of inputs, availing common services and marketing of products. ODOP for the scheme will provide the framework for value chain development and alignment of support infrastructure.	Food processing	Ministry of Food processing industries, Govt. of India	There may be more than one cluster of ODOP products in one district. There may be a cluster of ODOP products consisting of more than one adjacent district in a State. The ODOP product could be a perishable Agri produce, cereal-based product, or a food product widely produced in a district and their allied sectors. Besides, certain other traditional and innovative products including waste to wealth products could be supported under the Scheme. For example,	https://mofpi.nic.in/pmfme/one-district-one-product

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
					honey, minor forest products in tribal areas, traditional Indian herbal edible items like turmeric, amla, haldi, etc.	
40	Prime Minister's Employment Generation Programme (PMEGP)	The programme is concerned with generating employment opportunities in rural as well as urban areas of the country through setting up of new self-employment ventures/projects/micro enterprises.	Industry	Ministry of Micro, Small and Medium Enterprises (MoMSME), Govt. of India	The main focus of this programme is on traditional artisans and unemployed youth to arrest put migration from rural to urban areas. SHGs are also eligible to apply.	https://cdn.s3waas.gov.in/s368d30a9594728bc39aa24be94b319d21/uploads/2020/08/2020082731.pdf
41	Soil Health Management (SHM)	SHM aims at promoting location as well as crop specific sustainable soil health management and judicious application of fertilizers. Under the SHM, soil testing labs can be established at district / block level.	Agriculture/Horticulture	National Level Advisory Committee, Executive Committee and State Level Committee under the National Mission for Sustainable Agriculture (NMSA), District Level Executive Committee (DLEC)	Main objectives are i. Employment generation for rural youth. ii. To improve timeliness in analysis of soil samples. iii. Introduction of the Single Window approach from collection to issue of SHC so as to minimize delays and maximize convenience to farmers iv. Online delivery of soil health cards to the farmers using Soil Health Card Portal. v. Provide soil testing facilities to farmers at their door step.	https://soilhealth.dac.gov.in/Content/Guideline_Soil TestingLab_Project.pdf

S. No	Name of Scheme	Details of Implementation	Sector	Nodal Department	Notes, if any	Reference
42	Pradhan Mantri Kisan Samman Nidhi	The scheme aims to supplement the financial needs of all landholding farmers' families in procuring various inputs to ensure proper crop health and appropriate yields, commensurate with the anticipated farm income as well as for domestic needs.	Directorate Of Land Records, Govt. of H.P.		Beneficiary: A landholder farmer's family is defined as "a family comprising of husband, wife and minor children who own cultivable land as per land records of the concerned State/UT". The existing land-ownership system will be used for identification of beneficiaries for calculation of benefit. Benefits: Under the Scheme an income support of Rs.6000/- per year is provided to all farmer families across the country in three equal instalments of Rs.2000/- each, every four months.	https://cdn.s3waas.gov.in/s3577bcc914f9e55d5e4e4f82f9f00e7d4/uploads/2020/05/20200501119.pdf

PART D: MONITORING FRAMEWORK FOR THE RESTORATION PLAN

The monitoring framework has been divided into two phases. The first phase (restoration phase) encompasses the time frame of implementing the restoration activities. The second phase (post restoration phase) relates to the time frame after 3 years of restoration, when the polygrid is reopened for grazing. The indicators that need to be monitored during the restoration phase have been designed in a manner that the same will help to generate a database which will form the baseline for future evaluation. The data collection framework has also been developed. These indicators will help to assess and evaluate the restoration activities. The indicators for the post restoration phase along with the indicators for the restoration phase will together provide a broad picture and a complete understanding of the restoration programme. This will also help to assess the success of the entire restoration plan. Based on the learnings from this assessment, the restoration plan can be modified, as when required, by the Forest Department. This revision should be carried out in consultation with all stakeholders.

The following steps are recommended for the monitoring of restoration of grasslands.

1 Phase: Restoration Phase (First 3 Years)

Place: Selected Enclosed Polygrid for Restoration

1.1 Creation of Plantation Database

Any successful restoration plan would require an organised database. The database should keep records of all the collected seeds, their variety, site of collection, date of collection, associated labour and material costs and so on. Such data should be assessed for plantation success i.e., most successful or dominant species, most biologically strong seeds used etc. at the end of one polygrid restoration cycle and before choosing the next polygrid plantation. Such data can also suggest the details on local seed viability, adjusting the plantation/nursery calendar and budgetary revisions. An indicative datasheet template is attached in Annexure 2.

1.2 Establishing Photo Stations

Photo stations refer to permanent photography places. These are established to capture photographs of a specific area over time, in order to visualize and monitor the change in the area. Generally, a steel T-Post is placed at a certain point in the area under restoration, facing a particular direction with a broad view of the plantation. GPS location is taken for each photograph to locate the position in future. Photo station monitoring[63] can be done in any three of the following ways or all together, depending on the area of plantation, required objectives and available manpower;

[63] Gearhart A and Launchbaugh K. Photo Monitoring for Ranchers Technical Guide. A Pacific Northwest Extension Publication (Online). Source: http://www.extension.uidaho.edu/publishing/pdf/PNW/PNW671.pdf

i. Single view monitoring: A camera is placed over the steel structure and generally a photo is taken over time from the same position to compare the changes in the area visually.
ii. Multiview monitoring: The steel T can also be placed in the middle of the planted area from where the monitoring can be confirmed in four cardinal directions (North, South, East, West). In this case a photograph is taken from a single T-shaped steel platform at each of the four directions and grassland growth is compared visually at all the directions together.
iii. Ground monitoring: Photographs can also be taken of the ground (cover) within the planted area at certain locations. Such photographs require permanent markings for photo capture by placing a wooden square box or four wooden stubs at each corner to locate the area in future.

Few representative images have been included in the annexure 9. Photographs are suggested to be taken at the start of the plantation in early summer and at the end of the summers just before the winter sets in. Indicative datasheet templates are attached in Annexure 3.

1.3 Species Composition (identification of native and invasive species)

Monitoring of species composition is important step, in order to measure the success of the restoration activities (plantation) being undertaken in the degraded grasslands. Seasonal (non-winter) nested quadrats[64] in each planted polygrids will help in estimation of the most dominant or rare species, growth rate, distribution or spread, invasive species etc. Such estimates yield a basic idea about which species have the highest survival chance in the restored sub river basin and restoration plans can be modified accordingly for better management. This can also help to identify key species of grasses and legumes in each areas area under restoration. Collection of field data can be easily performed by the trained para-taxonomists under the guidance of the Forest Department. It is recommended to collect this data at the beginning and end of each non-winter season at each restoration site. Any invasive species, that are encountered during these surveys, should be de-weeded from the polygrids on priority basis. An indicative datasheet template is attached in Annexure 4.

1.4 Soil Quality

Monitoring of soil quality and availability of nutrients is crucial for the successful implementation of the grassland restoration. Soil in the area that has been chosen for plantation, should be monitored at the beginning of each season (early summer and post monsoon). Soil pH, organic carbon, electrical conductivity, soil nitrate-nitrogen, phosphate-phosphorus and potassium should be tested using standard protocols. These have been provided in Annexure 1. regularly. It is expected that the soil nutrient condition will improve

[64] Multiple different size of small quadrats inside a larger quadrat area are called nested quadrat. Here, nested quadrat can be as small as $1m^2$. Usually, the size increases from $1m^2$ to $5m^2$ to $10m^2$ inside a larger quadrat size of $20m^2$. Refer Coulloudon, Bet., Eshelman, K., Gianola, J., Habich, N., Hughes, L., Johnson, C., Pellant, M., Podborny, P., Rasmussen, A., Robles, B., Shaver, P., Spehar, J., Willoughby, J. 1997. Sampling Vegetation Attributes, USDA, Bureau of Land Management, Denver, Colorado. Pp. 164.
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044175.pdf - ---- instead of et al, please add full citation

after the establishment of the plantations, especially nitrogen fixing legumes. Maintaining a site-specific record sheet for each soil nutrient is essential to monitor the success of the restoration activities. An indicative datasheet template is attached in Annexure 5.

1.5 Springshed Discharge

Higher elevations in the Himalayas within the study area, have been recorded to suffer from water scarcity and altered precipitation due to climate change. This has impacted natural vegetation growth and therefore, measuring and monitoring water availability within restoration sites is important.

Monitoring of springshed discharge by measuring the volume of water through stop-watch-container method[65] is the most cost effective and easy way. Springshed water discharge in this method is measured through a known volume container such as 5 litre bucket and a stopwatch. First the bucket is placed under the discharge point and the stop watch is started immediately. Then the time for filling the bucket from the water of spring flow is measured and discharge is calculated. Suppose, a spring takes 30 seconds to fill the 5-litre bucket, then the spring discharge is as follows;

30 seconds = 30/60 minute = 0.5 minute

Discharge = Volume/time

= 5 litre/0.5 min

= 10 litre per minute.

Discharge data at the beginning of summer and end of monsoon should be recorded every year. Monitoring water discharge can help in reassessment of polygrid or plantation selection site over the years in the region for future plantations for the grassland restoration. An indicative datasheet template has been attached in Annexure 6.

1.6 Climate

Climate plays a crucial role in the success of the restoration of grasslands in the high altitudes. The location of the restoration sites allows only 6 months of plant growth since, half of the year, the region is under snow cover. This determined the species selected for plantation. However, climate change impacts on precipitation intensity and timing have been noted in the region as well as receding number of glaciers in the area. These changes can severely impact the restoration success as well as existence of grasslands in these areas in the near future. It is therefore recommended to monitor the regional climate from the very beginning, collect and analyse the climatic data of the area, which will help to align the timing of the plantations in the area, for the success of the same. Required data can be collected from the regional weather station (Shimla) Indian Meteorological Department (IMD) initially, followed by

[65] Bamola, V., Ngullie, A., Kumar, R., Sharma, A., Gautam A. 2018. Community based Springshed in Response to drying springs in Nagaland. In: Climate Change: Impact, Adaptation & Response in the Eastern Himalayas, pp. 40–51, ISBN: 978-93-88237-16-1, Excel India Publishers, New Delhi, India

installation of data loggers and hand held enviro-meters for micro climatic data in the region. An indicative datasheet template has been attached in Annexure 7.

2 Phase: Post Restoration (After first 3 years)

Place: Selected Open Polygrid for Restoration

2.1 Impact of Grazing on Species Growth:

Grassland growth monitoring without grazing disturbances by livestock and wild ungulates is important in order to determine the key forage species (both grasses and legumes) in the area and also for for comparing the natural growth with that of grazing disturbed grass and legume species. In order to evaluate this,a small (10 square feet) grazing exclosure can be demarcated in the restoration area,at the beginning of the plantation. Plant species and their height should be measured at the beginning of summer and post monsoons just before winter within the exclosure every year. Such data can help in the identification of key species, most foraged species and growth differences in the natural (enclosed) and grazed area. After the end of first three-year plantation cycle the collected data will help to revaluate the choice of species for plantation in the next polygrid for restoration. The species growth for both outside the exclosure and inside should be recorded in similar quadrat data sheet. An indicative datasheet template has been attached in Annexure 8.

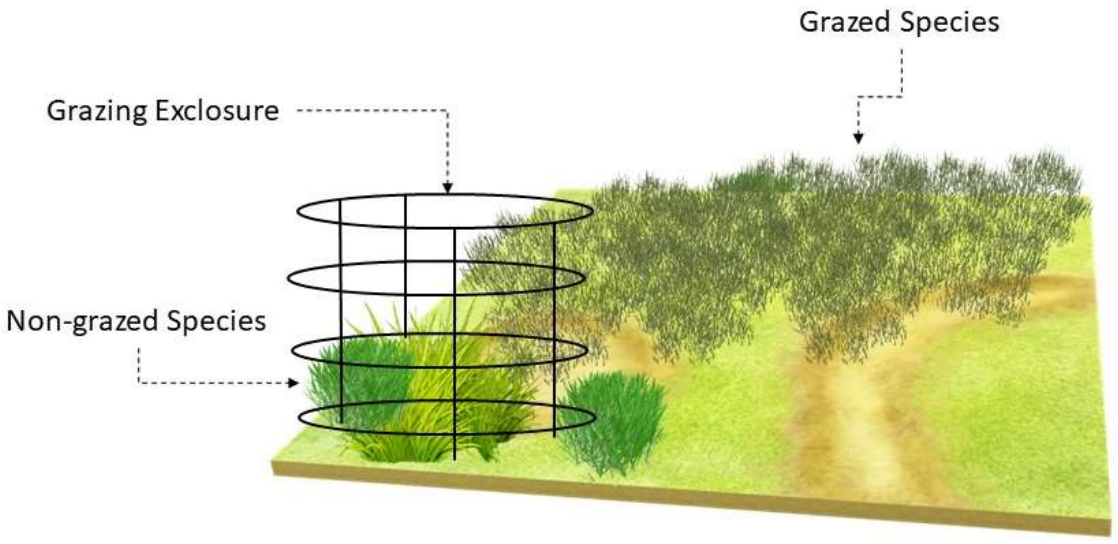

Figure 1: A representative image of grazing exclosure in a pastureland

2.2 Implementation of Geographic Information System

Monitoring of larger areas in isolated or rough terrain is a cost and labour intensive exercise. . Progress therefore can be monitored using modern scientific tools and techniques. Analysis of satellite imagery for the assessment of degradation or restoration can carried out using GIS platforms. Baseline data for the restoration in selected sub river basin has been already prepared through the present study by ICLEI – Local Governments for Sustainability, South Asia, delineating degraded areas with appropriate methodology. The same can be repeated easily for the reassessment of the restoration success. Care needs to be taken that the satellite data is sourced for the same month as that was used during the analysis for assessment of degradation. The Forest Department can carry out the same through their GIS cell or can carry out this assessment in collaboration with academic institutions or NGOs (who have the required expertise). Monitoring should be performed at an interval of five years.

2.3 Reassessing Ecosystem Services

Perception of local stakeholders on the success of plantation is another indicator, measuring the success of grassland restoration. Local perceptions on the growth and spread of grasslands within and around the restoration sites, availability of required forage for their livestock in the restored sites should be measured every five years. Responses of the local stakeholders of their perceptions of the present condition of the grasslands in the restored area may be revaluated post plantation activities. Survey questions, developed and used by ICLEI-Local Governments for Sustainability, South Asia (and shared in third report) can be used to evaluate the success, and level of degradation and same conditional stages of all the identified ecosystem services. These questionnaires can be administered by the Mahila Mandal, under the supervision of the Forest Department. The questionnaires will need to be administered to the local community as well as the Gaddis. These perspectives from both the local residents and Gaddis should be considered essential to the monitoring programme for evaluating grassland restoration efforts.

2.4 Revising Budget

Appropriate financial allocation and timely disbursement of the same plays a crucial role for the successful implementation and completion of grassland restoration While a tentative or provisionally approved budget can be used to initiate the implementation, it is reasonable to track cost at each step of the programme, so that the allocated budget for each activity can be reasonably utilized and unnecessary expenses can be identified and minimised. A review of the budget should be undertaken at the end of each three-year restoration cycle.

Annexure 1: Protocols for soil nutrient analysis

Soil pH

Air-dried soil was sieved using mesh no. 8 sieve and the fraction that passed through sieve was collected and used for estimation of pH, percent organic carbon and matter and N, P, K levels. Soil and distilled water was mixed in the ratio of 1:5 and stirred on a magnetic stirrer for 30 min. The soil suspension was allowed to stand for 30 min and clear supernatant was used to measure soil pH. Orion digital pH meter (Model 201) was used to determine the pH. For each sample three replicates were used. The mean of three replicates were taken as a measure of soil pH.

Percent Organic Matter

Walkley and Black's rapid titration method (Jackson, 1973) was used to determine organic carbon. 0.25g sieved soil sample was placed in 500 ml conical flask. 10 ml of 1N $K_2Cr_2O_7$ was added to the soils followed by 20 ml of concentrated H_2SO_4. The flask was gently shaken and then kept covered with watch glass. The flasks were allowed to stand for 30 minutes. At the end of 30 minutes period, 200ml distilled water was added followed by 10 ml of H_3PO_4 and 1 ml of diphenylamine solution (0.5 g of diphenylamine in 80 ml distilled water and 20 ml H_2SO_4). The sample was titrated against 1N Fe $(NH_4)_2$ $(SO_4)_2.6H_2O$ and dull green was taken as the end point. The amount of ferrous ammonium sulphate required to titrate the sample mixture was recorded. A blank (without soil) was used as control. % organic carbon was obtained by the following formula:

$$\% \text{ organic carbon} = \frac{(V_1 - V_2)\ X100X.003}{W}$$

Where,

V_1= Volume of the titre required to neutralize $Cr_2O_7^{2-}$ in the blank,

V2= Volume of the titre required to neutralize the unreduced $Cr_2O_7^{2-}$ in the test sample,

W= Weight of the soil in grams,

0.003= Conversion factor (derived on the basis that 1ml of 1N, and

$K_2Cr_2O_7$ is equivalent to 3 mg carbon).

Percent organic matter was calculated by multiplying the % organic carbon with 1.724 (van Bermmelen factor derived on assumption that the organic matter is represented by 58 % carbon).

Nitrate-nitrogen (NO_3-N)

Soil nitrate-nitrogen was determined by colourimetric method using salicylic acid (Cataldo et al., 1975). 10 g of dried, sieved soil was extracted with 20 ml of 0.5 M K_2SO_4 by constant shaking for 30 minutes. After extraction, the sample was filtered through filter paper (Whatman no.42) to obtain a clear solution. 0.5 ml of the sample was pipetted in test tube and 1 ml of 5 % freshly prepared salicylic acid solution (5g of salicylic acid in 95 ml of conc. H_2SO_4) was added. The reaction mixture was incubated for 30 min and O.D. was taken at 410 nm on a spectrophotometer (Bausch and Lomb, Spectronic 20). The concentration (µg/ml) of the reaction mixture was determined by reading the O.D. from calibration curve.

Nitrate standard was prepared by dissolving 7.223 g KNO_3 (dried at 105^{o}C for 2 hours and cooled in a dessicator) in deionized water. A stock solution of 1000µg/ml concentration was used for preparation of standards ranging in concentration from 1 to 10 µg/ml nitrate. These standards were prepared by appropriate dilution of the stock and processed in the same way as the test sample.

The NO_3-N in the sample was calculated by:

$$NO_3\text{-N } (\mu g/ml \text{ soil}) = \frac{CXV}{W}$$

Where,

C= Concentration of NO_3-N in test sample read from the calibration curve,

V= Extract volume (ml), and

W= Weight of sample (g).

Phosphate-phosphorus (PO_4-P)

Molybdenum blue method was used to estimate the PO_4-P content in the soil samples (Allen et al., 1974). 1 g of air-dried, sieved soil sample was extracted with 25 ml of 2.5% acetic acid by constant stirring for 30 minutes. The suspension was filtered through Whatman filter paper no. 1 and the filtrate was used for phosphate analysis. 10 ml of soil suspension was taken in a 50 ml test tube and 2 ml acidified ammonium molybdate solution [(a) 5 g $(NH_4)_6 Mo_7O_{24}.H_2O$ in 40 ml H_2O, dissolved by warming; (b) 56 ml conc H_2SO_4 added to 80 ml water and cooled; added (a) to (b) and the final volume was adjusted to 200 ml with deionized water] was added to it. After mixing thoroughly, 2 ml $SnCl_2$ (freshly prepared by dissolving 0.5 g $SnCl_2.2H_2O$ in 250 ml of 2% HCl) was added. Reaction mixture was agitated on a cyclomixer and the samples were allowed to stand undisturbed for 30 minutes at room temperature. OD was taken at 700 nm on Bausch and Lomb Spectronic 20 spectrophotometer; 2.5% acetic acid was taken as blank.

Standard solution (100 ppm) of phosphate was prepared by dissolving KH_2PO_4 in deionized water. Six serial standards in the concentration ranging from 0-30 ppm were prepared from the KH_2PO_4 stock standard solution. The concentration of PO_4-P in the test sample was calculated by:

PO_4-P (ppm)= $\frac{AX25}{10}$

Where,

A= Concentration of PO_4-P in the test sample read from calibration graph,

25= Total volume of the sample (ml), and

10= Aliquot (ml) of the sample used.

Potassium (K^+)

Potassium was estimated using the method described by Allen et al. (1974). 1 g of air-dried and sieved soil sample was extracted with 25 ml of 25 % acetic acid by constant stirring for 30 minutes. The suspension was filtered through Whatman filter paper no. 1 and the filtrate was used for potassium analysis by Atomic Absorption Spectrophotometry. Elemental analysis was carried out on Shimadzu (AA-640-12) Atomic Absorption Spectrophotometer and the instrument was calibrated using 1 ppm and 2 ppm potassium standard solutions. Absorbance readings of the soil extract were measured at a wavelength of 766.5 nm.

K in the test sample was calculated by:

K (ppm)= $\frac{C \quad X \quad V}{10^4 X \ W}$

Where,

C= Concentration of the sample (µg/ml),

V= Extract volume of the sample (ml), and

W= Weight of the sample (gm).

Annexure: 2

Datasheets – Plantation Database

Table 1: Indicative datasheet for collection of details on the plants/seeds/plugs used for each plantation site for the restoration program.

Place		**Site No**		**Cycle Year 1/2/3**	
GPS reading		**Elevation**			

S.No	**Name of Species**	**Life form (Seed/Plug etc)**	**Cost (INR)**	**Sourceof the species**	**Date of order/Collection**	**Date of Delivery**	**Viable up to**	**Approved by**	**Remarks**

Table 2: Datasheet for noting labour costs per activity during the restoration program at each site.

Place		**Site No**		**Cycle Year 1/2/3**			
GPS reading		**Elevation**					
S No	**No of Labour hired**	**Date of Hiring**		**Daily Wages (INR)**	**Task Assigned**	**Number of man days used to complete each task**	**Assigned by**

Annexure: 3

Datasheet – Photo Station

Table 3: Representative datasheet of photo collection for monitoring restoration.

Place				**Site No**		**Cycle Year 1/2/3**		
GPS reading				**Elevation**				
S. No	**Photo station ID**	**Photo station GPS**	**Photo Number/ID**	**Date**	**Time**	**Direction (N,S,E,W)**	**Photographer**	**Type of Photo (Landscape/Ground)**

Annexure: 4

Datasheets – Species composition

Table 4: Representative datasheet of quadrat for monitoring restoration.

Place		Site No		Cycle Year 1/2/3		Date								
GPS		Elevation				Quadrat size								
S.No	Species	Plant Type (Grass/Legume)	Origin (Native/ Invasive)	No of Individuals/Quadrat										
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	

Annexure: 5

Datasheet – Soil Quality

Table No 5: Representative datasheet of soil quality for monitoring restoration.

Place		**Site No**		**Cycle Year 1/2/3**				
GPS reading		**Elevation**		**Date**				
S. No	**Sampling Point**	**GPS of Sampling point**	**Soil Type**	**pH**	**Potassium (ppm)**	**Organic carbon (%)**	**Available Nitrogen (kg/ha)**	**Available Phosphorous (kg/ha)**

Annexure: 6

Datasheet – Spring shed Monitoring

Table 6: Representative datasheet of water discharge for monitoring restoration

Place		**Site No**		**Cycle Year 1/2/3**		
GPS of nearest polygrid		**Elevation**				
S. No	**Spring shed GPS**	**Date**	**Time**	**Volume of Bucket (Litre)**	**Time to Fill (Minutes)**	**Water Discharge (Litre/Minute)**

Annexure: 7

Datasheet – Climate

Table 7: Representative datasheet of climate data for monitoring restoration

Place		Site No		Cycle Year 1/2/3		
		Elevation				
S. No	Polygrid GPS reading	Date	Time	Minimum Temperature °C	Maximum Temperature °C	Precipitation (mm)

Annexure: 8

Datasheets – Species composition (Within Enclosure)

Table 4: Representative datasheet of quadrat for monitoring restoration.

Place		Site No		Cycle Year 1/2/3		Date								
GPS reading		Elevation				Quadrat size	1 x1 m							
S.No	Species	Plant Type (Grass/Legume)	Origin (Native/ Invasive)	No of Individuals/Quadrat										
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	

Annexure: 9

Images for Photo point Monitoring:

Figure 15: Representative image of photo point monitoring. Source: https://www.agric.wa.gov.au/rangelands/grassland-monitoring-sites-pastoralists-western-australia

Figure 16: Representative image of photo point monitoring. Source: http://www.extension.uidaho.edu/publishing/pdf/PNW/PNW671.pdf