MANUAL FOR COMPREHENSIVE ENVIRONMENTAL AND SOCIO-ECONOMIC MONITORING IN KAILASH SACRED LANDSCAPE, INDIA

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Citation:

Rawat.G.S and Gopi.G.V (Ed.) (2017). Manual for comprehensive environmental and socio-economic monitoring in Kailash Sacred Landscape, India. Wildlife Institute of India, Dehradun-248001, India. 195pp.

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FOREWORD

The Himalayan region, one of the important biodiversity hotspots on earth, is well known for its varied ecosystems having immense biological, geo-hydrological, socio-cultural and aesthetic values. Also termed as 'third pole' or 'water towers' of Asia, this region provides numerous ecosystem services to the millions of people living both within and adjacent regions in the varied landscapes. However, most of the ecosystems in the region are undergoing rapid changes due to chronic stress caused by natural and anthropogenic drivers including climate change. This has implications for the flow of ecosystem services and overall human wellbeing in the region. Therefore, scientific management of these ecosystems for sustaining services and monitoring their health under changing environment becomes imperative. Need for long term ecological monitoring of sensitive ecosystems, especially under the wake of changing climate, has been felt strongly all over the globe. However, very few initiatives have been taken to establish the baseline data following standard monitoring protocols and build capacity of various stakeholders in detecting the changes in the biological and socio-economic environment. Recently, the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India has initiated a programme, 'Long Term Ecological Observation Network' in the country in order to institutionalize the scientific monitoring of ecosystems across various biogeographic zones of the country under changing climate. This initiative will give a boost to long term ecological monitoring in various parts of the country.

It is a matter of great satisfaction that Wildlife Institute of India (WII) and several national and state level Institutions based in the state of Uttarakhand have initiated a long term ecological monitoring in the Indian part of Kailash Sacred Landscape (KSL). Participatory monitoring forms one of the important activities of the ongoing KSL Conservation and Development Initiative supported by International Centre for Integrated Mountain Development (ICIMOD), an intergovernmental knowledge institution based in Kathmandu. This manual covers basic tools and techniques of monitoring various environmental parameters in the Himalayan region. The techniques described in the manual are applicable not only in India but also all across the Himalayan region. It is hoped that the researchers, volunteers and students interested in carrying out ecological research and environmental monitoring in the Himalayan region would find this manual very useful.

Place: Dehradun
Date: November 20, 2017

[Dr. V.B. Mathur]
Director

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PREFACE

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Need for systematic documentation of rapidly vanishing bio-resources in the Himalayan region and long term monitoring of environmental parameters in the wake of changing climate has long been felt by the ecologists and natural resource managers. Long term ecological and socio-economic monitoring (LTESEM) was visualized as one of the major components of Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI) since early stage of programme formulation. Accordingly, the International Centre for Integrated Mountain Development (ICIMOD), under its transboundary landscape programme, organized a series of expert consultations and workshops to finalize key parameters and protocols for monitoring. During the first phase of programme implementation (2013-'17), the Kailash partners tested these protocols in their respective countries. It was decided that the detailed methods used for monitoring various parameters would be compiled and disseminated among researchers, teachers and students desirous of initiating ecological observations and monitoring. Keeping this in view, we have brought out this manual covering various tools and techniques giving specific examples from Indian part of Kailash Sacred Landscape (KSL).

We are thankful to ICIMOD, especially Dr. David Molden, Director General, Dr. Eklabya Sharma (Deputy Director General), Dr. Rajan Kotru (Programme Coordinator, Transboundary Landscape Initiative), Mr. Swapnil A. Chaudhri (programme coordinator, KSLCDI), Dr. Nakul Chettri, Component Lead, LTESEM and entire Kailash Team for encouragement and facilitation of KSLCDI programme implementation in India. We also acknowledge the help and support extended by the Forest Department, Govt. of Uttarakhand, District Administration, different line agencies, members of Van Panchayat and Biodiversity Management Committees at different pilot sites in District Pithoragarh. We thank Dr. V.B. Mathur, Director WII, Shri D.V.S. Khati, Principal Chief Conservator of Forests (Wildlife), Govt. of Uttarakhand, Dr. Rakesh Shah, Chairman, Uttarakhand Biodiversity Board for helping us in various ways. All the team leaders and members of Kailash Programme in India are thanked for their team spirit and active participation during the implementation of the first phase of Kailash Programme.

(G.S. Rawat)
(On behalf of Editorial Team)

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CHAPTER 1: COMPREHENSIVE ENVIRONMENTAL MONITORING IN KAILASH SACRED LANDSCAPE

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1.1 Background

Several institutions and individuals have contributed to our current knowledge and understanding of biophysical and socio-economic environment in Indian part of Kailash Sacred Landscape (KSL) during recent years. The partner institutions involved in this programme have been collecting baseline data on key environmental parameters, viz., land use and land cover, geohydrology, availability and use of drinking water and bio-resources, distribution and abundance of major floral and faunal species including mammals, birds, fishes, invertebrates, invasive alien species (IAS), agro-biodiversity and socio-economics of the local communities within the pilot areas. During the first phase of Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI), several teams of researchers were trained in systematic data collection on various parameters. Based on the feedback from the KSL partners from all the three countries, ICIMOD brought out a Working Paper entitled "**Long-term environmental and socio-ecological monitoring (LTESEM) in transboundary landscapes – An Interdisciplinary Implementation Framework**" in 2015 (Chettri *et al.* 2015). However, need for a user-friendly field manual

The major goal of comprehensive environmental monitoring is to build the local and state level capacity for long term ecological research and environmental monitoring. The educational institutions and local research organizations are encouraged to take part in this activity.

giving details of sampling and monitoring techniques was felt for wider circulation among research and educational institutions in the landscape.

Kailash Sacred Landscape, like other parts of Hindu kush Himalaya (HKH), is bound to undergo rapid changes in biophysical as well as socio-economic environments due to selective harvest of non-timber forest products (NTFPs), out migration of the rural youth to the urban areas, rapid infra-structure development such as roads and dams. It is, therefore, desirable to document the current status of biodiversity and health of ecosystems and also, to quantify the patterns of changes in the landscape. Examples of key monitoring parameters include: fragmentation and degradation of forests; current levels of NTFP extraction; populations of rare, endangered and threatened species of flora and fauna; trends in degradation of ecologically sensitive habitats such as alpine rangelands, riverine forests and wildlife corridors; abundance and extent of IAS; status of agri-biodiversity and socio-economics of local communities, and their strategies to cope up with changing climate.

This document provides various tools and techniques for collection of baseline information on biophysical and socio-economic environments in KSL and suggests protocols for future monitoring. The protocols for monitoring these parameters are applicable for other parts of Himalaya. The manual has been prepared for graduate and postgraduate students, volunteers, researchers and Civil Society Organizations who may wish to initiate collection of baselines and monitoring activities in their respective areas. It is hoped that the researchers and students working in the region will find this manual useful.

1.2 Monitoring goals and objectives

The major goal of comprehensive environmental monitoring is to build the local and state level capacity for long term ecological research and environmental monitoring and also integrate this programme at the regional (transboundary) scale. The monitoring programme will support landscape level conservation of ecosystems, threatened species and habitats, and ensure continuous flow of ecosystem services. It is visualized that long-term environmental monitoring programme in the Kailash Sacred Landscape would greatly help in reducing the knowledge gaps, modeling, and prediction of climate change impacts at various scales. Specific objectives of the monitoring programme are as follows:

i. To establish an institutional mechanism for systematic recording of environmental changes including climatic variables in KSL,

ii. To promote the early identification of and response to potential adverse environmental impacts associated with anthropogenic pressures and natural changes within the KSL,

iii. To document the ecosystem response to conservation efforts and changed land use practices in KSL,

iv. To detect progressive changes in traditional cropping systems, livestock husbandry practices and agri-biodiversity in the region, *vis-a-vis* adaptations by local communities to changing climate, and

v. To facilitate and encourage regional knowledge sharing and trans-boundary cooperation for conservation of natural resources, globally threatened species and sites of ecological and cultural significance.

1.3 Broad framework of monitoring and use of this manual

This manual is a simplified version of the monitoring framework published by ICIMOD (Chettri et al., 2015). Though the methods of monitoring have been simplified, they are based on internationally accepted norms (Noss, 1990; Goldsmith, 1991; Spellerberg, 1991; and MRI, 2005). It is suggested that a hierarchical approach would be followed to monitor various environmental, biological and socio-economic parameters. At the landscape level, boundaries of larger ecosystems, areas under different land use and land cover (LULC) classes and changes in such categories would be monitored at regular intervals coordinated by Uttarakhand Space Application Centre (Chapter 2). GBPNIHESD has been collecting baseline data on geohydrology, aquifers, agri-biodiversity and alpine species (Chapter 4). Monitoring of faunal communities and their habitats have been initiated within certain pilot sites by WII (Chapters 7 - 10). Methods of socio-economic monitoring and use of certain high value products can be seen in Chapter 12. In addition to the key thematic areas given in this manual, a large number of other variables can be monitored in future. A tentative list of such parameters, scale of monitoring and suggested agencies is given as **Appendix 1.1.**

1.4 Institutional arrangements for monitoring and reporting

Successful monitoring programme would largely depend on establishment of reliable baseline information on key environmental parameters by the trained personnel from the professional bodies and subsequent collaboration and networking among them. Apart from the core institutions involved in the implementation of the first phase of KSLCDI, viz., GBPNIHESD, WII, UKFD, USAC, and CHEA, several other state, and local institutions could be invited to participate in this programme in future. Formal participation of schools and colleges through their environmental education programme and National Service Scheme (NSS) camps would greatly enhance multi-locational monitoring activity and human resource development in the area.

It is noteworthy that successful monitoring programmes require simplicity, reliability, accuracy, and repeatability. For continuity of the programme on a sustained basis it would be imperative that the methods and protocols are clearly understood and explained by the implementing agencies. The agencies and individuals involved in the monitoring programme will need to clearly understand the parameters to be monitored at various spatio-temporal scales, identity of the indicator species, locations of the monitoring sites /plots, transects, seasons, techniques of quantification, measuring frequency and methods of data analysis. The partner institutions are encouraged to identify qualified volunteers from colleges, Civil Society Organizations and local youth including students and involve them in annual monitoring events such as Annual Bird Count, Weed Surveillance, and Control, and vulture watch with clear questions, monitoring indicators and mechanism to report the results (**Fig. 1.1**). The identified teacher volunteers and other resource persons in the landscape will take interest in the programme only when they see academic and intellectual interest in the programme. The overall success of the programme will also depend on the clear signals and general acceptance of civil society and governments at large. The agencies involved in long term monitoring also need to be aware of certain pitfalls in this process. Such pitfalls include:

(i) Blind or total data gathering, irrespective of well-defined objectives and hypotheses;

(ii) Highly technical nature of data and need for sophisticated instrument to measure such parameters;

(iii) Inadequate infrastructure and support;

(iv) Lack of integration and isolated component wise monitoring;

(v) Low institutional priority.

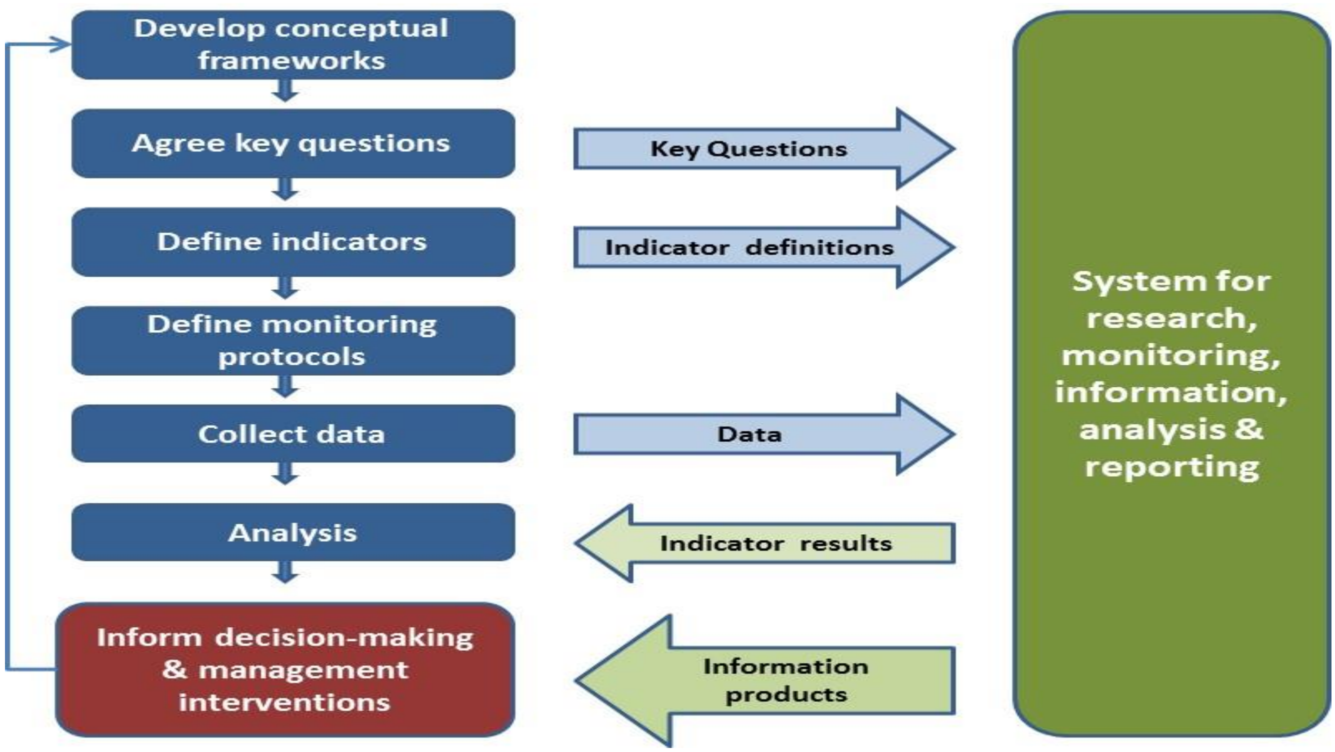

Figure 1.1: A simplified protocol for monitoring various environmental and socio-economic parameters in Kailash Sacred Landscape

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Appendix – 1.1: A tentative list of environmental parameters proposed for long term monitoring in Indian part of KSL, general approach of monitoring and agencies to coordinate the parameter. [**Coordinating Institutes**: CHEA = Central Himalayan Environmental Association; GBPNIHESD = G.B. Pant National Institute of Himalayan Environment & Sustainable Development; UKFD = Uttarakhand Forest Department; USAC = Uttarakhand Space Application Centre; USBB = Uttarakhand State Biodiversity Board; WII = Wildlife Institute of India]

Parameter	Variables / Parameter	Level / Scale	Approach	Coordinating Agency
Climate	Rainfall	Eco-climatic regions	Automatic Weather Monitoring Stations and other weather data	GBPNIHESD
	Mean Maximum and Minimum Temperature	-do-	-do -	-do-
	Relative Humidity	-do-	-do -	-do-
	Wind Velocity	-do-	-do -	-do-
	Solar radiation	-do-	-do -	-do-
	Snow fall	LS (Sub-alpine and alpine)	Snow gauging, Remote Sensing Data	-do-
	Snow deposition pattern	LS (Sub-alpine and alpine)	Snow gauging, Remote Sensing Data	-do-
Land Use / Land Cover	Land use / Land cover	LS	RS/GIS	USAC
	PA Coverage & Status	LS	RS/GIS	WII
	Forest Cover	LS	RS/GIS	USAC
	Area under Different categories of forests	LS	Forest Records	UKFD
	Development Projects (Road & other infrastructure)	LS	District Plan	UKFD
	Temporary LS Camps	Sub-alpine and Alpine	Forest Records	UKFD

	Sacred groves / sites	Ecosystem	RS/GIS; Forest Records	UKFD / USAC
	Historical Trend	Block Level	Forest Records	USAC
	Urbanization	Block Level	District Plan	District Administration
Cryosphere	Glacier Extent	LS	RS/GIS	USAC
	Melt water yield	Local	Manual	Volunteers
	Snowline shift	LS	RS / GIS	USAC
	Snow gauging	Local	Manual	USAC
Hydrosphere/ Water Resources	No & size of lakes & ponds	LS	RS/GIS	GBPNIHESD
	No of dams and reservoirs	River Valley	Official Records	GBPNIHESD
	Land use around water bodies	Local	Official Records	Volunteers / GBPNIHESD
	Water quality	Local	Laboratory Analysis	GBPNIHESD
	Sediment load	Local	Laboratory Analysis	GBPNIHESD
	No of Naulas (Aquifer wells)	Block wise	Block office	Volunteers / GBPNIHESD
State of Ecosystems	Alpine ES	Eco-climatic regions	RS/GIS	UKFD/USAC
	TMD	-do-	RS/GIS	UKFD/USAC
	TBF	-do-	RS/GIS	UKFD/USAC
	TCF	-do-	RS/GIS	UKFD/USAC
	Lentic	-do-	RS/GIS	UKFD/USAC
	Lotic	-do-	RS/GIS	UKFD/USAC
	Wetlands	-do-	RS/GIS	UKFD/USAC
	Outbreak of plant pathogens	Site specific	Ground survey	WII / GBPNIHESD
	Soil, water, and air pollution	Site specific	Ground survey	State Pollution Control Board
Biodiversity	Forest Structure & Composition	Eco-climatic regions	Permanent Plots	GBPNIHESD
	Rare threatened and endangered species	Wildlife Habitat	Permanent Plots / Trails	WII
	Non-timber Forest Products including Medicinal Plants	Forest Range	Permanent Plots / Trails	UKFD/ WII/ GBPNIHESD/USAC
	Culturally dependent species	Forest Range	Permanent Plots / Trails	Volunteers

	Threatened species	Habitat	Permanent Plots / Trails	UKFD/ WII/ GBPNIHESD/USAC
	Invasive species	Habitat	Permanent Plots / Trails	WII
Agri-biodiversity	No of food crops	Block	Questionnaire Survey / Citizen Science	GBPNIHESD
	Domestic Ls	Block	Questionnaire Survey	GBPNIHESD
	Land races	Block	Questionnaire Survey / Citizen Science	GBPNIHESD
Socio-Economics	Population structure of various ethnic groups	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Livelihood pattern	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Land holding pattern	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Livestock holding pattern (Sedentary, nuclear TH, and Semi-nomadic TH)	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Income from other NTFPs	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Income from tourism / pilgrimage	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Cross border trade	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Annual revenue from NTFPs	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Annual revenue from agriculture	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
	Annual revenue from animal husbandry	Block	Questionnaire Survey / Citizen Science	CHEA / Volunteers
Governance & NR Management	No and area of *Van Panchayats*	Block	Questionnaire Survey / Citizen Science	UKFD

	Forestry and conservation activities taken by FD under various schemes	Block	Questionnaire Survey / Citizen Science	UKFD
	Rights and access to NTFPs	Block	Questionnaire Survey / Citizen Science	UKFD
	Cases of Illegal trade of plant and animal parts	Block	Questionnaire Survey / Citizen Science	UKFD
	No of poaching cases	Block	Questionnaire Survey	UKFD
	No of human and animal damages by wildlife	Block	Questionnaire Survey / Forest Department Records	UKFD
	No of village-micro-plans	Block	Questionnaire Survey	UKFD
	Conservation /Eco-dev. Plans	Block	Questionnaire Survey	UKFD
Human & Livestock Health	Incidences of vector borne diseases in humans	Block	Records of Primary Health Centres	State Health Department
	Incidences of vector borne diseases in livestock	Block	Records of Veterinary Department	State Veterinary Department
Hazards (including extreme events)	Glacial Lake Outburst Floods (GLOF)	Site specific	Extent of damage	State Disaster Management Cell
	Cloud burst	Site specific	-do-	-do-
	Forest Fire	Site specific	-do-	UKFD
	Earthquakes	Site specific	-do-	-do-
	Landslides	Site specific	-do-	-do-
	Land-sinking	Site specific	-do-	-do-
Success of monitoring program	All parameters and Reporting mechanism	Country Program	- - -	GBPNIHESD

Chapter 2. Monitoring Landscape Level Changes Using Remote Sensing Tools

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2.1 Background

Remote sensing (RS) technology, coupled with Geographical Information System (GIS) offers a practical and cost effective way to study biophysical changes in the environment, especially over large areas (Langley et al. 2001; Nordberg and Evertson 2003). From aerial photographs to high resolution satellite images and from active to passive sensing, this technology has advanced considerably for wide use in environmental management and long term ecological monitoring. One of the most common uses of RS & GIS technology is the detection of changes in land-use and land-cover (LULC) which is, in turn, influenced by natural and socio-economic factors in time and space. Information on the rate and kind of changes in LULC helps in future planning and management of resources (Jensen and Cowen, 1999).

RS and GIS are the most effective tools to document and detect environmental changes. Using these tools, we have found that Indian part of KSL has undergone drastic decline in agriculture at higher altitudes and four times increase in area under urban settlements since past 35 years.

As part of long term ecological and socio-economic monitoring (LTESM) in the Indian part of Kailash Sacred Landscape, we generated baseline information on LULC, spatial distribution of a few floral and faunal communities and key vegetation types using standard RS & GIS tools. Analysis of these parameters at varying temporal and comparable spatial scales would allow us to detect changes in the environment. Hence, it is desirable to document the basic protocol for monitoring changes at the landscape scale based on RS and GIS for future analysis. In this chapter we give a broad outline of the methods used for geo-spatial analysis of key environmental parameters in the KSL and other mountainous terrains, few monitoring questions and initial trends observed based on time series analysis.

2.2 Monitoring framework and baselines

Currently, various time series multispectral satellite remote sensing data are in use for geo-spatial data analysis and environmental change detection. Satellite images at various scales are now available for various purposes. A list of medium resolution Remote Sensing sensors is given in the following table.

Table 2.1 Some medium resolution remote sensing sensors, their characteristics and application in vegetation mapping.

Sensor	Operation period	Scale/Resolution (m)	Swath (km)	Spectral range (µm)	No. of bands	Mapping applications
MSS (Landsat 1-5)	1972-1983	Regional, 79	185	0.50 - 12.6	4	vegetation mapping at community level
TM (Landsat 4-5)	1982-	Regional, 30	185	0.45 - 2.35	7	vegetation mapping at community level
SPOT	1986-	Local to regional 10, 20	60	0.50 - 0.89	3	community or species level
LISS-I	1988-	Regional, National 72.5	148	0.45 - 0.86	4	vegetation mapping at community level
LISS-II	1991-	Regional, National 36.25	146	0.45 - 0.86	4	vegetation mapping at community level

LISS-III	1995-	Regional to National 23.5, 70, 188	142	0.52 - 1.70	4	vegetation mapping at species or community level
MODIS	1999-	Global, continental, National 250, 500, 1000	2300	0.62 - 2.15, 3.66 - 14.38	36	Suitable for mapping land cover types (i.e. urban area, classes of Vegetation, water area, etc.)
ASTER	1999-	Regional to national 15, 30, 90	60	0.52 - 0.86, 1.60 - 2.43	14	vegetation mapping at species or community level
Cartoset -1	2005-	Local to regional, National 2.5	30	-	1	vegetation mapping at species or community level
OLI/TIRS (Landsat 8)	2013-	15, 30	185	0.42-	11	vegetation mapping at species or community level

ii) Ancillary data

Various ancillary data required for analysis and interpretation of satellite data and can be collected from various sources.

a) Survey of India (SOI) topographical sheets at 1:50000, 1:25000 and higher scale, old photographs/images for ground survey and preparation of base maps *viz.*, road, settlement, drainage, topography etc.

b) Administrative boundaries (eg., Districts, Villages, Panchayat boundaries) in geospatial format (shape file) (SOI, Panchayati Raj Department).

c) LULC map of 1:50k, 1:25k and 1:10k scale for reference (NRSC, Bhuvan portal).

iii) Field based information

Several ground control/truth points (GCPs) are required from various land use/ land cover and other landform units. A sufficient number of ground truth points and their representativeness are prerequisites for a successful classification and delineating changes. GCPs should be collected from various landform units with equal distribution in the landscape. Different collection strategies, such as single pixel, seed and polygon can be used.

iv) Hardwares and softwares

The following hardwares and softwares are required for processing and generation of information from satellite images.

Table 2.2 Hardwares and softwares required for change detection.

Type	Name	Utility
Software	ERDAS IMAGINE	Satellite data pre-processing, analysis, modeling
	ArcView GIS 3.2 & above	Visual Interpretation and analysis
	ArcGIS (9.x) & above	Mapping, various imagery based analysis, Topology building, modeling
	QGIS (open source)	Mapping, various imagery based analysis, modeling
	MS Office 2003, 2007 or higher	Documentation, statistical analysis, and presentation
Hardware	Computer	Data storage, software and internet support
	GPS	Collection of ground truth points

Steps involved in change analysis studies:

i. Acquisition and pre-processing of satellite data
    a) Radiometric corrections
    b) Geometric corrections

ii. Classification algorithm

iii. Classification approach:
    a) Visual interpretation technique
    b) Supervised and unsupervised classification technique

iv. Validation of classified outputs (accuracy assessment)

v. Determine the changes (change analysis)

i. Acquisition and pre-processing of satellite data

Accurate geometric rectification or image registration of remotely sensed data becomes a key issue in multi-source data integration, management, and analysis for many geometric applications. After receiving satellite data, image pre-processing is highly required. It includes the detection and restoration of bad lines, geometric rectification or image registration, radiometric calibration, atmospheric correction and topographic correction. If different ancillary data are used, data conversion among different sources or formats and quality evaluation of these data are also necessary before they can be incorporated into a classification procedure.

a) Radiometric correction

Correction of variation in data values that is caused by sensor malfunctions and atmospheric conditions is termed as radiometric correction. If a single date image is used in classification, atmospheric correction may not be required (Song *et al.* 2001). When multi-temporal or multi-sensor data are used, atmospheric calibration is mandatory. This is especially true when multi-sensor data, such as Landsat TM and SPOT or Landsat TM and radar data, are integrated for image classification. A variety of methods, ranging from simple relative calibration and dark-object subtraction to calibration approaches based on complex models can be used for radiometric and atmospheric normalization and correction.

b) Geometric correction

Sources of distortions can be grouped into two broad categories: The *observer* or acquisition system (platform, imaging sensor and other measuring instruments, such as gyroscope, stellar sensors, etc.) and the *observed* (atmosphere and Earth). These errors are of two types: i) those that can be corrected using knowledge of internal sensor distortion and ii) those that can be corrected with a sufficient number of ground control points. RMS error and control point error for each scene should be less than 0.5 pixel to have more accuracy.

ii. Classification Algorithm

Deriving information from satellite image is a complex procedure and the accuracy of thematic classes depends on the classification algorithm and a prior knowledge of land cover types of the reference area. Among different algorithm available for image classification traditional per-pixel classification is most widely used method. Review of literature suggests that the results from remote sensing study may vary from one environmental condition to other and hence methodological issues must be addressed with special reference to environment. In mountains, impact of topography on surface illumination condition is an important issue to be addressed for better classification accuracy. Several authors have suggested the incorporation of ancillary data (NDVI, DEM) with multispectral bands to reduce the impacts of topography. But studies suggest that even using ancillary data as additional band does not improve the accuracy much (Frank 1988, Itten and Meyer 1993). However, some statistical correction methods have successfully been used to reduce the impact of topography on surface reflectance (Leprieur *et al.* 1988, Civco 1989, Ekstrand 1996, Tokola *et al.*, 2001). Despite topographic correction, traditional per-pixel methods still encounter problems with deriving forest stand type maps from Landsat TM images of mountainous terrain, because of the large variability in reflectance within forest stands and spectral confusion of species (Meyer *et al.* 1993). Image classification based on segmentation (object based classification) has been used as an alternative to per-pixel classification (Ton *et al.* 1991, Woodcock and Harward 1992, Stuckens *et al.* 2000). Dorren *et al.* (2003) compared the performance of these two methods and concluded that an object-based approach fails to improve the accuracy of forest stand type maps in comparison with traditional per-pixel classification.

However, the forest stand type map derived with object-based classification agreed more with reality than the forest stand type map derived with per-pixel classification.

iii. Classification approach

Many factors, such as spatial resolution of the remotely sensed data, different sources of data, a classification system, and availability of classification software must be taken into account when selecting a classification method for use. Different classification approaches have their own merits. The question of which classification approach is suitable for a specific study is not easy to answer. We will use *visual interpretation technique, unsupervised* and *supervised image classification technique* to delineate land use/land cover. We will evaluate classification results based on field data, and corrected the areal estimates based on this evaluation.

a) Visual interpretation technique

Visual interpretation technique is the widely used technique in hilly terrains. Various thematic information is visually interpreted using diagnostic keys considering-tone or colour, texture, shape, size, association, pattern, shadow, altitude, and aspect. These certain fundamentals photo-elements or image characteristics on the image aid in visual interpretation of satellite imagery. This technique is appropriate to use considerably in the smaller scale (eg., village, watershed) for delineation of more accurate land use/cover classes. In figure 1. various LULC classes have been described by observing the various tone, texture in high resolution imageries at village and watershed level.

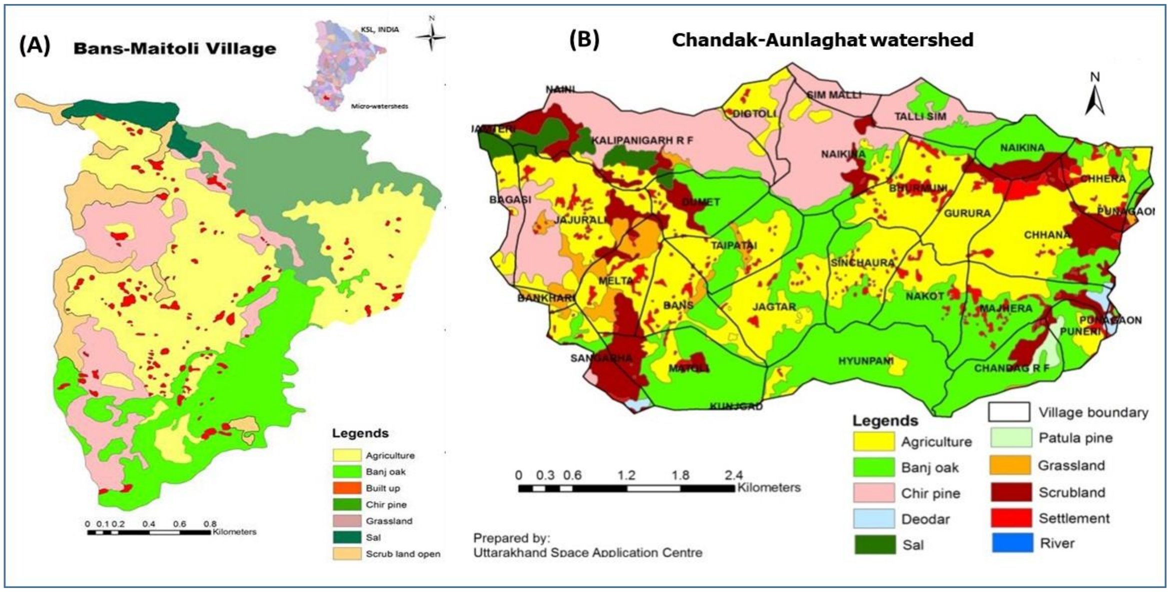

Figure 2.1 Land use/cover mapping (A) Village (Bans Maitoli) and (B) Watershed (Chandak-Aunlaghat) level by using visual interpretation technique at 1:10k scale.

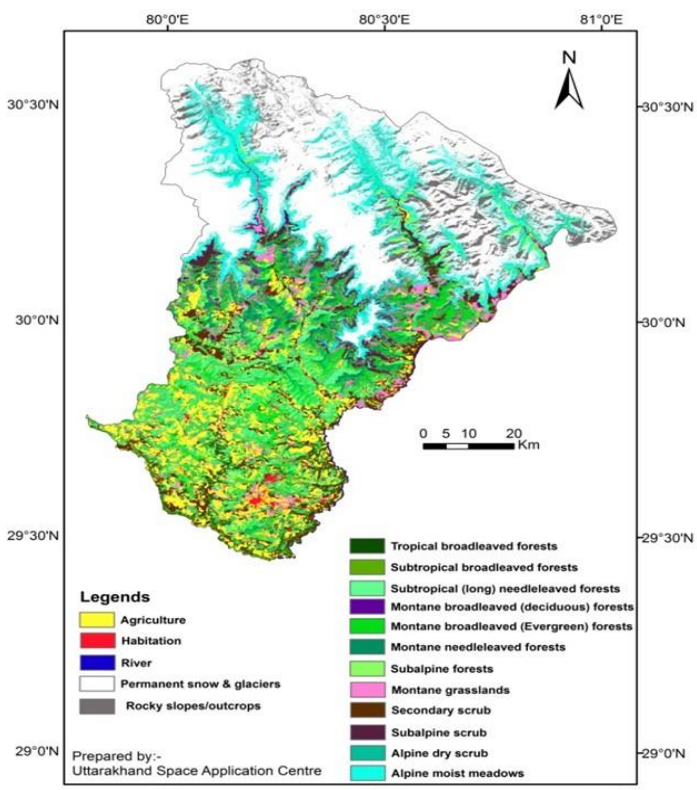

Figure 2.2 Land use/cover (vegetation) mapping by using unsupervised classification technique

b) Supervised and unsupervised classification techniques

Supervised classification, however, does require prior knowledge of the ground cover in the study area and is, therefore, a more intuitive method for land-cover change mapping. With the supervised approach, calibration pixels are selected and associated statistics are generated for the classes of interest.

In unsupervised classification, pixels are grouped based on the reflectance properties of pixels. These groupings are called "clusters" (Schowengerdt, 1997). The user identifies the number of clusters to generate and which bands to use. With this information, the image classification software generates clusters. The user manually identifies each cluster with land cover classes. It's often the case that multiple clusters represent a single land cover class. The user merges clusters into a land cover type. The unsupervised image classification technique is commonly used when no sample sites exist.

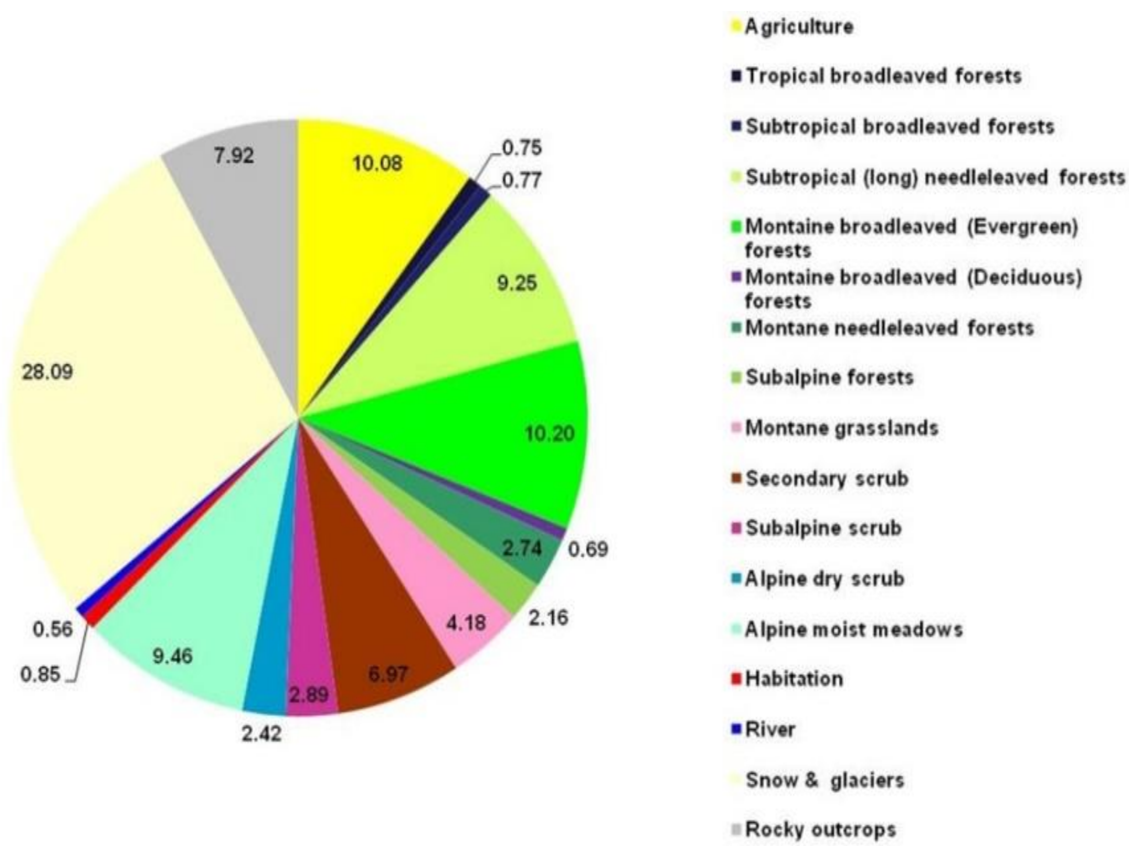

Figure 2.3 Area (%) of various vegetation types in KSL-India.

By using supervised classification technique land cover map was prepared for KSL-India at physiognomic level and depicted 17 land cover classes (figure 2.2). The map revels that the middle elevational zones were largely covered by forest vegetation surrounded by villages and agricultural areas. Continuous patches of natural grasslands and scrublands occupy mostly the high elevational zones adjoining to glacier and snow cover areas. Most of the highlands of northern landscape is represented as high alpine meadows and remains covered with permanent snows and glaciers. Snow and glaciers were the dominant land cover type found above 5300m elevation (Figure 3). This land cover was represented by 28.09% of the total area of KSL-India. The forests, second highest naturally occurring land cover type, were covering 26.38% (1878.25km^2) of entire landscape.

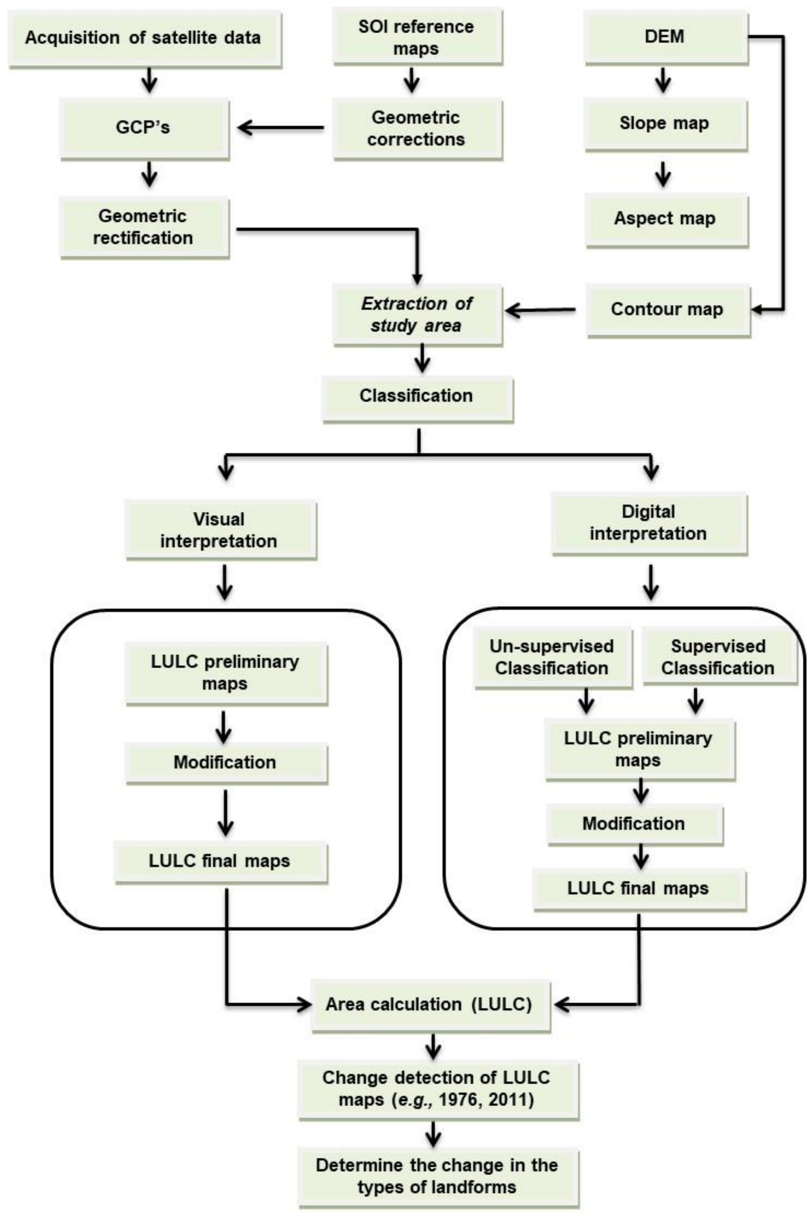

Figure 2.4 Flowchart of change detection methodology

iv. Validation of classified outputs (accuracy assessment)

Different approaches employed, ranging from a qualitative validation based on expert knowledge to a quantitative accuracy assessment based on sampling strategies. Due to the complexity of the biophysical environments, spectral confusion is common among land cover classes. Thus, ancillary data often used, to modify the classification based on established expert rules. Forest distribution in the mountainous areas is related to elevation, slope, and aspects. Data describing terrain characteristics can be used to modify classification results based on the knowledge of specific vegetation classes and topographic factors. Such data can be used to correct some classification confusions between different forest types and grassy slopes. Following are the three different methods can be used in accuracy assessment:

(i) **The user accuracy** is defined as the proportion of the correctly classified pixels in a class to the total pixels that are classified in that class. It indicates the probability that a classified pixel actually represents that category in reality.

(ii) **The overall accuracy** is defined as the total number of correctly classified pixels divided by the total number of reference pixels (total number of sample points) (Rogan *et al.* 2002).

(iii) **Kappa coefficient** is defined as a statistical measure of accuracy that ranges between 0 and 1, it measures how much better the classification is compared to randomly assigning class values to each pixel. For example, a Kappa of 0.76 means the classification accuracy is 76% greater than chance (Miller and Pool, 2002).

v. Determine the change (change analysis)

Change detection for landscape monitoring generally assumes overall phenological conditions to be comparable (particularly for bi-temporal change detection). Though the same acquisition dates considered as proxy for same phenological stage. For bi-temporal change detection, summer and winter are considered the best seasons because of their phenological stability (Hame 1988). In multi-date imageries, all source of variations is adjusted (absolute calibration) or normalized to a common standard (relative calibration), to detect changes (Jensen 1983, Caselles and Lopez Garcia 1989, Conel 1990, Coppin *et al.* 2001, and Elvidge *et al.* 1995).

A wide variety of digital change detection algorithms have been developed over the last two decades. Scientific literature reveals that univariate image differencing is the most widely applied change detection algorithm. It involves subtracting one date of original or transformed (e.g. vegetation indices) imagery from a second date that has been precisely registered to the first. With ‘perfect’ data, this would result in a dataset in which positive and negative values represent areas of change and zero values represent no change.

Post-classification comparison is another widely used method of change detection. It involves independently produced spectral classification results from each image. The principal advantage of this method lies in the fact that the two dates of imagery are separately classified, thereby minimizing the problem of radiometric calibration between dates. By choosing the appropriate classification scheme, the method can also be made insensitive to a variety of types of transient changes in selected terrain features that are of no interest (Colwell *et al.* 1980). However, the accuracy of the post-classification comparison is totally dependent on the accuracy of the initial classifications and the method is impractical for certain landscapes where deriving cover class with satisfactory level is difficult.

Change maps are also prepared to depict the spatial extent and locations of forest cover changes. The data obtained from change matrices was further used to calculate rate of change in each LU/LC class using the following formula (Puyravaud 2003):

$$r = \frac{1}{(t2 - t1)} \times In\left(\frac{\lambda 2}{\lambda 1}\right)$$

Where, r is the rate of land cover change, λ1 and λ2 are land cover class area at time t1 and t2 respectively.

For change detection, Landsat Multi-Spectral Scanner (MSS), TM, ETM, SPOT, AVHRR, radar and aerial photographs are the most common data sources, but new sensors such as Moderate Resolution Imaging Spectro-radiometer (MODIS) and Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) are becoming important. While scale is the most important factors deciding the acquisition of satellite images, purpose of the study and availability of good quality images greatly influence the decision.

2.3 Initial trends in land use/ land cover changes

Entire KSL-India landscape has been classified into seven classes namely Agriculture, Forest, Grassland, Scrubland, Settlement, Snow, and Water. Land use land cover maps were prepared for different years from 1976 and 2011 and there has been a positive and negative variation in each category. The area falling under each category for different years (1976 and 2011) has been given in table 2.4.

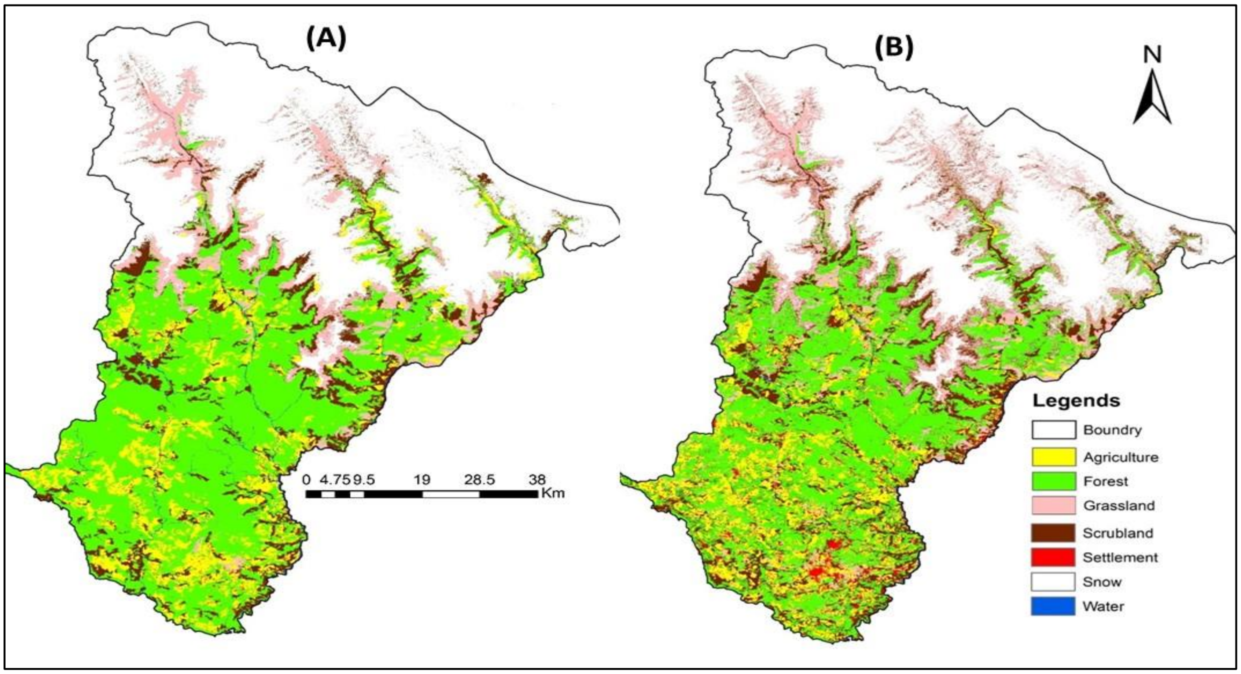

Figure 2.5 Land use/ cover maps of the KSL-India from (A) 1976 and (B) 2011

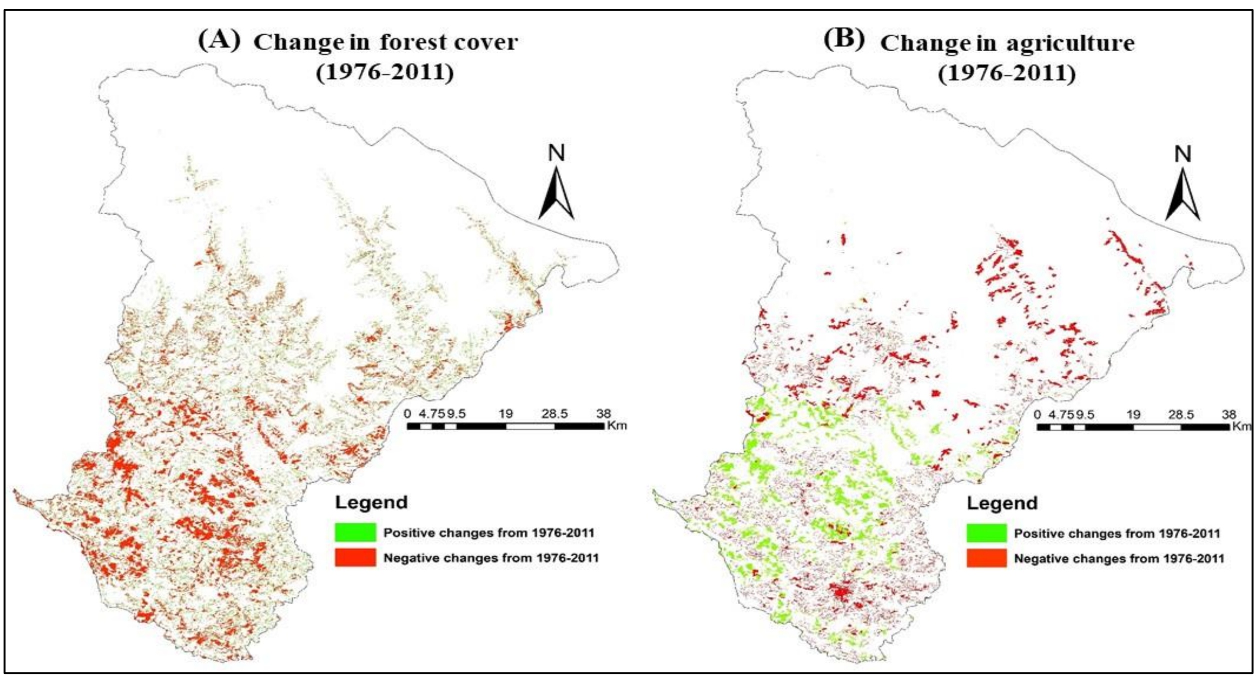

Figure 2.6 Land use/cover change during 1976-2011 in (A) Forest cover and (B) Agriculture area in KSL-India.

Table 2.4: Area and amount of change in different land use/cover categories in the KSL-India during 1976 to 2011.

Land use/cover categories	1976		2011		Overall Change (1976-2011)	
	km²	%	km²	%	km²	%
Forest	2388.80	33.52	1880.34	26.38	-508.46	-7.13
Agriculture	713.15	10.01	666.47	9.35	-46.68	-0.66
Grassland	543.89	7.63	966.84	13.57	422.94	5.93
Scrubland	588.37	8.26	866.18	12.15	277.82	3.90
Settlement	31.71	0.44	137.35	1.93	105.64	1.48
Water	58.74	0.82	38.94	0.55	-19.80	-0.28
Snow	2802.14	39.32	2570.69	36.07	-231.46	-3.25
Total	**7126.80**	**100.00**	**7126.81**	**100.00**	**0.00**	**0.00**

There has been gradual decrease in forested area from 1976 to 2011. The forests were covering 33.52% (2386.62km²) in the year 1976, which comes down to 26.38% (1878.25km²) in the year 2011. The overall agriculture land has slightly decreased (0.66%) since 1976, but figure 2.6B depict that the higher elevational agriculture area has more negative changes, whereas, it has increased in the lower elevational zone. Similarly, snow area has decreased about 3.25% since 1976. The grassland are has increased (5.93%) from 1976 to 2011, where it was about 543.89km² in 1976 was recorded 966.84km² in 2011. Similarly, scrubland (3.90%) has also remarkably increased over the period in the landscape. There is not very remarkable change in the area of water bodies. The settlement area was 31.71km² in 1976 and recorded 137.35km² in 2011. It means that the settlement land has increased in due respect of time. The maximum changes have been seen around urban areas in low elevational zones.

Land use/land cover changes have become a central component in current strategies for managing natural resources and monitoring environmental changes (Loveland et al. 2002). The advancement in the concept of vegetation mapping has greatly increased research on land use/ land cover change thus providing an accurate evaluation of positive and negative changes in the landscape. Table 2.4 and figure 2.6 reveal that both positive and negative changes occurred in the land use/cover pattern while comparing two different years (1976 to 2011) of imageries in KSL-India. During the last more than three decades the forests in the landscape has decreased mainly in the lower part of the landscape mainly around the settlements and roadsides (figure 2.6A). The negative changes have been seen in forests from 1976 to 2011 mainly in the lower altitude, which is mostly cleared for making roads, agriculture land, and converted into the scrubland by continuous lopping for daily use such as fuelwood and timber. The overall agriculture area has shown slight decreased (46.68km^2) over the period, but it has remarkable decreased in the areas in the high altitude (>2500m asl) regions of the landscape (Figure 2.6B) Whereas, agriculture area in low altitude area has increased.

More than 600 random ground truth points corresponding to each land cover classes were collected with the help of GPS during winter and pre monsoon seasons. These training points were used for accuracy assessment for final land cover map using kappa coefficient method (Congalton 1988). The overall accuracy for year 1976 was recorded 76% and 79% for year 2011.

Table 2.5: Land use/cover change matrix showing land encroachment (in %) of KSL-India.

Land use/cover Categories		Year 1976						
		Forest	Agriculture	Grassland	Scrubland	Settlement	Water	Snow
Year 2011	Forest	74.39	7.18	7.18	4.09	0.01	13.68	0.20
	Agriculture	9.12	61.16	61.16	0.82	0.02	9.94	0.00
	Grassland	5.24	19.14	19.14	14.00	0.00	2.89	6.91
	Scrubland	9.01	5.21	5.21	78.92	0.00	7.40	2.59
	Settlement	2.17	6.52	6.52	0.63	99.98	3.05	0.00
	Water	0.03	0.07	0.07	0.09	0.00	62.75	0.00
	Snow	0.04	0.71	0.71	1.45	0.00	0.28	90.31
	Total	100	100	100	100	100	100	100

To understand land encroachment for different land categories during the last more than three decades, a change detection matrix (table 5) was prepared which reveals that:

i) About 9% area of forest cover has been converted into agriculture and scrubland each, 5.24% area under grassland and 2.14% area under settlement.

ii) About 19.14% are of agriculture has been converted into grasslands, 7.18% area into forest, 5.21% into scrubland and 6.52% into settlements.

iii) About 13.34% area of grassland converted into scrubland and only 2.67% area into forests.

iv) About 14% area of scrubland has been converted into grassland and 4.09% area into the forested lands.

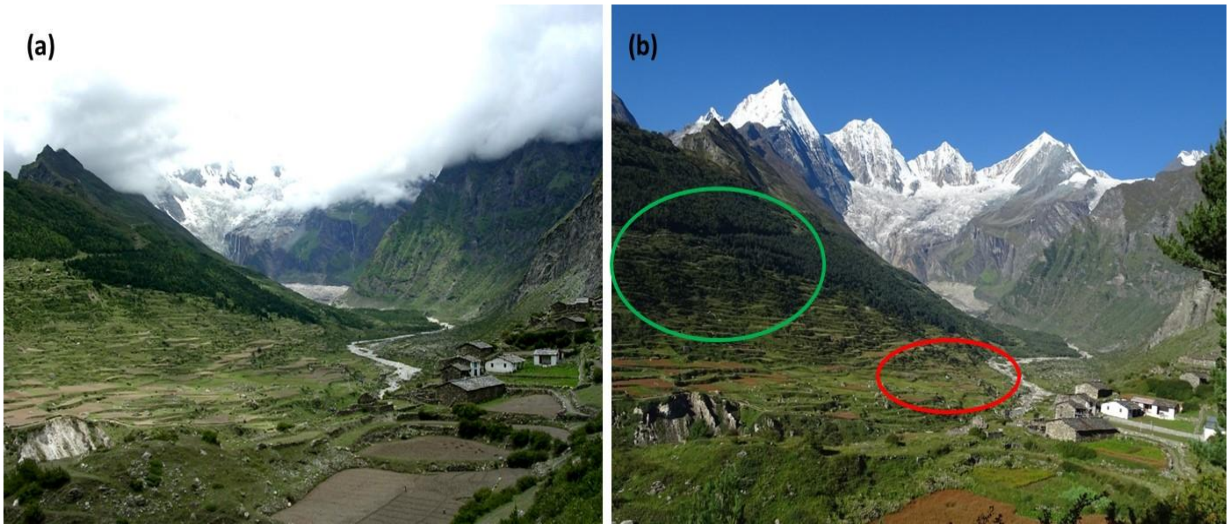

Figure 2.7. Photographic representation of positive (green circled) and negative (red circled) changes in Panchachuli basin (a) year 2004 and (b) year 2016.

2.4 Recommendations

Remote sensing images are key data sources for long term earth monitoring programs considering its great advantages (Nordberg and Evertson 2003). It is more easily obtainable to produce and update land use/cover over large regions if aided by satellite imagery and appropriate imagery analysis. The RS and GIS are considered as an effective monitoring and decision-support tool in generating information about latest land use/cover pattern in area and in dynamic changes. Regular monitoring should be done for natural resources, to see the change is negative or positive. The results reveal clearly the significance of the use of multi-temporal Landsat data which offers an accurate and economical way of mapping and conducting analysis on the changes in LULC during the study period 1976-2011.

Digital change detection techniques by using multi-temporal satellite imagery helps in understanding landscape dynamics. It is apparent from the study that urban (settlement) expansion is rapid than all the other land classifications and is one of the most important indicator to determine the status of all the other land classes. The results have shown that there is a significant increase in urban expansion mainly around low altitude, flat and township areas leading to a significant drop in forested land. It is thought that the main explanation for the rapid increase in settlement area is population growth and migration from rural areas/higher altitude (>2500m asl) to the district and block headquarters and more general economic development. Owing to migration from higher altitude the agriculture area has shown negative changes in the region.

Although remote sensing technology has tremendous advantages over traditional methods in mapping, one should have a clear understanding of its limitations as well. Three questions (Rapp et al 2005) should be asked when using the results of mapping from remote sensing imagery i) how well the chosen classification system represents actual land use/cover communities, ii) how effectively images from remote sensing capture the distinguishing features of each mapping unit within the classification and iii) how well these mapping units are delineated by photo-interpreters. In simple word, a well-fit land use/cover classification system should be carefully designed according to the objective of studies in order to better represent actual land use/cover/vegetation community compositions. Accurate and updated land use/cover change information is vital for any management planning of the landscape.

ACKNOWLEDGEMENTS

The authors wish to thank Director and Nodal Person (KSLCDI-India) G.B. Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD) for financial support and guidance. We thank Director of Programme Operations ICIMOD and his team, for their over-all support. We also thank the Ministry of Forests and Climate Change (MoEF&CC), Government of India for his support and cooperation in KSLCDI.

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Annexure- 2.1. Key RS-GIS based applications used for landscape monitoring in India can be used in KSL at various scales

Sl.no	Major Application	Data Used	Scale/ Resolution	Year	Highlights	References
1	Forest cover map	Landsat MSS Topographical maps, Landsat MSS, IRS LISS I, Resourcesat-1 & 2 AWiFS	1:1M 1:250K, 80m, 72.5m, 56m	1972-1975 and 1982-1985 1930, 1975, 1985, 1995, 2005, 2013	Initial efforts to map forest cover. No spatial change analysis Spatial analysis for Long-term forest cover change; Use of natural forest definition	National Remote Sensing Agency. Tech. Rep. 1985. Reddy et al. (2016)
2	Vegetation type map	IRS WiFS IRS LISS III	1:1M 1:50K	1998 2005-2006	Mapping of major vegetation types Classification scheme is focused on mixed, gregarious and locale specific classes	Roy et al. (2006) Roy et al. (2012)
3	Forest type and Land cover map	Resourcesat-2 AWiFS	56m	2013-2014	Classification is based on ecological rule bases followed by Champion and Seth's scheme of forest types	Reddy et al. (2015)
4	Spatial patterns of Forest fragmentation and fragmentation index	Forest cover map and Fragstat Spatial modeling	56m 500 x 500m grid	2005 2005-2006	Forest fragmentation was analysed based on landscape indices Classification of the fragmentation map cells as low, medium and high	Reddy et al. (2013) Roy et al. (2013)

5	Forest biomass Carbon pool estimates	Multi-source data	District level	1988, 1994	District wise RS based forest area, field inventory data of FSI	Chhabra and Dadhwal (2004)
6	Forest biomass Carbon pool estimates	Multi-source data	5 km grid	1930, 1975, 1985, 1995, 2005, 2013	Analysed forest canopy density maps and multi-source data	Reddy et al. (2016)
7	Forest burnt area map	Resourcesat-2 AWiFS	56m	2014	Pattern of fire incidences and burnt area in vegetation types	Reddy et al. (2017)
8	Land use/Land cover map	IRS LISS III	1:50K	2005-2006 and 2010-2011	Level III LULC maps of India prepared using three season multispectral data	http://bhuvan.nrsc.gov.in
9	Land use/Land cover map (Decadal)	Landsat MSS, IRS LISS I, Landsat TM/ETM+, Resourcesat-1 LISS III	80m, 72.5m, 30m, 23.5m	1985, 1995, 2005	Recorded overall land cover changes	Roy et al. (2015)
10	Land use/Land cover map	Cartosat-1 + Liss-IV merged product	1:10k 2.5m	2011	Land use/land cover of India	http://bhuvan.nrsc.gov.in

CHAPTER 3. MONITORING ECOSYSTEM SERVICES IN PILOT AREAS OF KAILASH SACRED LANDSCAPE - INDIA

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3.1 BACKGROUND

The Millennium Ecosystem Assessment (MA) concluded that nearly 60% of the earth's ecosystems that provide numerous services for human well-being have been degraded during the past half century (MA 2005). The process of ecosystem degradation is generally faster in the Himalayan region as compared to other areas of the Indian sub-continent as they are relatively young and fragile. This has direct implications for the local lives and livelihoods in the region. Hence, management of ecosystems for sustaining services forms one of the major components of ongoing Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI). This calls for participatory action research and continued hand holding of local communities towards achieving the sustained flow of services.

The Kailash Sacred Landscape provides numerous ecosystem services which are crucial for human wellbeing in the region. This chapter provides basic conceptual framework for recording ecosystem services and trends in their flow.

However, there are several challenges in achieving this in the landscape, *e.g.,* (i) All the ecosystem services flowing from the ecosystems in the landscape have not been assessed and documented; (ii) loss of such services due to degradation and fragmentation have not been fully realized by the local stakeholders; (iii) there is inadequate scientific understanding of ecosystem functioning and flow of services; and (iv) the community based organizations and line agencies in the region are not yet fully geared for participatory planning and implementation of integrated ecosystem management plans.

The Indian part of KSL comprises diverse terrestrial and aquatic ecosystems. The terrestrial ecosystems are further divisible into forests, grasslands and alpine meadows while human induced / modified systems are agro-ecosystems and village grazing lands and hill-side grasslands. Many patches of forests and hill tops in the landscape have been dedicated to the local deities by the local communities which help them in maintaining the ecosystem structure and functioning which need to be assessed and monitored at regular basis. Assessment and monitoring begins with a few basic questions such as: How do sacred natural sites (SNS), community managed forests and protected areas (PAs) within KSL-India compare with other sites in terms of flow of ecosystem goods and services? What are the economic potentials of various ecosystem services at pilot sites in KSL-India, and how are goods and services distributed across stakeholders and gender? How do changes in land use and land cover affect ecosystem services? What has been the impacts of management interventions on the supply of desired ecosystem services?

This chapter deals with the basic strategy of monitoring ecosystem services in the pilot areas of KSL- India where management interventions in the form of self-regulation of biomass extraction by the communities, eco-restoration, watershed development and participatory management of forests have been proposed and likely to be piloted in near future. In some cases, the communities have been following certain land use practices which influence ecosystem services. Major goods and services from the two pilot sites of KSL – India have been listed along with indicators, frequency of monitoring and methodological approach. Methods of data analysis, interpretation of monitoring results and prospects of involving community based organizations in monitoring certain parameters are discussed.

3.2 Conceptual framework for assessing ecosystem services

Figure 3.1 provides a conceptual framework showing socio-ecological system, ecosystem services flow, role of management and key drivers of change. This framework helps in identification of monitoring questions at the levels of ecosystems according to broad ecosystems or land use classes such as forest, grassland, wetland or agricultural lands. Each ecosystem can be further described in terms of its structure and functioning, vegetation structure, food web and soil, and key ecological interactions.

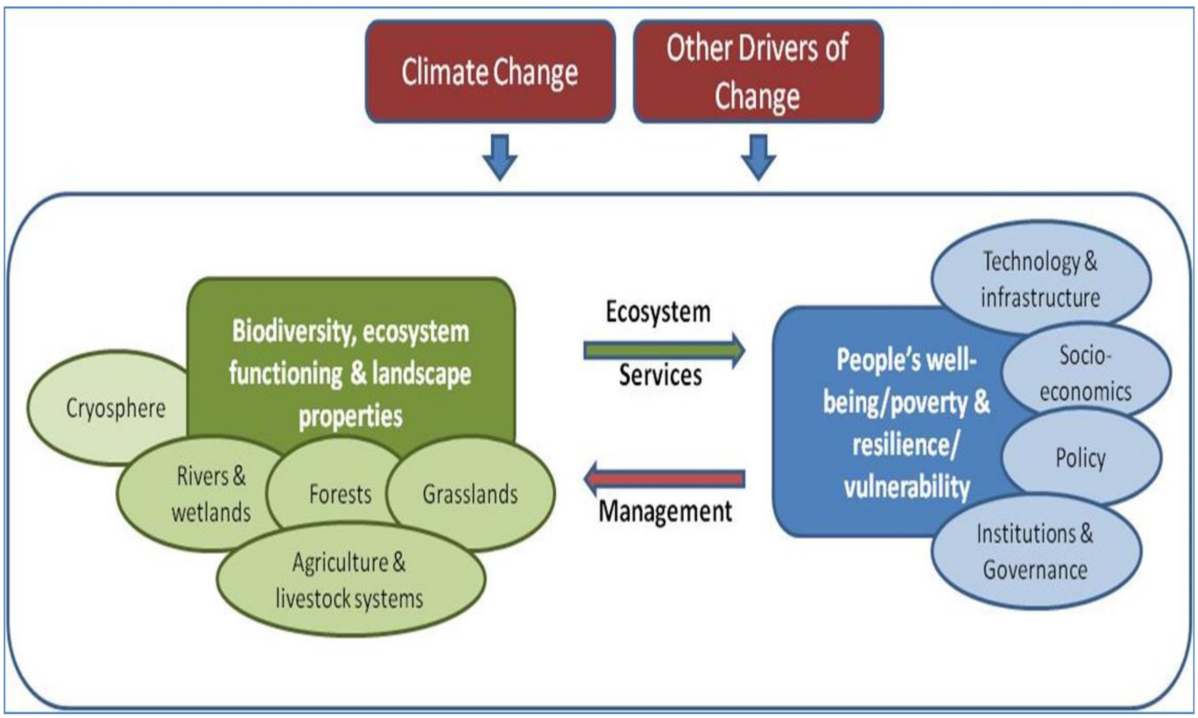

Figure 3.1 A broad conceptual framework of a socio-ecological system, ecosystem services and drivers of change (adapted from the ICIMOD Working Paper on LTESM).

Individuals and institutions desirous of initiating research and monitoring of ecosystem services flow will have to make clear distinction between ecosystem functioning and the amount of cultural, regulating and provisioning ecosystem services that the area can potentially supply. The supply of provisioning ecosystem services is mostly determined by the physical ecosystem structure, such as vegetation and food web composition (**Fig 3.2**). Regulating ecosystem services are mostly determined by the functioning of ecosystem processes, such as water and mineral cycling and capture of solar energy by plants. Key ecological interactions, such as pollination, can also be considered as regulating ecosystem services. The supply of cultural ecosystem services can be considered as emergent properties of the ecosystem as a whole, such as for concepts such as aesthetic beauty or educational use.

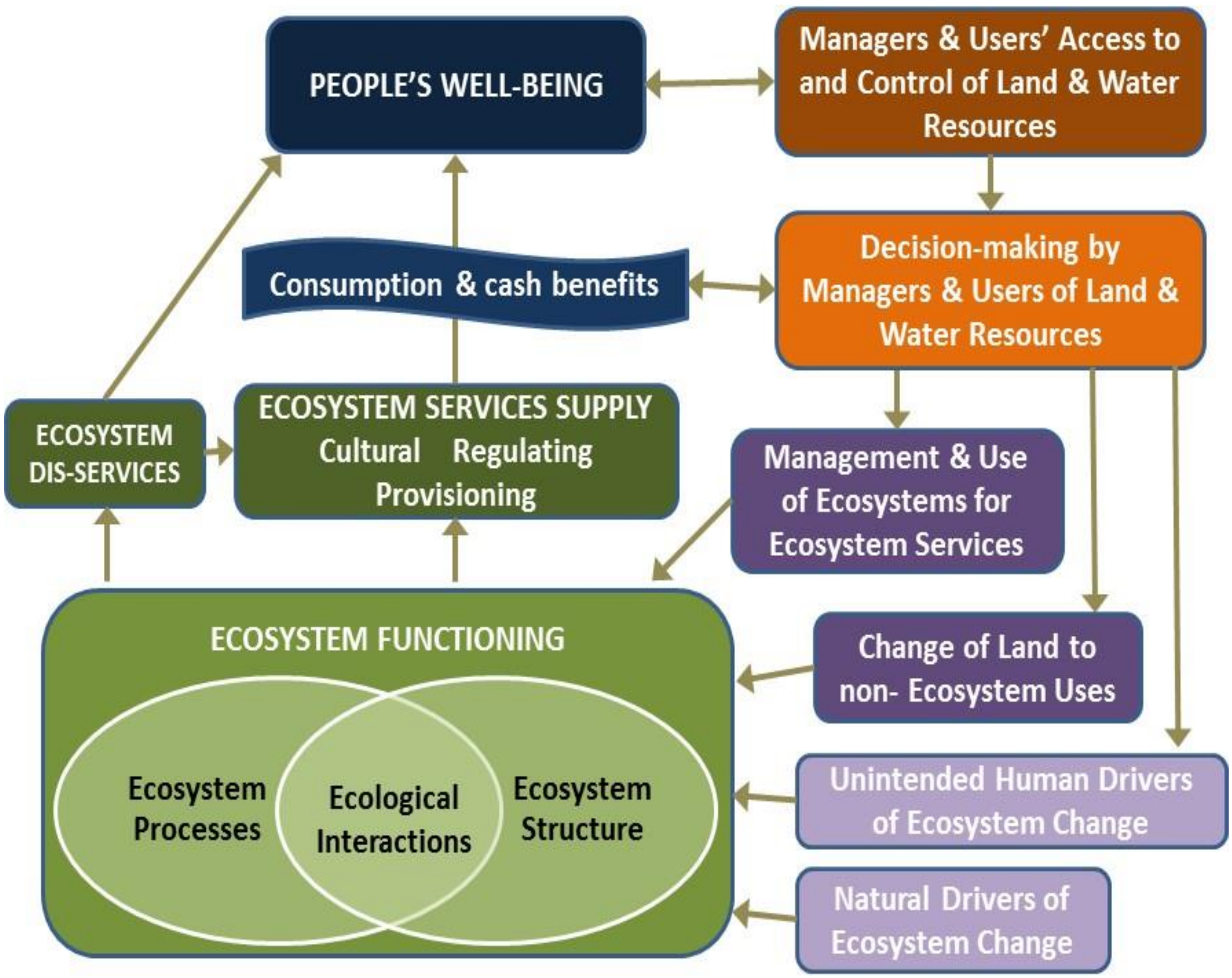

Figure 3.2 A conceptual framework to guide management and monitoring for ecosystem services (Produced by Philip Bubb for this document)

3.3 Ecosystem service metrics for pilot sites in KSL – India

The essential ecosystem services from the pilot areas of KSL – India include water for drinking and irrigation, biomass in the form of timber, fuelwood and fodder, and non-timber forest products (NTFPs) which contribute to the livelihoods and human well-being in the area. The ecosystem management plans visualize equitable sharing of goods and services taking into accounts the needs of women and poorer sections of the society. Although there are a large number of ecosystem services which can be taken up for valuation and monitoring, the following services have been selected for long term monitoring for the KSL-India pilot sites (**Table 3.1**).

There has been an increasing realization that quantification of various components of ecosystem services without linking them with human well-being makes very little sense to the policy planners and local communities. Hence, several authors (Tallis & Polasky 2011; Tallis *et al* 2012) have advocated to separate the production function (the *supply*), requirements vs. actual use by the communities (the *services*), and the *benefit* derived by the communities along the ecosystem service supply chain (**Figure 3.3**). Conceptually, the *supply* denotes full potential of the ecological functions in an ecosystem whether or not humans actually recognize, use or value it. Measuring the actual *delivery* of services to people also requires information on demand for and use of such services. Thus, supply and service metrics provides a means of quantifying the value of ecosystem services, valuing their impacts on well-being and constructing policy-relevant indicators of trends (Nicholson *et al* 2009). Likewise, final step in the supply chain represents how much the flow of a given service contributes to human well-being (Tallis *et al* 2012). The selected ecosystem services and associated metrics proposed for pilot sites of KSLCDI are shown in Annexure 3.1.

It is important to note that some of the services and benefits are contained at a local scale while other services flow out at the larger landscape. Several ecosystem services such as climate regulation, soil formation, air quality, spiritual and religious values, are not being included in the monitoring programme at this stage due to lack of market prices for such services.

Table 3.1: Key ecosystem services selected for monitoring in Bans-Maitoli and Himkhola watersheds, KSL - India (VP = Van Panchayat; RF = Reserved Forests; NTFP = Non- timber Forest Products; BM = Bans-Maitoli; HWS=Himkhola Watershed; SNS= Sacred Natural Sites).

Major services	Specific services	Where to monitor
Provisioning services	Fresh water for drinking	B-M; HWS
	Water for irrigation	B-M
	Timber production	VPs and RFs in B-M and HWS
	Fuelwood production	-do-; Agricultural fields and borders of respective villages
	Fodder production (both leaf and grass fodder)	Grassland Restoration Sites; village surrounds in B-M and alpine rangelands in HWS
	Non-timber Forest Products	HWS / alpine meadows
	Crop production	Agro-ecosystems, B-M, and HWS
	Livestock production	-do-
Supporting services	Nutrient cycling	Restoration sites, B-M and HWS
Regulating services	Regulation of CO_2	SNS
	Control of soil erosion	Restoration sites /agricultural fields
	Pollination	Agro-ecosystems
Cultural services	Spiritual and religious values	SNS
	Recreation and tourism	SNS; RFs and VPs

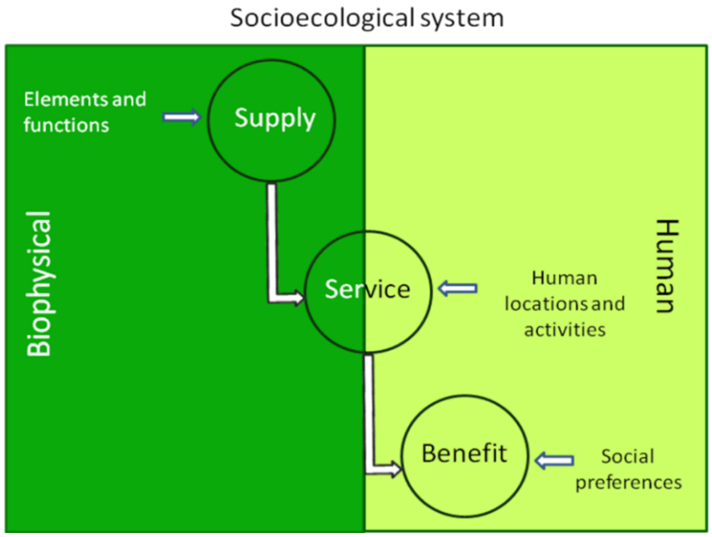

Figure 3.3 Components of the ecosystem services supply chain (Adapted from Tallis *et al.* 2012)

3.4 Monitoring protocol and approach

Most of the ecosystem services selected for long term monitoring in the KSL-India (Table 3.1) are dynamic in nature and their supply varies in space and time. For example, degree of slope and depth of soil may influence forage production and type of rocks and habitats may influence distribution and abundance of high value medicinal plants. Similarly, changes in land use and land cover may also influence nutrient and energy flow. It is visualized that most of the services and benefits would be monitored at sample plots, eco-restoration sites and experimental plots where services and benefits are likely to change as a result of intervention. Based on the objectivity and feasibility of sampling and their relevance to human well-being at the local as well as regional scales, a total of 13 parameters have been selected for two pilot sites in KSL-India (Table 3.2). General approach, proposed methodology, and frequency of monitoring are also given. Monitoring approach for each parameter is described below:

1. **Drinking water**

First step towards assessment of drinking water in the pilot area is mapping of spring-shed and preparation of overall water budget for Chandak - Aunlaghat watershed. For the Bans-Maitoli village, it is proposed to make an assessment of supply – demand ratio, which will serve as baseline data. It is also proposed to measure the flow of drinking water near the spring head that supplies most of the water in the village and also at the lower end of the village during lean season. Water quality at both the points will be tested for standard parameters including contaminants and coliforms. Availability and use of water for selected hamlets especially which are prone to water scarcity would be measured annually during peak summer. Overall analysis of water quality for aquatic ecosystem for standard parameters such as Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Status of Primary Producers, pH, Salinity, temperature, and turbidity would be monitored once in a season at selected points using portable water analysis kit by as separate team (Sivakumar et al. 2015, this volume).

2. Water for irrigation

Presently nearly 50% of the agricultural fields in Bans-Maitoli are irrigated and rest in rain-fed area. As part of livelihood enhancement under KSLCDI, a few farmers having marginal land holding would be encouraged to grow off-season vegetable. Amount of water available and drawn by such farmers will be measured annually and also income generated through enhanced crop production (as a measure of benefit) would be recorded regularly using questionnaire and direct interview.

3. Timber production

Most preferred tree for house construction in Bans-Maitoli is sal (*Shorea robusta*). However, it is available only in very limited quantity. On the other hand, Himkhola watershed has greater choice of species and availability is better, *albeit* variable across socio-economic groups. For both, the pilot sites baseline data on population / age class structure of 5 most valuable timber species would be measured especially within VPs, RFs and private lands. Similar observations would be made at the intervals of three years to see the supply and benefits drawn by the local communities and adjacent villagers.

4. Fuel wood production

It is estimated that about 7200 Quintals of fuel wood is consumed by the villagers of Bans-Maitoli per year (@11 kg per day per household). With the increased supply of cooking gas, kerosine and electricity fuel wood consumption should decline leading to reduced pressure on forests. The status of fuel wood availability and use pattern in Himkhola WS is different due to non-availability of cooking gas and colder climate. For each pilot site, maps showing fuel wood collection areas with respect to each hamlet would be prepared using PRA tools i.e., participatory natural resource mapping, preferred species of fuel wood and their availability (ranking) in VP and RFs which would be re-assessed at the interval of 3 years.

5. **Fodder production**

Easiest measure of fodder production in the pilot site is in terms of volume per unit area. Leaf fodder is usually collected from the trees and shrubs largely from the private lands where farmers rear fodder trees, whereas grass fodder is collected from both bunds of agricultural fields as well as grasslands or hay plots which are protected from livestock grazing. Fodder requirement of the communities depends on the livestock holding pattern and socio-economic status. Two hamlets in each pilot site would be selected for monitoring annual leaf and grass fodder consumption. Data would be compiled with the help of volunteers.

6. **Production of Non-timber Forest Produce**

Hill bamboos and wild medicinal herbs including caterpillar mushroom (*Ohiocordyceps sinensis*) are the major NTFPs in the Himkhola watershed. In Bans-Maitoli area Babhyo (*Eulaliopsis binata*) is collected for making broom and ropes. Data on the availability of these resources would be collected through participatory resource appraisal (PRA) tools and stakeholder workshops. Currently, these tools are also being used for participatory natural resource mapping (PNRM) in the landscape. Annual consumption of wild medicinal plants as household remedies as well as quantity of medicinal herbs sold in the market and cash income generated would be recorded for the sample hamlets / villages on annual basis.

7. **Crop production**

Two simple parameters under this category, proposed for monitoring are total harvest of traditional and cash crops (species wise) from the pilot hamlets. The data will be disaggregated according to altitude and type of agricultural land (irrigated, rain-fed). Based on the prevalent market price of cash crop, total income per family (especially targeted for livelihood improvement) would be estimated.

8. Livestock production

Most of the farmers in the pilot sites own a number of domestic livestock. The pattern of livestock holding has been changing drastically in recent years, e.g., reduction in the number of buffaloes, increase in the number of goats compared to sheep. The livestock production has linkages with inputs to agriculture (in terms of manure and draught), nutrition (dairy products, meat) and cash income. Pattern of livestock grazing, feed supply, and total benefit would give an idea about service and benefit linkages especially for the sections of the society who are heavily dependent on livestock rearing.

9. Nutrient cycle

Standing state of nutrients in restoration sites and reclaimed agricultural land is expected to improve over the years. C:N ratio and NPK within monitoring plots of restoration sites will be measured once in 3 years following standard procedures (Dey and Yaduvanshi 2001). As part of ecosystem management plan, a few agricultural fields, especially in rain-fed areas, need to be taken up on experimental basis for nutrient amelioration and soil and moisture conservation using sloping agriculture land technique (SALT). Baselines on standing state of nutrients at such fields would be collected and monitored subsequent to management intervention.

10. Control of soil erosion

As per the Ecosystem Management Plan prepared for Bans-Maitoli area, it is proposed to enhance retention of soil on hill slopes (forests, grasslands and agricultural fields) by increasing ground cover, bioengineering tools and use of SALT. Through these activities, the project plans to enhance regulating services at the experimental sites. Silt load in the streams water channels flowing through the experimental sites would be used as indicator of soil erosion control. Silt load would be measured at 8 – 10 points during July – August on 5 rainy days every year using locally fabricated sediment sampler (Ongley 1996).

11. Carbon stock in sacred natural sites

Inventory data on standing live and dead trees and lying dead wood will be used to calculate the carbon stock at representative sites within VP, Sacred Groves and RFs of both the pilot sites. Standardized calculations for converting tree measurements into volume, biomass, and finally carbon will be would be estimated using allometric equations. The sacred forests do have ability to accumulate and store carbon over time as essential part of the global carbon cycle. It is proposed to make use of this opportunity and monitor the carbon stock for future opportunities on Carbon credits and Payment for Ecosystem Services.

12. Pollination service

Sampling of insect visitors would be done at different strata of in agricultural fields for major agricultural and horticultural crops dependent on insect vectors for pollination. Sampling would be done on sunny days during spring. Insect nets would be placed to capture honeybees visiting flowers within random plots of 4 m^2 (2x2 m) or at lower branches of fruit trees (peach, apricot, and mango) within 2 m above ground. At each sampling station all insects visiting flowers would be sampled for 15 min between 9:00 and 12:00 following Taki et al., (2011). To maximize comparability during each sampling period, all fields will be sampled in two sequential four day periods.

13. Cultural services from sacred natural sites and other features of landscape

All the sacred natural sites (SNS), prominent geological features and religious sites including water bodies and spring-heads have tremendous educational, cultural, aesthetic and social values. Although a separate study is being initiated on the methods of analyzing cultural services and 'sacredness' of such sites, it is proposed to establish baseline on the number of visitation to selected sacred natural sites in both the pilot areas from local and distant locations. At present, there is negligible income to the local communities from nature-based tourism but it is likely increase in near future. One parameter proposed for monitoring the benefit derived by the communities due to nature based eco-tourism in and around SNS is total income from this activity and its distribution among various sections of the society.

3.5 Data analysis, prediction of trends and capacity building

Most of the variables suggested for measurement and subsequent monitoring in this document are based on the priority issues identified for ecosystem management in pilot areas. Estimating mean values for most of the provisioning services for given units of time and space will not require any sophisticated analysis. However, results based on quantification of individual parameters need not be interpreted in isolation. Extrapolating some of the observed trends for the larger landscapes would require in-depth analysis of service mapping and patterns of flow. The parameters measured through this programme would help in tracking the key services and benefits from various ecosystems and also in analyzing the trends in distributional equity among various socio-economic groups. It is visualized that some of the services which flow at larger geospatial scale can be used to formulate policies for mainstreaming ecosystem services in development planning at district, state, and transboundary scales. For example, the services in the form of clean drinking water flowing from the catchment as a result of good practices and amount of carbon stored in the sacred groves can be used to negotiate for payment for ecosystem services (PES) in near future. It would also be necessary to develop an institutional mechanism for participatory monitoring of these parameters and making it compatible with the standard protocols as used by GEO BON Es.

Changes in land use and land cover, vegetation structure and composition and cropping pattern will affect flow and delivery of ecosystem services. How would flow of such services affect human well-being in the pilot areas and beyond is yet another pertinent question to be addressed. A separate study would be needed on this. Similarly, forest fires, spread of alien invasive species, crop damage by wild herbivores and natural disasters such as land slips and landslides would affect delivery of certain ecosystem services. Modelling ecosystem flows under different scenarios (e.g., Anonymous 2011; Nelson *et al.*, 2009) would be a desirable step.

Several parameters listed in this chapter can be monitored by the local volunteers and members of Van Panchayat and Self Help Groups (SHGs). Their capacity will have to be built and an institutional mechanism for data archiving, sharing and frequent analysis will have to be developed. For example, several community forest user's groups in Nepal have developed a system of community based forest carbon monitoring. Some of the Biodiversity Management Committee (BMC) members and SHGs will have to be trained in maintenance of high quality data, accurate estimation of carbon and other skills so that strong case could be built for payment for ecosystem services or forest carbon offset projects.

Table 3.2: Key Ecosystem Services, Parameters, and Protocol for Monitoring
(B-M = Bans-Maitoli; HWS = Himkhola Watershed; SNS = Sacred Natural Site)

Ecosystem Service	Parameters	Sampling Method	Time, Place, & Frequency of monitoring
1. Drinking water	Water quality and quantity	Water quality analysis Measurement of flow	Lean season Spring-head & Outlet B-M Annual
	% population with easy access to clean drinking water	Household survey Distance travelled to fetch drinking water	Lean season; Drought prone hamlet B-M Once in 3 years
2. Water for irrigation	Volume of water withdrawn by marginal farmers for irrigation	Measurement of flow (Volume estimation)	Lean season Fields of marginal farmers Annual
	Market value of enhanced crop production due to irrigation	Household survey Informer interview	Harvesting season B-M Annual
3. Timber production	Timber production	Girth-class distribution of timber species (Top 5 species); Estimation of timber volume	Summer VP and RF B-M and HWS Once in 3 years
	Market value of timber harvested	Market survey	Summer B-M and HWS Once in 3 years
4. Fuel wood production	Annual fuel wood consumption per family	Household survey Rank top 5 species in terms of weight and preference	Winter season B-M and HWS Annual
	Market value of total fuel wood consumed	Market survey	Annual B-M and HWS Annual
5. Fodder production	Volume of leaf forage collected from VP	No. of headloads collected from forest	Dry season B-M and HWS Annual
	Volume of grass produced at restoration site	Volume / Headloads harvested at restoration site	Post monsoon B-M and HWS Annual
	Market value of forage produced at restoration site	Market survey	Annual, both pilot sites
6. Production of NTFPs	Amount of hill bamboo used per family per year	House-hold survey PRA Tools	Summer HWS Annual
	MAP species used as home herbal medicine	PRA Tools; Stakeholder workshops; Top 5 species in order of preference	Autumn HWS Annual

		ranking and quantity used per year per family	
	MAP species collected for cash income	Household survey Market value of all the MAPs sold per year (HWS)	Autumn HWS Annual
7. Crop production	Production of traditional crops	Household survey Species wise production	Harvest season B-M and HWS Annual
	Production of commercial crops	Household survey	Harvest season B-M and HWS Annual
8. Livestock production	Production of non-commercial livestock	Household survey Species wise livestock holding per family	Winter B-M and HWS Annual
	Production of commercial livestock	Household survey No. of animals sold per year	Winter B-M and HWS Annual
9. Nutrient cycle	C:N ratio at restoration site	Walkey – Black Method (Dey & Yaduvanshi 2001)	Summer season B-M Restoration site Once in 3 years
	Standing state of nutrients in crop fields	Walkey-Black Method (Dey & Yaduvanshi 2001)	Winter B-M and HWS; Experimental sites Once in 3 years
10. Control of soil erosion	Mass of soil retained in the treatment area	Silt load estimation Sediment sampler (Ongley 1996)	Monsoon season B-M and HWS Annual
11. Regulation of CO_2	Carbon stock in VP and SNS	Allometric equations based on wood volume Estimation of soil carbon	Summer Monitoring plots in B-M and HWS Once in 3 years
12. Pollination Services	Pollinator diversity and abundance on various food crops	Belt transects and observation plots (Taki et al., 2011)	Rabi and Kharif crop flowering time B-M 2 seasons x 3 consecutive years and later at the interval of 3 years
13. Cultural Services from SNS	Income from nature-based eco-tourism	Household surveys Stakeholder workshops Rank 5 most attractive SNS / Eco-tourism sites with preference of visitors	Summer Chandak-Aunlaghat WS and HWS Once in 3 years

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Annexure 3.1: Tentative list of key questions, topics, and indicators for long-term monitoring of Ecosystem Services in KSL – India.

Suggested sites for monitoring: Pilot areas; Chandak-Aunlaghat and Himkhola Watersheds; For riverine / aquatic ecosystems: Ramganga river from Pancheshwar to Aunlaghat and Gokarneshwar Gad

Use of Ecosystem Services **Key questions: (i) What ecosystem services are people using? (ii) How important are ecosystem services to people's well-being? (iii) How significant are ecosystem dis-services in affecting people's well-being?**		
Monitoring topics	**Indicators / measurements**	**Methods & frequency of measurement**
(A) Provisioning ecosystem services and consumption across various socio-economic groups	*Per socio-economic group –* *Amounts harvested, amounts consumed locally, and cash income from:* Agricultural products; Livestock; Grass fodder; Tree fodder; Wild plants & animals for food; Timber; NTFPs for fibre, medicines; Fuelwood; Leaf litter for soil improvement; Freshwater for household use; Freshwater for crop irrigation;	Household surveys. (Participatory) Transects, quadrats, and field observations in forest types, grasslands, and agricultural lands. Once in 3 years.
(B) Regulating ecosystem services importance across various socio-economic groups	*Importance per household and/or socio-economic group of benefits to wellbeing and livelihoods from:* Regulation of water flows, magnitude of rainfall runoff, and aquifer recharge; Soil erosion control by vegetation;	Household surveys. (Participatory) Spring and stream water flow and quality sampling – 3 monthly? (Participatory) Transects & quadrats of soil quality and erosion evidence in forest

	Regulation of soil quality by micro-organisms and invertebrates; Regulation of invertebrate and animal crop pests by predators; Pollination of crops and fruit trees by insects, birds, and bats; Payments for ecosystem services.	types, grasslands, and agricultural lands. 6 monthly? Farmer's records of crop losses due to invertebrates and wild animals. Annual? Farmer's records of yields of crops and fruit trees that are pollinated by insects, birds or bats.
(C) Cultural ecosystem services consumption across various socio-economic groups	*Importance per household and/or socio-economic group of benefits to wellbeing and livelihoods from:* Spiritual or religious values of species, ecosystems, and landscapes.	Household surveys. Size of areas dedicated to deities. Religious or cultural controls on use of species.
(D) Human-wildlife conflicts	*Importance per household and/or socio-economic group of effects on wellbeing and livelihoods from:* Crop raiding by wild animals; Livestock losses due to mammal predators; Injury and changes in habits due to large mammal predators;	Official records of occurrences of crop raiding, livestock and personal losses due to predators, and compensation and legal cases. Annual? Household questionnaire surveys. Once in 3 years?

Ecosystem Service Supply (Per ecosystem type, e.g., Forests, Grasslands, Alpine Meadows): Key Questions: (i) How are ecosystem services changing in the landscape? (ii) Is the ecosystem service supply sufficient to meet the demand? (iii) Is the structure sufficient to supply desired ecosystem services? (iv) How are species (keystone and flagship) responding to changes?		
Monitoring topics	**Indicators / measurements**	**Methods & frequency of measurement**
Provisioning ecosystem services supply **(Ecosystem structure; harvested species)**	Extent of Ecosystem Type; Springs and pools in forest areas. Standing stock (biomass) and sustainable harvest levels of tree fodder; wild plants and animals for food; Timber; NTFPs for fibre, medicines; fuelwood; Leaf litter for soil improvement. Abundance and biomass of herbivorous mammals; Canopy cover; Shrub layer presence. Grass and herb coverage of soil; Extent of bare soil; Soil organic layer depth.	Geo-spatial analysis using remote sensing and GIS. Fixed-point photography. Participatory mapping. 3-5 years. For vegetation and soil: (Participatory) line transects, quadrats. Annual? For mammals: (Participatory) direct and indirect evidences using line transects, quadrats, field observations, camera traps in forest types. Once in 3 years.
Regulating ecosystem services supply **(Functioning of key ecosystem processes; key ecological interactions)**	Extent of Ecosystem types; *Water cycling* – soil moisture retention; water infiltration rate of soils; *Mineral cycling* – abundance of soil invertebrates and fungi; decomposition time of leaf litter; biomass of herbivorous mammals;	Geo-spatial analysis using remote sensing and GIS. Fixed-point photography. Participatory mapping. 3-5 years.

	Solar energy flow – grass and herb coverage of soil; canopy cover; plant biomass; tree growth rates; biomass of herbivorous mammals; biomass of predatory mammals; abundance of soil invertebrates and fungi. *Biological growth* - plant biomass; tree growth rates; biomass of herbivorous mammals; biomass of predatory mammals; abundance of soil invertebrates and fungi. *Herbivory* - grass and herb coverage of soil; *Predation* – abundance of predatory mammals and birds of prey; abundance of insectivorous birds; *Decomposition* - abundance of soil invertebrates and fungi; decomposition time of leaf litter; abundance of vultures; *Pollination* – abundance of bee colonies; *Seed dispersal* – abundance of frugivorous birds;	For vegetation and soil: (Participatory) line transects, quadrats. Annual? For mammals: (Participatory) direct and indirect evidences using line transects, quadrats, field observations, camera traps in forest types. Once in 3 years. For birds: (Participatory) transects, point counts, call counts for pheasants, field observations, camera traps. Once in 2 years.
Cultural ecosystem services supply **(Valued species, whole ecosystem properties)**	Abundance of culturally-valued species, including nationally and internationally threatened species; (e.g. pheasants, birds of prey, vultures) Presence of forest and landscape features of cultural importance;	(Participatory) transects, point counts, call counts for pheasants, field observations, camera traps. Once in 2 years.

Governance of Natural Resources (Management) Question: What is the capacity of local institutions (both modern and traditional) to ensure efficient, equitable and sustainable natural resource use?		
Monitoring topics	**Indicators / measurements**	**Methods & frequency of measurement**
River provisioning ecosystem services supply (ecosystem structure; harvested species)	Water quality; Abundance of water plants; Abundance of fishes; Abundance of invasive plant species; Abundance of invasive invertebrate species;	Basic water quality analysis including estimating BOD. Quarterly? Abundance of plants from transects and permanent plots. Annual? Abundance of fishes using catch per unit effort method at selected localities. Once in 2 years. Abundance of invasive invertebrates using systematic sampling of river bed. Annual?
River regulating ecosystem services supply (functioning of key ecosystem processes; key ecological interactions)	Abundance of amphibians (indicators of water quality and natural habitat condition);	Pitfall traps; voice recordings?
River cultural ecosystem services supply (valued species, whole ecosystem properties)	Abundance of culturally-valued species, including nationally and internationally threatened species; Presence of landscape features of cultural importance;	(Participatory) Transects, field observations, camera traps. Annual?

Effectiveness of governance for natural resource management	Existence of a management plan for Van Panchayat to supply multiple ecosystem services for all sectors of society (covering forests, grazinglands; Hay meadows); Existence of comprehensive ecosystem management plan covering drinking and irrigation water; No. of government and non-government agencies involved in management of forests and natural resources; No. of meetings and resolutions passed for improved management of forest, grasslands and water resources; % of women in meetings for management of forests, grasslands and water resources; % of women in organisational leadership and finance roles;	Questionnaire Surveys Official Records

Chapter 4. Approaching Spring Shed Management in Pilot Site of Kailash Sacred Landscape, India- *Assessment, Monitoring and Convergence Perspectives*

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4.1 Background

Spring water, emerging naturally from confined and unconfined aquifers, is the primary resource for sustenance of life in the Himalayan region. Springs are the major source of domestic and agricultural water for most of communities in the region (Valdiya and Bartarya 1989, 1991; Negi and Joshi 1996, 2004; Tambe et al. 2012). However, due to several reasons, such as changes in land-use patterns, changing climate, and various other natural and anthropogenic perturbations, existence of these natural water sources is severely threatened. Further, the ever increasing demand of growing population is also putting heavy pressure of on these springs.

Knowledge of hydrology and dynamics of springs is critical for effective management of water resources in the drought prone areas of Himalaya. This chapter provides scientific basis for mapping springsheds, their monitoring and management in pilot areas of KSL.

All this has resulted in drying up of large number of springs in the Himalayan region. Several other springs are following similar trends and thereby adversely affecting the life of dependent communities. A study by Mahamuni and Kulkarni (2012) has reported that across Indian Himalaya nearly 8,000 villages are under acute water shortages due to drying up of springs. Another scientific report, nearly 3 decades back, had indicated that in the Kumaun region of Uttarakhand, nearly 75% of the springs have gone dry with an average decline of ~40% of discharge of springs during 1951 to 1986 (Valdiya and Bartarya 1989). They attributed this significant decline in spring discharge to changes in land-use patterns and vegetation.

Springs are fed by groundwater whose recharge is dependent on monsoon and winter precipitation. Therefore, changes in precipitation patterns significantly impact on the availability of groundwater and subsequently on discharge of spring water. The general decline of spring water in the region has, therefore, resulted into decline in per capita water availability consequently leading to increased social conflicts, drudgery of women and migration, particularly in the rural areas. This scenario calls for improved understanding of water balance (i.e. demand-supply patterns), social governance system, and geo-hydrological dynamics of ground water with the perspectives of aquifers that act as storehouse or the source. All this requires effective integration of science based approach with the customary bio-engineering interventions, and building synergy amongst diverse stakeholders, including community and community based organizations. Realizing this, a systematic and collaborative approach was tested to assess the spring water resources, monitor the discharge of selected springs and develop an approach for spring water augmentation using Spring-Shed Management (SSM) approach.

4.2 Spring-shed management (SSM)

The Spring-Shed Management (SSM) approach refers to a systematic practice of identifying springs and their recharge zones by characterizing them on the basis of their types, discharge trends, seasonality, and structural control (Mahamuni and Kulkarni 2012). The approach broadly considers two major aspects; (i) using knowledge of hydrogeology for understanding dynamics of springs, and (ii) adopting participatory approach of implementation and management. This approach helps in identifying the nature of underlying rocks and their behavior such as permeability, porosity, and structural aspects (i.e. strike and dip) so as to increase the understanding about types of springs and the aquifers feeding them.

Box 4.1.
Eight Step Approach of SSM

i. Comprehensive mapping of springs and Spring-Sheds.
ii. Setting up a data monitoring systems
iii. Understanding social and governance aspect.
iv. Hydro-geological mapping.
v. Creating conceptual hydro-geological layout of spring shed.
vi. Classification of spring types, aquifers and recharge areas.
vii. Developing spring-shed management protocols for implementation.
viii. Monitoring the impacts of spring revival.

Moreover, the approach also considers the groundwater hydrodynamics, which helps identifying the recharge area and forms the basis for laying out the precise interventions required for the preparation and implementation of SSM plans. Therefore, SSM allows a systematic and scientific assessment of spring water storage, its quality, and ways and means to augment groundwater availability and its conservation through community participation. Realizing this strength of SSM, under Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI), the eight step methodology (ICIMOD, 2016) was considered expert consultation and extensive group discussions with partner institutions in Indian part of KSL (Box 4.1).

4.2.1 *Intervention area*

The SSM approach was applied and tested in a pilot site at Gorang valley, Chandak-Aunlaghat Watershed (CAW), in KSL part of India formed the intensive study and intervention area. The Gorang valley, between 80°09.00' to 80°11.00' E long. and 29°36.00' to 29°37.00' N lat., has gentle sloping hills at its periphery and forms vast undulating plain composed of unconsolidated debris at its Centre. Total population of the Gorang valley, in 17 villages/ toks, is 4756 (806 households) with an average household size of 6. The location and Land use/ Land cover of target site has been depicted.

4.2.2 *Inventorying & mapping of springs*

Extensive surveys and interactions were conducted in the valley, which resulted in identification of 53 springs (27 Naula and 26 are Dhara). All these springs have been georeferenced and mapped. While conducting surveys the major focus was on: (i) locating all the natural springs following interaction with villagers; (ii) georeferencing each spring with the help of hand held GPS, and (iii) documenting the status/nature (seasonal/ perennial) of each spring. The elevation profile of the springs varies from the highest spring at 1826 meters amsl to lowest at 1546 meters amsl. Most of the springs (91%) are perennial. However, villagers revealed discharge of these greatly declines during summer season.

This leads to increased pressure and thereby the vulnerability of most of the springs during lean season (March-June). Following information on the dependency and vulnerability, 18 springs have been marked for long term monitoring. These identified springs are therefore subject to continuous observations for spring discharge measurements on fortnightly basis.

4.2.3 *Setting up of a data monitoring system*

As the spring discharge is directly controlled by the aquifer or groundwater level; its recharge depends on amount of precipitation received in a particular area. Therefore, to study overall water balance in the Gorang valley, rain gauges have been installed at various locations along elevation range covering different aspects of the valley (Figure 4.1; Table 4.1). These rain gauges were installed in collaboration with the identified local partner (Himalayan Sewa Samiti - HSS, Chandak, Pithoragarh) and identified resource persons from village community. Further,

Box 4.2.
Developing Para-hydro-geologists

i. Identification of willing, motivated and dedicated resource persons (RPs) from local community.
ii. Providing conceptual understanding of springs, spring-shed and its importance to RPs.
iii. Imparting hands-on training on monitoring and evaluation of springs and handling of the instruments. They were also exposed to approach of household survey.
iv. Engaging of trained RPs in designing approach for data collection from identified springs and households.
v. Validation through ground survey and data observation.
vi. Ensuring payment of minimum/ appropriate wages to identified RPs.

Figure 4.1- Left to right Installed rain gauge in Gourang valley, Training to para hydrologist, and monitoring discharge

one manual weather observatory (consisting of max-min and dry-wet bulb thermometers) has also been installed at HSS and one radar based water level sensor at the outlet of the valley for continuous measurement of total discharge in the Gokarneshwar stream. Discharge from selected springs was measured on fortnightly basis by the trained para-hydrogeologists from village community of the valley. Various aspects of developing para-hydro-geologists are included (Box 4.2).

Table 4.1. Details of nonrecording rain-gauges installed in Gorang valley

S.No.	Name of the station/ village	Latitude	Longitude	Elevation masl	Parameters measured
1	HSS, Chandak (Dharapani)	29°36.0049'	80°11.0108'	1892	Rainfall, Temperature, Relative Humidity
2	Chedda	29°37.103'	80°11.089'	1805	Rainfall
3	Majheda	29°36.086'	80°10.105'	1688	Rainfall
4	Digtoli	29°37.124'	80°09.021'	1702	Rainfall
5	Sankatiya	29°37.25'	80°09.49'	1380	Rainfall, Discharge

4.3 Understanding social and governance aspects

4.3.1 *Water Utilization Patterns and Adaptive Measures*

Towards assessing water utilization patterns in pilot site, extensive household surveys were conducted using structured questionnaire (Annexure I) and following outcomes of several focus group discussions - FGDs (Box 4.3). Analysis of datasets revealed that the spring water in Gorang Valley is mostly consumed for domestic purposes (49%) that include bathing, personal hygiene, laundry, house cleaning, and watering kitchen garden. This is followed by consumption for livestock sector (39%) and drinking purposes (12%). Study further highlighted that larger percentages of women (78%) were engaged in collection of water from springs.

Box 4.3.
Group Discussions (FGDs)

i. Potential stakeholders identified and ensured their representation in the group discussion
ii. FGDs targeted framing the structured questionnaire for survey.
iii. Deliberated on training contents for resource persons/ researchers for data collection using structured questionnaire.
iv. Discussed testing and validation of questionnaire outside the sampling frame
v. Identification and social groups considering gender and social structure.
vi. Making a sampling frame and cluster of village.
vii. Conducting FGD through trained resources person and using structured questionnaire.

Box 4.4.
Water Scarcity - Key impacts and adaptive measures

- Forced to (i) cover 1-2 km extra to collect water (44%), (ii) reduce water consumption (34%); adapting by way of constructing harvesting tanks/ hand-pumps (16%), and harvesting rainwater (6%).
- Additional 1 hr (approx.) is spent to collect water from far distant sources of water.
- Water scarcity mainly affected domestic (32%) and agriculture (29%) work, health (31%), and education (8%) of women.

The impacts of adaptive measures adopted by villagers to cope with water scarcity during summer are presented (Box 4.4). This water scarcity has affected rural women in different ways. Study emphasizes that owing to their major involvement in many household activities, the scarcity of water leads to increased drudgery of women and thereby affecting their health. In view of this and considering higher familiarity of women with the existing water scarcity related issues and coping strategies, it is agreed during FDGs that their greater involvement to be ensured for developing meaningful water management plans in the study area.

4.3.2 *Water Supply-Demand Analysis*

The information generated through household surveys and field based observations was used calculate supply demand (S-D) ratio. The same was calculated following the information on total availability and demand of water in each village (Box 4.5). The S-D analysis revealed that 8 villages in the valley are vulnerable in terms of water availability (Box 4.5). Villages with S-D ratio <1have been identified as vulnerable in terms of water availability. These villages are suffering from high water demand but lower availability; therefore, requiring immediate attention for planning and interventions for conservation and management of water resources.

Considering per capita availability of water, it was assessed as 33 litres per capita per day (lpcd) in the valley. This goes further down to 12 lcpd during summer season, mostly in upper parts of the valley. The estimated water availability in the valley is much lower than the limits (minimum 55 lcpd) prescribed by the Bureau of Indian Standards (BIS) and the guidelines of National Rural Drinking Water programme (NRDWP)-2013, Ministry of Drinking Water and Sanitation, Government of India for Twelfth Five Year Plan (2012-2017).

Box 4.5.
Water Vulnerable Villages of Pilot sites

S.No	Village	S-D Ratio
1	Bhurmuni	0.01
2	Dharapani	2.03
3	Naikina	0.06
4	Chanapandey	0.08
5	Dhungabhul	18.7
6	Gurura	0.3
7	Dharigaon	0.2
8	Halpati	11.36
9	Godiyagaon	2.62
10	Cheda	0.03
11	Nakot	10.3
12	Majhera	11.07
13	Kante	32.97
14	Ratwali	0.51
15	Digtoli	0.05
16	Sintoli	5.0
17	Sinchaura	8.0

4.4 Hydro-geological mapping and formation of hydro - geological layout

4.4.1 *Geological Investigation in the Gorang Valley*

As the geology of area plays a critical role in determining the geo-hydrological patterns, a detailed geological assessment of study site was conducted. Engagement of experts for this purpose is much desired. The detailed geological investigations were thus conducted across the valley. Results of these surveys showed that the dominating rock types in the valley are dolomitic limestone, talc, calc-silicate, magnesite, slate, quartzite, and metavolcanics that correspond to the Gangolihat Dolomite, Sor Slate, and Berinag formations. In Berinag quartzite the primary porosity is governed by its medium-coarse grained and even pebbly nature.

The Gangolihat Dolomite shows abundant example of having two sets of fractures/joints, pot-hole surfaces, caves and karst topography. At Bhurmuni village a number of sink holes are also noticeable. Within a wide zone of thrusted contact, the rocks are highly sheared, shattered, pulverized, weathered and fractured corresponding to the formation of innumerable planes of secondary porosity both in quartzite-metavolcanics and calc-silicate/dolomitic limestone and highly cleaved slate. The entire valley is covered by Quaternary debris, rock falls, landslide slope wash material which corresponds to both porosity and permeability. The secondary porosity seems to exceed the primary porosity (Figure 4.2).

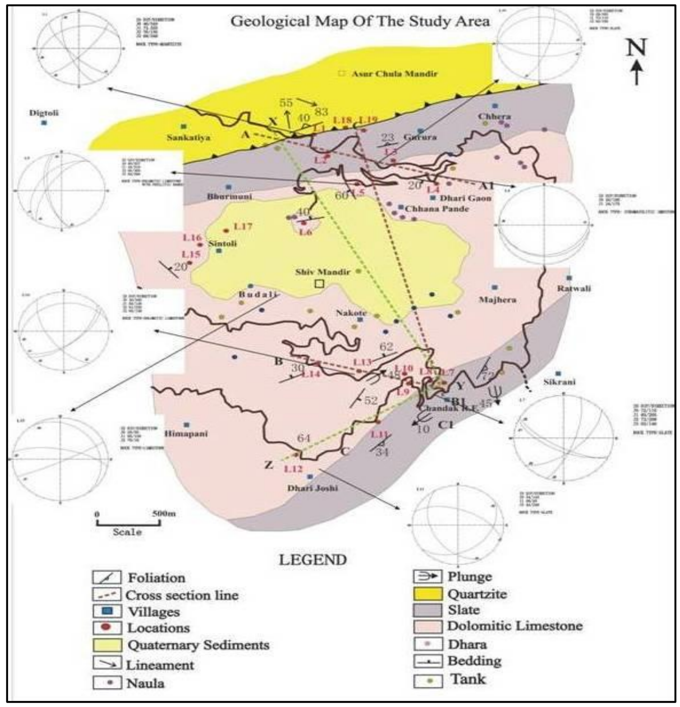

Figure 4.2- Geological map of the study area

It is a well-known fact that when the surface of the slope of the hill intersects the water table, groundwater moves out in the form of a spring or seepage and marshes or ponds are formed. Hence, water comes out from the contact point of the permeable and impervious layers.

Fracturing of rocks increases their permeability hundred to thousand times. The shallow fractured zones are therefore the favorable locations of groundwater. Fault gauge of a fault zone prevents downstream movement and thus causes accumulation of water in crushed rocks. Fault zone store large volumes of groundwater (Valdiya, 1980, 2013).

The karsts topography of limestone is always an ideal repository of groundwater. The Gorang valley watershed fulfills most of these prerequisites. Keeping in mind the above mentioned points it is envisaged that the geomorphic slopes, geological structures and the rock formations exposed in the major part of the Gorang valley of Pithoragarh are favorable for groundwater resource. Various lithologies and their structutral control in the Gorang watershed were studied (Figure 4.3). The stereonet plotting shows the major secondary porosity in the form of bedding and joints dipping towards the valley as well as the interplay of these discontinuities and the contact between lithologies resulting in the origin of springs. The frequency of the springs has been largely controlled by the dolomitic limestone and the contact between quartzite and dolomitic limestone. Dolomitic limestone results in the formation of caves and pools for percolating water and acting as an aquifer and channels for the transportation of groundwater. Therefore, the structural control over the area is playing a major role in the flow of subsurface water. Springs can be seen located mostly at slates and dolomitic limestone lithologies or their contacts.

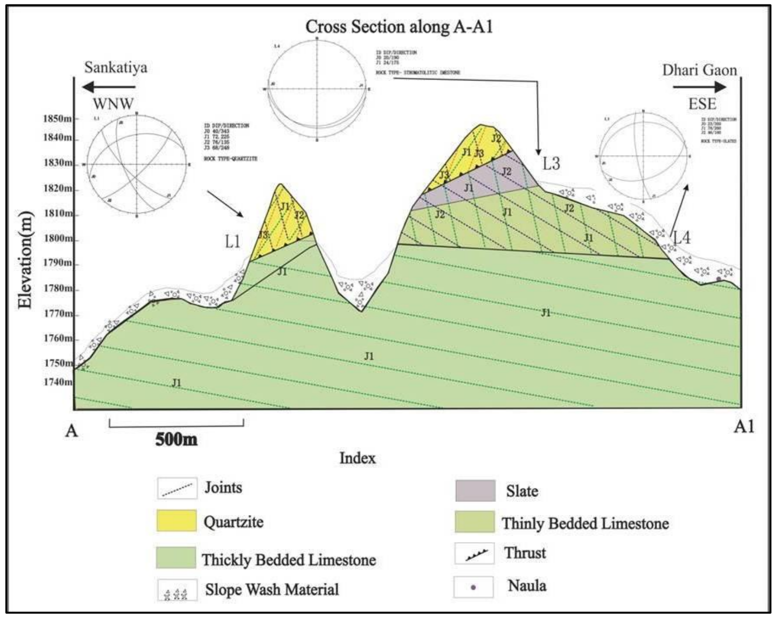

Figure 4.3.- Lithologies and their structural control.

The geological mapping shows the joint planes mostly dipping towards the valley slope indicating a dominant control of secondary porosity in the transport of ground water and formation of spring in the valley. The results indicate that the prevailing structural aspects (i.e. strike and dip) making (i) a pathway for groundwater movement towards the valley and (ii) favorable condition for spring recharge in the area.

4.5 Spring-shed Management Protocol & Interventions

Based on hydro-geological assessment, management protocols for implementation of SSM at Digtoli and Nekina villages of the valley were developed.

4.5.1 *Implementation of SSM in Digtoli & Nakina villages*

In Digtoli village 5 springs (namely; Shivalaya, Naunipani, Panigair, Padpani, and Bajni) were identified for implementation of SSM. Hydro-geological analysis suggests a majority of locally confined aquifers are controlled by fractures while Shivalaya spring is fed by unconfined aquifer. Most of the springs occur at the intersection of aquifer with topography as depressions or fractures at the escarpment slope. The specific hydro-geological description of different springs along with recharge zone identification and measures is discussed below.

The Shivalaya Spring

Figure 4.4- Shivalaya spring

It is the largest and perennial source of water in Digtoli village. The spring is located on unconsolidated debris (Figure 4.4) and water emanates from a source composed of slates. It has good storability and transmissivity. Hence, the water table would be near the surface of unconfined aquifer. Hence, it has vast recharge area lying above the source in the close vicinity of the village. *Therefore, it was suggested to practice cultivation with the slope of land tilted inwards. This will aid in pounding of water and natural recharge of the aquifer.*

Panigair and Padpani Springs

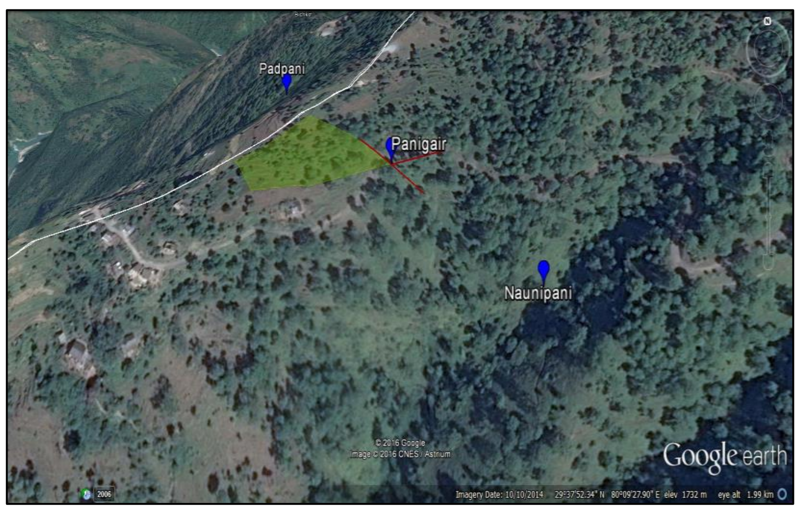

Figure 4.5.- Panigair and Padpani

The base rock for these springs is compact quartzite which acts as an impermeable layer. The percolated water flows through the inter-bedded sequence and cleaved slates supported by limestone as the base rock. The dip amount and direction of the rocks indicates that the common recharge zone is located far west from spring (Figure 4.5). Further, fractures and the cleavages in the slates allow the movement of water towards the springs. *Owing to this fact, the*

identified recharge zone serves as water tower for the recharge of both the springs. It is likely that the identified recharge zone may also feed the Naunipani spring.

Naunipani Spring

Figure 4.6.- Naunipani Spring

Naunipani, a fractured spring, is located at the topmost fracture line forming the Digtoli micro-watershed. It is located on a fracture extending right from the top of the watershed up to the origin point of the spring. The recharge zone of the spring is along the fractures in the escarpment slope (Figure 4.6) facing towards the fracture line. *Hence, trenches or the check walls should be made along the fractures above the spring.*

Bajni Spring

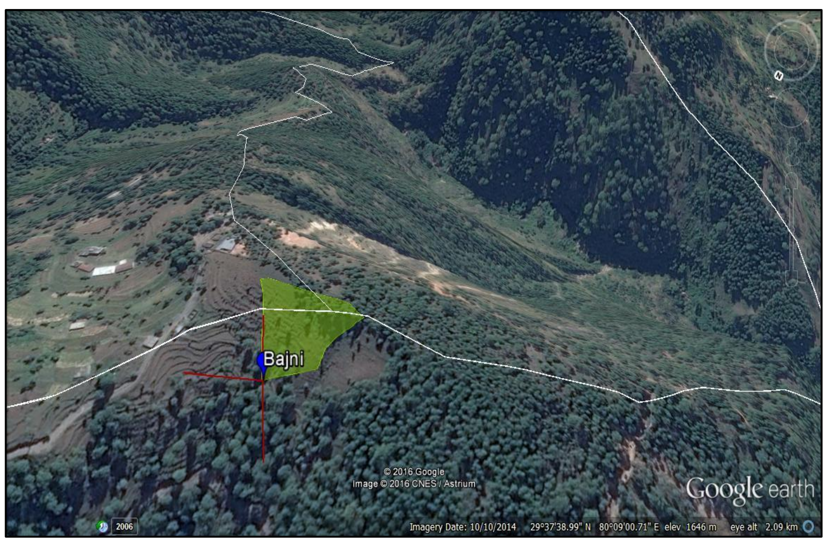

Figure 4.7- Bajni Spring

Bajni spring, originating on the dip slope, is formed at the contact of quartzite and the interbedded sequence. Its recharge area lies just above the slope (Figure 4.7) where quartzite is highly cleaved and fractured. Hydro-geological investigations indicate that its storability is expected to be low. *Therefore, recharge structures should be made on areas with thick soil so as to slow down the infiltration rate. Since functioning of recharge measures at this spring is challenging due to relatively higher slope (50^0), therefore, the recharge structure would require regular monitoring and maintenance.*

In general, it was found that the dominant rock types, quartzite, dolomitic limestone, slate, and phyllite show varying degree of deformation. Further, the strike of the rocks is N330° (NW-SE) dipping towards valley (N60° -NE) at angles varying from 9° to 65° from the horizontal. The ground water infiltrate through fractured quartzite, slate, and phyllite. At places, where unconsolidated debris is present, groundwater movement is also controlled by the topography. Hence, recharge zone for the individual spring is controlled by local geology and topography. Based on the hydrogeology of the study area, different kind of recharge structures are recommended as per varying slopes (Table 4.2).

Table4.2. Recommended Design of the trenches on the sloping lands

Slope	Size			Type
Degrees	Length (m)	Width (m)	Depth (m)	
<20	5.0	2.0	1.0	Ponds
20-30	2.0	1.0	0.6	Trenches
30-40	2.0	0.6	0.6	Trenches, Check walls
40-50	2.0	0.6	0.45	Trenches, Check walls

4.6 Implementing SSM plans

Having developed the plans and management protocol, it is important to have effective implementation. This calls for participation of diverse stakeholders ranging from community to various government departments and civil society agencies.

4.6.1 Seeking Convergence

Based on the primary understating of hydrogeology, plans for intervention and implementation of SSM were prepared in consultation with the community and various line departments of Pithoragarh District (Figure 4.8).

Figure 4.8.- Preparation of plans for intervention and implementation of SSM

Following, the village level interaction meetings, cluster level stakeholder's consultations were organized for strengthening of developed plans. Finally, meetings with district authorities and departments were organized in 2015 and 2016 for synergy building and developing approach for implementation.

Community engagement in implementation of SSM was ensured from the beginning for which several meetings, training, and field workshops were organized (Figure 4.9, Table 4.3). Initially, consultation was held with the community on understanding changing climate and its possible impacts on water resources.

Figure 4.9- Training and field workshop

Subsequently, a two-day training programme-cum-field workshop on "Assessment of water resources and climate change adaptation - *A partnership with rural communities*" was organized. HSS, Pithoragarh facilitated identification of local resources persons for survey work and collection of various primary information including hydro-meteorological observations. With a field exercise, demonstration was given to the identified resource persons on measurement of flow rate of the springs and collection of water samples to monitor spring water quality. Towards strengthening the approach of SSM, with facilitation of ICIMOD, a partner’s workshop was organized to design a common methodology for study and implementation of SSM. FGDs were conducted to assess the spring water governance system. Subsequently, two convergence meetings were organized with the community representatives of different villages of Gorang valley to establish linkages with the head of the Village Panchayats and the Van-Panchayats so as to get desired help in implementing the interventions. Finally, a one-day workshop was organized targeting rejuvenation of springs by community participation and demonstration on construction of trenches, ponds and plantation techniques to increase the retention of water and enrich the aquifers of the springs. The workshop succeeded in sensitizing and mobilizing the community towards monitoring and management of water resources.

Table4.3. Chronology of events for ensuring stakeholders engagement in implementation of SSM

S.No.	Event organized	Date and Venue	Participants	Broad outcomes
1	Consultation meeting on "Impacts of climate change on water resources"	September 2015; HSS, Chandak	Village representatives from Gorang valley	i. Sensitized community; concept of SSM was introduced ii. Identification of issues related to springs and water management
2	Training programme-cum-field workshop on "Assessment of water resources and climate change adaptation"	September 2015: HSS, Chandak (Pithoragarh)	Resource persons/ para-hydrogilogists from local community from Gorang valley	i. Questionnaire tested ii. Resources persons identified and trained for household survey, measurement of hydro-meteorological and water quality parameters ii. House hold survey initiated
3	Workshop on "Spring-Shed Management in Himalayas"	November 2015; TRC (Pithoragarh)	Representatives from partner organizations (ICIMOD, WII, UKFD, CHEA, ACWADAM, HGVS, HSS) and resources persons	i. Designed a common methodology for study and implementation of SSM across all the study sites in Indian and Nepal part of KSL ii. Joint field visit with UKFD; identified pilot sites for SSM ii. Hydro-gelogical mapping initiated at pilot sites
4	Consultation & convergence meetings with UKFD	February 2016; (Pithoragarh)	Official of UKFD and researchers of GBPNIHESD	i. Interventions initiated by UKFD at Digtoli
5	Focus Group Discussions	March-June, 2016; Gorang valley	Different social groups from villages of Gorang valley	i. Assessment of water utilization patterns, governance, management and other social issues related to springs
6	Convergence meetings with the community representatives	April-July, 2916; Gorang valley	Community representatives of different villages from Gorang valley	i. Made liaisoning with the head of the Village Panchayats and the Van-Panchayats to help in implementing the interventions
7	Consultative meetings with community	April-July 2016; Gorang valley	Individual households	i. Management plan for water resources developed in consultation with the individual beneficiary/ household

8	Training-cum-field workshop on "Rejuvenation of water resources through hydro-geological approach"	August 2016; Aitola tok in the van-panchayat (VP) of Nakina village	Village community from 4 different villages of Gorang valley	i. Awareness on rejuvenation of springs by bio-engineering measures, community role in maintaining health of the springs ii. demonstration on construction of trenches, bunds, and ponds; 50 trenches were made for demonstration ii. 200 saplings of Q.leucotrichophora and Q.glauca were planted in 1 hectare land of Van Panchayat
9	One-to-one consultation with line departments	August 2016; Pithoragarh	Various line departments of Pithoragarh District and researchers of GBPNIHESD	v. Shared SSM plan for Gorang valley with line departments v. Interventions made by UKFD at Nakina village for implementation of SSM

Following several rounds of consultations, an effective convergence with various government departments and the community based organizations (CBOs) was achieved. A field visit was organized jointly with the officials of Uttarakahnd Forest Department (UKFD) in Gorang Valley for identification of intervention area. Based on hydro-geological mapping, interventions for implementation of SSM at pilot site (i.e. Digtoli and Nakina) were made by the UKFD (Fig. 4.10).

Figure 4.10- Implementation of SSM at pilot site

4.6.2 *Monitoring the Impacts*

Considering that various ground interventions were made in June 2015, continuous monitoring of discharge of identified springs is being made since then. Therefore, for the identified springs, the discharge data for pre-implementation period in 2015 and post implementation period 2016-17 has been analyzed and compared. The preliminary analyses indicated that the discharge of selected springs has increased by 16-24% during different seasons. During the monsoon season (June-September) discharge of the selected spring is found increased by 24% while during post monsoon season (October-November) it is found to be increased by 20% from 2015. Similarly, 19% increase in winter season (December-February) discharge of selected springs in the valley has been observed. The pre-monsoon season (March-May) which coincides with the summer season is considered as most critical season in terms of water availability. Based on primary household survey it has been observed that during pre-monsoon period highest scarcity of water is felt in the valley. However, the post impact analyses indicate that after making spring recharge structures the discharge of selected springs has increased by 16% during pre-monsoon season.

4.6.3 *Continuing Monitoring*

Spring-shed management is a science based integrated approach which is expected to deliver the desired outputs in longer time frame. Therefore, a relatively extended temporal horizon is needed to assess and quantify its benefits in terms of spring recharge. Therefore, under the present phase of the KSLCDI, the datasets for two year (i.e. 2015-2017) seems inadequate to arrive at definite conclusion. However, the indicative trends are encouraging. In view of this, it would be appropriate to continue with monitoring of discharge for next three years so that the evidences are drawn from 5 years' datasets. We intend to achieve this through active community participation, especially through engagement of trained para-hydro-geologists.

4.7 Conclusion and Recommendations

We conclude that:

- The Spring-Shed Management (SSM) approach includes combination of advanced scientific methods and social engineering at the micro-watershed level to establish strong linkages between groundwater flows (hydrogeology), recharge areas, and springs distribution and patterns.

- The SSM also looks into community-level water management systems that could lead to empower communities to manage water and address the issues of efficiency, equity, and sustainability. Therefore, community participation is very crucial for implementation and monitoring of SSM.
- Further, for sustenance of such approaches stakeholder support such as technical advisory from academic institutions and synergy with various government departments is essentially required for SSM implementation.
- The pilot study shows immediate and direct benefits of SSM with an average increase in spring dischrge (~16%) during dry/ summer season leading towards water sutainability in the region. Further, this approach also has a number of long-term and indirect benefit such as increase in soil moisture and fertility, carbon sequestration throgh plantations, and decline in soil erosion and landslide events, and availability of forest based resources to community.
- The results of pilot study in Kailash Sacred Landscape part of India are indicative that integration of geo-hydrological maps and ecosystem based approach along with community participation is a prerequisite for success of any water recharge interventions. Therefore, SSM approach needs to be considered as integral part of all such large scale government run programmes/ initiatives in the region that are attempting to address the issue of water sustainability.

Acknowledgements

We sincerely thank all partner institutions of KSLCDI in India (WII, UKSBB, UKFD, CHEA) for their support Specific efforts and cooperation from UKFD in implementation of SSM at pilot site is duly acknowledged. Cooperation received from District Administration and various line departments of Pithoragarh is gratefully acknowledged. Our special thanks are due to inhabitants of Nakina and Digtoli. Mr. Jagdamba Prasad, Mr. P C Patni, Mr. Madan Patni and the para-hydrologists/ resource persons from community played crucial role in SSM implementation; we thank them.

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Annexure-I

Questionnaire for Focus Group Discussions on water Availability, Utilization, and Management

Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI)

1. **Demographic Information**

Village :	
Block :	
District :	
Distance from road :	
Total number of households :	
Average household size :	
Total population :	
Male/Female ratio or number :	

2. **Water Resources by Type**

2.1 Rivers / streams

2.1.1 What are the major rivers and stream in the area?

River/stream name	Distance from village (km)	Beneficiaries		Water availability (Seasonal, perennial)
		Villages	Households	
1.				
2.				
3.				
4.				
5.				

2.1.2 For what purpose is the river/streams water used?

Drinking	Livestock	Domestic purposes	Irrigation	others

2.1.3 Has the flow of rivers/streams changed over the past 10 to 15 years? (Increased, decreased, or remained the same)

....

2.2 Springs (naulas, dharas)

2.2.1 How many springs exist in the area and their type?

Location	Type of spring (naula, dhara)	Perennial	Seasonal	Completely dry	Priority

2.2.2 What volume of water do the springs discharge?
Perennial: Maximum………………, Minimum………………., Average……………….
Seasonal: Maximum………………, Minimum………………., Average……………….

2.2.3 For what purpose is the spring water used?

Domestic	Livestock	Domestic purposes	Irrigation	others

2.2.4 What changes have you noticed in the past 10 to 15 years in terms of water availability from springs?
....
....

2.2.5 How many springs have dried up during last 15 years?
....
....

2.2.6 What are the effects of heavy rainfall on the sources of water in terms of quantity and quality?
....
....

2.2.7 If water availability has decreased, how do you cope with it?
Drinking:...
....
House hold purpose (Washing, cleaning, etc.):..
Irrigation:..
....
Livestock:...
Others:...

2.3 Rain water harvesting:

2.3.1 Do you harvest rain water in your locality? How many households use this practice?
....
....

2.3.2 What kind of water harvesting system is commonly used (collection in drums and buckets, open storage tank, closed storage tank, plastic pond, groundwater recharge, etc.)?
....

2.3.3 What is the average capacity of household level rain water collection system?
....
....

2.3.4 What are the preferred uses of water from this source?
....
....

2.3.5 For how many months is the harvested water sufficient?
....

2.3.6 What is the level of acceptance for rain water harvesting system? Do you think this is a sustainable source of water for household use?
....
....

3. **Sources of Water for various uses**

3.1 For domestic use

3.1.1 What are the major sources of water for domestic use?

System	Number	Beneficiary Households
Tap water (Government)		
Hand pump		
Spring water (Naulas, Dharas)		
River/stream		
Tanker		
Rain water harvesting		

3.1.2 Is the quantity of water sufficient for all your domestic needs (including drinking, cleaning, washing, sanitation)?
....

3.1.3 What is the status of quality of spring water?
....
....

3.1.4 What changes in quantity and quality of water from different sources have you noticed in the past 15 years?
....

3.1.5 Methods of water purification.

Boiling water	chlorination	Filter with cloth	Sedimentation of silt	Other

3.1.6 If there has been a decline, how do you cope with it?...

3.2 Sanitation

Type	Volume of water used	Source of water	Number of households
Pit latrine			
Pukka latrine			
No latrine			

3.2.1 Is sufficient water available for all your sanitation needs? If not how do you cope with it?
....

3.3 **Agriculture**

3.3.1 Major Sources for irrigation:

Source	Type (Perennial, seasonal)	Irrigated area	Beneficiary households	Trend (Increasing/ decreasing)
River/Stream				
Spring (naula, dhara)				
Gul / canal				
Canal				
Rain water harvest				
Others				

3.3.2 Methods of irrigation:

Method	Trend (Increasing/decreasing)	Source	Remarks
Flooding			
Polyethene pipes			
Sprinklers/drip			
Others			

3.3.3 How much is the total area of irrigated land? ....

3.3.4 Is the quantity of water sufficient for all your agricultural needs (including irrigation and livestock)?
....

3.3.5 How are the irrigation systems managed (in terms of institution, rules, regulations)?
....

3.3.6 What changes in quantity and quality of water for agricultural use have you noticed in the past 15 years?
....

3.3.7 If there has been a decline in quality and quantity, how do you cope with it?

....
....

4. **Land Use and land related activities**

4.1 Land use

Land use	Estimated area (%)	Notes and remarks
Agriculture		
Forest		
Grazing		
Others		

4.2 Agricultural practices

4.2.1 What are the proportions of khet and bari lands?
....
....

4.2.2 How many crops do you harvest per year in khet and bari lands?
....
....

4.2.3 What are the major crops and cropping patterns?
in khet land:...
In bari land:...

4.2.4 What changes have taken place in the past 10 to 15 years in
Landuse?...
Crops?...
Cropping patterns?...
Agriculture style?..
Production and yields?...
Use of pesticides and chemical fertilizers?..

4.2.5 Impacts of water scarcity on agriculture and horticulture:
....

4.2.6 Any crop and tree sown and planted by you which do not affect from drought?
if yes name them: Crops..
Trees..

4.3 Forests

Forest name	Type*	Condition	User/Beneficiary	
			Villages	household
*government, private, community, religious, national park/reserve, others				

4.3.1 What are the natural forest species?
....

4.3.2 What are the species used in afforestation?
....

4.3.3 What are the water resources available within the forests?
Rivers/streams:...
Springs (naula, dhara):...
Gul/ canals:..

4.3.4 How are the water resources in the forests utilized?
....

5. **Women's Groups**

5.1 Who fetches water for household use?

Children	Women	Men

5.2 How much water does one person collect per day?
....

5.3 How many times does one have to collect water per day?
....

5.4 How much water does one household use per day?

For drinking (lit./day)	For domestic use (lit./day)	For livestock (lit./day)	Other purpose

5.5 How much time does it take to fetch water for household use?

	Summer		Monsoon		Winter	
Children	Distance	Time	Distance	Time	Distance	Time
Women						
Men						

5.6 How is water allocated for household use?

Drinking: ....%
Dish washing: ....%
Washing clothes:.................................%
House cleaning:..................................%
Toilet:..%
Others (specify)..................................%

6. Water Management

6.1 Who formulates policies and manages water demand during deficiency of water?

Village panchayat	Special community(group)	Self	Organizations	Other

6.2 Is there any scheme implemented in last 10 -15 years? yes---- no----
If yes, give details...
....

6.2 Water related disputes. yes..... no.......
if yes
a) water getting from springs............
b) water getting from tap...........
c) water from canal/guls...........
d) social status in society..........
e) other.......

6.2 Disputes related to water management, if any, are settled by

Sarpanch	Village panchayat	Government (Patwari, District administration)	other (specify)

6.3 Problems/impacts due to decline in water quantity/quality in last 15 years

a) Health related

Cholera	Diarrhea	Malaria	Jaundice	Other

b) on women

On education	Household activities	Agriculture, livestock, gardening related activities	On health	Other

c) on children

On education	Less interest towards studies	Health	School drop	Other

d) on livestock

Left animal husbandry	Decline in livestock number	Decline in livestock production	Health issues	Other

7. Upstream areas

7.1 In what conditions are the upstream areas of water resources that are used by the community? ....

7.2 Have there been any major changes over the past 15 years in terms of infrastructure, housing, land use?..

7.3 Are there any plans for development and land use changes in the upstream areas in the near future? ....

8. Climate change

8.1 Over the past 15 years have there been any major changes (in terms of amount and timing) in:

- Temperature:...
- Rainfall:..
- Cloud burst:..
- Heavy rainfall:..
- Flood in streams/ rivers:...
- Landslides:..
- Drought:..
- Hailstones:..

8.2 How did they impact on the water sources in the area (in terms of both quality and quantity)? ....

8.3 What are the impacts of climate change on the following:

- Agriculture:...
- Forest:...
- Socioeconomic status:..

8.4 How did people cope with impacts of climate change?
....
....
....

Chapter 5. Monitoring Vegetation Structure, Composition and Functional Aspects in Kailash Sacred Landscape

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5.1. Background

Vegetation forms the most obvious component of terrestrial ecosystems. Changes in terrestrial environment can be detected effectively by monitoring the structure, composition and functional aspects of vegetation at various spatio-temporal scales. At a local scale, one can generate baseline information on the populations of various species of conservation significance such as high value medicinal plants, rare and threatened species, ground cover and other parameters of vegetation (Rawat 2008) which can be monitored subsequently. However, at a scale of larger landscape, over a long term, the datasets generated from representative sites/vegetation types can provide information on patterns of changes under major interventions or impacts at the levels of physiognomy and broad structure.

Several parameters of terrestrial vegetation including NTFP species and their abundance, community structure, phenology and functional aspects have been identified along with the techniques for their monitoring in KSL.

Vegetation structure and composition also indicates availability and flow of ecosystem goods and services which in turn affect core ecosystem processes include water cycling, mineral cycling, solar energy flow and biological growth. For the terrestrial ecosystems, a large number of processes can be used as indicators for monitoring structure and functioning. For example, litter decomposition and the formation of humus are processes that are dependent on vegetation and the quality and quantity of its litter production. Litter fall produced by certain plants may be fully degradable and thus will not turn into highly decomposed organic matter, i.e. humus (Kang *et al.* 2009). Furthermore, the structure and activity of the decomposing microbial community affect the properties and formation of humus (Grayston & Prescott 2005).

5.2 Parameters for monitoring structural and functional aspects

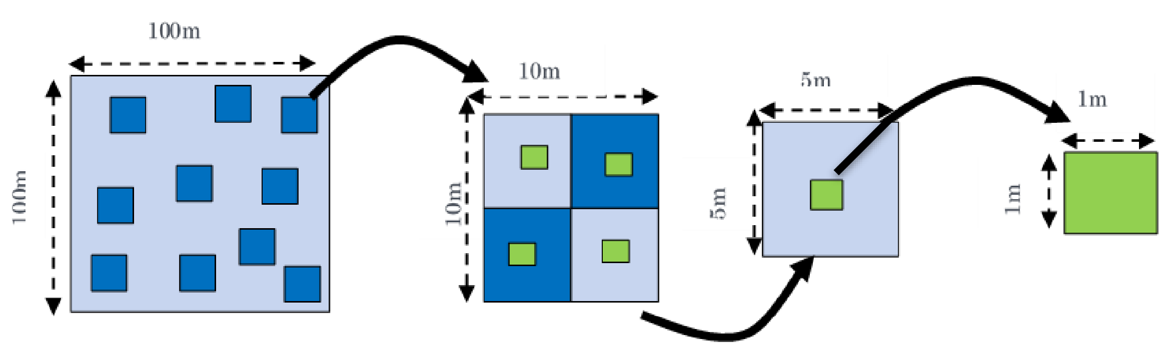
The parameters selected for monitoring vegetation structure and functioning in KSL - India have been listed in Table 1. These parameters have been selected based on their linkages with ecosystem services.

2.1. *Compositional Attributes - Permanent plots*

The representative forest vegetation and alpine areas have been identified for long-term monitoring in KSL-India. The base line for vegetation composition is generated using standard approaches of establishing permanent plots.

2.1.1. *Forest vegetation monitoring*

In each of the representative forest type, one hectare plots (100×100m) have been marked. Within these plots, ten (10×10m) quadrats for trees and tree saplings, twenty (5x5m) quadrats for shrubs and seedlings, and forty (1×1m) quadrats for herbs are laid randomly. In each quadrat, individuals of each species are enumerated; for trees Circumference at Breast Height (CBH; at 1.37m above the ground) is also measured (Fig.5.1).



[Each hectare permanent plot contains-ten (10×10m) quadrats for enumeration of trees and tree saplings; twenty (5x5m) sub-quadrats for shrubs & seedlings, and forty (11m) sub quadrat for herbs]

Figure 5.1. Schematic diagram of quadrats laid within hectare plot for trees, shrubs, herbs, and grasses

The vegetation compositional information for each permanent plot is compiled and analysed as follows:

- Prepare a master species list (alphabetically by family and scientific name) for all life forms (i.e., trees, shrubs, and herbs) in the forest plot and neighbouring areas. Highlight those species which are found in the sample plots.
- The compositional attributes of vegetation such as density, frequency, abundance, and dominance of constituent species can be analysed following Misra (1968). The Importance Value Index (IVI) is computed for all the tree species by adding the relative values of frequency, density, and dominance (basal area) following Curtis and McIntosh (1951) and Brown and Curtis (1952). The A/F ratio will also be assessed which indicates regular distribution if the value is <0.025, random distribution between 0.025 to 0.050 and contiguous distribution if >0.050 (Cottam & Curtis 1956). The formulae used for analysis are given (Box 5.1):

Box 5.1: Formulae used for analysis of vegetation compositional attributes

$$\text{Density/Quadrat} = \frac{\text{Total number of individuals in all the quadrats}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency (\%)} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Abundance/Quadrat} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

$$\textit{Mean of the circumference (C)} = \frac{\textit{Sum of all cbh of target species}}{\textit{Total number of individuals of target species}}$$

$$\textit{Mean basal area} = \frac{C^2}{4\pi}$$

Total basal area = Mean basal area × Density

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100$$

Importance Value Index (IVI) = Relative Density + Relative Frequency + Relative Dominance

- The diversity index, which makes the assumption that individuals are randomly sampled from an infinitely large population and also assumes that all the species from the community are included in the sample, is computed using Shannon-Weiner Index (Shannon and Weaver 1949):

$H' = \Sigma (ni/N) \times \ln (ni/N)$

Where, H′ = Shannon's information index of species diversity; ni = Total number of individuals of one species; N = Total number of individuals of all the species in one stand.

- Richness is calculated by counting total number of species observed in each plot/habitat.
- Evenness (Equability) is calculated using the Pielou's (1966) equation

Evenness (E) = H′/ H′ max. = H′ log S or H′/ln S

Where S = Number of species; H′ = Diversity

Evenness ranges between 0 and 1. If the evenness value is higher, the variation in communities between the species would be less.

Table 5.1: Distribution and details of permanent forest vegetation plots in KSL-India

Site/Plot (Codes)	Coordinates	Altitude & Aspect	Dominant vegetation type	General Information
CAW -1	N 29°37' 52.2 E 80°09' 35.9	1750 SW	Pine (*Pinus roxburghii*)	Van panchayat (Digtoli)
CAW-2	N 29°37' 42.2 E 80°10'27.2	1850 W	Oak (*Quercus leucotrichophora*)	Van panchayat (Naikina)
CAW-3	N 29°36' 13.0 E 80°11'11.0	1870 NE	Deodar (*Cedrus deodara*)	Reserve forest (Chandak)
HKW -1	N29°40.344" E80°03.763"	1520 m SW	Pine *(P. roxburghii)*	Reserve forests
HKW – 2	N29°38.148" E80°02.190"	1967 m Aspect-NW	Oak *(Q. leucotrichophora)*	Van panchayat
HKW -3	N29°37.764" E80°06.006"	925 m E	Sal *(Shorea robusta)*	Van panchayat

CAW – Chandak-Aunlaghat Watershed; HKW - Hat Kalika Watershed

Brief datasheet used for vegetation sampling in the field is given (Table5.2).

2.2 *Regeneration of climax species*

Six species of trees that form climax communities in two pilot sites, viz., Bans-Maitoli and Himkhola watershed have been selected for monitoring their age class structure and regeneration. These include Sal (*Shorea robusta*), Chir pine (*Pinus roxburghii*), and Banj oak (*Quercus leucotrichophora*) in the former and Hemlock (*Tsuga dumosa*), Timsu oak (*Quercus floribunda*), Kharsu oak (*Q. semecarpifolia*) in the latter. Population structure of these species will be recorded using standard phytosociological data within the plots marked permanently in the representative forest types.

2.3 *Above ground biomass in forest ecosystems*

Biomass can be estimated in total for stands or portions of stands as noted, but information on biomass distribution by plant component is often needed. Biomass plays major roles in the climate system: (i) photosynthesis withdraws carbon dioxide (CO_2) from the atmosphere and stores it in plants as biomass, part of which is transferred to the soil when it decomposes or is stored in protected soil carbon pools; (ii) biomass burnt by fire emits CO_2, other trace gases and aerosols to the atmosphere. Biomass affects other terrestrial Essential Climate Variables, like albedo (ECV T8), Land Cover (ECV T9), FaPaR (ECV T10), LaI (ECV T11), biomass (ECV T12) and Fire disturbance (ECV T13). The general lack of accurate spatial forest biomass data has been considered one of the most persistent uncertainties concerning global C budgets (Harrell *et al.*, 1995). The importance of biomass as an Essential Climate Variable is due to both its role as a carbon sink during the process of photosynthesis, its role in governing ecosystem productivity and its growing use for generation of bioenergy. Sustainable management of biomass sources, in particular forests, which store most of the Earth's biomass, contributes to reduction of CO_2 in the atmosphere, mitigation of climate change and protection of other ecosystem services including biodiversity conservation and water resources. Estimates of biomass change (due to land use and management practices or natural processes) enable a direct measurement of carbon sequestration or loss (as long as associated changes in soil carbon are accounted for) that can help validate carbon-cycle models and to quantify the human induced impacts on global climate change. Carbon emission from deforestation is the largest source of greenhouse gas emissions in many developing countries. Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) in Developing Countries could potentially achieve a reduction of 50 Gt of carbon until 2100 (Gullison *et al.* 2007).

2.4 *Forest cover*

Overall forest cover in the pilot areas, as well as canopy cover of the forests falling within Van Panchayats, Reserved Forests, and Sacred Forests, would be monitored. Canopy cover has been shown to be a multipurpose ecological indicator, which is useful for distinguishing different plant and animal habitats, assessing forest floor microclimate and light conditions, and estimating functional variables like the leaf area index (LAI) that quantifies the photosynthesizing leaf area per unit ground area (Jennings *et al.* 1999, Lowman and Rinker 2004). Secondly, many remote sensing applications involve estimation of either canopy cover (Gemmell 1999) or individual tree canopy area (Kalliovirta and Tokola 2005) as an intermediate stage in distinguishing the signals reflected from forest canopy and forest floor, after which, for instance, estimation of timber volume becomes possible (Bolduc *et al.* 1999, Maltamo *et al.* 2004). Vegetation type of the Kailash sacred landscape is in Annexure 4.

2.5 *Cover and abundance of invasive alien species*

An alien invasive species, viz., Kala Bansa (*Eupatorium adenophorum* or *Chromalena adenophora*) has led to drastic changes in structure of ground vegetation in forests, grasslands and agricultural fields of Bans-Maitoli. This has led to reduction in the biomass of palatable fodder grasses, negatively affected the regeneration of tree species. Hence, Kala Bansa has been taken for long term monitoring in terms of spatial extent, abundance, and cover. This would be monitored spatially using Remote Sensing and GIS once in 3 years. Also, at the scale of experimental (eco-restoration sites) and permanent plots, this species would be monitored in terms of cover annually.

2.6 *Forest floor litter mass*

It represents an input-output system on the soil surface and is important in the nutrition of woodlands, particularly those growing on soils of low nutrient status, where the trees rely upon the recycling of litter nutrients to a great extent. It represents also an important stage in the cycle of habitat conservation (Ashton 1975). Within each forest type the following parameters of litter will be assessed: fresh leaf litter, partially decomposed litter, reproductive/ miscellaneous litter and amorphous litter layer (humus).

2.7 *Standing state of nutrients*

The concentration of nutrients within the ecosystem usually depends upon a functional balance in their intra-system cycling (Jorgenssen *et al.* 1975). The nutrient status for an ecosystem can be monitored using parameters of vegetation, soil as well as litter. For monitoring the status of nutrients in the soil within selected permanent plots covering various ecosystems soil physico-chemical properties including C:N ratio will be analyzed and monitored following standard methods.

2.8 *Cover and abundance of fodder grasses at restoration sites*

The proportion of palatable grasses including tussock forming species at restoration sites, their diversity, cover, and biomass indicates the health of grasslands. It is proposed that Jhuli and adjacent open grassy slopes in Bans-Maitoli and selected grassy slopes in Himkhola watershed would be taken up for monitoring these parameters following standard protocol (Misra 1968; Rawat and Adhikari 2005) during post monsoon season annually.

2.9 *Abundance of high value medicinal plants*

High value medicinal plants, especially in alpine meadows in Himkhola watershed would be identified and sites for their monitoring would be marked permanently for regular monitoring during peak growing season. Role of medicinal plants in ecosystems have not been assessed so far. Hence, it is proposed to compare the sites of heavy medicinal plant extraction with controlled sites and assess their populations / response under varying conditions. The most common Non-timber Forest Products (NTFPs) extracted from the landscape are *Ophiocordyceps sinensis* (Keedajadi), *Picrorhiza kurrooa* (Kutki), *Dactylorhiza hatagirea* (Hathjadi/Salampanja), *Nardostachys jatamansi* (Mansi), *Rheum australe syn R. emodi* (Dolu), *Bergenia ciliata* (Pasahnbhed), *Allium stracheyii* (Jambu) and root bark of *Juglans regia* (Akhrot). Other species, viz., Atees (*Aconitum heterophyllum*), Bach (*Acorus calamus*), Chirayata (*Swertia chirata*), Kilmora (*Berberis aristata*), Banfsa (*Viola serpens*), Satuwa (*Paris polyphylla*), Mahamaida (*Polygonatum verticillatum*), Meetha (*Aconitum falconeri*), Samewa (*Valleriana hardwickii*), Thuner (*Taxus wallichiana*) and Somlata (*Ephedra gerardiana*) are collected for the local use by the local people. However, their commercial harvest is currently banned.

The status of all high value NTFPs can be quantified using Rapid Mapping Exercise (RME) technique following Rawat *et al.* (2004) to prepare an inventory of MAPs in an area. The layout of transect and sample plots is shown in Fig.5.2.

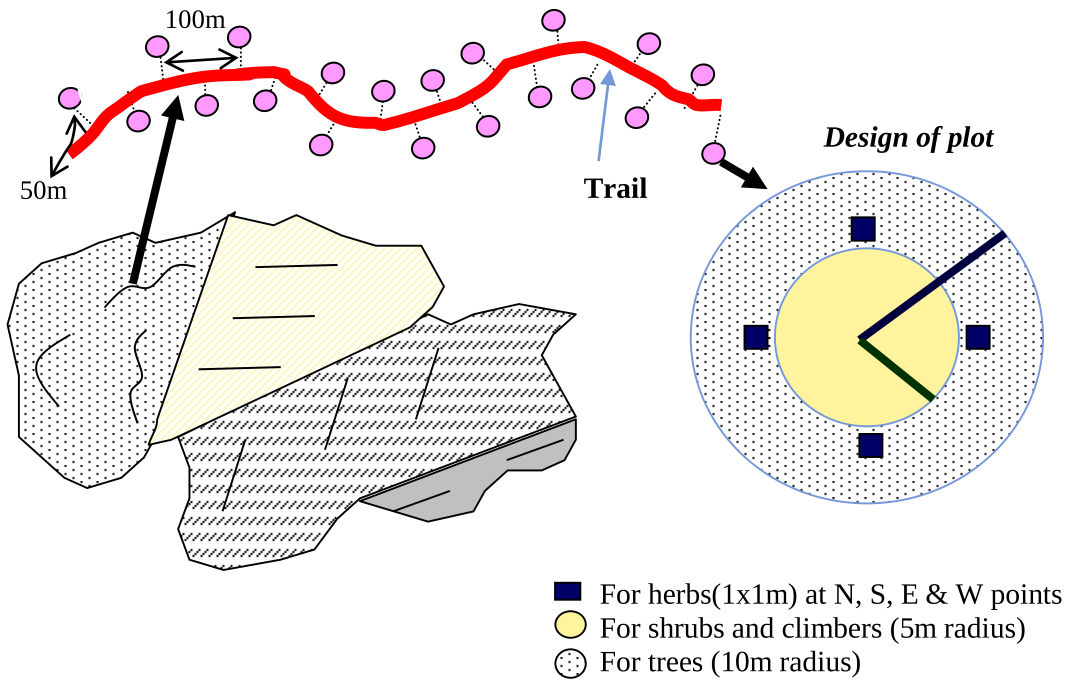


Figure 5.2. Stratification, layout of transects and sample plots (Rawat *et al.* 2004)

2.10 *Litter fall*

Litter fall produced by plants is the main source of organic matter for forest soil. Plant organs die, and ultimately whole plants die, but dead plant material, or litter, continues to have powerful effects on ecosystems, driving nutrient turnover, soil formation, and atmospheric composition. Soil properties, in turn, have strong impacts on plant community composition, diversity, and productivity. Although litter 'quality' and climate are the major determinants of decomposition, there is evidence that, to some extent, the microbial community can adapt to different litter types. Plant species' variation in decomposition is often related to variation in litter physico-chemical characteristics, such as C:N ratio, nitrogen and lignin content (Meentemeyer 1978; Aber & Melillo 1982; Melillo *et al.* 1982), tensile strength (Pérez-Harguindeguy *et al.* 2000) and, as recently suggested, leaf pH (Cornelissen *et al.* 2006). Pattern of litter fall will be assessed in different forest ecosystems following Adhikari *et al.* (1995).

2.11 *Phenology*

The timing of recurring biological phases, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species. The "phase", or "phenophase", may be the date of bud initiation, bud break, unfolding of first leaf, leaf growth, flowering and leaf senescence. The timing of phenophases is very important in biological systems and processes as it influences factors like the length of the growing season, frost damage, timing and duration of pests and diseases, water fluxes, nutrient budgets, carbon sequestration and food availability. Qualitative assessment of major tree, shrub and fodder grasses would be recorded at sampling sites on seasonal basis.

2.12 *Decomposition of fallen phytomass*

Plant species have the potential to alter these controls through changes in plant species identity, plant species interactions, and plant–decomposer interactions (Cornelissen 1996; Hooper *et al.* 2000; Gartner & Cardon 2004; Wardle *et al.* 2004). Plant species identity effects on decomposition have been widely studied and have contributed greatly to our knowledge of the control of litter quality on carbon and nutrient cycling in terrestrial ecosystems (Hobbie 1992; Cornelissen 1996; Cornelissen & Thompson 1997; Vivanco & Austin 2006). This parameter would be analysed qualitatively within permanent plots.

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Table 5.2: Vegetation Sampling: Field Datasheet

Plot name……………………….Major forest type……………………… Date………………

Plot location (lat, long. & Alt.)………………………....

Canopy (%)……..   Slope (^{0})……   Aspect……..........................

Grass cover (%)………Rock cover (%)……   Invasive sp cover................ (%)………Observer……………………………………......Affiliation................

Trees/Saplings (10×10m)					Tree Seedling/ Shrub species (5×5m)		Herb species (1×1m)		Remarks
Species name	*CBH (cm)*	*Ht (mt)*	*Ist Branch (mt)*	*L/ UL*	*Species name*	*No. of individuals*	*Species name*	*No. of individuals*	

Tree: CBH= Circumference at breast height (i.e. 1.37m), Ht= Height of tree, L/UL= Lopped/ Unlopped, se= seedling, sa=sapling, Sh=shrub, C=climber,

Annexure 5.1: Parameters suggested for monitoring forest structure and functioning in Kailash Sacred Landscape

Parameters	What to monitor	Where	How to monitor	Indicator/Purpose	Monitoring period
Vegetation Structure	Regeneration pattern of climax species	Banj oak, Chir pine and Sal forests in Bans-Maitoli	• Quadrat sampling will be done to study the regeneration pattern	• Better understanding of forest crop	After two year
	Aboveground biomass (tree, shrub and herb layer) and C stock	Banj oak, Chir pine and Sal forests in Bans-Maitoli	• Well established regression equations will be used, while for ground layer clipping will be done within 5, 1x1m quadrats	• Get the total stock available (biomass as well as carbon) in various ecosystems	After three years
	Forest floor litter mass	Banj oak, Chir pine and Sal forests in Bans-Maitoli	• Litter on the ground will be categorised as follows: fresh leaf litter, partially decomposed litter, reproductive/miscellaneous litter and amorphous litter layer (humus) and • 9 quadrats (50x50cm) 3 below the canopy, 3 in open place and 3 where canopies are overlapping) will be laid	• Will provide an idea (qualitative) that how much microbial activity is taking place • Leaching of nutrients decomposition	After two year
	Physico-chemical properties (Texture, moisture, water retention capacity, pH, OC, N,P, K etc.)	Banj oak, Chir pine and Sal forests in Bans-Maitoli Along water sources (Dhara&Naula)	• Through well-established methods	• In the initial stage, before intervention, nutrient status • After intervention nutrient status	Repeat observations will be made after two years
	Weed infestation	Banj oak, Chir pine and Sal forests in Bans-Maitoli and agricultural fields	• Along transects abundance will be assessed • After a distance of 25m, a circular plot (5m radius) will be laid to see the cover percent of the weed (*Eupatorium* & *Ageratum*), while one nested plot (1x1m quadrat) will be laid to get the abundance data in all habitats	• Provide conducive environment to grow more native species	These plots will be marked to assess the status of weed after a year period
	Fodder production	Jhulli and adjacent open areas	• Diversity, cover, and density of native grass • Biomass available as fodder	• Indicates health of the grassland	After a year period
	High value Medicinal plants	Himkhola watershed	• Plots will be laid to assess the abundance of high value MAPs in diverse habitats	• Over the period use of MAPs	Population assessment after a year period

			• Permanent plots will be marked wherever population of any species is found		
Functional Aspects	Litter fall	Banj oak, Chir pine and Sal forests in Bans-Maitoli	• 9 Litter traps (50x50x15cm) 3 below the canopy, 3 in ope place and 3 where canopies are overlapping) will be laid • Monitoring after two years	• Availability of litter to the community for various purposes, mainly for cattle shed if any collection is being made • Direct loss of nutrients to the system	1.
	Phenology	Qualitative phenological observations	• Major species (trees, shrubs and fodder grasses) • Information on maximum individuals at flowering will be jotted down every year	• May indicate the climatic variability over the period	1.
	Decomposition	Banj oak, Chir pine and Sal forests in Bans-Maitoli	• Thickness of the humus layer and moisture percent in the soil may indicate the decomposition rate	• Mineralization in the soil is fast or slow	

Annexure 5.2. Long-term monitoring of vegetation parameters, tentative locations and plot dimensions in KSL-India

Location	Elevation (m)	Plot dimensions	Number of plots	Frequency of sampling	Parameters /Indicators
Chandak-Aonalghat forest	2000m 1200m 500m	1 ha divided into 10x10 m plots (3 randomly located stands across forest type)	10 subplots of 10x10 random selection for trees, ten 25 m^2 for shrubs, twenty $1m^2$ for herbs	Annual	- Species composition - Density - Crown cover - Ground cover - CBH - Regeneration - Biomass - Soil C, N
Hat-Kalika	2000m 1000m 1600m				
Himkhola	2300-3200				

Chapter 6. GLORIA Sites for Monitoring Alpine Vegetation in Kailash Sacred Landscape, India

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6.1 Background

The planet earth is facing rapid climate change (Solomon *et al* 2007). It is evident that the recent three decades have been progressively warmer than all earlier decades (Hartmann *et al* 2013). The predictions of global mean surface warming of up to 2.6 to 4.8 °C towards the end of the 21st century, relative to 1986–2005, are indicative of possible drastic alterations of existing biosphere patterns (Collins *et al* 2013). While all ecosystems will be impacted by changing climate, high-mountain ecosystems are considered to be particularly sensitive thereby causing biodiversity loss, habitat degradation and landscape modifications (Sala *et al* 2000, Korner 2003).

The Global Observation Research Initiative in Alpine Environments (GLORIA) consists of a global network of alpine vegetation monitoring sites. Two GLORIA sites have been established within KSL India in order to monitor impacts of climate change on alpine vegetation. Monitoring protocol has been described.

The evidences from global mountains indicate that the Himalaya is experiencing the drastic global climate change outside of the poles. The region is predicted to experience a rise in temperature of 5–6^0 C and precipitation increases of 20–30% by the end of the twenty-first century (Solomon *et al* 2007, Kohler and Maselli 2012), making them among the most threatened non-polar regions of the world. Since the cold biomes at high elevations are regarded among the most dynamic systems on earth due to rising temperatures (Gonzalez *et al* 2010, IPCC 2013), it is expected that the alpine zone in the Himalaya will experience most rapid changes in its biodiversity patterns and processes. However, there have been very few attempts to understand such rapid changes and their wide ranging consequences. The Intergovernmental Panel for Climate Change (IPCC) described the Himalayan Region as data-deficient in terms of climate monitoring (2007). Further, the paucity of long-term climate data in the region, and uncertainty of data quality has been underlined on account of compatibility and mismatch of instrumentation and methodology (Negi *et al* 2012). This situation calls for urgent attention of researchers towards generating robust data-sets following globally compatible methodology. The urgency for Long Term Ecological Research (LTER) and use of uniform long term approach and standard methods in the region has recently been underlined (Rawal *et al* 2015).

The alpine environments in the Himalaya are very rich and unique in plant diversity (Rawal and Dhar, 1997; Dhar, 2002; Telwala *et al* 2013) and represent one of the most sensitive ecosystems to global warming (Theurillat and Guisan 2001). Number of studies from other mountain regions have proved that as a consequence of global warming, plant species and communities in high mountains are moving upwards and may get eliminated if already at mountain summits (Pauli *et al* 2012). However, presently we lack systematic studies from globally accepted long period monitoring plots/sites, which consequently restricts in assessing changes and building prediction scenarios over a long temporal scale in alpines of Indian Himalaya.

Towards addressing this gap, the G.B. Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD) under Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI) and NMSHE Task Force on Forest Resources and Plant Biodiversity has initiated establishing Long Term Ecological Monitoring (LTEM) sites following standard GLORIA approach in alpine zone of Kailash Sacred Landscape-India.

6.2 GLORIA APPROACH

The Global Observation Research Initiative in Alpine Environments (GLORIA), consists of a global network of monitoring sites (known as target regions) coordinated by the University of Vienna Institute of Ecology and Conservation Biology. It targets monitoring of changes in species richness (number of species), species composition (loss or gain of individual species), patterns of vegetation (changes in % cover), soil temperatures of microhabitats, and snow cover (indirectly through temperature measurements). GLORIA is a rapidly growing international research network which assesses climate change impacts on the plant species richness of the high mountain ecosystems.

The field manual (Pauli *et al* 2004), which describes simple, cost effective protocols, known as the Multi-Summit Approach forms an essential prerequisite for collecting comparable data from different mountain regions. Being simple in application, this protocol has encouraged number of scientists/researchers across the globe to establish and regularly monitor GLORIA target regions. Beyond monitoring the impact of changing climates on alpine peaks, GLORIA also aims to assess climate change-induced impacts on biodiversity and habitats and thereby contributing to international efforts of mitigating biodiversity and habitat losses. Observations from target regions worldwide are being compiled by the GLORIA coordination office and are available for analyses by the scientific community. There are currently 42 countries participating in the program and 130 active GLORIA target regions (www.gloria.ac.at), including the Indian GLORIA sites.

6.3 GLORIA SITES IN KSL-INDIA

Realizing that the KSL-India has large portion under alpine zone and recognizing sensitivity of alpine vegetation towards changing climate, the teams of researchers under KSLCDI and Forest Resources and Plant Biodiversity Task Force under NMSHE (National Mission for Sustaining Himalayan Ecosystem) joined hands to use GLORIA protocols for establishing two long-term alpine vegetation monitoring sites in KSL-India (i.e., Pithoragarh district, Uttarakhand). The sites were selected in such a manner to represent Monsoonal Greater Himalayan conditions (1 site) as well as non-Monsoonal Trans Himalayan condition (1 site). The baseline data generated during the establishment of monitoring sites in target regions provides an opportunity for assessment of any changes in biodiversity that may be related to changes in climate.

One target region each, comprised of four summits, was established in the Chaudans - Greater Himalayan region (altitude ranges 3773-4266 m asl) and Byans in Trans Himalayan region (3999 - 4154 m).

6.4 Summit vegetation sampling

Four summits representing an altitudinal gradient of vegetation patterns characteristic for their respective mountain regions were selected to constitute each GLORIA target region (Figure 6.1). The study areas of each summit encompasses the top 10 vertical metres, and these areas satisfied the six criteria adapted from Pauli *et al* (2004) for selection of GLORIA sites. On each summit, four permanent 3x3 m areas were established 5 vertical metres from the summit and in each cardinal direction (Figure 6.2). Boundary markers were permanently marked using white paint on rock or iron nails secured in soil, depending on the substrate. Within each 3x3 m area, the four corner 1x1m quadrats were sampled thus making a total of 16 quadrats per summit. Within each 1x1 m quadrat, the uppermost cover surface types were described and a complete vascular plant species inventory and percentage cover of each of the species was compiled. In addition, frequency counts of the vascular plants within each 1x1 m quadrat were also recorded. This was done by laying a frequency frame (grid) over the quadrat with 100 cells and recording presence/absence of each species.

Each summit was additionally divided into eight permanent Summit Area Sections (SAS); four sections in the upper five vertical meters and four sections in the lower, each in a cardinal direction (Figure 6.2).

Plant species nomenclature follows (Uniyal *et al.,* 2007) and plant checklist, the Tropicos. Within each SAS a full species inventory and cover was collected as well as the cover of surface types, area, elevation, slope, and aspect. Data loggers that measure soil temperature every hour were installed in the centre of each 3x3 m area, 10 cm below the surface. Photos were also taken of all elements of the sampling design to aid in relocating boundary markers and for the purpose of photo monitoring.

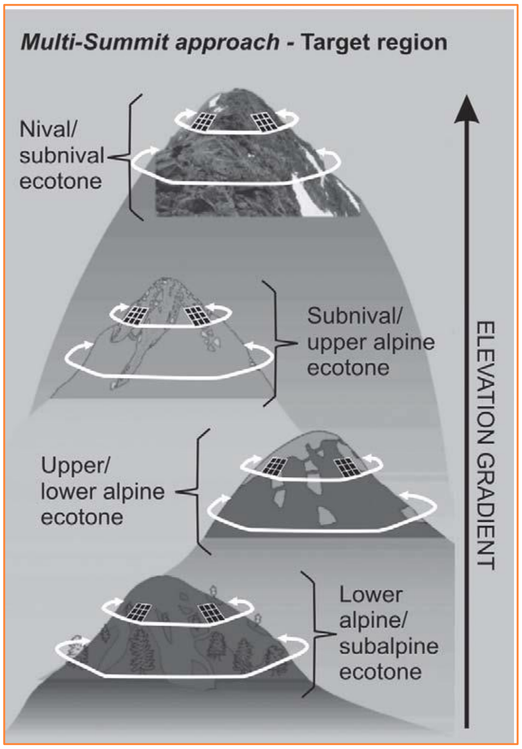

Figure 6.1. Four summits of different altitude represent a target region. White lines indicate lower boundaries of the 5 and 10 m vertical summit areas *(adopted from Pauli et al., 2004)*

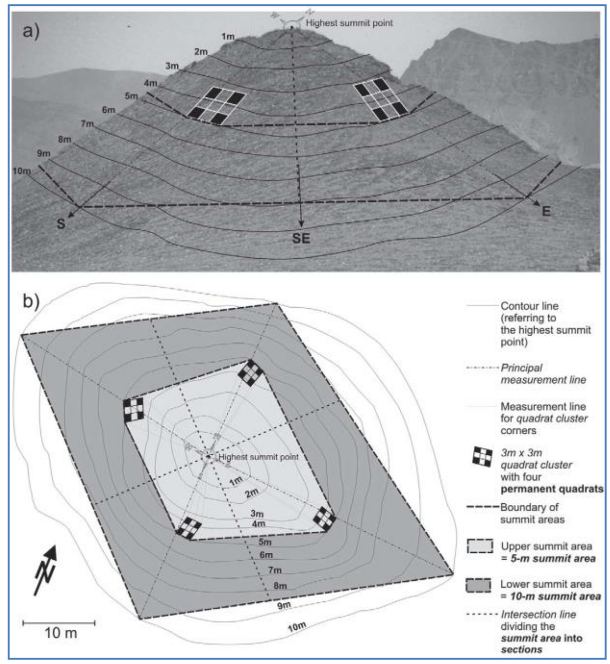

Fig. 6.2. The Multi-Summit sampling design shown on a hypothetical example summit: (a) oblique view with schematic contour lines; (b) top view. The 3m x 3m quadrat clusters and the corner points of the summit areas are arranged in the main geographical directions. Deviations from the exact direction may be necessary in some cases. The quadrat clusters can be arranged either on the left or on the right side of the principal measurement line, depending on the nature of the terrain and habitat. As a general rule, left and right is always defined in the sight to the summit. *(adopte from Pauli et al., 2004).*

6.5 The outcomes

Two GLORIA sites have been established in Kailash Sacred Landscape of India. The details of the summit, altitude, geographical location of sites in Chaudans (IN-CHU) and Byans Valley are presented in Table 1 and 2 respectively. The Chaudans Valley target region happens to be the first GLORIA target region in Indian Himalayan Region.

In CHU target region, a total of 121 plants were recorded. The Bhairav Ghati (BHT) summit recorded maximum number of plants (78 species). The Kharangdhang (KHA), Ganglakhan (GAN) and Sekhuakhan (SKN) summits recorded species of 57, 47 and 26 respectively. While comparing the number of species among the summits, the lower elevation has represented by highest number of species, when compare to the higher elevations.

In BYN target region, a total of 44 plants were recorded. The Shyang (SHY) summit recorded maximum number of species (42 species). The Chaga (CHA), Kuti (KUT) and Eurong (EUR) summits recorded species of 40, 38 and 25 respectively. While comparing the number of species among summits, the lower elevation has represented by highest number of species generally (except KUT), when compared to the higher elevations (Figure 6.3). The species composition in different aspects is provided in Figure 6.4. Various steps of GLORIA site establishment in Byans valley are depicted (Plate 6.1).

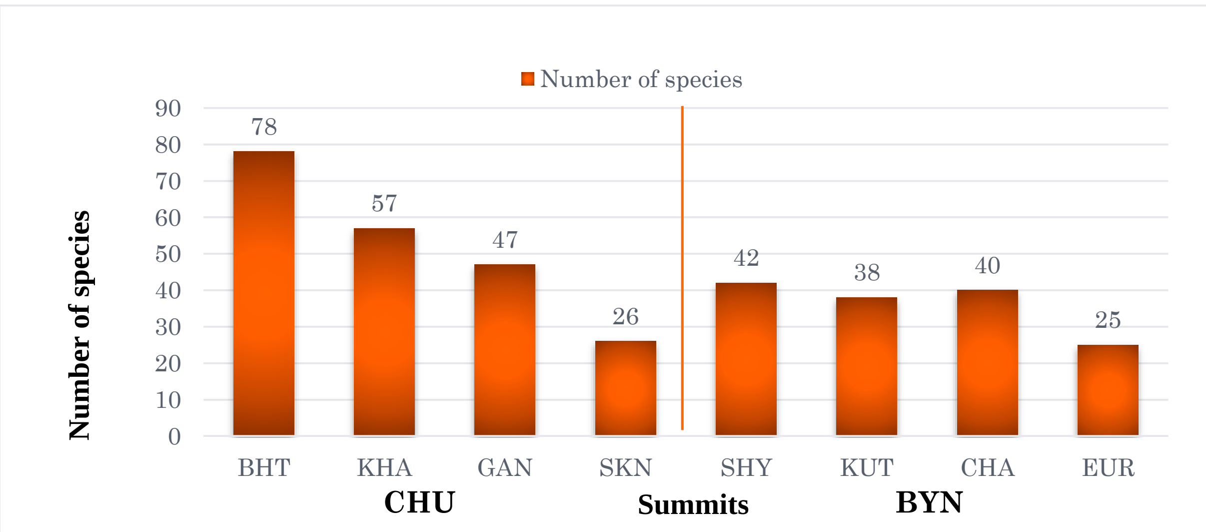

Figure 6.3 Plant species richness at different summits of GLORIA TRs in KSL

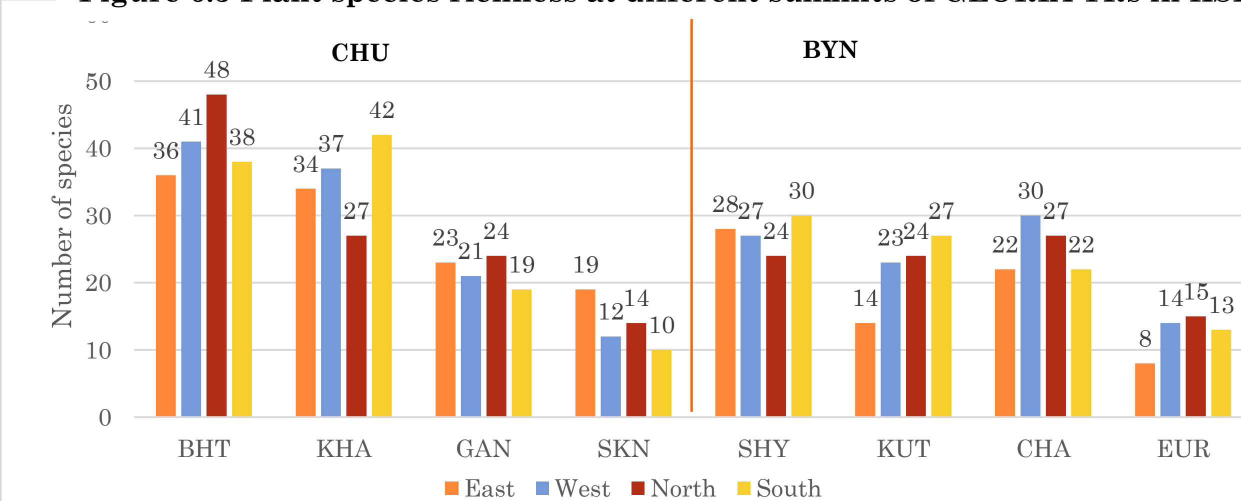

Figure 6. 4 Plant Species richness across aspects of summits of two GLORIA TRs in KSL - India

Plate 6.1.: Establishment of GLORIA Site in Byans Valley, KSL – India

A- Selection of the summit
B- Marking of HSP
C- Measuring of 5m & 10 m points
D- Laying of 3m×3m quadrat cluster
E- Laying of 1m² quadrat
F- Sampling of individuals
G- Marking of Summit Area Section (SAS)
H- Activation of temperature logger
I- Installation of temperature logger

Table 6.1 Summits of GLORIA's Active Target Region (TR) in Chaudans (IN-

Locality (Summit Code)	Altitude & Geographical location	Vegetation zone	Plant species richness
Bhairav Ghati (BHT)	3773m Lat: 30°02.782'N Long: 80°39.122'E	Lower alpine above the tree line. *Danthonia, Kobresia,* and *Jurinea* dominated	78 species (62 genera; 32 families)
Kharangdhang (KHA)	3881m Lat: 30°02.927'N Long: 80°39.320'E	Transition between the middle alpine and upper alpine. *Oxygraphis, Geranium,* and *Trachydium* dominated	57 species (44 genera; 26 families)
Ganglakhan (GAN)	4060m Lat: 30°03.113'N Long: 80°39.575'E	Upper alpine top region. *Trachydium, Kobresia, and Potentilla* dominated	47 species (38 genera; 21 families)
Sekhuakhan (SKN)	4266m Lat: 30°03.783'N Long: 80°39.927'E	Transition between the upper alpine and nival. *Potentilla, Kobresia,* and *Geum* dominated	26 species (24 genera; 17 families)

Table 6.2 Summits of GLORIA's Active Target Region (TR) in Byans Valley

Locality (Summit Code)	Altitude & Geographical location	Vegetation zone	Plant species richness
Shyang (SHY)	3999 m Lat: 30°18.573' N Long: 80°45.830' E	Lower alpine; above the tree line. *Danthonia cachemyriana* dominated	42 species (35 genera; 23 families)
Kuti (KUT)	4038 m Lat: 30°18.336' N Long: 80°45.528' E	Transition between the lower and upper alpine. *Danthonia cachemyriana* and *Juniperus indica* dominated	38 species (29 genera; 20 families)
Chaga (CHA)	4062 m Lat: 30°18.615' N Long: 80°45.951' E	Upper alpine; the top region. *Juniperus, Danthonia,* and *Potentilla* dominated	40 species (34 genera; 19 families)
Eurong (EUR)	4154 m Lat: 30°18.645' N Long: 80°46.165' E	Transition between upper alpine and nival. *Danthonia cachemyriana* and *Juniperus indica* dominated	25 species (20 genera; 16 families)

6.6 WAY FORWARD

- Observations recorded at the species level from the GLORIA summits forms the baseline for long-term monitoring of species responses to climate change. It is expected that different individual species will respond to climate change in different ways (Pauli *et al*. 2004). It is essential to follow the observations in these summits every five years' interval.
- Considering that the Indian Himalayan region represents diverse climatic regimes across its east to west extent, it is therefore imperative to have more GLORIA sites from representative alpine areas of different biogeographical provinces. While GBPNIHESD being the nodal R&D institution for the region is expected to expand GLORIA network in IHR, other interested organizations are required to join hands with the Institute for fast coverage of the region.
- Considering the importance of climate change research in alpin of Himalaya and given the challenges of working in these areas (Box 6.1), there is a need to have strategic planning for undertaking research in the Himalayan alpines. Specifically, there is a need for allocating larger Government Funds for R&D in alpine areas which would cover establishing adequate network of monitoring sites, including GLORIA, and continuous flow of data-sets through long-term monitoring for prediction modelling and developing appropriate adaptation and mitigation strategies.

Box 6.1: Challenges of undertaking R&D in Himalayan alpines

- Majority of the alpines in Himalaya are very difficult to approach hence carrying equipments to the experimental sites is difficult and requires additional care and resources.
- The tradition of pastoralism is prevalent in most of the high Himalayan regions; it makes the task difficult while selecting the undisturbed summits.
- The connectivity of roads to alpines is very scarce, one has to walk on foot to reach the alpines in Himalaya.
- The weather is uncertain. One never knows how the weather will change.
- One need to be very cautious while selecting the summits because the terrain is very difficult and fragile in most of the regions.
- Uncertainty of getting all sites intact is of high level due to frequent natural hazards like landslides, cloud burst, etc.

Acknowledgements

We thank to Dr. P.P. Dhyani, Director, GBPNIHESD, for guidance and encouragement. Our sincere thanks are due to Dr. G.S. Rawat, Scientist - G, Wildlife Institute of India, Dehradun for suggestions w.r.t. selection of sites. The assistance and help during field surveys by various members of GLORIA expedition is thankfully acknowledged. Partial funding support from ICIMOD under Kailash Sacred Landscape Conservation and Development Initiative, and DST, GoI under NMSHE Task Force Forest Resources and Plant Biodiversity is gratefully acknowledged.

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Chapter 7. Monitoring Mammals in the Kailash Sacred Landscape

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7.1 Introduction

For effective wildlife management, prior knowledge of species diversity, distribution and abundance is essential, so as to detect significant changes and thus appropriate management interventions. Efficient and reliable methods are required for monitoring changes in species abundance in protected areas or conservation landscapes. Monitoring of wild mammalian populations in the Himalayan region is full of challenges due to remoteness and rugged terrain. This is particularly true for the Greater Himalaya, arranging logistics for regular monitoring can be very difficult. This paucity is apparent all over the Greater Himalayan range, including protected areas and conservation landscapes in India, Nepal, and Bhutan (Sathyakumar *et al*. 2014).

Wild mammals in the Himalayan region occupy diverse habitats and exhibit a wide rane of behavior. Depending upon their nature and preferred habitat, several techniques can be used to record their presence / absence, habitat use and abundance. Some of the techniques are described in this chapter.

The Kailash Sacred Landscape (KSL) is one of the significant Himalayan landscapes in the western Himalaya due to its trans-boundary conservation values apart from the rich and diverse biodiversity and socio-cultural values. Spanning over 7,000 km^2, KSL encompasses areas with diverse elevation, aspect, slope, vegetation and human use categories where conservation is a challenge. The KSL region has various land use categories and several line departments with conflicting mandates and activities. In the recent years, the area has experienced many policy level changes and management modifications which may have altered the livelihood practices of the local communities and may have also changed the habitat status of wild animals. Monitoring changes in wildlife distribution and abundance would act as an important indicator of the health of these ecosystems. Recent landscape-level remote sensing studies in Khangchendzonga BR (Tambe *et al*. 2012) revealed that, for the long-term security of this unique mountain landscape, the park management need to evolve innovative co-management models, take adequate safeguards for vulnerable habitats, strengthen buffer zone management and focus conservation measures on high impact areas. Monitoring wildlife species in the area would be useful to detect overall management effectiveness as many species are excellent indicators of habitat quality and management interventions.

7.2 The mammals

Except for some mammals such as the barking deer (*Muntiacus muntjac*), sambar (*Rusa unicolor*), goral (*Nemorhaedus goral*), Gray langur (*Semnopithecus schistaceus*), Rhesus macaque (*Macaca mulata*), common leopard (*Panthera pardus*) and wild pig (*Sus scrofa*) which are widely distributed, all other mammals of the Himalayas are rarely encountered. Even commonly encountered and widely distributed mammals need monitoring from a management perspective. For instance, a wildlife manager would like to know whether the increased incidence of crop damage by wild pigs or Asiatic Black Bear (*Ursus thibetanus*) in the Himalayan villages is directly proportional to their numbers or not. Similarly, the increased incidences or reports of livestock killing by large carnivores such as Snow leopard (*Panthera uncia*), Common leopard, Wolf (*Canis lupus*) and wild dog (*Cuon alpinus*) in the Himalaya may be related to their numbers or decline in their natural prey. Needless to emphasize that monitoring mammal abundance is very crucial for their conservation and management in the Himalayas.

7.3 Wildlife monitoring in the Himalaya

Monitoring animal abundance in the Himalaya is difficult due to the following reasons: (After Rodgers, 1990; Sathyakumar, 1993, 1994, 2004; Bhattacharya *et al.* 2009)

(a) Nature of terrain is extremely steep, rugged and in some cases inaccessible. Animals such as the Himalayan tahr (*Hemitragus jemlahicus*), goral, and serow (*Capricornis thar*) inhabit such inaccessible terrain.

(b) Most of the animals occur in low densities.

(c) Animals such as the Himalayan tahr have specific habitat preferences which usually vary seasonally.

(d) Some animals are predominantly nocturnal or crepuscular making observations difficult. Eg. Himalayan musk deer (*Moschus chrysogaster*), serow and many small carnivores.

(e) The status, ecology, and behaviour of almost all the animals in the Himalayas are yet to be known.

Monitoring wildlife and their habitats in the Himalaya involves more time, manpower and funds and could vary from simple overall monitoring on a qualitative basis to detailed quantitative studies. While the former is a rapid assessment technique, the later is a long term intensive study.

7.4 Techniques for monitoring mammals in the Himalaya

7.4.1 Presence/Absence monitoring or Occupancy assessments

This is a simple technique which involves recording of presence/absence of a given species in a small sample unit and repeating it over the years. Rodgers (1990) has described the technique of recording species presence/absence and has put forward some ideas on how simple estimates of abundance could be obtained. Toposheets of 1:50,000 scale or other large scale maps can be used for identifying sample units such as grid, transects, trails, and plots. The sample unit size depends on the species of interest. While species with large home range sizes such as the Snow leopard (*Panthera uncia*) require a grid of large size, species with smaller home range sizes (Eg.Musk deer) require grids of smaller sizes. In the Himalaya, one could also use sampling units that could be easily demarcated based on natural features. For instance, a small catchment or water shed or a *nullah* (stream) with ridges as natural boundaries could be easily demarcated as a sampling unit. Recording species presence/absence in the grids or sampling units could be either based on actual sightings or indirect evidences such as dung, tracks, other signs and from reliable secondary information (local people, forest staff etc.). The presence/absence maps for each species thus generated can be improved by adding qualitative information on species abundance such as rare, common or abundant. Repetition of this exercise on an annual basis helps in monitoring animal distribution and abundance over the years.

Camera traps could be a useful tool in confirming existence of many wildlife species that are nocturnal or shy, particularly small carnivores. If camera traps are placed in a proper sampling design (grids), the capture data of species could be used to obtain relative abundance estimates such as capture rates and population estimates using mark-recapture models.

7.4.2 Encounter rates

Much of the Himalayan region has a good network of trails, paths, ridges, and *nullahs* which offer excellent opportunity to monitor animal abundance for a given area. Encounter rate (ER) is a simple expression of number of animals encountered per unit effort. It could be expressed as number of animals seen/km walked or number seen/hour search. In areas where a network of trails, paths or tracks is not available, monitoring trails could be established. Encounter rates can be based on actual sightings or indirect evidences such as signs and tracks. This technique has been found to be of much use in monitoring mammals such as goral, tahr, sambar, barking deer and other mammals in the Himalaya based on actual sightings (Sathyakumar *et al*. 1993; Sathyakumar, 1993, 1994, 2004). Encounter rates based on indirect evidences such as scats and scrapes has been found to be useful for the snow leopard (Fox *et al*. 1987; Sathyakumar, 1993, 2004). For a nocturnal mammal such as the red giant flying squirrel (*Petaurista petaurista*), ER could be based on feeding signs encountered in the forest floor (oak leaves, nuts, cones etc.) and also on frequency of calls heard during dusk, nights or dawns. Similarly, feeding, resting and other signs can be used for obtaining ER of Asiatic black bear. Sufficient field knowledge of identifying indirect evidences is a pre-requisite for obtaining reliable ER.

7.4.3 Scanning method

Ungulate such as blue sheep, tahr, and goral inhabit steep areas with open grassy slopes and less tree cover. Such habitats offer an excellent opportunity to scan for animals while they are feeding or resting. This technique involves careful scanning of such areas with a good pair of binoculars or a spotting scope from a vintage point. Two independent observers with watches set to each other can scan the same area from two different vantage points and latter on tally for double counts. Early mornings and late evenings are ideal for scanning (Sathyakumar, 1993, 1994, 2004). The scanning could be done during the period 0600h to 0900h and 1500h to 1800h, however, scan duration may vary from one to three hours, depending on the weather conditions.

Scanning techniques can be used to obtain ER (# seen/hour search) as well as total counts for the area. Group Density could be estimated using Point count approach as well (Laake et al. 1993). On regular repetitions for a month or a season, total count for that period could be obtained which the maximum is counted on any one day of that month/season (Green, 1979; Sathyakumar, 1994, Sathyakumar et al. 2014). Regular monitoring of goral/ tahr numbers for a given area can be done on a long term basis.

7.4.4 Silent drive count

Green (1985) was the first to use this density estimation technique for mammals such as the musk deer and serow. It is similar to the block drive census. It involves more time, manpower, funds and so is not repeatable frequently. In this method, the area of interest identified within a habitat is divided into small blocks using features such as ridges, streams and foot paths as boundaries. A base line is identified and 10 to 12 men are spaced at intervals of 30 to 50 m. All these men should have some knowledge of the block in which the drive is to be conducted and their line of travel. The men are instructed to scramble quietly through the patch and record ungulates sighted. Three to five men called 'observers' are placed strategically above the forest level and other vantage points to spot and record ungulates which otherwise might have got flushed undetected from the block. All men have watches which are set to the watch of the drive count coordinator. Data on time, species, number and location with reference to the line of travel and direction of movement of the ungulate are recorded. It would be ideal to conduct drives in early mornings or late afternoons. Duplicate records arising from the same animal being sighted in adjacent blocks is minimised by conducting drives in a direction that would flush them outside the study area rather than towards adjacent patches. This technique not only helps in obtaining absolute density estimates for musk deer and serow but also helps in monitoring their numbers for a given area over the years (Sathyakumar 1994, 2004, Vinod and Sathyakumar 1999).

7.4.5 Line transects or Distance sampling

Line transect method is a simple technique for estimating animal density involving less time, effort and funds. Burnham *et al.* (1980) have described the technique in detail and hence not described here. However, in the Himalayas, the applicability of this technique depends largely on the terrain, accurate measurement of data and the non-violation of the assumptions required for using this technique. For estimating density of barking deer, sambar, and goral this technique was found to be useful (Sathyakumar, 1993; Sathyakumar, 1994) This method could also be used on existing trails/paths that could serve as curvilinear transects/trails (Vinod and Sathyakumar 1999, Sathyakumar et al. 2014).Moreover, line transects can also help in obtaining Encounter rates.

7.4.6 Camera trapping based abundance and Population estimation

The map of the identified catchment or intensive study area could be divided into 4 km^2 blocks using Geographic Information System (GIS) (ARC GIS 9.1). For simplicity, the area could be categorised into different survey zones according to the habitats, viz., sub tropical (<1,500m) temperate (1500–300 m), sub-alpine (3000–3500 m) and alpine (> 3500 m) and the camera traps could be deployed corresponding to the area coverage of the survey zones and their accessibility Since the study species are rare and the area vast, the strategy would be to survey more sampling units less intensively rather than less sampling units more intensively (Mackenzie & Royle, 2005). Monitoring of camera traps should be done at regular intervals of time to check functioning and changing the batteries and memory card. Density estimates for species that could be identified based on their coat patterns could be obtained using capture/recapture frame work and home range approaches (Bashir et al. 2013).

7.4.7 Dung counts

Dung are reliable indicator of animal's presence, abundance, and habitat use. Estimating dung density of an ungulate species in a habitat is an indirect way to know about its abundance or density (Bennett et al., 1940; Rodgers, 1991; Sathyakumar, 1994). The dung counts could be made within a 20 × 2 m belt transect laid at every 100 m interval along the trails. For every trail, wherever possible, the dung plots could be nested within the 10 m ×10 m plots laid for vegetation cover estimation.

7.4.8 Habitat monitoring

Remote sensing is a valuable tool for monitoring larger areas in the Himalaya. Long term ecological research (LTER) sites are ideal for monitoring changes in the habitat on a smaller scale but involve much time, effort and funds. A simple technique for monitoring habitat changes in presented below:

7.5 The repeat photography technique

This technique involves photography of a habitat from a vantage point at regular intervals of time and comparing for changes. The camera equipment used for all repeated photographs and the vantage point should be the same. Photographs should be obtained for an area on three consecutive days of a month or a season and repeated for the same dates over the years. Repeat photographs help in monitoring overall changes in the given area such as the impact of a grazing land or a cattle camp within the forest, erosion, colonisation of vegetation on land slide areas etc. Gaston & Garson (1992) had used this technique over a period of ten years in the Great Himalayan National Park, Himachal Pradesh to monitor changes in Wildlife habitats.

7.6 Conclusion

Estimating animal density in the Himalayas is difficult and requires more effort, time and funds. Monitoring animal numbers in response to protection, disturbance, fire, controlled grazing is crucial. The techniques suggested in this paper have advantages of being simple, easy to execute and requires less man power, time and funds, except for musk deer and serow. Similarly, repeat photographs are much cheaper when compared to the use of remote sensing data for smaller areas.

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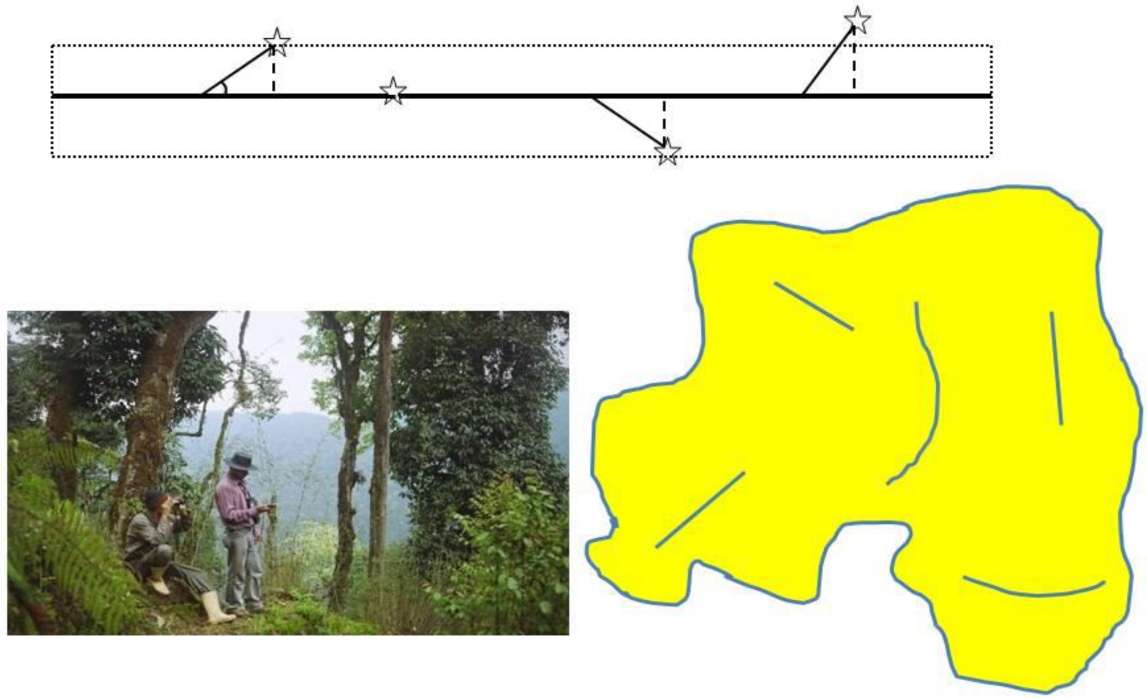
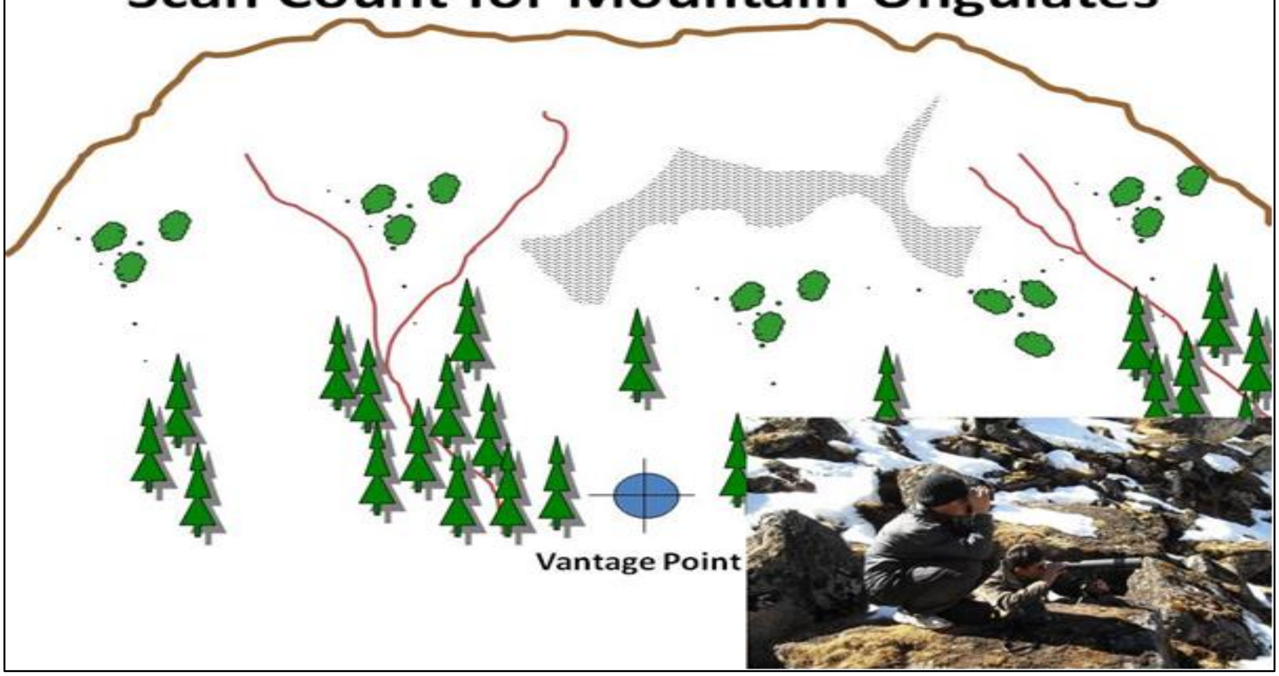
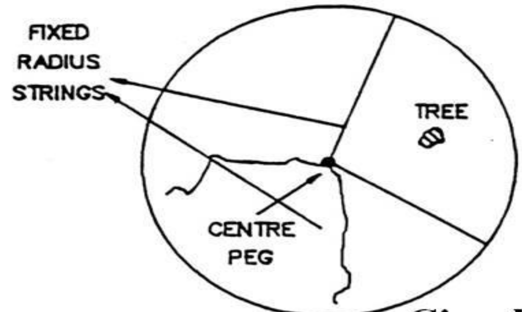
Line Transect Sampling



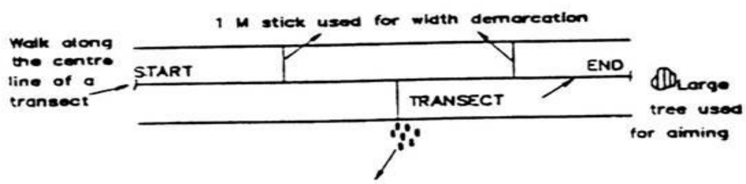
Scan Count for Mountain Ungulates



Dung Count

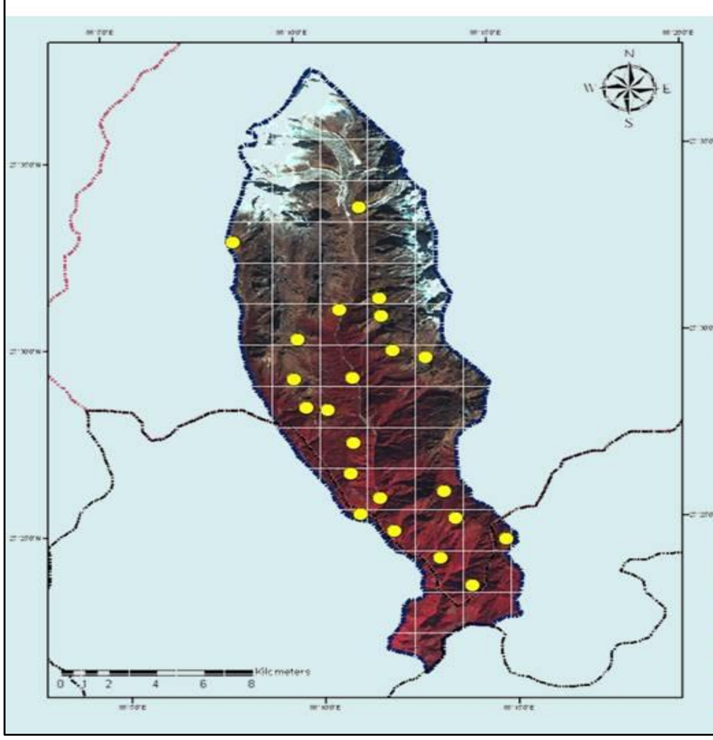


Circular Plot



Belt Transect

Camera Trapping



Annexure 7.1. Data sheet for Distribution Survey

Name of the Beat: **Location:** **Area of the beat:** **(ha./km²)** **Date:**

Name of the Observer: **Name of the Trail:** **Location of the trail:** **GPS:**

Length of the trail: **km** **Start time:** **End time:**

S.No	Species	No. of individuals in the group	Broad habitat type	Number of Indirect evidences recorded (if any)				Remarks (If scat sample collected for genetic analysis. provide Id number of sample
				Tracks	Scats/ pellet groups	Calls	Other signs	

Other species reported in beat but not recorded during the survey:

……………………………………………………………………

Chapter 8. LONG TERM MONITORING FOR BIRDS IN Kailash Sacred Landscape - INDIA

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8.1 Introduction

Monitoring programs are the main source of information on the population status of species of conservation concern, whether fluctuating population increasing or decreasing and therefore have a significant role in setting conservation action priorities. a species whose population is declining will be of higher conservation priority than one that is not. Monitoring has more uses than this, however. If a monitoring program is well designed, it can be a research tool in its own right providing that suitable environmental data (e.g. habitats, predators, food supplies, weather) are collected, or are available elsewhere. Frequently, such analyses provide early pointers towards the underlying causes of trends in species numbers (Sutherland *et al.* 2004).

Birds form an integral part of any ecosystem and are considered as indicators of ecosystem health. KSL harbours a rich diversity of birds owing to a wide range of vegetation and habitat types. This chapter deals with hows, whys and whats of monitoring birds in the landscape.

Birds are one of the best indicators of environmental quality and health of any ecosystem. They are highly mobile vertebrates and can be easily observed (Garber and Garber 1976, Holmes *et al* 1986). Studies on avian communities have been found to be one of the effective tools in monitoring an ecosystem (Sundaramoorthy 1991). Avian communities are also susceptible and responsive to change in the land use pattern (Daniels *et al.* 1992). Research at community level of birds in Indian subcontinent is essential as, large scale changes due to destruction, fragmentation, disturbance, etc; are taking place in natural habitat of birds (Sherry & Holmes, 1985). Large numbers of bird species live in the Himalayas (Inskipp and Inskipp 1985; Martens and Eck 1995).

Birds in Kailash landscape - Globally more than 10,530 species of birds found and 1,263 species are from India (Praveen *et al.* 2016) and more than 54 % of the Indian birds, a total of 686 avifaunal species recorded from the state Uttarakhand only (Mohan and Sondhi 2014) shows how rich is the state in terms of bird richness. More than 86% of the state is mountainous region and a vast range of elevation supports various habitat types for the birds in the region. Indian portion of Kailash sacred landscape located the far east district (Pithoragarh) of the Kumaoun Himalayas in Uttarakhand and comprises with the four main climatic zones such as Subtropical, Temperate, sub-alpine and alpine zones which supports variety of habitats in the landscape and this diversity in habitats supports different variety of birds and high endemism. The major habitat types of the landscape are Subtropical Sal and Pine forest at lower elevational range, then temperate oak and temperate mixed forest, sub-alpine forest and alpine scrub. Very few studies on bird conducted in the Kailash landscape, a study was conducted in Gouri valley and total 227 species (Raza 2005) of birds were recorded and 315 species are mentioned in Pithoragarh Forest management plan, (2011-2021) including 10 pheasant species and all the vulture species. Our study is focused in the lower elevational range of the landscape between the 500m als to 2500m asl, and Sub-tropical Sal and Pine forest, Temperate oak and Mixed forest are the major forest types in the lower reaches of the landscape and it is highly divers region in the landscape in term of birds altogether 195 species of birds were recorded belonging to the 14 orders and 48 families. Among them, 88 species are resident 102 species are migratory including altitudinal migration. Some of the conservation important species are i.e. Cheer pheasant, Himalayan monal, Styre tragopan, and all the vulture species. Migratory species are also having the high conservation values.

As part of Long Term Ecological and Socio-Ecological Monitoring (LTESM) in Indian portion of Kailash Sacred Landscape (KSL – India), regular observations would be made on selected taxa of birds seasonally in different ecosystems viz., Forests, Grasslands, Agro-ecosystems, and Riverine ecosystems in pilot areas.

8.2 Methodology and Approach

Key parameters for monitoring, monitoring method and approaches have been listed in Table 1. Data sheets for recording birds are given as Annexures 1-6.

8.2.1 Diversity and richness

Within each pilot area forests, grasslands and other habitat types would be stratified. Common transects for other faunal groups would be identified and bird transects would also be laid in the same area. Bird species diversity and richness would be estimated using Point count method (Bibby *et al.* 1992). The sampling points would be placed along the identified trail. At each sampling point along the line of walk (transects of 0.8 to 1.2 kms), the observer will count birds for a duration of 10-minutes. Two points would be spaced about 200 ms apart and will be monitored twice in each season.

Along the trail habitat parameters for birds would be measured using 10 m radius plots. In each plot parameters/information like canopy cover, grass cover, shrub cover, litter cover, altitude, slope, and aspect will be recorded. In each plot, the disturbance factors like cattle presence, tree cutting, tree lopping, human presence, and data will also be collected.

8.2.2 *Abundance and distribution of Galliformes*

Galliformes, commonly referred to as 'gallinaceous birds' or 'game birds', is a large and diverse group of birds. The pressures of hunting and poaching activities that are aimed at their meat and plumage have long been under severe throughout the western Himalaya (Gaston *et al* 1983). Habitat degradation and fragmentation also plays an important role in declining the population of them. Pheasants form the most appropriate group of birds for long-term monitoring as they can be seen and identified by the field staff easily and the health of their population indicate the better conservation status (Ramesh *et al.* 1998). Galliformes would be sampled in both the pilot sites once in a year.

8.2.2.1 Encounter rates

Encounter rate technique would be executed during winter when the pheasants descend to lower elevation and the visibility is high which leaves little chance for these species to evade the observer. Later part of April and first week of May are the ideal months for doing call counts.

It is proposed to use Encounter Rate method for abundance and distribution of Galliformes. This method involves walking on any predetermined trail and counting all the pheasants on both side of the trail. Encounter rate is expressed as ER = n / L (Caughley 1975), where n = Number of groups or individuals seen and L = Distance covered. The changes in the population can be understood by comparing the estimated value over years, but the same estimate becomes biased when comparing the population changes between habitats due to the role of visibility factor that determine the detectability (Ramesh 1997). The usage of this technique for estimating and monitoring population of galliformes has started in the recent past and has been used by Islam 1982, Kaul and Ahmed 1993 and Sathyakumar *et al.* 1993.

Along the trails and transect lines habitat parameters would be recorded as described in section 2.1 above.

8.2.2.2 Call counts

Most of the pheasants are elusive in nature and are often found in thick under growth forest that makes direct sighting difficult. The males, however, give loud chorus during dawn hours during their breeding season. Counting the calls will give useful index of the population in a given area. The general and widely used method of call count is that the calls of pheasants are recorded from a fixed radius plot laid all along the trail or from selected vantage points. 200 - 300m radius plot (in early morning time) would suffice to count the calls of pheasants like Kalij pheasant, Cheer pheasant and Black francolin in lower elevation range and Himalayan monal, Koklass and Western tragopan in high elevation range. Centre of the plots should be permanently marked in the field so that this will enable any one to carry out the call count from the same plot over the years. It is also necessary to record the calling birds by facing one direction as it will help to find out double counting by both observers placed in successive calling stations.

8.2.3 Distribution, Abundance and activity patterns of Vultures

Population of vultures is declining drastically. *Gyps* vultures were in decline were first raised by Prakash (1999), and further declines and local extinctions were soon reported across a wider area of India (Prakash and Rahmani 1999; Prakash 2003). In some studies in parts of Nepal, population of Bearded vulture is declining rapidly (Acharya *et.al.* 2010). So it's becomes an important to monitor the Vulture species for determine the baseline information on the population and distribution in KSL India. Vultures would be monitored at the roosting sites, dump sites and carcasses area in the both the watersheds on annual basis.

8.2.3.1 Monitoring at garbage dump sites

Monitor the Dump and roosting and carcasses sites once in a month when weather conditions are clear. Dump site should be monitor in morning 10:00am to 02:00am and roosting sitee in the evening for 4 hours, carcasses should be monitored for whole day from the arrival of dead body to the consume of it. Direct count of vultures would be done at dump sites .

The number of species their individuals and their age class should be recorded. Time of species individual's arrival, direction of arrival to site, time of departure to site, time of staying at site, time of different activities should also be recorded. If possible several photographs of birds present at these sites (and soaring above it) should be taken for verification of the species and their age classes. For roosting sites various habitat parameters should also be recorded.

8.2.4 Total count for wetland birds

KS Landscape have rich source of water plenty of major and minor rivers are there and some of the hydropower dams also supports the water birds such as ducks, grebes and lapwings and stilts, etc. these wetlands also support rich variety of migratory birds such as common teal, Northern shoveler, Common pochard, etc.

For estimating the population of these birds we use the total count bird censes technique in which we select a vantage point from where the visibility of the wetland is high and then count all the birds in wetland and surrounds if the size is too large then wetland is occularly divide into different small strata and then count the birds in each stratum.

Table 8.1: Avifaunal groups, monitoring sites, Methodology and frequency of monitoring in KSL – India (B-M = Bans- Maitoli Village; CAWS = Chandak – Aunlaghat Watershed; HWS = Himkhola Watershed).

Group of Avifauna	**Monitoring sites**		**Method**	**Frequency of Monitoring**
Vultures	Bans Maitoli and Himkhola Watershed		Observation at carcass/dump/roosting sites	Once in month
Pheasants	Cheer	CAWS	Encounter rate	Winter
	Kalij	CAWS		
			Call Count Ramesh et.al. 1998	Last Week of April to First week of May
	Black francolin	B-M		
	Himalayan Tragopan	HWS	Encounter rate	Winter
	Koklass Pheasant	HWS		
			Call Count	Last Week of April to First week of May
	Himalayan Monal	HWS		
Passerines	Agro ecosystem	B-M HWS	Point Count Bibby et.al 1992	Twice in a season
	Forest ecosystem	B-M HWS	Point Count	Twice in a season
	Grassland ecosystem	B-M HWS	Point Count	Twice in a season
	Riverine ecosystem	CAWS	Point Count	Twice in a season

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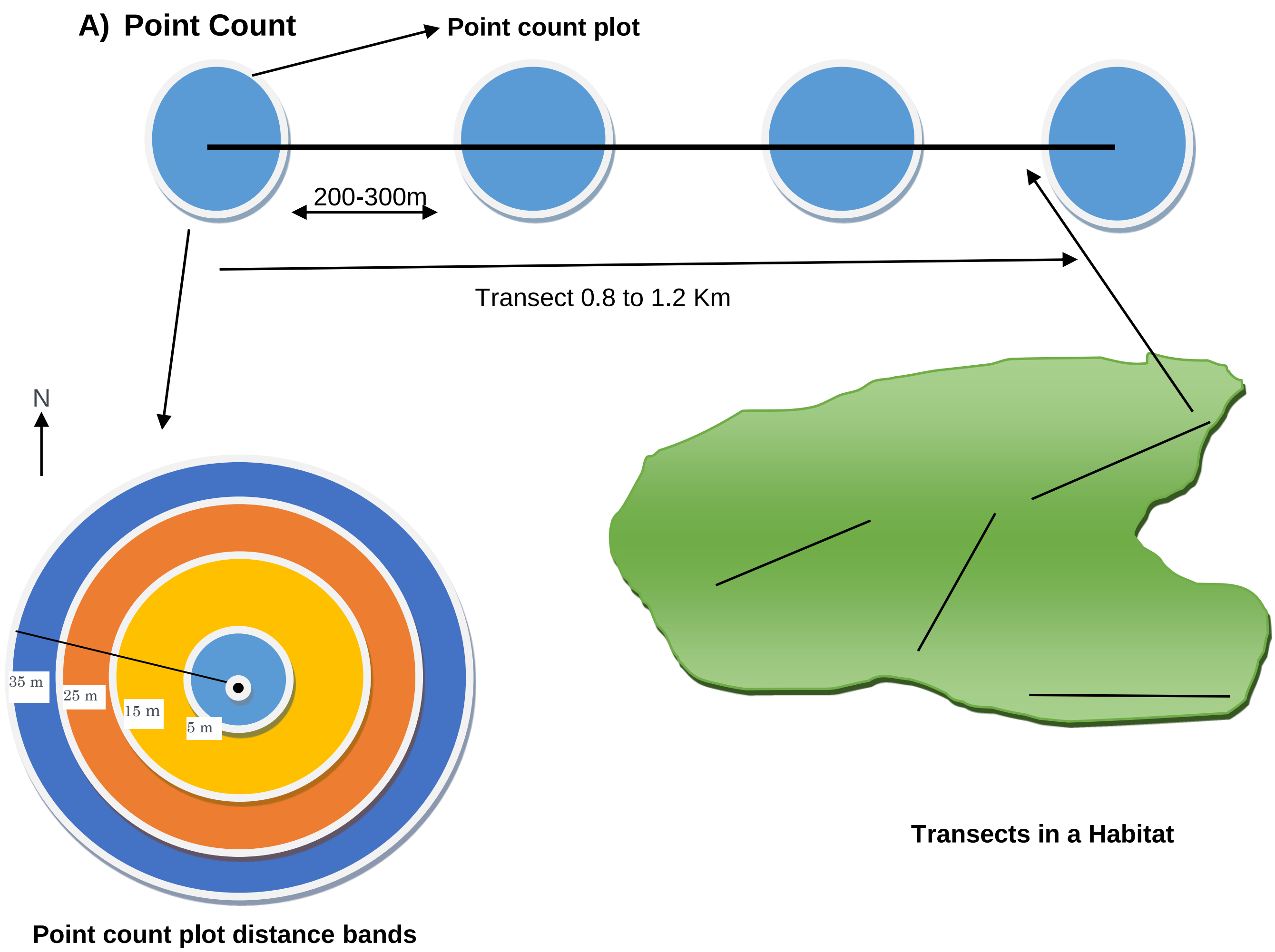
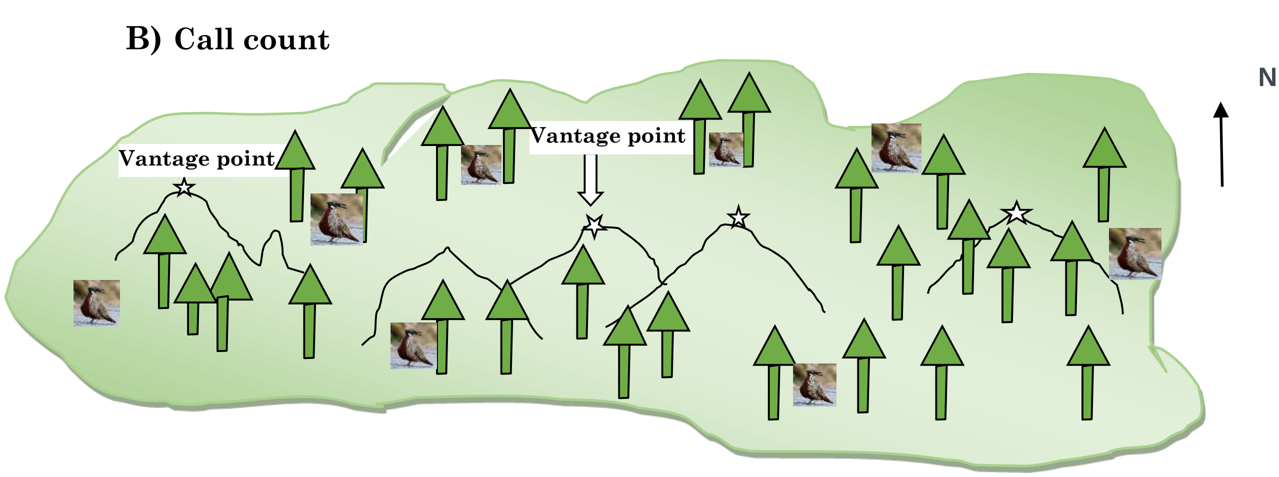
Annexure 8.1.: Sampling design of different bird census techniques

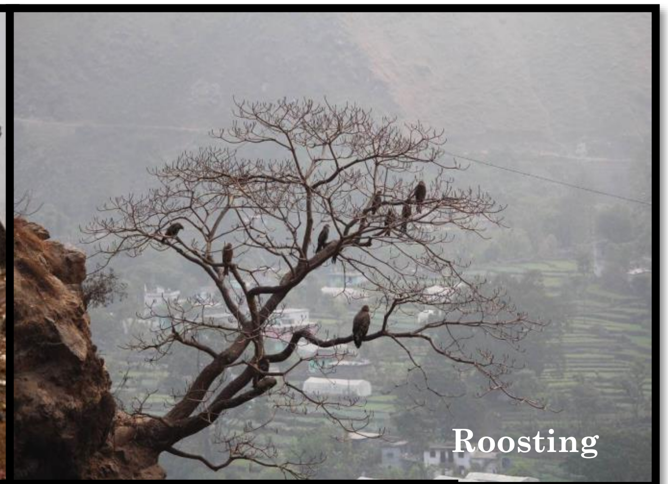
Sampling design





C) Monitoring at garbage/dump/roosting site

Garbage



Roosting

Scanning and Monitoring

Carcass site

Annexure 8.2: Data Sheet for Point Counts of birds

Area ___________

Date_______ Trail id ________ Point No______

Time Start______ Time End_______ Weather________

Habitat_______ Canopy Cover (%) ______ Grass Cover (%) _____

Shrub Cover (%) ____ Litter Cover (%) _______ Aspect _____ Slope_____

Latitude____________ Longitude______________ Altitude (m) ___________

S.N.	Name of species	No of Individuals	Distance (m)	Strata	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Strata – 1 = Ground, 2 = Tree trunk, 3 = Lower canopy, 4 = Middle Canopy, 5 = Upper canopy, 6 = Shrub, 7 = Wire and Pole.

Disturbance Factors- Tree Cutting – Low (0-2) Moderate (3-5) High (>5)

Tree Lopping – Low (0-2) Moderate (3-5) High (>5)

Cattle Presence- Yes (Direct / Evidence) No

Distance from Road or Village - Km.
Observers -

Annexure 8.3 : Data sheet for Encounter Rate of Pheasants in KSL India

Area______ Trail id________ Date___________

Time Start______ Time End_______ Weather________

S.N.	Sighting time	Distance travelled (Km)	Species	Number of Individuals				Remarks
				Male	Female	Sub-adult	Unknown	
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Observers –

Annexure 8.4: Data sheet for Habitat Assessment of birds in KSL India

Date: _________ Sampling plot:________ Species sighted___________ Habitat:_____________ Topography:______________

Altitude________________ Latitude____________ Longitude_____________ Aspect _____

Slope______

%Ground Cover:______ %Canopy Cover:_____ %Shrub Cover:______

%Herb Cover:_________ %Grass cover______

Tree species (10m)	No.	Shrub species (5m)	No.	Ground Cover (0.5*0.5)	No.	Regeneration species (5m)	No.
				Herb species		Seedling	
				Grass Species		Sapling	

Disturbance Factors- Tree Cutting – Low (0-2) Moderate (3-5) High (>5)

Tree Lopping – Low (0-2) Moderate (3-5) High (>5)

Cattle Presence- Yes (Direct / Evidence) No

Distance from Road or Village - Km.

Observers –

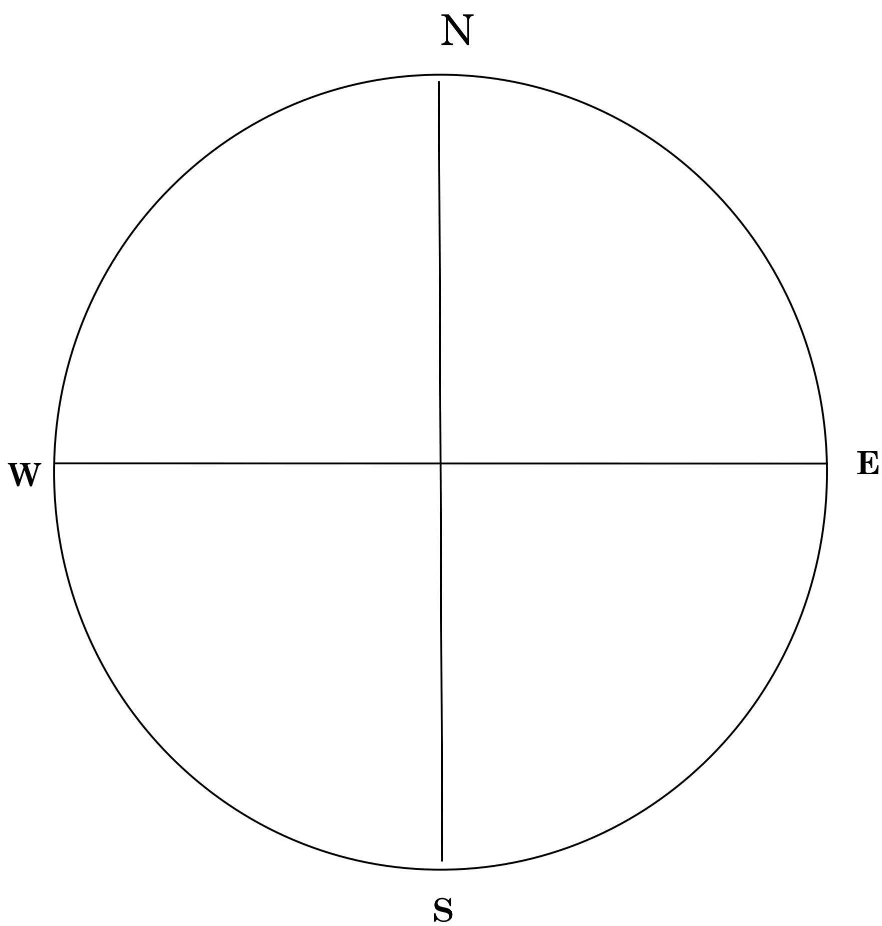
Annexure 8.5: Data sheet of Call Count for Pheasants

Date: ________ Trail / Plot id: ________ Weather___________

Start time _______ End Time ______________ Habitat:_____________

Topography ______________ Altitude________________ Latitude____________

Longitude_____________ Aspect _______________ Slope__________



Species codes- Kalij Pheasant (KP), Cheer Pheasant (CP), Black francolin (BF), Himalayan monal (HM), Koklass pheasant (KO), Western Tragopan (WT).

Annexure 8.6 : Data sheet for Vultures at Dump / Carcass Site

Date: _________ **Area/Site**_______ **Weather**___________

Time Start______ **Time End**_______

Major Habitat Type___________ **Topography** ______________ **Altitude**________________

Latitude____________ **Longitude**_____________ **Aspect**____________

Slope___________

Number of fresh livestock carcasses- **1** **2-5** **6-10** **11-25**

Species	Juveniles	Sub adults	Adults	Arrival time	Departure time	Activities	Activity time

Activities- 1 = Soaring, 2 = Perching, 3 = Sitting on ground, 4 = Feeding.

Other Scavengers

Mammals (Sp)	Birds(Sp)	Numbers	Time of Arrival	Time of Departure	Activities	Time of Activities

Observers –

Annexure 8.7 : Data sheet for Vultures at Roosting site

Date: _________ **Area/Site**_______ **Weather**___________

Time Start______ **Time End**_______ **Habitat** ___________

Canopy Cover________ **Grass Cover**______ **Shrub Cover**_______

Topography ______________ **Altitude**________________ **Latitude**____________

Longitude_____________ **Aspect**____________ **Slope**___________

Vulture Species	Juveniles	Sub adults	Adults	Tree species and Number / or Ground	Height of tree	Remarks

Observers –

Annexure 8.8- Bird Checklist recorded from Kailash Sacred landscape - India

Sr.No.	Family	Common name	*Scientific name*	IUCN Status	G P trend
1	Pheasianidae	Kalij pheasent	*Lophura leucomelanos*	LC	Decreasing
2	Pheasianidae	Cheer pheasant	*Catreus wallichii*	VU	Decreasing
3	Pheasianidae	Black francolin	*Francolinus francolnus*	LC	Stable
4	Pheasianidae	Chukar partridge	*Alectoris chukar*	LC	Stable
5	Pheasianidae	Hill partridge	*Arborophila torqueola*	LC	Decreasing
6	Accipitridae	Red headed vulture	*Sarcogyps calvus*	CR	Decreasing
7	Accipitridae	Bearded vulture	*Gypaetus barbatus*	NT	Decreasing
8	Accipitridae	Egyptian vulture	*Neophron percnopterus*	EN	Decreasing
9	Accipitridae	Cinereous vulture	*Aegypius monachus*	NT	Decreasing
10	Accipitridae	Himalayan vulture	*Gyps himalayensis*	NT	Stable
11	Accipitridae	Griffon vulture	*Gyps fulvus*	LC	Increasing
12	Accipitridae	White rumped vulture	*Gyps bengalensis*	CR	Decreasing
13	Accipitridae	Slender billed vulture	*Gyps tenuirostris*	CR	Decreasing
14	Accipitridae	Golden eagle	*Aquila chrysaetos*	LC	Stable
15	Accipitridae	Steppe eagle	*Aquila nepalensis*	LC	Decreasing
16	Accipitridae	Bonelli's eagle	*Aquila fasciata*	LC	Decreasing
17	Accipitridae	Crested serpent eagle	*Spilornis cheela*	LC	Stable
18	Accipitridae	Mountain hawk eagle	*Nisaetus nipalensis*	LC	Decreasing
19	Accipitridae	Black eagle			
20	Accipitridae	Black eared kite	*Milvus migrans lineatus*	LC	Unknown
21	Accipitridae	Shikra	*Accipiter badius*	LC	Stable
22	Accipitridae	Pallid harrier	*Circus macrorus*	NT	Decreasing
23	Accipitridae	Eurasian sparrowhawk	*Accipiter nisus*	LC	Stable
24	Accipitridae	Himalayan buzzard	*Buteo refectus*	LC	Unknown
25	Falconidae	Common kestrel	*Falco tinnunculus*	LC	Decreasing
26	Falconidae	Peregrine falcon	*Falco peregrinus*	LC	Stable
27	Anatidae	Common teal	*Anas crecca*	LC	Unknown
28	Charadriidae	Red wattled lapwing	*Vanellus indicus*	LC	Unknown
29	Charadriidae	River lapwing	*Vanellus duvaucelii*	NT	Unknown
30	Scolopacidae	Common sandpiper	*Actitis hypoleucos*	LC	Decreasing

31	Rallidae	White breasted waterhen	*Amourornis phoenicurus*	LC	Unknown
32	Apodidae	Alpine swift	*Takymarptis melba*	LC	Stable
33	Apodidae	Little swift	*Apus affinis*	LC	Increasing
34	Apodidae	Himalayan swiftlet	*Aerodramus brevirostris*	LC	Stable
35	Columbidae	Eurasian Collared-dove	*Streptopelia decaocto*	LC	Increasing
36	Columbidae	Oriental turtle dove	*Streptopelia orientalis*	LC	Stable
37	Columbidae	Spotted dove	*Spilopelia chinensis*	LC	Increasing
38	Columbidae	Emerald dove	*Chalcophaps indica*	LC	Decreasing
39	Columbidae	Common pigeon	*Columba livia*	LC	Decreasing
40	Columbidae	Common wood pigeon	*Columba palumbus*	LC	Increasing
41	Columbidae	Snow pigeon	*Columba leuconota*	LC	Stable
42	Columbidae	Hill pigeon	*Columba rupestris*	LC	Decreasing
43	Columbidae	Wedge tailed green pigeon	*Treron sphenurus*	LC	Stable
44	Cuculidae	Asian koel	*Eudynamys scolopaceus*	LC	Stable
45	Cuculidae	Common hawk cuckoo	*Hierococcyx varius*	LC	Stable
46	Cuculidae	Eurasian cuckoo	*Cuculus canorus*	LC	Decreasing
47	Psittaculidae	Rose ringed parakeet	*Psittacula krameri*	LC	Increasing
48	Psittaculidae	Slaty headed parakeet	*Psittacula hamlayana*	LC	Stable
49	Psittaculidae	Plum headed parakeet	*Psittacula cyanocephala*	LC	Decreasing
50	Picidae	Speckled piculet	*Picumnus innominatus*	LC	Stable
51	Picidae	Brown fronted woodpecker	*Dandrocopos auriceps*	LC	Stable
52	Picidae	Yellow crowned woodpecker	*Dandrocopos mahrattensis*	LC	Stable
53	Picidae	Grey headed woodpecker	*Picus canus*	LC	Stable
54	Picidae	Scaly bellied woodpecker	*Picus sqamatus*	LC	Stable
55	Picidae	Lesser yellownape	*Picus chlorolophus*	LC	Stable
56	Picidae	Greater yellownape	*Picus flavinucha*	LC	Stable
57	Megalaimidae	Great barbet	*Megalaima virens*	LC	Stable
58	Megalaimidae	Blue throated barbet	*Megalaima asiatica*	LC	Stable
59	Phalacrocoracidae	Great cormorant	*Phalacrocorax carbo*	LC	Increasing

60	Phalacrocoracidae	Indian cormorant	*Phalacrocorax fuscicollis*	LC	Unknown
61	Alcedinidae	White breasted kingfisher	*Halcyon smyrnensis*	LC	Increasing
62	Alcedinidae	Common kingfisher	*Alcedo atthis*	LC	Unknown
63	Alcedinidae	Crested kingfisher	*Megaceryle lugubris*	LC	Decreasing
64	Upupidae	Common hoopoe	*Upupa epops*	LC	Decreasing
65	Meropidae	Green bee-eater	*Merops orientalis*	LC	Increasing
66	Meropidae	Chestnut headed bee-eater	*Merops leschenaulti*	LC	Increasing
67	Strigidae	Asian barred owl	*Glaucidium radiatum*	LC	Increasing
68	Strigidae	Mountain scops owl	*Otus spilocephalus*	LC	Stable
69	Strigidae	Collered owlet	*Glaucidium brodiei*	LC	Decreasing
70	Strigidae	Jungle owlet	*Glaucidium cuculoides*	LC	Stable
71	Strigidae	Brown wood owl	*Strix leptogrammica*	LC	Decreasing
72	Corvidae	Black headed jay	*Garrulus ianceolatus*	LC	Stable
73	Corvidae	Eurasian jay	*Garrulus glandarius*	LC	Stable
74	Corvidae	Red billed blue magpie	*Urocissa erythrorhyncha*	LC	Increasing
75	Corvidae	Yellow billed blue magpie	*Urocissa flavirostris*	LC	Stable
76	Corvidae	Grey treepie	*Dendrocitta formosa*	LC	Decreasing
77	Corvidae	Rufous treepie	*Dendrocitta vagabunda*	LC	Stable
78	Corvidae	Large billed crow	*Corvus macrorhynchos*	LC	Stable
79	Corvidae	House crow	*Corvus splendens*	LC	Stable
80	Oriolidae	Maroon oriole	*Oriolus traillii*	LC	Unknown
81	Timaliidae	Streaked laughingthrush	*Garrulax lineatus*	LC	Stable
82	Timaliidae	White throated laughingthrush	*Garrulax albogulris*	LC	Stable
83	Timaliidae	White crested laughingthrush	*Garrulax leucolophus*	LC	Decreasing
84	Timaliidae	Rufous chinned laughingthrush	*Garrulax rufogularis*	LC	Decreasing
85	Timaliidae	Jungle babbler	*Trudoides striata*	LC	Stable
86	Timaliidae	Rufous sibia	*Heterophasia capistrata*	LC	Unknown
87	Timaliidae	Striated laughingthrush	*Garrulax striatus*	LC	Decreasing
88	Timaliidae	Rusty cheeked scimiter babbler	*Pomatorhinus erythrogenys*	LC	Stable
89	Timaliidae	Streaked breasted scimiter babbler	*Pomatorhinus ruficollis*	LC	Stable

90	Timaliidae	Black chinned babbler	*Stachyridopsis pyrrhops*	LC	Stable
91	Turdidae	Grey winged blackbird	*Turdus boulboul*	LC	Decreasing
92	Turdidae	Black throated thrush	*Turdus atrogularis*	LC	Unknown
93	Turdidae	Long billed thrush	*Zoothera monticola*	LC	Decreasing
94	Timaliidae	Bar throated siva	*Siva strigula*	LC	Decreasing
95	Timaliidae	Blue winged siva	*Minla cyanouroptera*	LC	Decreasing
96	Sturnidae	Common myna	*Acridotheres tristis*	LC	Increasing
97	Sturnidae	Jangle myna	*Acridotheres fuscus*	LC	Decreasing
98	Sturnidae	Chestnut tailed starling	*Sturnia malabaricus*	LC	Unknown
99	Pycnonotidae	Red vented bulbul	*Pycnonotus cafer*	LC	Increasing
100	Pycnonotidae	Himalayan bulbul	*Pycnonotus leucogenys*	LC	Increasing
101	Pycnonotidae	Black bulbul	*Hypsipetes leucocephalus*	LC	Stable
102	Pycnonotidae	Mountain bulbul	*Hypsipetes mcclellandii*	LC	Stable
103	Pycnonotidae	Ashy bulbul	*Hemixos flavala*	LC	Stable
104	Estrildidae	Scaly breasted munia	*Lonchura punctulata*	LC	Stable
105	Estrildidae	White rumped munia	*Lonchura striata*	LC	Stable
106	Muscicapidae	Blue whistlingthrush	*Myphonus caeruleus*	LC	Unknown
107	Muscicapidae	Blue capped rockthrush	*Monticola cinclorhynchus*	LC	Stable
108	Muscicapidae	Chestnut bellied rockthrush	*Monticola rufiventris*	LC	Stable
109	Muscicapidae	Grey bushchat	*Saxicola ferreus*	LC	Stable
110	Muscicapidae	Pied bushchat	*Saxicola caprata*	LC	Stable
111	Muscicapidae	Common stonechat	*Saxicola torquatus*	LC	Stable
112	Muscicapidae	Oriental magpie robin	*Copsychus saularis*	LC	Stable
113	Muscicapidae	Golden bush robin	*Tarsiger chrysaeus*	LC	Stable
114	Muscicapidae	Verditer flycatcher	*Eumiyas thalassinus*	LC	Stable
115	Muscicapidae	Grey headed canary flycatcher	*Culicicapa ceylonensis*	LC	Stable
116	Muscicapidae	Ultra marine flycatcher	*Ficedula superciliaris*	LC	Stable
117	Muscicapidae	Dark sided flycatcher	*Muscicapa sibirica*	LC	Stable
118	Muscicapidae	Slaty blue flycatcher	*Ficedula tricolor*	LC	Stable

119	Muscicapidae	Rusty tailed flycatcher	*Muscicapa ruficuada*	LC	Stable
120	Muscicapidae	Variable wheatear	*Oenanthe picata*	LC	Stable
121	Muscicapidae	Small niltava	*Niltava macgrigoriea*	LC	Stable
122	Muscicapidae	Rufous bellied niltava	*Niltava sundara*	LC	Stable
123	Muscicapidae	Blue capped redstart	*Phoenicurus caeruleocephala*	LC	Stable
124	Muscicapidae	Black redstart	*Phoenicurus ochruros*	LC	Increasing
125	Muscicapidae	Blue fronted redstart	*Phoenicurus frontalis*	LC	Stable
126	Muscicapidae	White capped redstart	*Chaimarrornis leucocephalus*	LC	Stable
127	Muscicapidae	Plumbeous redstart	*Rhyacornis fuliginosa*	LC	Stable
128	Muscicapidae	Spotted forktail	*Enicurus maculatus*	LC	Stable
129	Muscicapidae	Little forktail			
130	Muscicapidae	Slaty backed forktail	*Enicurus leschenaulti*	LC	Stable
131	Muscicapidae	Himalayan bluetail	*Tarsiger rufilatus*	LC	Stable
132	Monarchidae	Asian paradise flycatcher	*Terpsiphone paradisi*	LC	Stable
133	Dicruridae	Spangled drongo	*Dicrurus hottentottus*	LC	Stable
134	Dicruridae	Ashy drongo	*Dicrurus leucophaeus*	LC	Unknown
135	Dicruridae	Crow billed drongo	*Dicrurus annectans*	LC	Unknown
136	Laniidae	Long tailed shrike	*Lanius schach*	LC	Unknown
137	Laniidae	Grey backed shrike	*lanius tephronotus*	LC	Stable
138	Passeridae	Russet sparrow	*Passer rutilans*	LC	Stable
139	Passeridae	House sparrow	*Passer domesticus*	LC	Decreasing
140	Sylviidae	Greenish warbler	*Phylloscopus trochiloides*	LC	Increasing
141	Sylviidae	Grey hooded warbler	*Phylloscopus xanthoschistos*	LC	Stable
142	Sylviidae	Lemon rumped warbler	*Phylloscopus chloronotus*	LC	Stable
143	Sylviidae	Humes leaf warbler	*Phylloscopus humei*	LC	Stable
144	Sylviidae	Tickell's leaf warbler	*Phylloscopus affinis*	LC	Stable
145	Sylviidae	Blyth's leaf warbler	*Phylloscopus reguloides*	LC	Stable
146	Sylviidae	Grey sided bushwarbler	*Cettia brunnifrons*	LC	Stable

147	Sylviidae	Black faced warbler	*Abroscopus supercillaris*	LC	Stable
148	Zosteropidae	Oriental white eye	*Zosterops palpebrosus*	LC	Decreasing
149	Sittidae	Velvet fronted nuthatch	*Sitta frontalis*	LC	Decreasing
150	Sittidae	Chestnut bellied nuthatch	*Sitta castanea cinnmoventris*	LC	Unknown
151	Sittidae	Wallcreeper	*Tichodroma muraria*	LC	Stable
152	Certhiidae	Bar tailed treecreeper	*Certhia himalayana*	LC	Decreasing
153	Paridae	Great tit	*Parus major*	LC	Increasing
154	Paridae	Black lored tit	*Parus xanthogenys*	LC	Stable
155	Paridae	Green backed tit	*Parus monticolus*	LC	Stable
156	Aegithalidae	Black throated tit	*Aegithalos concinnus*	LC	Stable
157	Sylviidae	Common tailorbird	*Orthotomus sutorius*	LC	Stable
158	Cisticolidae	Grey breasted prinia	*Prinia hodgsonii*	LC	Stable
159	Cisticolidae	Striated prinia	*Prinia crinigera*	LC	Stable
160	Campephagidae	Long tailed minivet	*Pericrocotus ethologus*	LC	Stable
161	Campephagidae	Scarlet minivet	*Pericrocotus flammeus speciocus*	LC	Stable
162	Hirundinidae	Red rumped swallow	*Cecropis daurica*	LC	Stable
163	Hirundinidae	Barn swallow	*Hirundo rustica*	LC	Decreasing
164	Fringillidae	Common rosefinch	*Carpodacus erythrinus*	LC	Decreasing
165	Fringillidae	Dark breasted rosefinch	*Carpodacus nipalensis*	LC	Stable
166	Fringillidae	Yellow breasted greenfinch	*Carduelis spinoides*	LC	Stable
167	Decaeidae	Fire breasted flowerpecker	*Dicaeum ignipectus*	LC	Stable
168	Nectariniidae	Purple sunbird	*Cinnyris asiaticus*	LC	Stable
169	Nectariniidae	Fire tailed sunbird	*Aethopyga ignicauda*	LC	Stable
170	Nectariniidae	Black throated sunbird	*Aethopyga saturata*	LC	Stable
171	Nectariniidae	Crimson sunbird	*Aethopyga siparaja*	LC	Stable
172	Nectariniidae	Green tailed sunbird	*Aethopyga nepalensis*	LC	Stable
173	Chloropseidae	Golden fronted leafbird	*Chloropsis aurifrons*	LC	Stable
174	Chloropseidae	Orange bellied leafbird	*Chloropsis hardwickii*	LC	Decreasing
175	Motacillidae	Grey wagtail	*Motacilla cinerea*	LC	Stable

176	Motacillidae	White wagtail	*Motacilla alba*	LC	Stable
177	Motacillidae	White browed wagtail	*Motacilla maderaspatensis*	LC	Stable
178	Motacillidae	Olive backed pipit			
179	Motacillidae	Paddy field pipit	*Anthus rufulus*	LC	Stable
180	Motacillidae	Rosy pipit	*Anthus roseatus*	LC	Stable
181	Rhipiduridae	White throated fantail	*Rhipidura albicollis*	LC	Stable
182	Rhipiduridae	Yellow bellied fantail	*Chelidorhynx hypoxantha*	LC	Stable
183	Timaliidae	Whiskered yuhina	*Yuhina flavicollis*	LC	Unknown
184	Timaliidae	Stripe throated yuhina	*Yuhina gularis*	LC	Decreasing
185	Emberizidae	Rock bunting	*Emberiza cia*	LC	Increasing
186	Emberizidae	Crested bunting	*Melophus lathami*	LC	Stable
187	Prunellidae	Rufous breasted accentor	*Prunella strophiata*	LC	Stable
188	Prunellidae	Black throated accentor	*prunella atrogularis*	LC	Stable
189	Cinclidae	Brown dipper	*Cinclus pallasii*	LC	Stable
190	Campephagidae	Large cuckooshrike	*Coracina macei*	LC	Stable
191	Sturnidae	Spot winged starling	*Saroglossa spiloptera*	LC	Decreasing
192	Phylloscopidae	Buff barred warbler	*Phylloscopus pulcher*	LC	Stable

Abbreviations

IUCN status = LC (Least concern), NT (Near Threaten), V (Vulnerable), EN (Endangered), CR (critically endangered)

GP Status = Global population trend

Chapter 9. Participatory monitoring of aquatic ecosystems in Kailash Sacred Landscape with special reference to fishes

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9.1 Introduction

The rivers that originate in the Himalaya provide sustenance, livelihoods, and prosperity to millions of people living in India and neighbouring countries. The Kailash Sacred Landscape represents a wide range of bioclimatic zones and ecosystems, rich natural and cultural resources, and a wide variety of globally significant biodiversity including unique Himalayan fish diversity (Badola, 2001; Talwar and Jhingran, 1991; Uniyal and Kumar, 2006). Environmentally fragile cold water river ecosystems of the Kailash Landscape provides essential habitat for large numbers of threatened cold water fish species that are under acute pressure from environmental change and human activities, including dam/barrier constructions and climate change. Wetlands in KSL provide several ecological goods and services and major rivers such as the Ganges, Indus, and Sutjej drains from KSL. These rivers are used for multiple purposes including irrigation and hydropower generation, and they support large downstream populations, notably in South Asia (Zomer and Oli, 2011).

Fishes are extremely good indicators of aquatic habitats. We suggest several species of fishes and a few abiotic parameters for the ecological monitoring of aauatic habitats in KSL.

There are a number of ecologically and culturally significant lakes, streams and rivers in KSL - India. A total of 134 fishes have been reported from KSL, of these, 90 species reported from the Indian part of KSL (Zomer and Oli, 2011). *Schisothorax* spp. is the most dominant fish in the KSL region. Diversity of fish varies across altitudinal gradient in Himalaya due to variation in temperatures and velocity of water. For example, *Glyptothorax* sp. and *Pseudecheneis* sp., occur in the torrential conditions of the Himalayan riverine system. Moreover, game fish such as mahseer (*Tor putitora*), katle (*Neolissochielus hexagonolepis*), and asala (*Shisothorax* species are also common in KSL. Species such as *Tor putitora, Garra spp., Xenentodon cancila, Tor tor* and *Neolissochilus hexagonolepis* occur in the Indian part of KSL as these species reported from the Pancheshwar and Kali rivers. Of these, mahseer, snow trout and catfishes are livelihoods for some people in the region. Common fishes of KSL which could be monitored regularly are given in Table 9.1.

Table 9.1. Common fishes of KSL

S.No	Scientific name	Vernacular name	Common Name
1.	*Schizothorax richardsonii*	Asla	Snow trout
2.	*Barilius bendelisis*	Jhujjia	
3.	*Barilius vagra*	Jhujjia	
4.	*Naziritor chelynoides*	Sor	
5.	*Tor putitora*	Sor, Mahseer	Mahseer
6.	*Garra gotyla*	Pathar chatta, pandit macchi	
7.	*Parachiloglanis hodgarti*	Kabadyal	
8.	*Pseudoecheneis sulcatus*	Kabadyal	
9.	*Glyptothorax*	Kabadyal	
10.	*Nemacheilus rupecola*	Gadera	
11.	*Nemacheilus multifasciatus*	Gadera	
12.	*Nemacheilus montanus*	Gadera	
13.	*Mystus cavasius*		Catfish

9.2 Need for monitoring fishes and aquatic ecosystems in KSL

Fishes are excellent indicators of healthy aquatic ecosystem. Rich fish diversity with good condition factors is expected in the undisturbed streams and rivers (Sivakumar, 2008). The distributions of freshwater fishes are influenced by many factors operating at different scales. At a regional scale, freshwater fish distributions are influenced by historical (postglacial dispersal) and environmental (climate) factors. At local scales, distributions are influenced by abiotic (e.g. water chemistry) and biotic (i.e. species interactions) factors. These factors can be viewed as hierarchical filters that influence fish. The fresh water fish diversity in the hill streams of KSL is unique because of the different geomorphic conditions, changing thermal regimes and fast water current. There are a multitude of factors, which are responsible for the unique distribution and the varying abundances of fishes in KSL. It is now expected that the effects of climate change and other anthropogenic pressures affecting wetland ecosystem and fish diversity of KSL, which needs to be monitored to find remedial actions so that the normal ecosystem services of wetlands in KSL would be available for humankind forever. The major parameters of ecosystems, indicators, and approaches proposed for for monitoring aquatic ecosystems and fishes in KSL are given in **Table 9.2.**

Table 9.2. Proposed parameters of aquatic ecosystems and fishes for long term monitoring in KSL – India

Theme	Key Parameters	Indicators	Approach & Monitoring Frequency	Scale
Aquatic Ecosystem Services	Ecological status of Rivers	Good quality water with adequate primary producers and fishes; Less number of invasive species	Basic water quality analysis including estimating BOD and abundance of fishes using catch per unit effort method	Ramganga river from Pancheshwar to Aunlaghat Gokarneshwar Gad
Biodiversity Monitoring	Status of aquatic fauna and their habitats	Status and abundance of fish fauna Amphibians	Seasonal abundance of fishes based on the catch per unit effort at selected localities Once in 2 years	Ramganga river from Pancheshwar to Aunlaghat Gokarneshwar Gad

9.3 Participatory monitoring of fishes

Wetlands of KSL can easily be monitored by the local communities by observing the abundances of certain common and commercially important fishes along with qualities of water that available in these wetlands especially the streams and rivers. However, the Golden mahseer, snow trout and catfishes could be used as indicator fishes for long term monitoring of streams and rivers of KSL. Cold water fish such as snow trout is normally occurring in the higher altitude streams and rivers and their distribution is largely determined by water flow, temperature and low turbidity. Therefore, this species could be used to monitor the changes in the water flow and temperature of streams and rivers in KSL. Similarly, being omnivore and carnivore, golden mahseer and catfish respectively, can be considered as umbrella species in the lower altitude streams and rivers of KSL. Further, these three species are also commercially important, livelihoods and recreation of many people dependents on these three species in KSL. Therefore, it is easier for fishermen or local communities to monitor their abundance in their places.

A few people in the KSL are known to do fishing occasionally for recreation and others do it for livelihoods. Of these people, a few volunteers would be selected for participatory monitoring of fish populations. Such people would be asked to record total number of fishes, viz., golden mahseer, snow trout and catfish once in a month that have been caught in their fishing nets (gill nets/cast net) need to be counted and weighed. These data along with other simple habitat parameters need to be entered in the following data sheet (**Table 9.3**). These data can be used to estimate the abundance of fishes by assessing the Catch Per Unit Effort (CPUE) and to estimate the condition factors of fishes which would reveal the health and environment conditions of the fish and ecosystem respectively. Intensive monitoring would be carried out in the same area whereas other biodiversity monitoring of the project going to happen so that there would be convergence which would help to link the association between terrestrial and aquatic landscapes.

Table 9.3. Long term monitoring of fishes and their habitats of KSL

Date	Time	Place	Species (Mahseer/ snow trout/ catfish)	Length	Wt	Flow (high/ Slow)	Depth	Turbidity (High, medium, low)	Net used (gill/ cast/ rods)

9.4 Monitoring of water quality

Water quality in the wetlands and aquatic ecosystems would be done following standard protocol. Key parameters selected for monitoring include Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Status of Primary Producers, pH, Salinity, temperature and turbidity would be monitored once in a month or season using portable water analysis kit. Further, the water flow would also needs to be measured using hand held digital water flow meter along with depth and wetted width of rivers/streams. All these data need to be entered in the following data sheet and analyzed for the water velocity, volume and its qualities, which are important. These parameters would be recorded in a standard format as below (Table 9.4).

Table 9.4: Format for recording water quality parameters

Date	Time	Site (Lat/ Long/Alt)	Temperature	BOD	DO	pH	Salinity (EC)	Turbidity	Primary producer	Velocity/ depth/ width

9.5 Assesment on aquatic ecosystem services

Various ecosystem services of streams and rivers of KSL that have been mentioned below would be assessed following the methods described against each parameter.

5.1 ***Provisioning Services***: Products obtained from ecosystems, including food, fibre, fuel, genetic resources, ornamental resources, freshwater, biochemical, natural medicines and pharmaceuticals.

5.2 ***Regulating Services***: Benefits obtained from the regulation of ecosystem processes including air quality regulation, climate regulation, water regulation, erosion regulation, water purification, waste treatment, disease regulation, pest regulation, pollination and natural hazard regulation.

5.3 ***Cultural Services***: Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences, including cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism.

5.4 ***Supporting services*** are ecosystem processes necessary for sustaining the production of all other ecosystem services. Examples are primary production (plant growth) and nutrient cycling for soil formation and water quality regulation.

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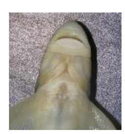
Annexture 9.1 - Identification of indicator species

Golden Mahseer

Family: Cyprinidae **Scientific name: *Tor putitora*** **IUCN status: Endangered** **Maximum Size: 2.7 meters; 54 Kg.**	
Large size fish, it can be easily differentiated by large size scales on the body; head longer than the depth of body. Body colour: in adults, flanks are golden orange to yellow which fades into silvery white on belly. Scales tinted with numerous black dots along the lateral line. Fins are yellow in colour. Two pairs of short barbles present along the corner of the mouth and mouth is moveable. It differs from all other mahseer by presence of large head, narrow and long body. It prefers large rocky pools and rapids and it feeds on worms, insects, molluscs and small fishes. Adults are common in the main river, whereas, juveniles prefer the small streams.	

Snow trout

Family: Cyprinidae **Scientific name: *Schizothorax richardsonii*** **IUCN status: Vulnerable** **Maximum Size: 60 cm**	 
Body cylindrical, head flattened on under surface, snout rounded and smooth. Suctorial mouth located in ventral surface of head, scales very small. Head and dorsal region of the body gray, flanks and belly silver white. Large size specimens, flanks are golden brown colour. **It has** habit of scrapping the rocky substratum in the streams and feeds mainly on unicellular algae and detritus. It is very common and wildly distributed in streams and rivers of KSL.	

Catfish

<table>
<tr>
<td>Family: Bagridae

Scientific name: Mystus cavasius

IUCN status: Least concern

Maximum Size: 40 cm.</td>
<td></td>
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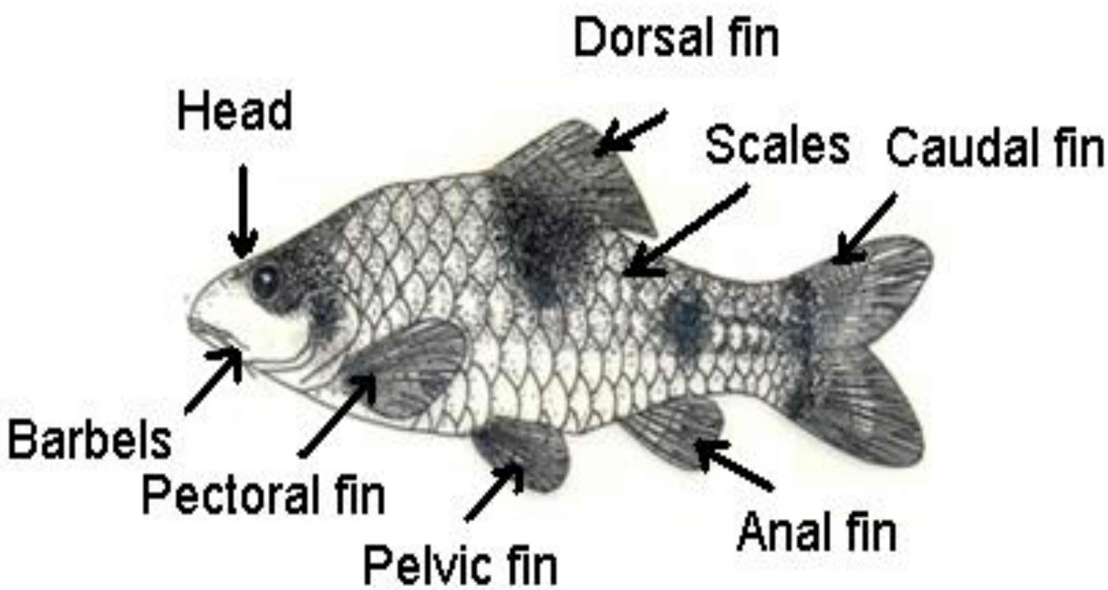
<tr>
<td colspan="2">It is a medium size catfish. Head dorso-ventrally compressed and body laterally compressed. It can be easily distinguished from other Mystus catfish by presence of long adipose dorsal fin start immediately after dorsal fin and presence of long maxillary barbels which run up to anal fin end. In addition to that the body muscular bands are clearly visible along the flank. Body silver colour with yellow shade and head dark grey in colour. It is commonly occur in low land streams, river and reservoirs. It feeds on worms and aquatic insects. This species is distributed in lower altitudes of KSL.</td>
</tr>
</table>

Fish identification method

Fish identification is somewhat different from identifying birds, which usually have body colours and distinctive patterns. So do same fish, but with many of the characteristic points are much more restrained, for example: number of rays in fins, lateral line scales, lateral transverse scales, body shape etc. For making easy identification, one can start familiar with some of unique body parts of fishes: colour, pattern and shape. Distribution range information also gives a basic idea about particular species. Before moving into the identification user should familiar with the general morphology and body parts of a fish. The general morphology and major body parts are described in illustration (Figure 9.1). Traditionally, fish identification and classification are carried out on the basis of some morphometric and meristic traits. It is also necessary to familiarize with characteristic features of some important group fishes occur in the reason. The major groups of fishes reported in this region are belonging to the family Cyprinidae, Bagridae, Sisoridae and Channidae. In order to identify some important freshwater fishes inhabiting in Himalayan waters, this section descries the salient features of major freshwater family and also major identification characters of common freshwater fishes.

Figure 9.1. General Morphology and body parts of a bony

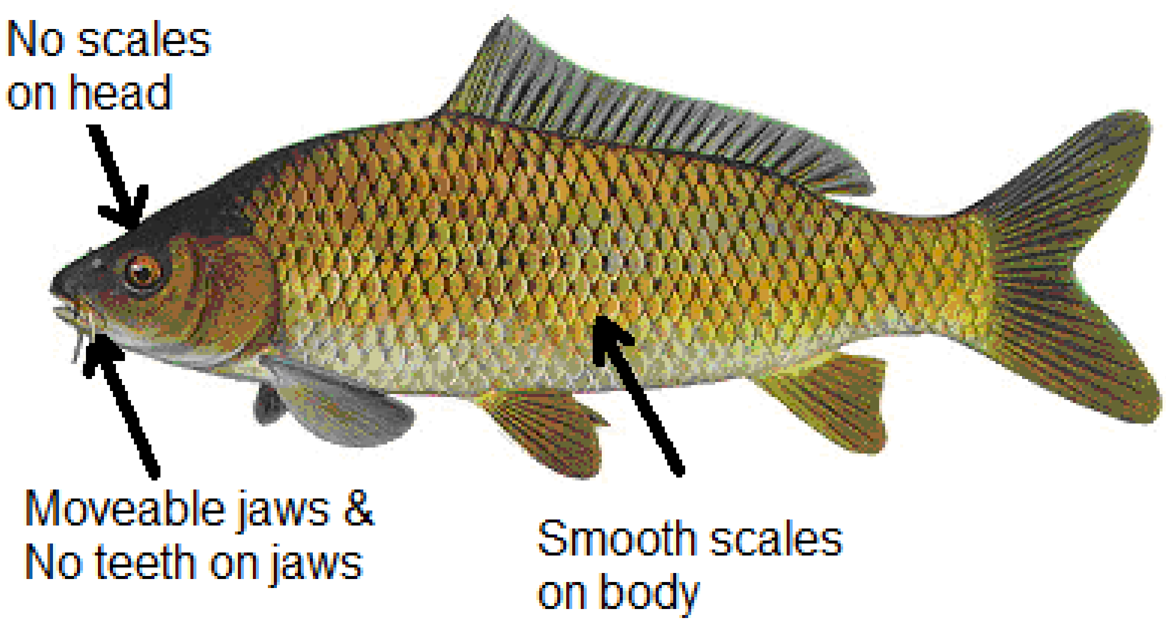


Characteristic features of Cyprinidae

Cyprinidae are generally called carp family, it includes mahseers, snow trout, barbs, barils, danio, minnow, etc. They are highly diverse groups occupie in all possible aquatic habitats such as streams, rivers, lakes, ponds, canals etc. The followings are the major genus under this family: *Tor, Schizothorax, Labeo, Cirrhinus, Barilius, Garra* and *Puntius*. The important salient features of this family are:

- Body covered with scales and no scales on head
- Body scales are dome shaped with smooth margin
- Dorsal fin composed of soft branched rays, anterior ray unbranched
- Usually moveable upper jaw
- Short barbels some time present along the corner of mouth
- No teeth on jaws, but pharyngeal teeth are present along gill arch

Key identification characters for family Cyprinidae

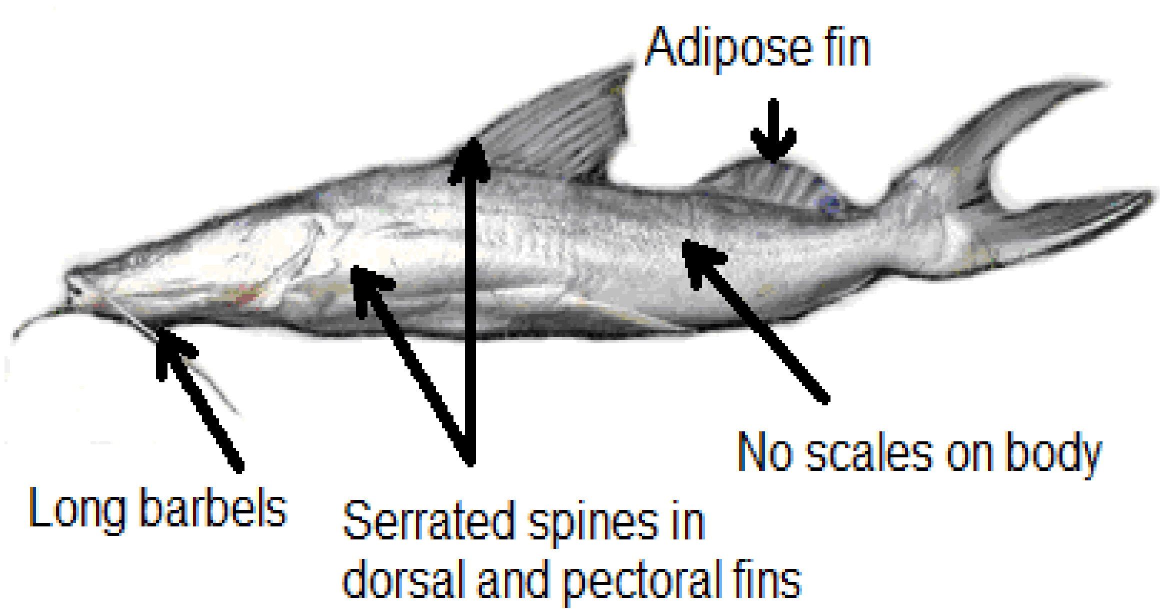


Characteristic features of Bagridae

Members of this family are commonly called as catfishes, because of presence of long barbells around the mouth. They are more ancient and widely distributed group, occurs in south and south east Asia and Europe. Members of this family are predatoary carnivores, feed on aquatic insects, worms and fishes. The major genus under this family are: *Mystus, Aorichthys, Batasio* and *Rita*. The important salient features of this family are:

- Scales absent
- Long barbels around the mouth
- Dorsal and pectoral fins with well-developed spine
- Anal fin base short with few rays
- A short membranous out growth occur after the dorsal fin, called adipose fin
- Teeth present on jaws

Key identification characters for family Bagridae

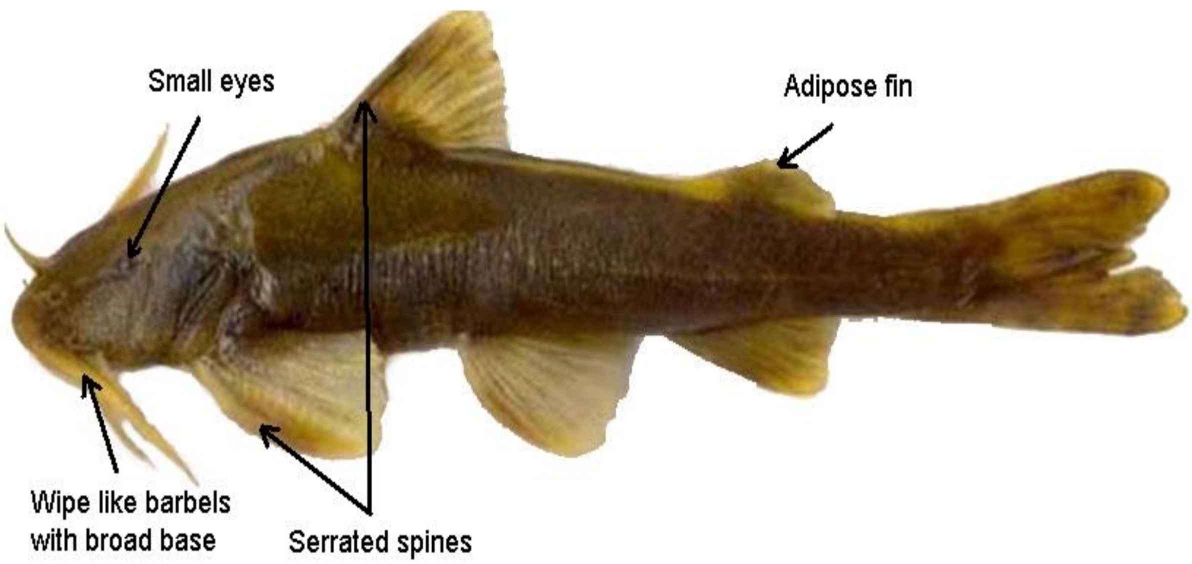


Characteristic features of Sisoridae

Sisoridae fishes are another family of catfishes, generally inhabits in rapids and pools of high mountain streams and rivers. The fish which inhabit in high altitude are usually having adhesive pad on the thoracic region. The members of this family are *Bagarius, Glyptothorax, Glyptosternum, Sisor* and *Hara*. The identification features of this family are:

- No scales on the body
- Adhesive apparatus on the thoracic often present
- Paired fins (pectoral and pelvic fins) placed horizontally
- Pectoral fin with strong spine with serrations
- Barbles on upper jaw strong base, whip like with broad base

Key identification characters for family Sisoridae

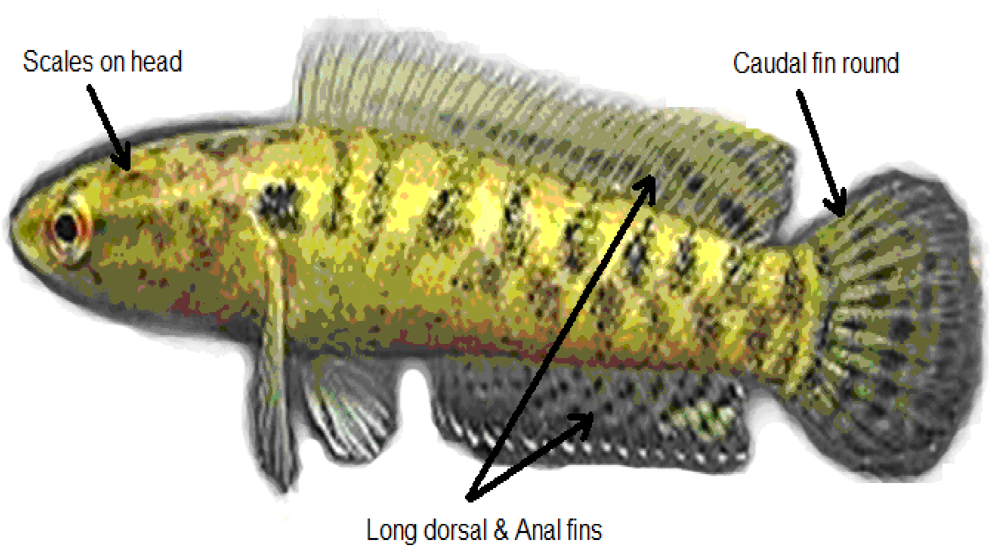


Characteristic features of Channidae

This group of fishes is called snake-headed and they can able to take atmospheric oxygen for respiration, hence they also called as air-breathing fishes. This family has only on genus *Channa* represented in India and there are six valid species were reported from Indian waters. They are generally in habits in low land streams, rivers, reservoirs, lakes and ponds. The salient features of this family are:

- Head with large head scales on top
- Long dorsal and anal fins
- Caudal fin round
- Large mouth and Jaws with teeth

Key identification characters for family Channidae



Annexure 9.2. Various ecosystem services and indicators that can be monitored. (Source http://www.ecosystemservices.org.uk/ ecoserv.htm)

PROVISIONING SERVICES	
Services	**Measurable Indicators**
Food	Food production in tons/ha Fish catch/ day Milk production in lt/year
Sustainably produced crops, fruit,	
livestock, semi-domestic animals,	
fish and other aquatic	
Resources	
Water	Total freshwater resources in m^3
Ornamental resources	Number of species used for handcraft work; Amount of ornamental plant species used for gardening from sustainable sources
Sustainably produced ornamental	
wild plants, wood for handcraft,	
Seashells	

REGULATING SERVICES	
Regulation of water flows	Infiltration capacity/rate (e.g. amount of water/ surface area)
Regulating surface water runoff	volume through unit area/per time; Soil water storage capacity in mm m^{-1}
Aquifer recharge etc.	Floodplain water storage capacity in mm m^{-1}
Waste treatment and water	Removal of nutrients by aquatic ecosystems (ton or
Purification	percentage); Water quality in aquatic ecosystems
Capture and removal of nutrients and contaminants	(sediment, turbidity, phosphorous, nutrients)
CULTURAL SERVICES	
Aesthetic information	Abundance and score of objects; landscape types
Amenities provided by the Aquatic ecosystem or its components	
Recreation and ecotourism	Abundance or area of recreation sites; recreational opportunity spectrum
canoeing, rafting,	
diving, recreational fishing, animal	
Watching	

Chapter 10. Monitoring insects in pilot sites of Kailash Sacred Landscape – India

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10.1 Background

Monitoring is considered as an essential component of any viable strategy to conserve biological diversity because it provides a basis to track the status of various components of biodiversity over time in the context of different management regimes (Common & Norton, 1995). What, where, when and how to monitor are the most pertinent questions in any scheme of monitoring. At least two approaches exist in this regard: (i) firstly, periodical `blind' or `total' data gathering on each and every species or element of habitat those are occurring on a fixed, permanent transect, plot, etc., subsequent data analysis and infer what has happened to species richness, diversity, productivity, succession, etc., and (ii) secondly, based on the preliminary knowledge of the study area, selected taxa are identified as "indicator" or "vital signs" for monitoring. Hilty & Merenlender (2000) have reviewed the criteria for selecting indicator taxa, step-wise process for selection of indicator taxa, and to test the criteria against the indicator taxa that are currently being used to monitor ecosystem health. Invertebrates have been widely proposed and used as indicator taxa for monitoring.

Several groups of insects such as dragon flies, butterflies, moths and bees can be used effectively as indicators of environmental change. This chapter deals with basic tools and techniques for collection of baseline data and subsequent monitoring of

10.2 Insects as Bio-indicators

Insects are the most diverse and abundant of all terrestrial animals. Insects play significant roles in the ecology of the world due to their vast diversity of form, function and life-style, their considerable biomass, and their interaction with plant life, other organisms and the environment. Since they are the major contributor to biodiversity in the majority of habitats, except in the sea, they accordingly play a variety of extremely important ecological roles in the many functions of an eco-system. As pollinators, they contribute to the reproduction of most flowering plants. Insects are often the first decomposers of dead plants and animals, and introduce microorganisms that continue this process and release nutrients for new plant growth. As an important ecosystem component, insects are excellent bioindicators of various environment conditions, which makes them important in monitoring ecosystem conditions.

10.3 Proposed taxa for monitoring

Insect indicators of various environment conditions will be monitored in a few pilot areas of KSL – India. Insects will be sampled along trails and within permanently marked plots located covering a wide elevational gradient and different vegetation types and agricultural fields. Two sampling approaches *viz.* quantitative and presence/absence will be employed to monitor insect diversity in the landscape. Monitoring will be conducted across 3 seasons.

As insect is a hyper diverse group and largest group in animal kingdom representing about 30 different insect orders. Due to vastness of the group, it is not possible to monitor the entire insect taxa. Therefore, past studies have targeted on focal groups as indicator for predictions of environmental change. During current study, following insect taxa which are indicator of various environmental conditions will be monitored:

Dung beetles (Sacarabaeidae): Dung beetles are good indicator of anthropogenic disturbance. They are very sensitive to environmental changes and are considered well-suited as bioindicator organisms (Klein, 1989; Favila & Halffter, 1997). Dung beetles are efficient in removing debris and dung controlling parasites and secondarily dispersing seeds.

Butterflies (Lepidoptera: Rhopalocera): Butterflies are frugivores have been used as bioindicators of biodiversity throughout world. Many butterfly species are known to occur in spatially structured populations that usually follow the classical metapopulation concept, making them good biological models in various studies (Thomas & Hanski, 2004). Their easy detectability in the field, specific habitat requirements and rapid response to biotope changes make them useful indicators in ecology and conservation (Thomas, 2005; Van Swaay *et al.,* 2008).

Dragonflies (Odonata): Dragonflies are predacious and good indicator of river ecosystem health. They are inextricable linked to the aquatic ecosystem. Some species prefers standing water bodies like reservoirs, lakes, backwaters, ponds or even seasonal rain water puddles while other prefer running water like rivers, rivulets, hill streams etc. Being supreme predator, odonates play crucial roles in ecosystem functioning.

Pollinators: Pollination is a pivotal process in almost all productive terrestrial ecosystems. Tropics and mountain ecosystems highly dependent on pollinators. Although large group of animals are involve in pollination process but 96% of the pollination is done by bees. Bees provide valuable ecosystem services. Pollination is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems. In agro-ecosystems, pollinators are essential for orchard, horticultural and forage production.

***Agriculture pests*:** Insect like many beetles, moths, grasshoppers, and aphids are responsible for large amount of crop damage.

Ants: Most published literature on ants as indicator uses them as environmental indicator (Underwood & Fisher, 2006; Phillpott *et al.,* 2010). Ant assemblages are focal ecological indicators of restoration, often showing increasing species richness with restoration age. Certain functional groups also behave in predictable ways in response to disturbance and changes in the environment (Golan *et al.,* 20011).

10.4 PROPOSED METHODS

Well established sampling protocols for insect collection will be adopted in different selected sampling plots. Odonates, pollinators and butterflies will be sampled by visual encounter and sweep netting on transects. Beetles and ants will be sampled through pit fall traps, vegetation beating and visual encounter. The detailed descriptions of the collection techniques are as follows.

4.1 *Pitfall Trapping*: Pitfalls will be used to trap the ground dwelling insects like beetles and ants (Magagula, 2003). The pitfall traps consist of small deep plastic jar, one-third filled with 30% ethyl acetate and a few drops of liquid soap/detergent. The pitfall traps will be left open for a period of three days to a week, as this allows increasing the catch and maintaining the specimens in good condition before processing in the laboratory for their identification.

4.2 *Sweep Netting*: this involves collection through herb and shrub layer swinging net for a standard number of times (Coddington *et al.,* 1991, 1996). This sampling method will be applied to collect the foliage and flying insects like pollinators and ants, from low level vegetation of shrubs (up to 2 m in height). The sweep nets consist of a handle and ring and the collection will be made on white canvas. The net will be emptied at regular intervals to avoid loss and destruction of the specimen. During sampling time sweep net will be moved back and forth to cover all ground layer herbs and shrubs till all vegetation in the sampling plots will be swept thoroughly.

4.3 *Ground Hand Collection*: Ground hand collection involves the collection of insect samples from ground to knee level (Coddington *et al.,* 1991, 1996). This method of sampling is used to collect the ants and beetles, which are found to be visible in the ground, litter, in broken logs, rocks etc.

4.4 *Aerial Hand Collection*: Aerial Hand collection involves the collection of insect samples from knee level to arm length level (Coddington *et al.,* 1991, 1996). This method accesses free-living insects on the foliage and stems of living or dead shrubs, high herbs, tree trunks etc.

4.5 ***Vegetation Beating***: The method is employed to accesses insects living in the shrub, high herb vegetation, bushes, and small trees and branches (Coddington *et al.,* 1991, 1996). The insects will be collected by beating the vegetation with a stick and collecting the samples on a cloth (1 x 1m).

4.6 ***Light Traps:*** This sampling involves collection of insects, which are active at night. This method will be employed for recording beetles.

Data will be collected on pre-described format (Annexure-I). Collected data will be analyzed for comparing insect diversity in forests and agriculture along various seasons. Encounter rate and density is a simple expression of number of animals encountered per unit effort/ area. Encounter rate and density can be based on direct or indirect sightings evidences and could be expressed as number/km and number/area respectively. Comparison with baseline data will help in long term monitoring of ecosystem conditions in Kailash Landscape.

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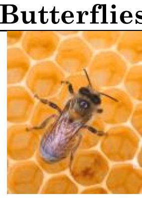
Annexure- 10.1- <u>DATA SHEET FOR INSECTS MONITORING IN KAILASH LANDSCAPE</u>

Date & Time: Transect ID: Habitat:
Temperature: Humidity: Weather:
Start GPS N: Start GPS E: Start Time:
Start Elevation: End GPS N: End GPS E: End Time: End Elevation:

Name of Observer:

Insect group	Species	Abundance	Host plant	Activity	Disturbance signs (Dung, livestock, lopping, wood cutting, fire sign, human presence etc.)	Remarks
 **Dung beetles**						
 **Butterflies**						
 **Pollinators**						
 **Agriculture Pests**						
 **Ants**						
 **Dragon Flies**						

Chapter 11. Monitoring agrobiodiversity in Kailash Sacred Landscape through citizen science approach

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Background

The Himalaya, one of the global biodiversity hotspots, exhibits overwhelming diversity in both wild and domesticated species. Of the domesticated species of plants and animals, traditional agricultural crops and age old farming practices are of special conservation significance. The agricultural diversity, also termed as agrobiodiversity or agri-biodiversity (Box 11.1), is the backbone of human survival in the remote mountain regions and has significantly contributed towards sustenance of diverse indigenous communities within and outside the region. However, all across the Himalaya as elsewhere in the world, over the time, there has been a considerable erosion in this diversity and associated knowledge practices thereby raising several issues of ecological conservation, food–nutrition and economic sustenance of local-indigenous people in the region.

Box-11.1

Agri-biodiversity Defined

'Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture and all components of biological diversity that constitute the agricultural ecosystems, also named agroecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes'. *Source: www.cbd.int/agro/whatis.shtml*

'The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fiber, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators) and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.' *Source: www.fao.org/docrep/007/y5609e/y5609e01.htm*

Various researchers have contributed for improving our understanding on agricultural diversity of the Himalaya. In general, complexity of traditional farming systems, which represent an intermixing of crop husbandry and forest resources, has remained an attraction of researches (Ramakrishnan 1992; Rao and Saxena 1994). Likewise, role of women folk in maintaining the agricultural systems in the region has been yet another popular area of investigations (Maikhuri et al 1996). Also, the energy and economic efficiency of mountain farming system in the north-west Himalaya has been worked out in details (Singh et al 1997).

In west Himalayan state of Uttarakhand, which largely represents mountain topography and predominantly reflects rural setting, subsistence agriculture remains the core of household economy. Within the state, Kumaun region is specifically well known for diversity of its agricultural practices and exhibits a great deal of variation in crop diversity. Overall, the agrodiversity of Kumaun is often influenced by the crop composition and crop rotation. In general, along an altitudinal gradient, variations in agrodiversity are influenced by variations in a number of ecological factors and difference in agricultural practices. Largely in this region rain-fed agriculture is prevalent. Irrigated agriculture is confined to few valley areas. The traditional agricultural system of Kumaun is characterized by its dependence on local resources and locally developed technologies. Agricultural land use on terraced slopes is dispersed as patches in the matrix of forests. Cropping systems are largely built around two seasons, the rainy season and the winter season. Most interestingly, in spite of small land holdings (average size<1 ha), the number of crops cultivated by a household may vary from 10-20. A high level of crop diversification is achieved through rotation of pure crops in space and time, and through mixed cropping system. However, in recent past, with changing human priorities and aspirations accompanied by unprecedented change in land-use, the traditional agriculture in Uttarakhand has been affected considerably. All across the region rapid loss in agri-diversity and associated knowledge practices has been witnessed. This scenario calls for an urgent attention for: (i) documentation of existing agrodiversity and its associated knowledge, (ii) monitoring changes (i.e., loss of genetic diversity), and (iii) developing strategies for protection and conservation. However, among others, it would also require innovations in our thinking and approaches of implementation.

The Target Landscape

The Kailash Sacred Landscape–KSL, that spreads over 31,000 km^2 area in adjacent portions of Tibetan Autonomous Region (China), India and Nepal, with immense spiritual and sacred values is one amongst the most revered and sacred landscapes for millions of people across the globe. It represents a highly complex and diversified system in terms of biological and physical attributes leading to richness of bio-physical and life support values ranging well beyond its physical boundaries. An astonishing range of diversity in socio-cultural systems prevail throughout the landscape and exhibits dynamic linkages with natural resources. While much of the landscape is recognized for prevalent wilderness, it is equally known for its richness of traditional agricultural systems. The rich and unique agricultural heritage of this landscape is however under rapid process of transformation. As a result, this ecological and cultural heritage of the landscape is under severe threat.

Considering the Indian part of KSL, which represents a unique bio-cultural area, it has historically evolved to form a rainbow of bio-cultural plurality. The landscape represents a site of ethnic intermixing and cultural assimilation not only from the mainland of India but also across the borders. Over the millennia, the people have moved through the high passes and settled down in this region making the landscape a Centre of activities of ethnic, lingual and cultural groups. This intermixing and the upward and downward mobility of social groups had played important role in evolving the divine diversity of the landscape. This diversity is reflected in all forms and practices of domestications ranging from multi-cropping to pastoral herding. The traditional farming communities of the landscape have been maintaining large number of crop varieties and livestock from generations, and are custodian of its agricultural biodiversity. Farming of KSL-India landscape is primarily terrace farming, fragmented and rain-fed, traditional and labor intensive, largely organic and mixed cropping, relatively less productive, and heavily dependent on livestock and forests. Majority of the farmers have small land holdings and women acts as the backbone for sustaining agriculture. Some of the features of agriculture in the landscape are given (Plate 11.1).

Plate 11.1: Glimpses of agriculture in the KSL-India

However, due to variety of reasons ranging from land-use changes to land degradation to increase in population, increasing wildlife conflicts, to unprecedented out migration of inhabitants to changing aspirations the scenario of agriculture in the landscape is changing rapidly. Apart from these, and perhaps most importantly, reluctance of young generation towards agriculture is alarming. They do not appreciate values of hill agriculture. All these socio-environmental factors have resulted in rapid erosion of agrobiodiversity of the landscape. Unfortunately, this loss of gene-pool has not attracted attention of concerned and is not being recorded and reported. Therefore, assessment and monitoring of existing agrodiversity of target landscape assumes a high priority.

Monitoring agro-system in KSL

Monitoring agricultural changes is a highly challenging task as the agriculture system is influenced by multiple factors (Sachs et al 2010). Across the world few attempts have been made to monitor the agriculture change (Becker-Reshef et al 2010; Kaushalya et al 2014; Pittman et al 2010). Most of the available monitoring system have extensively used satellite remote sensing information. However, in the Himalayan landscape – where agriculture is practiced mostly on marginal lands and challenging terrain – relying on remote sensing may not provide the complete picture. Moreover, the hill agriculture needs to be viewed more seriously for its importance from genetic diversity angle. This requires documentation of such diversity from most of the landscape area.

In the above context, an innovative approach of engaging School Children in documentation of agri-diversity of a representative landscape of Uttarakhand was attempted under Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI), a trans-boundary collaboration programme of three neighbouring nations, i.e., China, India and Nepal, that is being facilitated by International Centre for Integrated Mountain Development (ICIMOD). The idea of engaging school children carried dual objectives: (i) to reach-out maximum of landscape in minimum time, and (ii) to inculcate appreciation for landscape's agricultural diversity among children.

Engaging with Students - an innovative approach

Realizing that the agrodiversity of the landscape is eroding fast, and the young generation largely remain unappreciative about the value of this diversity, an intervention was made with school children (6-12 standard). Idea was to involve them in generation of information about agrodiversity of their surroundings so that they (i) get connected with hill agriculture, (ii) understand the traditional systems of hill agriculture and appreciate knowledge base of their elders, (iii) get sensitized about the threats on hill agriculture. Also, it was intended to gather optimum information using minimum resources and investing minimum time.

Identification of Centers of Activity

Towards covering maximum landscape, it was agreed to have activity across horizontal and vertical transects. In both the transects schools were identified strategically to cover maximum diversity and each identified school was considered as Centre of Activity (CoA). The diagrammatic representation of such CoAs along two transects is depicted (Figure 11.1.a&11.1. b).

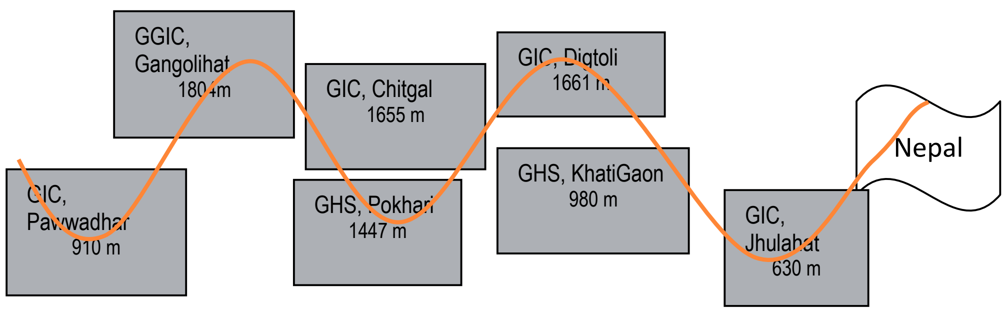

Figure 11.1.a: Centres of activity along horizontal transect

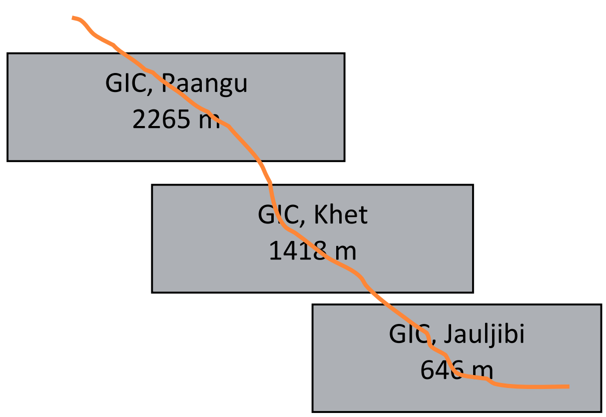

Figure 11.1.b: Centres of activity along vertical transect

'Agri-biodiversity - Our Heritage' Campaign

- The activities were performed in a campaign mode. The teams of researchers under KSLCDI-GBPNIHESD were developed and intensive deliberations on structure and content of campaign held. Upon agreement amongst team members, a letter specifically designed for this purpose acted as catalyst to sensitize and encourage school children to participate in the campaign (Box 11.2).

Box 11.2- Letter from Hill Agriculture to Students in KSL-India

My Dear Friends

Greetings!

At the outset, let me introduce myself to you all - I am hill agriculture, serving the people of this region for millennia. Over the centuries, with love and devotion of your forefather's I could thrive through the miseries of time. The innovative farming practices that your grand-grandfather adopted, and wherein location specific modifications were brought by successive generations, have made me uniquely diverse. This you can easily see in crops, landraces, and associated farming practices. Often people say this diversity in me has not only contributed for food and nutrient security but also in gene pool conservation. I feel elated hearing this and, in fact, very proudly begin to associate myself with heritage status

Alas! Everything, however, is not so good now. You will agree, with changing life styles and aspirations most of you are no more interested to be associated with me. I am really aggrieved to see, the young people – like you, are keeping a distance from me. Friends, I can't survive without your love and affection. My health is deteriorating and surprisingly none of you is concerned about it. This hurts me. I am told man is the wisest of all. But think whether this neglect of mine is a wise act in your part? Will this disconnect with me lead you much forward? Let me bring to your kind information that without you noticing, a large chunk of valuable genetic resources and the knowledge base, associated with me, has already disappeared. Many others are following the same path. I am really afraid, if this trend continues you may lose this heritage of yours. And, remember, without my existence your survival will be on stake.

Being associated with you for so long, it is my duty to caution and advise you to kindly look at me. Your ignorance has made me weak. I vividly remember when kids like you would visit the agriculture fields along with elders and ask so many questions about me. Deep connect of yours that time made me strong and I helped you sustain. Those who researched on my potential have proved that the wide diversity, which I possess, has great potential to adapt and survive through the vagaries of climate change and other natural calamities. This would, in other words, mean I can support your sustenance even under worst case scenario. I am willing to adopt to modernity without compromising my core values, so that even most fashionable of your friends appreciate my qualities.

Hope you have now understood my importance for your existence. It is still not too late provided you act very fast. I am told, realizing this, G.B. Pant Institute of Himalayan Environment & Development, an organization mandated for in-depth research and development on issues of Environment & Development in the Himalaya, has made a beginning towards promoting your association with me. This institute, under the project called "Kailash Sacred Landscape Conservation and Development Initiative" has planned a campaign "Agri-biodiversity – Our Heritage" with students. This campaign intends to:

- ❖ Motivate hill students for connecting themselves with hill agriculture
- ❖ Involve the students in generating information on prevailing diversity within me
- ❖ Infuse an excitement of association and accomplishment amongst students

I consider this a great opportunity for you all. Register yourself with this campaign when you meet them, and see how this small contribution from your side makes a big difference.

I shall remain in touch to learn about your experiences. God bless you!

Affectionately yours

Hill Agriculture

- The campaign thus entitled *'Agri-biodiversity - Our Heritage'* was designed in such a way to cover most of the landscape within the stipulated time frame of 10 days.

- The campaign along the horizontal transect was carried out from Talla Seraghat (landscape's western extreme) to Jhulaghat (landscapes' eastern extreme). Whereas for vertical transect it ranged from GIC Jauljibi (646 m asl) to GIC Pangu (2265 m asl)

Plate11.2: Various steps of motivating students

- Teams of researchers from KSLCDI-GBPNIHESD approached different CoAs. With the permission of school administration, the platform available in the form of general assembly was effectively used for sensitization and motivation of the students. Contents of "Letter from Hill Agriculture" were read by a selected student. Theme note of campaign was recited and a talk was delivered by GBPNIHESD representative focusing on the following issues: (a) Definition of agrobiodiversity, (b) Importance of agrobiodiversity in our life, (c) Agrobiodiversity in the context of changing climate, (d) Assessment of the status of agrobiodiversity in a village, (e) communicating the message on the importance of agrobiodiversity to local community.

- During follow-up interaction, students were encouraged to share their views and experiences. Their willingness to participate in the campaign was obtained and teams were formed amongst willing students. All willing students of a particular village were kept in one team. Considering the size of the village groups further sub-groups were formed to cover crop groups such as cereals, pulses, oilseed and vegetables.

- Each student of the group was provided with small zip polythene bags and asked to collect as much of diverse types (varieties) of available seeds of different crop groups in respective villages. Students were exposed to basic methods of seed collection and labeling. Students were also provided with label formats for information recording in each case. Collected seed samples from schools were brought to institute for recording and analysis. Various sensitization and motivational events organized at each CoA are depicted (Plate 11.2).

Involving local farming community

In spite that the programme was student oriented, it draws significantly from farming communities. The students who belong to these farming communities were asked to visit their parents/elders in respective villages for collection of information and seed samples. They were given basic understanding of conducting interviews with the parents or/and other farmers of their own villages. This way the local farmers also get sensitized on the process and its importance and becomes an information provider for entire assessment and monitoring process. It was also believed, if opportunities of incentive base mechanisms for *in situ* conservation arise in future, some of these farmers can be involved in conservation of specific landraces. The information sheet which was filled by students in consultation with farmers is given (Box 11.3).

Box 11.3- Information sheet used by the students for information collection

Agrobiodiversity Information Sheet

Name of the person provided seed sample: Shri/Smt ....

Name of the crop: ....

Name of the variety (local name): ....

Specific characters of the crop variety:

1. ....

2. ....

3. ....

Sowing time: .... Harvesting time: ....

Is there any variety(ies) of crops which they used to grow in past but is not in cultivated now? Name such variety (ies): ....

....

If yes; why these varieties are not being grown now? Give reasons: ....

....

Name the new varieties being grown these days, which were not under cultivation in past:

....

Give reasons of preference for these varieties...

....

Name of the student: .... Class: ....

Name of School: ....

Name of village: ....

Date of collection: ....

Note: Please remember collecting about 50-75 gram of seed sample for each variety available with the farming family

The Campaign Outcomes

Approaching the landscape

Following the results of this campaign, it is safe to mention that it proved to be rapid and cost effective approach towards (i) creating an excitement among students to participate and contribute for assessment of agrobiodiversity, (ii) reaching maximum of the landscape within very short period, and (iii) generating maximum information. The following table (11.1) summarizes all these features of the approach.

Engagement of a total of ten Centers of Activity (Schools)in the campaign, resulted in involvement of 943 students (60.3% girls; 39.7% boys) representing 82 villages and collection of 3780 sample collections within a span of 10 days.

Table 11. 1: Engagement of students in the campaign and broad outcomes

S.l.	CoAs	Catchment & Transect	Altitude (m, asl)	Participation			No of samples	No of Villages / hamlets
				Girls	Boys	Total		
1	Pokhari	Saryu & E. Ramganga/ Horizontal transact	1447	39	28	67	224	8
2	Pawwadhar		910	112	105	217	755	11
3	Chitgal		1655	35	39	74	309	3
4	Gangolihat		1804	145	0	145	494	14
5	Digtoli	E Ramganga/ Horizontal transact	980	27	10	37	179	10
6	Khatigaon		1661	46	58	104	495	5
7	Jhulaghat		630	80	62	142	665	13
8	Jauljibi	Kali & Gori/ Vertical transact	646	2	6	8	37	4
9	Khet		1418	35	23	58	262	7
10	Pangu		2265	48	43	91	360	7
Total	**10**	**3**		**569**	**374**	**943**	**3780**	**82**

Optimizing Information Generation

Further grouping of 3780 seed samples and information thereof enabled the KSLCDI team to come-up with an exhaustive information on prevalent diversity across various crop groups and crops. A total of 245 crop varieties/landraces across 69 crop species (cereals 3, Pseudo-cereals and millets 8, pulses 14, oilseeds 6, vegetables 23, and spices 15) were inventoried. Detailed outcome of this exercise is presented (Table 11.2).

While pooled by Centers of Activity, the information revealed that Pangu (89), Puwadhar (79) and Khatigaon (70) centers are possessing maximum representative agrobiodiversity. Interestingly, all these centers are relatively remotely located. Details of diversity across different centers has been depicted (Table11.3). More importantly, while analyzing further, the information on existing diversity of crops in each of the investigated village has been documented which may form a basis for status monitoring of agrobiodiversity over a long period.

Table 11.2: Details of agrobiodiversity in Kailash Sacred Landscape - India

Crop Group/ Crop (Hindi)	Name (English)	Scientific name	No & names of varieties listed by students	
1: Cereals (03)				
Dhan	Paddy	*Oryza sativa*	47	Anchun, Bara, Basmati, Bauna, Blocky, Chhaimasia, Chhota, Chhotiya, Chinafour, Chinburi, Curmuliya, Dana basmati, Dhoriya, Dudhiya, Geru, Jav, Jhusi, Jhusi kamal fool, Jwanla, Kala, Kalachuni, Kaladhuni, Kalashal, Kalathuni, Kalthuda, Kapkoti, Lal, Lal Block, Lal shudiy, Lama, Lamba, Mota, Pahari, Parmal, Patla, Pila, Pokhya, Rai muni, Rajmati, Remun, Ropai a, Roti, Safed, Sal, SimiTimasia, Sunchori
Genhu	Wheat	*Triticum aestivum*	23	Bakutiya, Bara, Chhaimasia, Chhota, Dabkhani, Dapti, Dudhiya, Japani, Jhusy, Jyoti, Lal, Laman, Lamba, Mota, Munar, Pahari, Panjabi, Pila, Safed, Shalimar, Shankar, Thang, Blocky
Makka	Maize	*Zea mays*	18	Asauji, Bansi, Bara, Chhaimasia, Chhota, Dhaula, Jhuni, Kaini, Kotli, Lal, Masori, Murli, Murliya, Pahari, Pila, Safed, Shankar, Timasia
2: Pseudo cereals and Millets (08)				
Bajara	Sorghum	*Pennisetum glaucum.*	4	Chhamasia, Lal, Safed, Jhusi
Chua	Amaranth/Chaulai	*Amaranthus viridis*	3	Lal, Safed, Malchua
Jwant (Jai)	Oat	*Avena sativa*	1	Jwant
Kauni	Foxtail millet	*Setaria italica*	1	Kauni
Madira	Barnyard millet	*Echinochloa crus-galli*	7	Chhamasia, Jhusiya, Kala, Lal, Mura, Safed, Vikasi
Madua	Finger millet	*Eleusine coracana*	11	Bhura, Blocky, Chhaimasia, Jhadua, Jhakru, Kala, Lal, Nangchun, Navchuni, Nepali, Timasia
Jaun	Barley	*Hordeum vulgare*	5	Chhaimasia, Jhusiyari, Jhusi, Safed, Kala
Fafar	Buckwheat	*Fagopyrum esculentum*	1	Fafar

3.*Pulses (14)*				
Arhar	Pigeon pea	*Cajanus cajan*	1	
Chana	Chickpea	*Cicer arietinum*	1	
Gahat	Horsegram	*Macrotylom auniflorum*	3	Lal, Safed, Panchmasia
Masoor	Lentil	*Lens culinaris*	4	Chhamasia, Chhota, Kala, Safed
Matar	Pea	*Pisum sativum*	7	Timasia, Chhamasia, Kalyu, Hari, Kali,Safed, Kosi
Rajama	Kidney bean	*Phaseolus vulgaris*	23	Bagani safed, Bari rajma, Bhura, Chitkabar, Gol raama, Gulabi Rajma, Hara rjma, Indrasan, Jamuni, Jhaliamalia, Kala lamba, Kala-jamuni, kala-Rajma, Kali neeli, Lal, Lal safed, Murli, Peela, Safed, Safed Chhota, Safed kala, Safed neela, Sarpila
Soyabeen/bhatt	Soybean	*Glycine max*	6	Safed, Lal, Hari, Kala, Kali chhoti, Bhura
Urad	Blackgram	*Vigna radiata*	5	Chhamasia, Hari, Kali, Safed, Timasia
Lobia	Lobia	*Vigna unguiculata*	2	Lobia, Sunt
Gurunsh	Gurunsh	*Vigna trilobata*	1	
Bakula	Bakula	*Vicia faba*	1	
Sem	Adzuki bean	*Vigna angularis*	1	
Mung	Green gram	*Vigna mungo*	1	
4. Oilseeds (06)				
Sarson	Mustard	*Brassica juncea*	4	Sarsson, Kali, Pili, Lofer
Sunflower	Sunflower	*Helianthus annuus*	1	
Til	Sesame	*Sesamum orientale*	4	Bhura, Kala, Lal, Safed
Alsi	Linseed	*Linum usitatissimum*	1	
Mungfali	Groundnut	*Arachis hypogaea*	1	
Rai		*Brassica nigra*	7	Boksai, Kali, Kanni, Kantedar, Pahari, Rayata, Sumari
5: Vegetables (23)				
Kaddu	Pumpkin	*Cucurbita maxima*	2	Pahari gol, Kaddu
Palak	Spinach	*Spinacea oleracea*	2	Pahari, Palak
Lauki	Bottle gourd	*Lagenaria siceraria*	1	Lauki
Meetha karela	Meeth akerela	*Cyclanther apedata*	1	Meetha karela
Aalu	Potato	*Solanum tuberosum*	3	Pahari, Lal, Safed
Lahi	Lahi	*Brassica juncea*	1	Lahi
Muli	Radish	*Raphanus sativus*	3	Pahari, Safed, Muli
Baigan	Brinjal	*Solanum melongena*	1	Baigan

Shimla mirch	Capsicum	*Capisicum annuum*	1	Shimla mirch
Torai	Ridge gourd	*Luffa acutangula*	1	Torai
Karela	Bitter gourd	*Momordica charantia*	1	Karela
Halak			1	Halak
Piyaj	Onion	*Allium cepa*	1	Piyaj
Hau			1	Hau
Jharmari			1	Jharmari
Ugal	Fagopyum	*Fagopyrum esculentum*	1	Ugal
Chaulai		*Amaranthus caudatus*	1	Chaulai
Chamsur		*Lepidium sativum*	1	Chamsur
Bhindi		*Abelmoschus esculentus*	1	Bhindi
Tamatar	Tomato	*Lycopersicon esculentum*	1	Tamatar
Band Gobhi	Cabbage	*Brassica oleracea*	1	Band Gobhi
Sajan			1	Sajan
Kakdi	Cucumber	*Cucumis sativus*	1	Kakdi
6: Spices (15)				
Lahsun	Garlic	*Allium sativum*	1	Lahsun
Dhania	Coriander	*Coriandrum sativum*	1	Dhania
Haldi	Turmeric	*Curcuma domestica*	1	Haldi
Methi	Fenugreek	*Trigonella foenum-graecum*	1	Methi
Bhang	Hemp	*Canabis sativa*	1	Bhang
Bhangira		*Perilla frutescens*	1	Bhangira
Jakhia		*Cleome viscosa*	1	Jakhia
Adrak	Ginger	*Zingiber officinale*	1	Adrak
Mirch	Pepper	*Capsicum annuum*	1	Mirch
Chhipi		*Angelica glauca*	1	Chhipi
Sekua		*Allium stracheyi*	1	Sekua
Jhusu			1	Jhusu
Thai		*Thymus vulgaris*	1	Thai
Jeera	Cumin	*Cuminum cyminum*	1	Jeera
Dhunar	Allium	*Allium wallichii*	1	Dhunar
			245	

Table 11.3: Crop diversity at different centers/locations in KSL-India

Center	Cereals		Pseudo cereals &Millets		Pulses		Oilseeds		Vegetables		Spices		Total	
	S	**V**	**S**	**V**	**S**	**V**	**S**	**V**	**S**	**V**	**S**	**V**	**S**	**V**
Chitgal	3	9	5	9	10	13	4	5	10	13	11	11	**43**	**60**
Gangolihat	3	5	5	6	9	12	5	6	12	12	7	7	**41**	**48**
Pawwadhar	3	25	4	12	12	16	4	7	11	12	7	7	**41**	**79**
Pokhari	3	13	4	7	10	18	3	6	10	11	4	4	**34**	**59**
Digtoli	3	6	3	4	10	11	5	8	9	10	2	2	**32**	**41**
Jhulaghat	3	13	5	6	10	13	6	12	15	17	4	4	**43**	**65**
Khatigaon	3	21	4	7	10	13	5	9	11	16	4	4	**37**	**70**
Jauljibi	3	7	1	1	0	8	1	1	1	1	4	4	**10**	**22**
Khet	3	21	5	8	7	15	3	5	4	4	3	3	**25**	**56**
Pangu	3	12	3	5	8	43	3	3	12	15	9	9	**38**	**87**

S - species; V - varieties

The Way Forward

Considering the feasibility of implementation, cost effectiveness, and potential of reaching maximum of the landscape at a given time, it would not be an exaggeration to claim that this is one of the most suitable and robust approaches for reaching-out the largest section of a given landscape. The approach, as tested in present case, gives three fold benefits by way of: (i) inculcating among young school children appreciation for surrounding agrodiversity. They feel excited in information generation and enthusiastic about outcomes of exercise; (ii) facilitating multi-location information generation and assessment; (iii) providing possibilities of future monitoring of changes. The village/center level documentation of agrodiversity has provided the base line on existing diversity, which can be used for long-term monitoring either at center or village level.

All ten centers and 82 villages can thus become sites for long-term monitoring of agrodiversity. The datasets generated in present case can be further analyzed for assessment of status of various species/varieties in the landscape. This can be achieved through simple frequency of occurrence estimation. However, while considering long-term monitoring, among others a few specific aspects need special attention (Box 11.4).

In-view of the above, and realizing far going implications of sensitization of youth, there is a need to further invest on this approach by way of formal engagement with education system. This type of exercises can be linked with Incentive Based Mechanisms (IBM). For instance, students should get special credits, appreciation, fellowships and/or opportunity to interact with experts in the subject at higher centers of learning. Also, the outcomes of such exercises must be recognized by relevant agencies. It is further recommended that the provisions need to be made for establishing dedicated computation and display facility at each Center of Activity so that these centers emerge as learning and demonstration centers on landscape agrodiversity. All this will lead to increased ownership of school administration and young students on information generated and resultant documentation.

Box 11.4: Specific aspects of agrobiodiversity that need attention

- Village based agrobiodiversity status
- Village wise information about varieties/landraces that are less grown or not in practice of cultivation these days
- Name and location of farmers practicing cultivation of rare or less common varieties/landraces of crops
- Conservation and developmental value of key varieties
- Validation of varieties/landraces with the help of experts
- Nutrient analysis of some interesting/ medicinally important varieties
- Mapping of geographical extent of key varieties

Acknowledgements

The enthusiastic participation of 943 students from 10 schools (representing 82 villages) made this campaign successful. We thank them. The support received from school administration at all 10 centers is greatly appreciated. We sincerely thank the villagers who cordially shared information and seed samples with the students. Help and cooperation received from various team members of KSLCDI-GBPNIHED is gratefully acknowledged. The funding support from ICIMOD under Kailash Sacred Landscape Conservation and Development (KSLCDI) is thankfully acknowledged. We sincerely thank the Director GBPNIHESD for facilities and encouragement.

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Chapter 12. Socio Economic Study for Long Term Monitoring in Kailash Sacred Landscape

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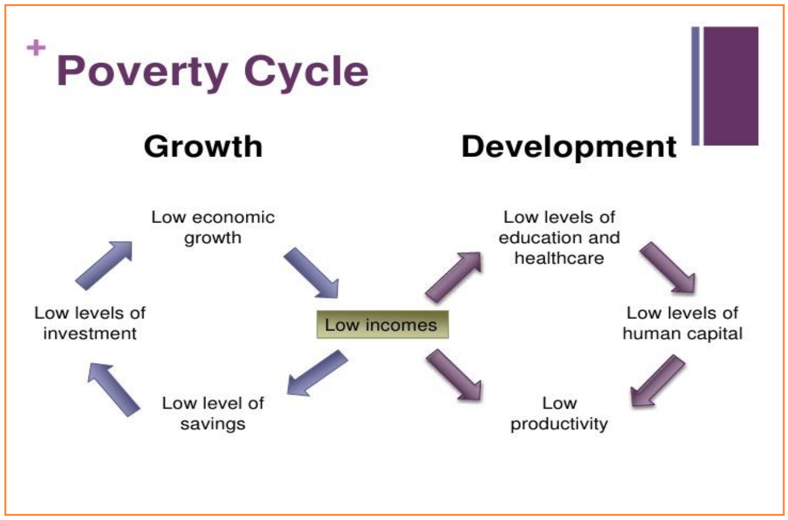
12.1 Background

In Uttarakhand the dependence of people on natural ecosystem is high, thus the state is considered highly vulnerable to climate change. Forest resources and agriculture provides the major livelihood for local people in the Himalayan region. However, indiscriminate biomass harvesting from forests and alarming reduction in agricultural production because of various reasons such as Human wildlife conflict, Mass migration, Lack of livelihood options and so on is common feature. This phenomenon considerably affected people's livelihoods and creates ample drudgery and stress. In addition, over last few decades climate change has emerged as an overriding factor, which is likely to impact upon sustenance of people in climate change vulnerable regions i.e. mountains.

Kailash Sacred Landscape Conservation and Development Initiative (KSLCDI) is a transboundary programme of three participating countries including China, India, and Nepal. The objectives of the programme are to help preserve the unique biological diversity, ecosystem goods and services, and the value-based cultural heritage while developing the livelihoods of the local communities of the Landscape. The component 'Innovative Livelihood Options and Adaptation to Change' aims to improve livelihoods by implementing innovative on-the-ground activities while simultaneously promoting ecosystem management and efficient use of natural resources including water and energy. It works through relevant partners in specific pilot areas to engage marginal communities in income generation activities that reduce pressure on natural ecosystems.



The overall objective of socioeconomic study is to congregate baseline information on current/existing livelihood options (farm and non-farm based) and their contribution to household income and well-being in pilot villages where interventions are to be made. Such study is of significant value and help to understand the pre-intervention or early situation in pilot villages so that a comparison can be made on the outcome of programme intervention. The study provides essential background information for *ex* post impact evaluation and serves as a reference paper. In addition, the findings of socio - economic study also assist the overall programme and the partners to design sustainable and locally adapted activities for the future interventions in context of climate change and out migration. The socio economic study attempts:

- Assessment of socio-economic status of households in pilot villages covering demographic information, capacities and assets, agriculture and livestock pattern, energy consumption, dependency on natural resources and financial and social capital.
- Establishment of baselines on prevalent practices in production, collection and marketing of prioritized high value products.
- Approaching communities view about resource use, situation and tendencies.
- Lay basis for post project evaluation or results based monitoring to assess whether any improvement in livelihoods and income is happening.
- Educating and encouraging communities for adopting appropriate technologies for sustainable livelihoods in a participatory manner.

Thus, Socio Economic study is key for planning and laying out the foundation for implementation of programmes towards sustainable development of communities based on their views and assessment made for long term benefits in terms of conservation and development.

12.2 Methodology and approach

12.2.1 Step Method for Baseline Study and Programme Implementation/ Execution

A multi-disciplinary team, inclusive of experts and grass root level team formed prior to socio economic study. Members in team represents diverse fields i.e. environment, agriculture, economics, sociology, etc. A step-by-step method applied for generating the information has been outlined below:

Step 1: Collection of secondary data: The collection and summation of secondary data - information from reports, development plans and census data – facilitate in building up knowledge about the particular area where execution of programme is proposed and also to collate with primary data. Secondary information collected from different stakeholders- individuals, organizations and institutions working in the pilot areas.

Step 2: Collection of primary data: Baseline data collection through the structure household questionnaire to have in depth information of socio-economic profile. It gives insight about the present scenario and communities' aspiration and views towards livelihood options. For above steps both qualitative and quantitative methods are applied. The method comprised of conducting a household survey based on specific schedule, key informant interviews and village level meetings.

Step 3: Participatory Rural Appraisal (PRA): PRA is a tool that helps outsiders to understand village systems by applying various techniques as well as direct observation and discussion. This ensures implementers/researchers about the situation and makes them familiar with local resources, challenges and issues to be addressed for socio economic and sustainable development. The PRA tools to identify the problems are as follows:

- Timeline: It helps the team to understand the history of the village, major events, and misfortunes and how the event affects the community.
- Seasonality: Seasonality helps to give an idea of the livelihood activities with respect to seasonal variation prevails in the area. The trend analysis helps to know the changes with time in livelihood and socio economic pattern.
- Focus Group Discussion (FGD): FGD provide detail and diverse views on existing issues, need and possible solutions for challenges leading to sustainable development with heterogeneous group of people.
- PRA exercise included techniques i.e. recording daily schedule, historical transects, resource mapping, seasonal calendars, direct observation and individual interviews.

Step 4: Initial assessment: This is likely to involve a combination of different participatory methods and actions. These help the team - and participants:

- Develop a historical understanding of the area and knowledge on present livelihood
- Identify issues of gender, age and power and their reflection in local institutional arrangements
- Discover how local people define well-being
- Understand the range of assets, activities and capabilities that create different livelihood strategies
- Develop categories of well-being and rank sample households

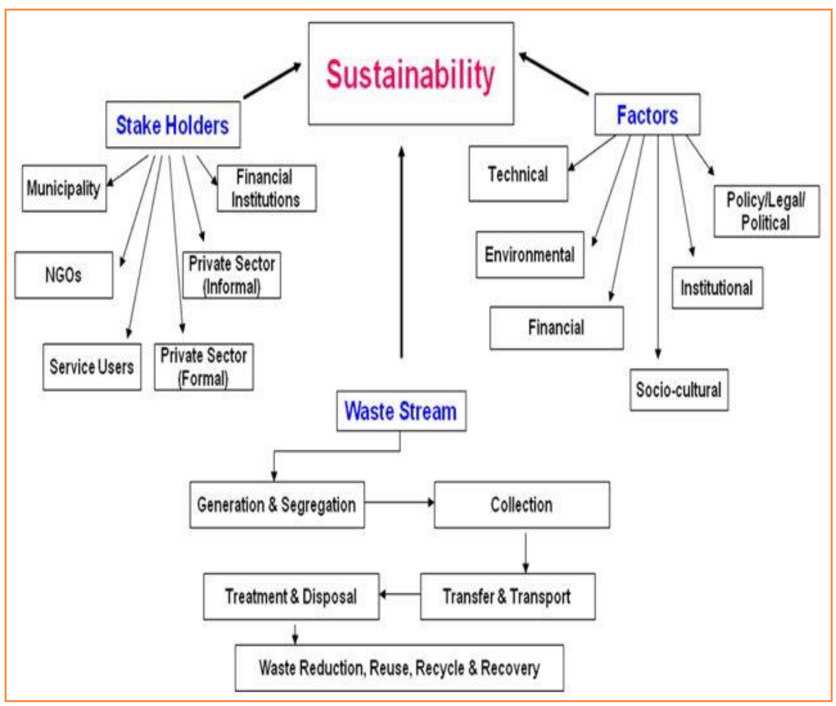
- Assess the key aspects of the vulnerability context - risks, hazards and trends
- Identify connections between local level issues and factors which affect them that originate in the broader environment

Step 5: Reflection, vision and prioritisation: This is about reflecting back and analysing the information that has been synthesised from fieldwork and secondary data with local people again to make sure that the activity which is identified, is going to provide maximum benefit to the target person. Vision of the team should be clear when the activities is finalised or prioritise, it need to be emphasized on the economic analysis, local recourses, market and sustainability.

Step 6: Activity design and appraisal: This involves carrying forward the analysis, reflection and prioritisation undertaken into activity design and appraisal. Depending on priorities, the identified activity can be analysed/ planed properly.

Step 7: Identifying the alternative livelihood activities: The best livelihood option need to be identified through cost-benefit analysis; availability of resources/inputs locally; market analysis; risk involved and sustainability.

Step 8: Preparation of future action plan for identified activity: This involves preparing action plan and breakeven point of the activities as per the objectives stated in the project.



Step 9: Programme implementation: Once the action plan is appraised, the implementation is needed following participatory approach.

Step 10: Rapport Building and identification of beneficiaries: It is vital to develop a trust with the villagers by having regular interaction; visits; truthfulness; and positive attitude honestly. The second most important step is to identify the target beneficiaries or stakeholders. The stakeholders may be asset less, marginal farmers, exploited section of that area, artisans', labourers, etc.

12.2.2 Data collection applying schedule and questionnaire

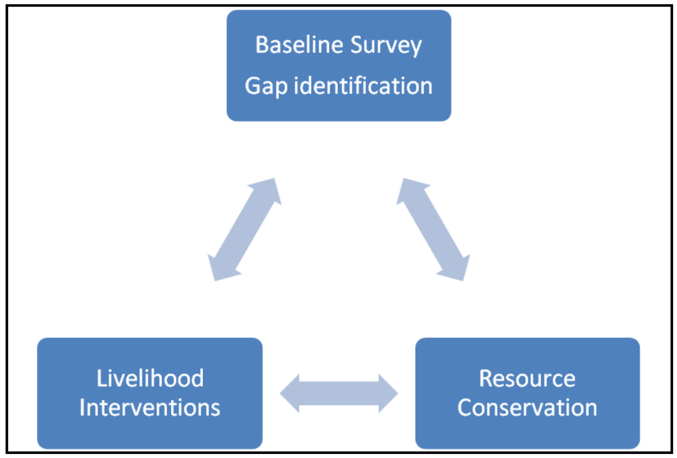
For collecting primary information structured survey three different questionnaires developed. These included information at village level, socio- economic information at household level and baseline information about the selected products and value chains at village level. The questionnaires designed to cover various aspects such information on the current socio-economic and demographic aspects, food security, and ownership of assets, value chain indicators such as production, sales, margins, value addition, marketing, arrangements and linkages among chain actors of prioritized value chains in the pilot villages.

A) Village Level Data Collection: The questionnaire for collecting baseline information at village level contained sets of questions prepared for collecting village level information. This included the following:

- Area characteristics and demography
- Access to facilities such as school, health centre, road, markets, agricultural inputs, extension services and financial institutions
- Agricultural and non-agricultural sources of income
- Water and energy related
- Dependence of communities on forest and other ecosystems;
- Institutional and governance aspects
- Skills and capacities
- Gender aspects such as gendered access, use, and ownership
- Impact of climate change and farmers' response
- Vulnerability with respect to household well being

B) Village Level Data Collection for Products and Value Chain: This instrument designed for collecting value chain related information. It contained list of questions organized into following sections:

- General information about the product
- Production
- Processing and value addition
- Market/ marketing
- Business environment and support system, and
- Other miscellaneous information.



C) Household Data Collection with Focus on Socioeconomic Status: This questionnaire designed to collect household level information. It contained sets of questions related to livelihoods that include:

- Human capital such as literacy, education, occupation, and skills and capacities.
- Physical assets such as types of house, water supply, and household assets, main sources of energy, access to facilities, etc.
- Natural capital such as access to agricultural land, main crops/ fruits/ NTFPs, timber, access to van panchayats and government forests, etc.
- Financial assets such as total annual income and income sources, expenditure, savings and loans.
- Social capital such as membership and participation of household members in formal/informal institutions.

These instruments/questionnaires developed by ICIMOD involving relevant experts and inputs by CHEA. For ensuring quality data collection questionnaires tested in field, revised, and finalized by CHEA together with ICIMOD team. Enumerators trained in information collection using the survey instruments.

12.2.3 Sampling techniques for survey

The village level information collected by visiting the villages, through organizing village-based workshops, and FGDs in each village. Household was the basic element of the sampling for collecting socioeconomic information at household level. The 30% of the household for the sampling was randomly selected in three different clusters i.e. Chyura, OSV and Van Raji clusters.

12.2.4 Data processing and analysis

Data analysed using simple means, and percentages. No special statistical methods or tests employed. Surveys conducted in different villages/ areas overall averages for each village/ area used without being weighted for numbers of respondents. The data analysis is done by using the software Microsoft Excel for final documentation.

12.2.5 Key parameter and socio-economic (well-being) status of the House hold

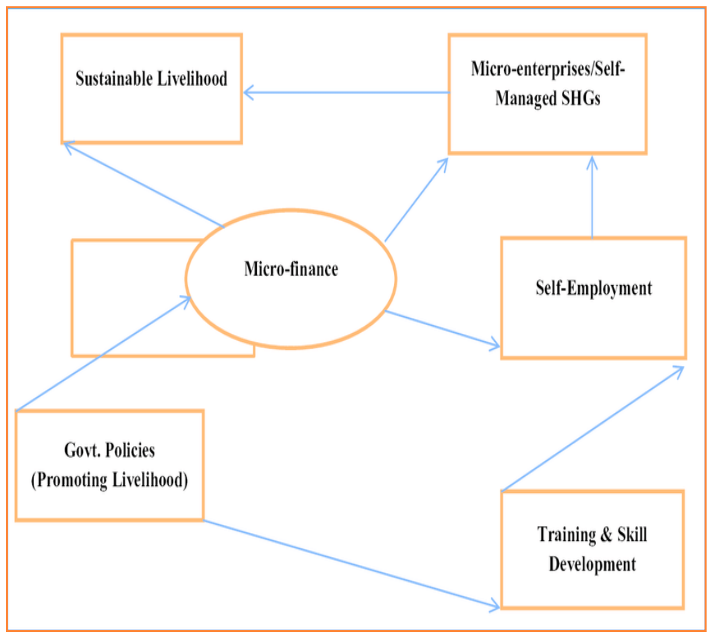
Regarding to socio-economic (well-being) status, majority of households falls under the category of either poor or medium income group. Socioeconomic status of the households was defined using the following criteria:

a) **High socio-economic households:** Having large house with slates or tin roof and separate animal shed, above 0.4 hectares or equivalent land; ample irrigation facilities, well connectivity to the market, use improved varieties of seed and inputs; have ample livestock; at least one family member engaged in job, business or other secure job with a substantial cash income; children attend schools and colleges in towns; most family members are literate; and rarely depend on forest products for livelihoods and other income from fruits, vegetables and livestock.

b) **Medium socio-economic households:** Have medium size house, with or without slates or tin roof and a separate animal shed; 0.2 - 0.4 hectare of land; irrigation facility availability; connectivity to market; keep 3-4 livestock; a household member is engaged in a small business or other secure off-farm job with a reasonable cash income; send children to schools and colleges in nearby villages; also rely on common property resources and government (non-FUG) forests for forest products; little income from fruits, vegetable and livestock.

c) **Low socio-economic households:** Work on daily wages for most of the year to survive; shortage of food for 3 to 6 months; mostly disadvantaged groups (davits/lower castes) people although some high caste people also fall in this category; few (mostly children) are literate small house; less than 0.1 hectare of poor quality unirrigated land, irrigation facilities are insufficient and negligible; not well connected to market and surplus production is lacking; insufficient livestock to meet their needs; less choice on the source of income; household members must work for on daily wages throughout the year as labourers; depend on common property resources and government forests for forest products.

12.3 Baseline and initial trend



Promotion of value chains of high value niche products and services and responsible heritage tourism, are main areas selected for interventions. These options have the potential to contribute to mountain people's livelihoods without compromising the environmental sustainability. Adaptation activities including water and energy technologies, strengthening local institutions, integrating governance and gender in the development programme, and integration of the private sector are integral part of these interventions to address the issue of sustainability of the programme in the long run. The overall outcome is to increase the income level of target communities by 3-10% and at least one interest group is actively engaged in trade of local traditional products. Five value chains selected for upgrading and promotion through product development and market linkages. These value chains include: chyura honey and chyura butter based value added products (soap, lip balm, scrub, etc.), kidney beans, bamboo handicraft and off-seasonal vegetables. The selected value chains represent a balanced and promising combination of economic sectors, altitudinal zones, and offer options for cross-country comparison and exchange. These products have been selected from a list of products identified based on an extensive field survey and consultation with partners, ICIMOD, experts, local communities, government and non-government organizations working in the area. The product selection was based on their evaluation on core selection criteria for potential value chains clustered around their product features, the existing and potential markets, the environmental sustainability of production and trade as well as on the possible impacts of environmental and socioeconomic changes for the local people with transboundary essence.

The baseline study was conducted in the 17 villages in the KSL CDI pilot area located at an altitude from 789 to 1,701 m and the climate varies between sub-tropical to temperate and summarized here under:

Value Chains	Pilot sites	Remarks
Chuyra honey and chyura ghee based by-products (soap, lip balm, etc)	6 villages of Bin Development Block (Gogna, Bera, Jamradi, Nisni, Selguwani, Khitoli)	Villages with potential for chyura ghee and honey production and possibilities to expand in around 100 villages
Off Season Vegetable (OSV)	2 villages of Bin Development Block (Bans and Jajurali)	Villages close to Pithoragarh township and villages fall in Chandak watershed with potential to expand the learning in Gorang valley
Kidney beans and bamboo handicraft	9 Vanraji villages of Didihat, Kanalichina and Dharchula Development Blocks (Aultadi, Bhaktirwa, Chifaltara, Jamtadi, Gainagaon, Kimkhokla, Kulekh, Kuta-Chaurani, Madanpuri)	Vanraji community –169 very poor households generating livelihoods by farming on small plots of highly marginal lands and wage labour

The initial trends and results of Phase I activities have shown encouraging results with lots of learnings and possibilities for Phase II and government agencies:

12.3.1 Chyura honey and Chyura by product

In pilot villages where Chyura trees grow abundant and naturally, communities practice bee keeping since last 4 decades. Kailash initiated to promote and upgrade the traditional bee keeping methods and knowledge. Since 2013, the attitudinal change and acceptance towards advance technologies have been reflected among the beekeepers and communities. Beekeepers have also realized the importance of movable hives for producing higher quantity of honey without disturbing the bee colonies and also in managing the hives during different seasons.

Communities of Chyura belt extract oil from the seeds of Chyura fruits. Traditionally it is used for cooking. An initiative was made under KSL project by making of hand made Chyura soaps. A recipe has been developed with the help of scientific institutions for soap making. Now a pool of community members is making Chyura soaps. They supply honey and soaps to potential markets, fairs and exhibitions.

The encouraging part is that this intervention had increased the market value of Chyura oil as well publicizing niche products at regional level, although still potential is not fully tapped which can outreach up to 100 villages for commercial gains.

12.3.2 Off season vegetable promotion (OSV)

Farmers of Bans and Jajurali villages cultivate vegetables since many years. Earlier the quantity and quality of the vegetable crop was less and they majorly used to do the farming for self-consumption. After the intervention all 200 households (SHGs, JLGs and individuals) are gradually maximizing the benefits through OSV value chain in these two potential villages. After conducting a series of awareness programmes, training and consultations the high yielding varieties were made available to the beneficiaries along with allied inputs to

ensure qualitative and quantitative production as well as an encouraging amount of earning from the market supply of the vegetable crops. Now value addition of spices, millets and pulses has been initiated at pilot level which had motivated the women SHGs/JLGs for taking the initiative at mass scale. This intervention can be expanded in whole Gorang valley and Chandak watershed as a sustainable VC in convergence with partners and government departments.

12.3.3 Promotion of Kidney Bean and Bamboo Crafts among Van-Rajis

Van Rajis are the smallest group among all the tribes in Uttarakhand state and population ratio is only 0.02% of overall percent of all the tribes in state. Van Raji community completely depends on forests for their livelihoods. Deficiency of livelihood options, poor educational status and lack of medical facilities are making their living very difficult and challenging.

The pro poor value chain introduced as a pilot among Van Raji community has turned one of the successful and sustainable intervention. After the intervention, financial gain from Kidney bean are contributing at small level but had change the mindset to get involved in agricultural practices thus sustainability is assured. It had also ensured nutritious food availability.

Bamboo plantation and crafting is supplementing them to upgrade their traditional craft skills with additional income. The plantation has been made to create a pool of bamboo resource for reducing the dependency on natural forests. All families have planted bamboo seedlings, depending on availability of land and their willingness in craft making.

The training and regular facilitation has resulted in motivating women and now skilled up for initiating in raw material collection and converting raw material into appropriate size for crafting.

Attention has been paid to develop better forward linkages as well as technical interventions to promote entrepreneurship. One successful and important step was signing up MoU with private organization. This collaboration is being continued for sustainable market development and to avoid problems of capital in long run. Since the Kailash brand launched and applied with packaging it is turning attractive and being recognized in promotional events.

12.3.4 Cultural and natural heritage tourism development

Tourism has been identified as an important option with potential to generate alternate income and reducing adverse impact in Landscape biodiversity, given profound historical, cultural and spiritual values of the landscape the activity was worked out.

To develop a cadre of skilled community in terms of eco-tourism development, multiple trainings programs were organized i.e. Housekeeping and hospitality, Bird watching, Rock climbing and Kitting, etc. and identified various modes of eco-tourism in the area such as Nature walks, Home stays, Village excursions, Camping, Hiking after rigorous exercise.

Finally, there are various groups who are now skilled up to take tourism as a potential livelihood source. Some of them have already started working in this sector. A proper marketing and publicity channel is still required to give a push to the intervention.

12.3.5 Climate Change Adaptation: Water and Energy

The water scarcity is common in mountains and all the activities especially agro based are dependent on rains. 2-3 hours per day are required to fulfil the water demand and resulting in drudgery. Further the abrupt rainfall and long dry spells has worsened the conditions. Similarly, the fuel wood is required by each of the household and its affect both the human and forests.

After awareness programme, training and consultations the concept of RWHT was taken up on contribution basis which has resulted in huge success. Now the beneficiaries are having the stock of water for at least 30-40 days for domestic use and backyard irrigation. It has also reduced the time consumed in water collection and women specifically utilizing the saved time in taking care of themselves and their kids. Big success is that all tanks are intact and maintained.

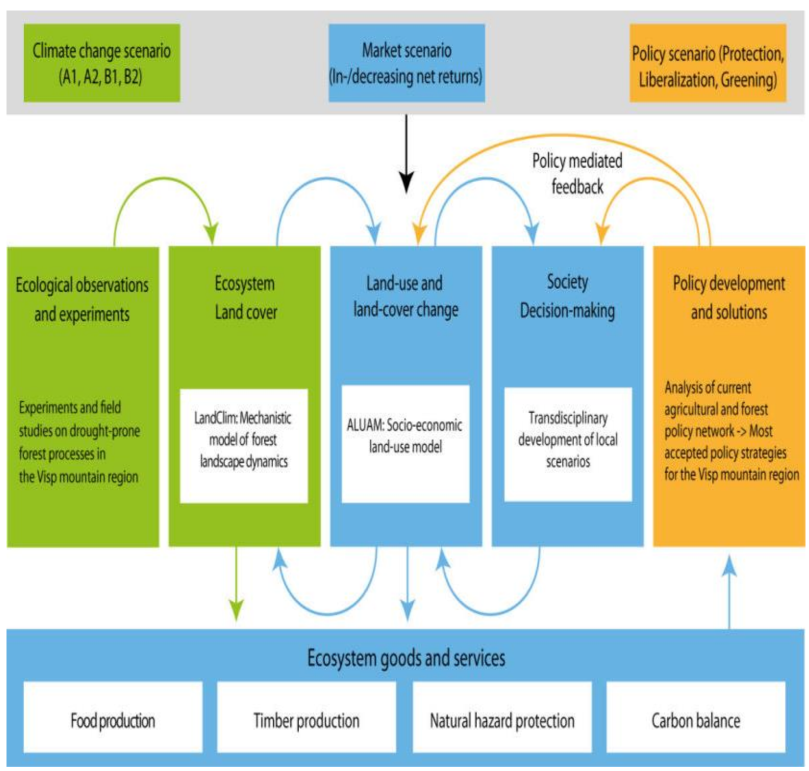
The concept of biogas is a huge success of project in breaking the myth that biogas is not successful in mountains due to cold. All the biogas is operational and providing energy for around 3-4 hours everyday. This had made positive impact on reducing forest exploitation. Now 35% of fuel wood consumption is reduced with time saving and clean energy option for beneficiaries.

12.3.6 Strengthening Skills and Sustainable Management of Yarsa Gumba:

This intervention was initiated in various villages of Yarsagumba collectors in Darma, Chaudas, Byas and Johar valleys of Uttarakhand. The aim of the awareness program was to make the communities of Yarsagumba collectors, more aware about sustainable harvesting of Yarsagumba conservation and also for a better market mechanism.

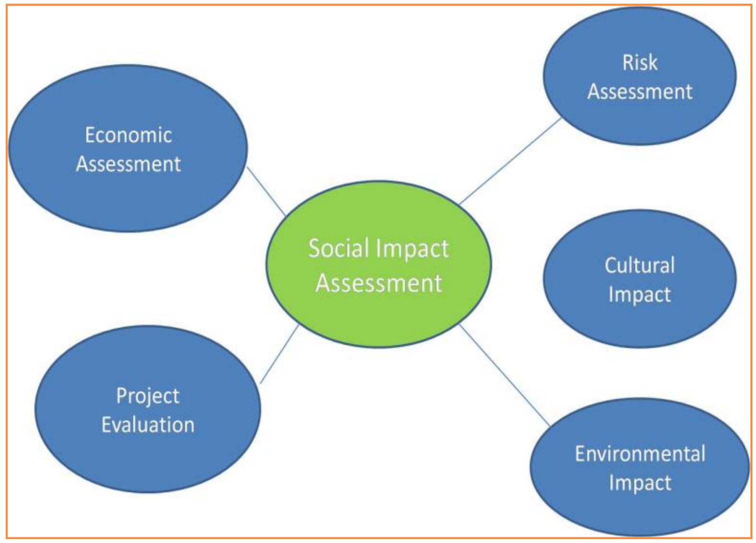
During the intervention, various awareness workshops were organized with various stake holders such as community and line departments. A policy brief draft has been developed and has also been shared with state government.

12.4. Conclusions



Socioeconomics or socio economic study clearly shows the success rate of all income generation activities during long term monitoring of interventions at the same time how these interventions are shaping the social processes. In general, it clearly analyzes how societies progress, stagnate or regress because of the income generating promotional activities/interventions.

The overall work and its implementation as well as the initial trends clearly indicate potential for long term socio economic monitoring simultaneously with conservation and development initiative in the landscape.



The framework clearly speaks about the promotion and management of various livelihood generating activities, value chains, promotion of niche products for the rural communities of Kailash landscape and also showcasing and conservation of natural and cultural aspects as a heritage of the landscape and also working for the climate change adaptation for a better and sustainable livelihood for now and future generations of Himalayan communities at a transboundary level.

The overall study is useful for all partners, practitioners, NGOs, development agencies and extension workers of landscape as guiding tools for further planning and implementation for sustainable development and diversity conservation in the landscape. And it is also expected that the learning evolved from the intervention and information material developed from the various activities will help Government and line departments to link up their schemes and promotional activities with various development activities and development of new policies for conservation of mountain communities on social, cultural and financial basis.

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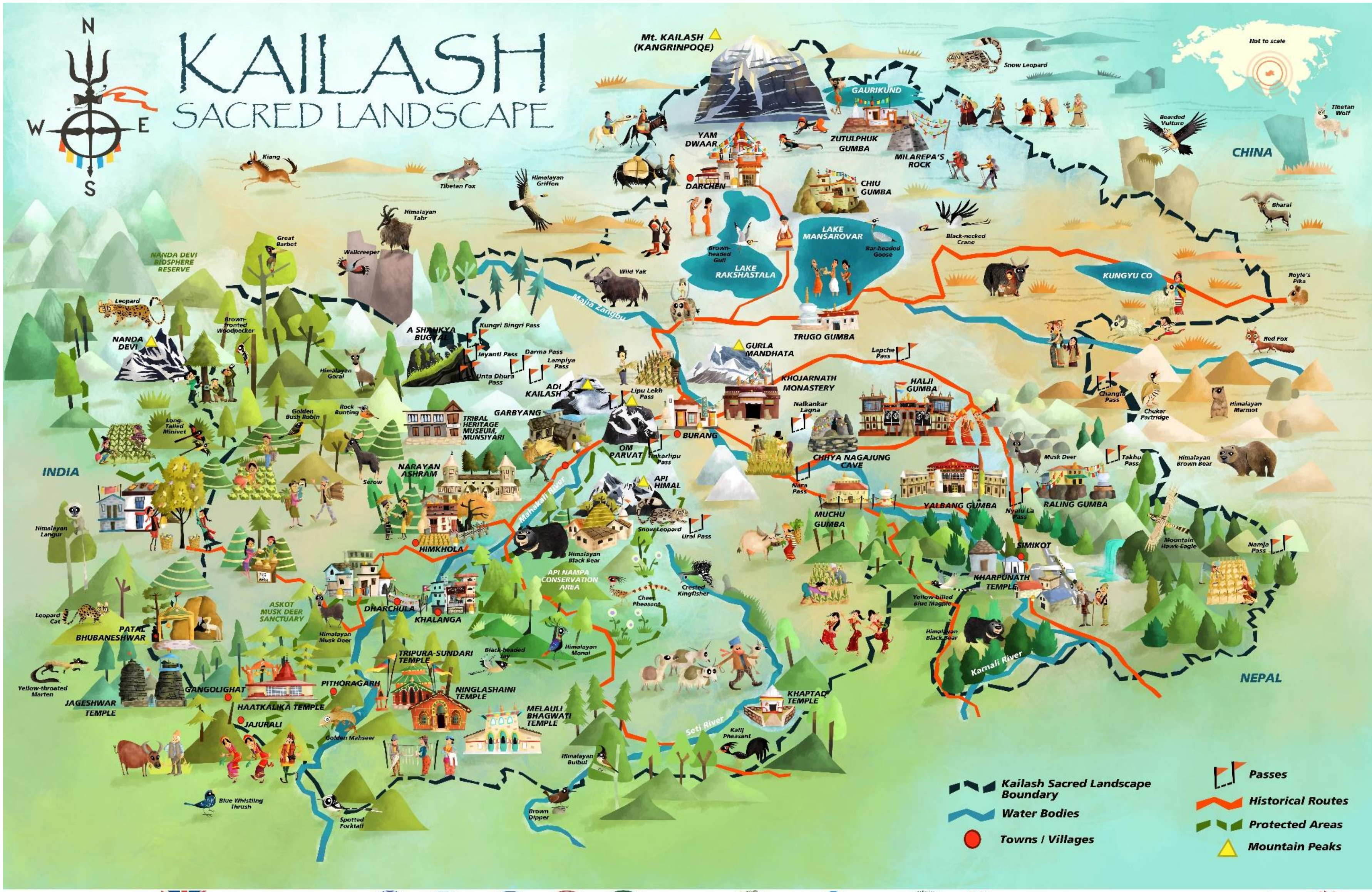
Annexure 1



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Annexure 2


冈仁波齐神山景观
北
西
东
南
冈仁波齐峰
Not to scale
杨大尔
米拉热巴
曲乌寺
塔钦镇
玛旁雍错
拉昂错
公珠错
中国
印度
尼泊尔
曲古寺
纳木那尼峰
科迦寺
哈吉寺
阿比峰
罗尔林寺
冈仁波齐神山景观边界
水域
镇/乡
山口
历史路线
保护区
山峰

Annexure 3

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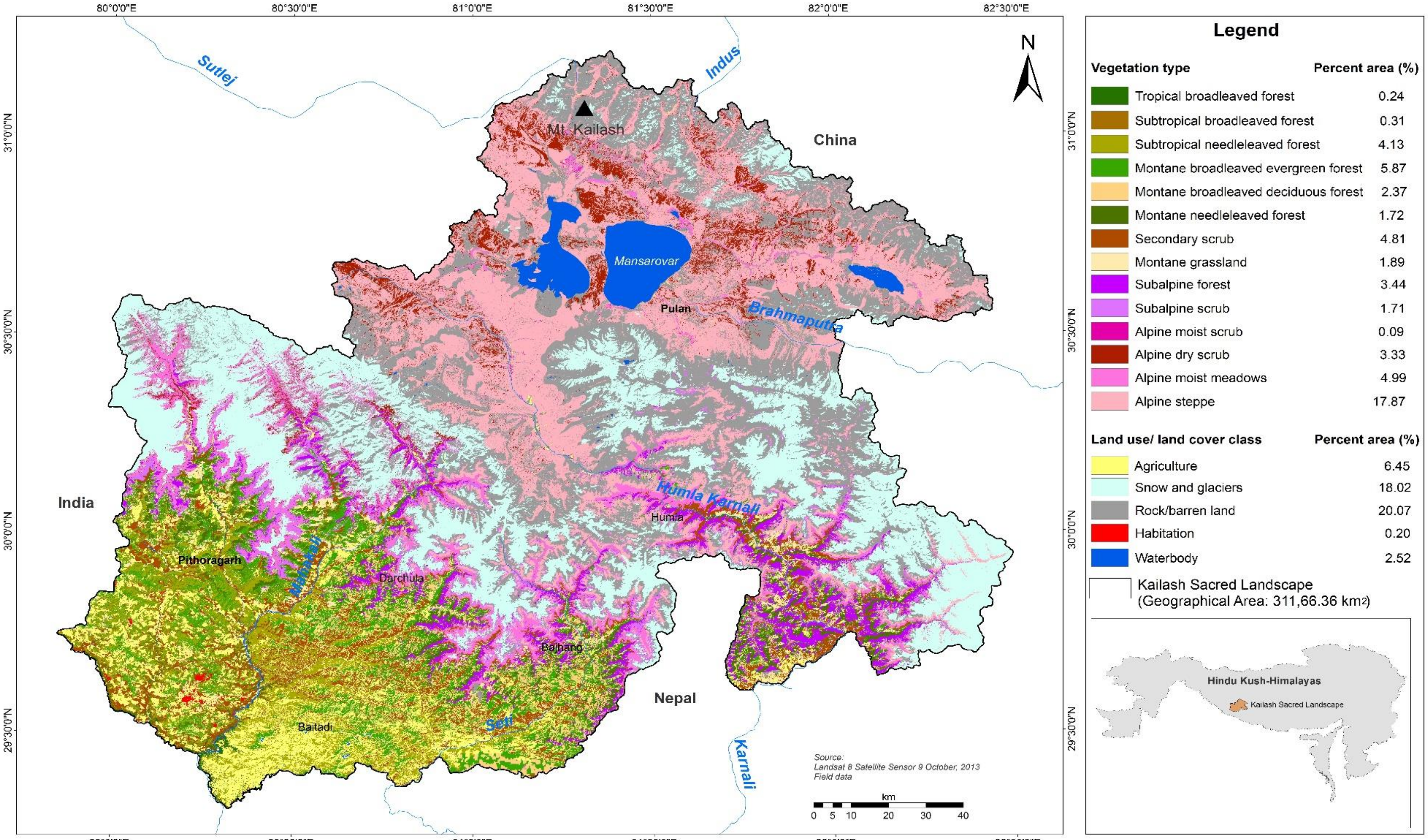
Wildlife Institute of India

Annexure 4

Vegetation Type and Land Cover Map of Kailash Sacred Landscape



Development Partners

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