Field report on the Preliminary Feasibility Study

On

Walking Trees along Lifezone Ecotones in Barun Valley, Nepal
(A pilot project to develop key indicators for monitoring Biomeridians - Climate Response through Information & Local Engagement)

Report Prepared By:
The East Foundation (TEF), Sankhuwasabha, Nepal
and
Future Generations University, Franklin, WV, USA

Submitted to
Department of National Parks and Wildlife Conservation
Babar Mahal, Kathmandu

June 2018

Table of Contents

Contents **Page No.**

List of Figures

List of Tables

Appendix A: List of Community Survey Data

Appendix B: List of Maps

1. Background

According to Disaster Prevention Network (2009), Nepal ranks 4th in the list of vulnerable countries to climate change. It is one of the most disaster prone countries in the world, ranking 23rd in the world in terms of natural hazard related deaths. As Earth's climate changes, the balance and distribution of plants and animals adjust. Climate change impacts have transcended national borders and impacted several geographical areas, especially the Himalayas, increasing the rate of snowmelt and threats of glacial lake outburst floods. The increasing trend in greenhouse gas emissions and rise in surface temperatures temperature has affected the people, resources and economy of Nepal.

A global climate phenomenon is happening, but it is local responses to that which shall mitigate its consequences. This project begins a new approach to monitoring changes in the balances of plants and animals—and from this monitoring, how people, by using such data, can evolve increasingly effective responses. It has been indicated that managing the adverse impacts of climate change on livelihoods, agriculture, water resources, energy, biodiversity and national wellbeing has been a challenge which requires a national adaptation agenda.

A proposed series of international biomeridians will create a baseline of change along intact natural balances on each continent. Local community monitoring will track how locales are changing, measuring their change against the biomeridians. The project outlined here utilizes both high-tech monitoring and local knowledge. The vision is to establish a framework for global tracking of climate change impacts on local life. The consequence will inform and empower communities to direct change they need, and it will grow a global voice from the local level of informed action.

Future Generations University's history in large environmental action and in community engagement equips the University to advance this project. The University is a direct successor institution to The Mountain Institute, where the CEO/founder of both The Mountain Institute and Future Generations University is Dr. Daniel C. Taylor. The 1983 Tree Bear Expedition of Woodlands Institute (now The Mountain Institute), West Virginia, USA culminated into the creation of Makalu-Barun National Park in Nepal and the Qomolangma Nature Preserve in the Tibet Autonomous Region of China. Whether we preserved the tree bear or the Yeti is a different story but surely our partnerships preserved their habitats in the Himalaya. These projects were completed by creating local partnerships, e.g., with local villages, a range of senior Nepali scientists, and appropriate government agencies.

Now, we envision to develop Barun valley as a living observatory of global climate change and/or changes induced by major infrastructural developments. This report summaries the results of a pilot/feasibility study for developing the Walking Trees along Lifezone Ecotones in Barun Valley, the first of a series of global biomeridians monitoring climate change and adaptation.

2. Rationale

Nepal is facing a wide range of impacts from climate change including changes in rainfall patterns, longer droughts, increased risks of glacial outburst and higher temperatures. These changes are having negative impacts on agriculture and food security, water resources, forests and biodiversity, health, tourism and infrastructures. This leads to reduced adaptive capacity and increased vulnerability of communities and ecosystems. Accordingly, there is a need to enhance the adaptive capacity and resiliency of both ecosystems and communities.

The study of Gaire et al. (2014) in central Nepal identified treeline shifting in tandem with climate change, which has widely been reported from various parts of the world. In Nepal, several impacts of climate change on the physical environment have been observed, but study on the biological impacts is lacking. Nepal's climate has been influenced by the Himalayan mountain range and South Asian monsoon, characterized into four distinct seasons: pre-monsoon (March-May), monsoon (June-September), post monsoon (October-November), and winter (December-February). Global warming has led to an average earth surface temperature increase of about 0.7 °C in the 20th century (IPCC, 2007). The temperature increase in the same period was not the same in all regions. It is noted that the temperature increases in the Northern Alps and the Southern Alps are 1.3 °C and 1.7 °C respectively (Rebetez and Reinhard, 2007).

Comparable data for the Himalayan mountain system is not available. The Himalayan region, including the Tibetan Plateau, has shown consistent warming trends during the past 100 years (Yao et al., 2006). Recent studies have indicated that the trend of warming differs at different altitudes. Studies conducted by ICIMOD (Sharma et.al. 2009) revealed that there is an increased magnitude of warming (0.01 to 0.06^{0}C/yr.) with elevation in the eastern Himalaya (Table 1). This is confirmed in Eastern Nepal, where progressively higher warming rates have been recorded with increasing elevation (Sharma et al., 2009).

Table 1: Temperature trends by elevation zone for the period 1970–2000 (°C/yr.)

Elevation zone	Annual	Months			
		DJF	MAM	JJA	SON
Level 1: (<1000 m)	0.01	0.03	0.00	-0.01	0.02
Level 2: (1 –4000 m)	0.02	0.03	0.02	-0.01	0.02
Level 3: (> 4000 m)	0.04	0.06	0.04	0.02	0.03

Source: Sharma et.al. (2009), ICIMOD

Natural vegetation has already been exhibiting response to global warming. The impacts of this warming on ecosystems - especially on climatically sensitive systems like the treeline ecotone - have become visible. But the magnitude and rate of advancement depend on local topoclimatic conditions (Meshinev et al., 2000, Sturm et al., 2001, Mazepa, 2005, Kullman, 2007). In Nepal Himalaya, Suwal et.al. (2016) found that the rate of shift of *Abiesspectabilis* (a conifer of subalpine zone) was approximately 20 meters per decade for the upper species limit. Alpine treeline species show strongly increased growth rates (Paulsen et al., 2000; Motta and Nola, 2001; Motta et al., 2006).

In addition, Alpine plant communities and species composition are also changing (Keller et al., 2000; Pauli et al., 2001; Walther et al., 2005). Predicted climate warming (IPCC, 2001a) is expected to result in structural changes of forest and vegetation as well as in a rise of the alpine treeline (OcCC, 2002). As Suwal et al. (2016) quotes based on various authors, "the extent and limits of the treeline ecotone are confounded by different factors such as the presence of herbivores, forms of treeline, land use dynamics, geomorphology, moisture and local temperature besides the impact of global warming." Studies conducted by Bhatta and Vetaas (2016), Matteodo et al. (2013), Parmesan and Yohe (2003), Sturm et al. (2001), and Telwala et al. (2013) indicated that an upslope or poleward shift of species at the treeline can be seen as a result of global warming, too.

Latitudinally, Nepal lies in the subtropical climatic zone, but due to mountainous terrain the country mirrors all the climatic zones of the world within a short span of about 250 kilometers. As such, the country has a wide diversity of vegetation bands with or without distinct visible ecotones. Upward shifting of the treeline would contribute to migration of species, resulting in changes to the floristic composition, ecosystem structure, and ultimately ecosystem services. In the long run, this might lead to an impact on human livelihood.

These changes prompt the need to study species shifting along various life zones and the impact of climate change upon local ecological and economic improvement potentials. Local communities have developed adaptation strategies to manage risk and uncertainty through traditional knowledge. Practice and belief are transferred gradually from generation to generation, but communities are not aware of recent climate change and its impact upon their subsistence. Local communities participating in studies of shifting life zones and the resulting economic and lifestyle consequences will develop knowledge and skills allowing Self-Evaluation and Efficient Decision making (SEED) for sustainable nature conservation and economic development. This will lead to determination of key indicators that can be monitored and analyzed by local communities themselves, contributing both to sustainably development and to scientific knowledge.

3. Study Methodology

The overall purpose of this pilot project was to conduct a feasibility study for development of a full proposal on **Walking Trees along Lifezone Ecotones in Barun Valley**. The full proposal aims to develop key indicators monitoring Biomeridians - Climate Response through Information & Local Engagement. Such work in the Barun will contribute to supporting Makalu Barun and its buffer zone not only to address climate change impacts on biodiversity but also to ensure and build the community resilience and adaptation practices. The overall goal of the biomeridian project is to develop socio-ecological resilience and adaptive capacity of local communities in changing environment based on local ecological knowledge.

Feasibility Study Objectives:

1. Generate disaggregated socio-economic data of Hatiya Village Development Committee and the study site
2. Conduct an ethno-ecological study and generate a database based on human biodiversity
3. Set up vertical transect from Barun-Arun river confluence to treeline (along the Yeti Trail) with monitoring stations logging temperature, relative humidity, birdsong, and wildlife
4. Initiate and pilot ecosystem-based adaptation (EBA) income generating program and initiate monitoring the impact of climate change on livelihoods and adaptation practices
5. Build coordination mechanism with Nepal Academy of Science and Technology (NAST), Department of National Parks and Wildlife Conservation (DNPWC), and Future Generations University to develop future plans, full proposal, and climate change adaptation plan for Barun Valley

The larger biomeridian project vision is to grow a global discourse informed by community-centered observations. The results go beyond data collection. They take a step toward democratizing climate discourse. The beginning has started now off the several mountains that comprise the Everest massif, with the engagement by communities allowing informed adaptation of Life to climate change. It is hypothesized that key indicators determined based on the local ecological knowledge (LEK; ethnobiology, agro-ecosystem, religio-culture, socio-economy) for a particular community / site will help the community to understand changes in the ecosystem and ultimately make the local communities capable of mitigation and resilience.

3.1 Contextual Framework

Mountain Transects/Biomeridians: Windows on Climate Change

The Biomeridian Concept: Although the term is new, the idea goes back two centuries to Alexander von Humbolt. One mountain slope can encapsulate the natural diversity typically found Equator to poles, mirroring latitudinal shifts in vegetative and animal complexes. With climate change, established relationships of plants and animals on a mountain slope will alter: some species disappear, invasive species enter, and the balance of plants and animals is expected to “walk uphill” with rising temperatures.

Establishing transects (biomeridians) on selected mountain slopes will create monitoring lines for climate change. Biomeridians are proposed for Asia, Africa, South America, and the Pacific. Along each, observation nodes will be established at regular elevation increments. In each, vegetation will be described and temperature and humidity will be monitored. Audio recording will record sounds day and night in order to catalog bird populations, which are the most rapidly adjusting of all life forms to habitat change. Local communities will collect data and contribute personal knowledge to the project.

The Barun Biomeridian: A first biomeridian is being established in the Barun Valley off the Mt Everest massif. Nepal's Makalu-Barun National Park is an intact preserve from biological tropics to the arctic-like first, fourth, and fifth highest summits of the world. No resident life forms are above 5,400 m, while the valley bottom contains a rich biology with tropical species such as tree ferns.

An initial budget is in place. Communities are committed, as are scientists in Nepal and worldwide. The model established here with the Barun biomeridian will inform extension of the global biomeridian project to Africa, South America, and the Pacific, building off other scientific monitoring that is underway.

Engaging Large-scale People's Participation

Biomeridians have value beyond describing transects that monitor climate change (e.g., trees walking uphill). To guide communities as they evolve effective response, in other regions mini-biological transects (from undisturbed to highly impacted sites) will mimic the biomeridians. Paired experiments can be set up using the biomeridians as references, to inform adaptations by local communities around the globe who have set up the mini-biomeridians.

These mini-biomeridians can also be experimental sites where actions by people are tracked. Communities through trial and error will be developing responses. If cataloged globally, these will show increasingly effective responses to climate change. Sharing experiences (along with data) will position effective local action in a global forum. A growing body of solutions will be forming for the climate challenge.

In this way, communities will be literally put on the map, as data from local transects feeds into global databases. Local additions will not just find answers to climate change, but through their participation empower communities. Empowered action is what will ultimately evolve answers in the world that comes, driven by the energies of people, adapting, always fitting to changing local reality.

There is a specific role for youth groups in this process. They have expertise with the technologies. They are the ones who inherit the changing climate—they need a role with evolving the solutions. Youth organizations will be key partners in this project (Scout troops, schools, etc.). These local sites will simplify the complex, multi-sensory monitoring of the biomeridians so adapted mobile phones (they record sound, pictures, humidity, and temperature) will be the technology.

3.2 Study Area Description

Natural Ecological System

Eastern Nepal covers five life zones below treeline: Sal zone (below 1000m altitude), Schima zone (1000 - 2000m), Evergreen Oak zone (2000 - 2600m.), deciduous Maple zone (2600 - 3000m) and Abies conifer zone (3000 - 4000m) (see Table 2). Within the life zones, Dobremez and Shakya (1975) reported nine ecological/vegetation zones in the Barun watershed: *3-Castanopsisindica* forest, *Castanopsistribuloides* forest, *Quercus lamellosa* forest, deciduous mixed broad leaved forest, *Betula utilis* forest, *Abiesspectabilies* forest, Rhododendron-Juniper shrubland, Rhododendron shrubland, and Alpine slopes with *gramineae*.

Table 2: Bioclimatic zones in Arun basin

Bioclimatic zones	Altitude (m.)	Indicator plants
Tropical	Below 1000	*Shorearobusta, Lagerstroemia, Duabanga, Terminalia*sps
Sub-tropical	1000 – 2000	*Schimawallichii, Castanopsistribuloides, C. indica, C.hystrix, Engelhardtiaspicata, Alnusnepalensis*
Temperate	2000 – 3000	*Quercus lamellosa, Q. lineata, Daphne phylum himalayense, Acer campbellii, Magnolia campbellii, Machus*sps.
Sub-alpine	3000 – 4000	*Abiesspectabilies, Betula utilis,* Rhododendron shrubland over 1 m tall
Alpine	4000 – 5000	Herbs, grasses, Rhododendron shrubs of less than 0.5m, *Juniperusindica*
Nival	Above 5000	Permanent snow and ice

Source: Shrestha, 1989

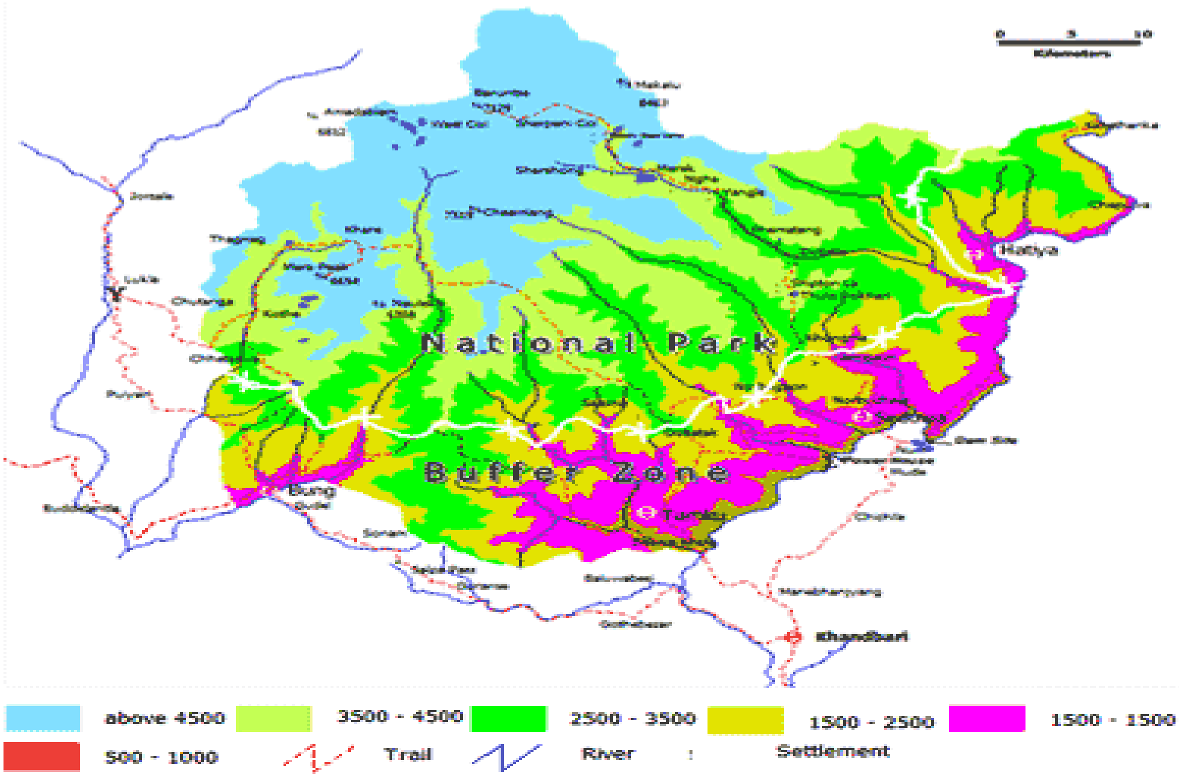


Figure 1: Makalu-Barun Elevation Distribution

Source: DNPWC map

Each life zone and ecological zone is endowed with a diversity of plant as well as animal species. Species and their composition might differ from life zone to life zone, and from ecological zone to ecological zone, but their persistence in the life zones/ecological zones is a result of setting balance between species-to-species interactions such as neutralism, competition, amensalism, parasitism, commensalism, protocooperation and mutualism. Whether climate change/global warming will affect ecosystem function depends on how interactions among species are influenced. Several studies have shown alterations in trophic relationships and energy-flows in both predator-prey and plant-herbivore interactions as a consequence of rising temperatures (Stenseth & Mysterud, 2002; Visser & Both, 2005; Durant et al., 2007). A few studies have shown that climate warming may generate temporal mismatches among the mutualistic partners (Hegland et.al. 2009). On the other hand, upward shifting of species due to global warming has been reported from the studies of researchers but the magnitude and rate of advancement depend on local topoclimatic conditions (Meshinev et al., 2000, Sturm et al., 2001, Mazepa, 2005, Kullman, 2007). As such, the biomeridian project will carry out a study of species shifting and the consequences in the project site by establishing permanent plots in each ecological/vegetation zone.

Socio-cultural Ecological System

Local communities have been using natural resources and ecosystem services for their subsistence for thousands of years. They have developed adaptation strategies to manage risk and uncertainty, and have accumulated local ecological knowledge (LEK). According to Berkes et al. (2000), LEK is understood as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment." LEK contributes to people's resilience, the capacity of human groups or individuals to cope with the disruption of their livelihoods and with a loss of security as a result of the impacts of social, economic or ecological changes (Adger, 2000).

Begossiet et al. (2002) noted that LEK is not evenly distributed and is generally limited to small groups, increasing the probability of losing knowledge through cultural oscillation. Furthermore, LEK heterogeneity may constitute a sign of LEK erosion due to local societies' acculturation (Benz et al., 2000). Therefore, the intra- and intercultural heterogeneity in LEK systems contributes to their overall fragility and to people's vulnerability to changes, as LEK is linked with their socio-ecological resilience and adaptive capacity (Ruiz-Mall_en and Corbera, 2013).

It is, therefore, anticipated that traditional social-risk management strategies and local ecological knowledge contribute to their resilience and adaptive capacity development, the goal of proposed project. In this context, homogenous cultural-community based studies of LEK including the exploration of ethnobiologically significant species, are conducted as a part of this project.

Socio-economic System

Economy has become a key driver influencing the natural as well as socio-cultural ecological systems. For the success of this project, some economy related interventions must necessarily be conducted. Interventions based on the present needs of local communities are implemented, in addition to key indicator development activities.

In the context of growing global challenges to human beings due to climate change, local communities are the user and guardian of natural resources/ecosystem services. Knowledge and understanding of climate change and its consequences are required to cope with the underlying challenges of sustainable subsistence. Communities' resilience and adaptive capacity must be developed.

This necessity prompts the need for transferring scientific knowledge/findings to local communities, in addition to developing their capacity for monitoring climate change and its consequences; local community-friendly key indicators must be determined. In addition, quantitative study of the indicators is required along the ecological zones for scientific analysis. As such, the intention is to determine LEK-based indicators (community-friendly indicators based on communities' own ecological knowledge) and to provide scientific training to communities on indicators and their monitoring process.

Regular monitoring of the key indicators will lead to the development of subsistence plans, which in turn will support and refine key indicators. Through this process, self-evaluation and efficient decision making (SEED) will be developed by local communities. From the past studies it has been learnt that certain regular supports to the local communities are required to achieve the goal.

3.3 Experimental Design and Data Collection Methodology

Biomeridians, starting with one in the Barun Valley, Nepal, will provide a baseline for studying changes to Life due to climate change. The Barun Biomeridian has been started, reaching from approximately 1100 m elevation to 2700 m (treeline) elevation: from Barun Dovan to Ramite. Seven monitoring stations, located at 300 to 500-m elevation intervals along the Yeti Trail and also in Lingum and Syaksila villages, were established as part of the pilot project. Community surveys were conducted at local villages to establish socio-cultural and socio-economic baselines as well.

At monitoring stations the following data were collected:

- Location
- Photos
- Vegetation information
- Temperature and humidity time series
- Audio recording
- Wildlife camera traps

Ecological Data Collection

An ecological study was carried out along the Yeti Trail with a belt transect of 40m x 6m size (Van der Hammen, Mueller-Dombois, and Little, 1989) used to collect quantitative data of lifezone's dominant species. A concentric circular plot system (DRFS, 2015) was used to collect quantitative data of saplings and seedlings of dominant species. Geocoordinate data along the Yeti Trail were collected using Garmin GPS with +/- 3m error. Ecological and geocoordinate data of the locations of the installed devices were collected.

Audio Data Collection

Audio recordings were made using Wildlife Acoustics Song Meter SM4 loggers. These dual-channel waterproof loggers were programed to record a specific periods day and night to monitor birds, insects, and mammals.

Temperature and Humidity Data Collection

Temperature and humidity were recorded in 15-minute increments using HOBO MX2301 data loggers.

Wildlife Cameras

Two Browning Strike Force Pro wildlife cameras were installed at Kali Khola and Ramite Danda to detect passing wildlife. The camera traps will photograph wildlife during the day and use infrared flash photography to document nighttime wildlife. Two additional cameras are ready to be installed at higher elevations after the monsoon passes.

GIS Data Analysis

The Department of Survey, Nepal Government's topo data generated based on 1:50,000 scale aerial photography of 1992 and field verification done in 1996 was used for analysis of the topography, elevation-based ecological zone mapping, and landuse/landcover of Barun watershed. ArcGIS software was used for digitization, analysis, and mapping.

Secondary Data Collection

Relevant documents, articles, journals, maps and GIS data, research studies and plans and policies related to climate change, vulnerability, ecosystem-based adaptation, resilience capacity, climate justice etc. were reviewed. For the study of ethnography and social economic information, prescribed methodologies were reviewed.

Community Survey

Community surveys were conducted in Simbung, Syaksila, and Lingam/Mangkhim. These survys collected information on the number and gender of students in local schools and the educational status of local residents. Information about the types and timing of agricultural crops was noted. The wealth ranking of households was recorded, as well as information about local development groups. See Appendix A for community survey results listed in a series of tables.

4. Study Findings

The main activities completed in this pilot Barun Biomeridian project were as follows:

- Identification of site for installing climate monitoring devices (based on GIS analysis and field observations)
- Installation of seven monitoring stations along the Yeti Trail biomeridian transect
- Training of local community members for device installation, monitoring, and data retrieval
- Desktop review of secondary information
- Conducted consultation meeting with the local people
- Conducted site visit to local communities for ethno and socio-economic studies

- Developed and initiated pilot income generation programs and climate change monitoring data management system
- Prepared institutional framework and coordination mechanism
- Developed local level coordination and central level coordination mechanisms

Detailed results of these activities are included in the following sections.

4.1 Geographic Summary

Barun Valley/Watershed and Settlements

The Barun River is one of the major rivers of Arun valley/watershed. It starts from the Makalu glacier and flows Barun Dovan, the confluence of Barun River and the Arun River. It has a number tributaries including Saldima Khola. The Barun watershed extends over 47182 hectares within the short span of aerial distance of about 40 km and from about 1100 m altitude to 8463m and Mt. Makalu. The valley/watershed does not include any settlements; nearby settlements include Sempung, Syaksila, Lingam, and Mankhin. The drainages of Syaksila flow down to Wan Khola and Arun River while that of Sempung flows to Arun River. Similarly, the drainages of Lingam and Khandim flow to Thado Khola and Arun River (see Appendix B, Map 1).

Topography of Barun watershed

Barun watershed consists of slopes and aspects of various degrees, and a number of bioclimatic zones. GIS analysis revealed that 52 percent of the land surface falls under moderately accessible slope (30^o - 60^o) while 46% lies in gentle sloppy category (below 30^o) and 2 % is steep slope (above 60^o) (see Table 3 and Appendix B, Map 2). A large portion of land surface, i.e. 45%, remains permanently covered by snow and ice (above 5000 m), followed by upper alpine (28%), lower alpine (11%), upper subalpine (8%), and so on (see Table 3 and Appendix B, Map 4). Only 9% of total area lies below 3000m.

Table 3: Distribution pattern of slopes and/by bioclimatic zones

Altitudinal range (m) (Bioclimatic zone)	Area (ha) by Slope			Total area	
	Gentle (< 30^o)	Moderate (30^o -60^o)	Steep (> 60^o)	(ha)	(%)
1100-1500	23	48	0	72	0.2
1500-2000	121	291	118	430	0.9
2000-2500	455	786	23	1265	2.7
2500-3000	830	1402	24	2257	4.8
3000-3500	1235	2347	33	3615	7.7
3500-4000	1997	3145	64	5207	11.0
4000-5000	6830	6295	137	13263	28.1

>5000		10184	10330	560	21075	44.7
Total area	(ha)	21678	24645	859	47182	100.0
	(%)	46	52	2	100.0	

In general, the Makalu mountain range is south facing but the eastward flowing Barun River and its tributaries face north and south directions creating various degrees of aspects. GIS analysis revealed that Barun watershed has less than one percent flat area while east facing and south facing slopes have the highest prevalence, each constituting 28% of the watershed area. West and north facing slopes each represent 21% of the watershed area (see Table 4 and Appendix B, Map 3).

Table 4: Distribution of aspect and/by bioclimatic zones

Altitudinal range (m) (Bioclimatic zone)		Area (ha) by Aspect					Total area	
		Flat	North (0^o-45^o & 315^o - 360^o)	East (45^o -135^o)	South (135^o - 225^o)	West (225^o - 315^o)	(ha)	(%)
1100-1500		0	20	26	25	0	72	0.2
1500-2000		2	142	120	150	16	430	0.9
2000-2500		1	315	471	272	206	1265	2.7
2500-3000		2	533	782	466	474	2257	4.8
3000-3500		5	835	1091	980	705	3615	7.7
3500-4000		12	1112	1536	1359	1188	5207	11.0
4000-5000		195	2497	4119	3794	2659	13263	28.1
>5000		39	4501	5109	6521	4904	21075	44.7
Total area	(ha)	257	9954	13254	13566	10151	47182	100.0
	(%)	0.5	21.1	28.1	28.8	21.5	100.0	

Landuse/Landcover of the Barun Watershed

The Forests Resource Assessment Project of Nepal Government generated landuse/landcover data of high mountain and high Himalaya in 2015 but the data is only available in printed report format. Hence, the land use/land cover data of 1996's topo map has been used. As per the topo data, the Barun watershed is largely covered by the landcover of "others" category (74%) (see Table 5 and Appendix B, Map 5), which is less suitable in the context of biological resources because it includes the land cover of glacier, barren land, cliff, and sandy areas. Forestland covers 14% of the watershed, followed by shrubland (12%). Less than one percent of land area is classified as cultivated land.

Table 5: Distribution pattern of landuse/landcover and/by bioclimatic zone

Altitudinal range (m) (Bioclimatic zone)		Area (ha) by Landuse/landcover					Total area	
		Forest	Bush/Shrubland	Grassland	Cultivated land	Others	(ha)	%
1100-1500		0	60	0	6	7	72	0.2
1500-2000		289	123.04	0.0	2	16	430	0.9
2000-2500		1215	22	1	1	26	1265	2.7
2500-3000		2001	183	4	0	69	2257	4.8
3000-3500		2009	1303	85	0	218	3615	7.7
3500-4000		1021	2111	29	0	2046	5207	11.0
4000-5000		17	1861	2	0	11377	13258	28.1
>5000		0	15	0	0	21058	21073	44.7
Total area	(ha)	6552	5679	120	8	34816	47176	100.0
	%	13.9	12.0	0	0	73.8	100.0	

4.2 Vegetation and Ecotones of Barun Watershed

Dobremez and Shakya (1975) had determined 500 m altitudinal the interval of lifezone ecotone based on 250,000 scale study (Table 7). Since the species of ecotone become more sensitive to climate change and respond first, it was felt a need of determining lifezone ecotone at small scale. But as the lower subtropical zone has been transformed into cultivated land and shrubland, and the upper subtropical zone is under community forest and private land owner and is under heavy anthropogenic pressure, the intact natural vegetation was lacking in the zones. This made almost not possible to identify the lifezone ecotone in the zones. Ecotone identifying study above subtropical zone was hindered by heavy raining and snow fall.

Dobremez and Shakya (1975) prepared an ecological map of eastern Nepal at 250,000 scale. Based on this map, the Barun watershed has eight ecological/bioclimatic zones (Table 6). According to the landuse data of 1996, the lower subtropical zone (1000-1500m) is covered by shrubland and cultivated land (Table 5 and Appendix B, Map 4) while the climatic climax vegetation of this zone is Chilaune (*Schima wallichii)* dominated forest. Present field study observed only few trees of the dominant species which are also found sporadically occurred. As such, the quantitative data collection of the species along a belt transect could not be possible.

The upper subtropical zone is the zone of Musure katus (*Castanopsis tribuloides)* dominated forest. This ecozone is now under private and community forest management system. Present field study observed the zone under heavy anthropogenic pressure, and the understory covered by cardamom plantation and weeds. Livestock grazing was found in the community forest. Although *Castanopsis tribuloides* is the dominant species of the zone in climatic climax vegetation, the species was observed sparsely distributed. In belt transect study, only one tree of the species was recorded. Concentric circular plot method was used to collect quantitative data of sapling and seedling of *C. tribuloides* in the plot, but due to degradation/deterioration of ground vegetation, sampling and seedling of the species was not found in the plot.

In upper subtropical zone, tree species of Malta (*Macaranga* sps), Chilaune (*Schima wallichii)*, Gogan (*Sauraja nepalensis)*, Angeri (*Lyonia* sps), Bilaune (*Maesa chisia)* etc. (Table 7) were observed. In south facing slope, Simal (*Bombax ceiba)*, Dhanshree (*Zizyphus* sps) were recorded. A tree of Simal of about 10 m height was recorded at about 1700m altitude in cultivated land on the way to Lingam while this species has been reported to be distributed to about 1400m only. At lower elevation, i.e. about 1100m, the species was found in flowering stage but there was no sign of flowering at 1700m. According to the locals, the tree flowers about a month later.

In collinean ecological zone, more of less intact forest of Thulo phalant/Bajrantha (*Quercus lamellosa)* was found in north facing slope. Along the way, the forest was not disturbed but most of the forest area did not have under-coverage and very few shrubs were observed. Along the route to Paireni, most of the vegetation was composed of small bamboos/ nigalo. The forest was sparsely dense and had Jingane, LekKaulo and Kharani (*Symplocos* sps) with few shrub plants (Table 7). There was a buffalo herder having its shed inside the national at about 2300 m in Tuting.

Table 6: Major tree species recoded along the Yeti Trail

SN	Barun Dovan-syaksila (1250m)	Lombang-Tembong CF (1850m)	Along the Yeti Trail (1932m)	Deurali (2093 m)	Moshe Kharka (2157m)	Paireni (2115m)	Tuting (2300 m)
1	Katus (Castanopsis sps)	Gogun (Sarauria nepalensis(	Rakta Chandan	Laliguran (Rhododendron arboreum)	Dhalne	Dhalne	Champ
2	Chialune (Schima wallichii)	Saur (Betula alnoides)	Musiranga	Champ	LekKaulo	LekKaulo	
3	Utis (Alnus nepalensis)	Phalant (Quercus sps)	Champ (Michelia sps)	Katus	Jhigane	Jhigane	
4		Kangel	Jingane	LekKaulo	Raktachandan	Raktachandan	
5		Dudhilo (Ficus sps)	Phalant	Jhingane	Champ	Champ	
6		Chilaune	LekKaulo	Phalant	Nigalo (Arundinaria sps)	Nigalo	
7		Kaulo (Persea sps)	Kharani (Symplocos sps)	Saur	Laligurans	Laligurans	
8		Stinging nettle (Urtica dioca)	Magarkanchi			Kharani	
9		Other shrubs					
10		Utis					

Table 7: Ecological zones in Barun watershed

Bioclimatic /ecological zones	Altitude (m.)	Major forest types
Lower subtropical	1000-1500	*Schima wallichii, Castanopsis indica* forest
Upper subtropical	1500-2000	*Castanopsis tribuloides* pure forest or mixed with *Schima wallichii, Rhododendron arboreum, Lyonia ovalifolia, Eurya acuminate, Quercus glauca, Camellia kissi*
Collinean	2000-2500	*Quercus lamellosa* forest with *Quercus lineata, Quercus glauca, Lauraceae*
Montane	2500-3000	Deciduous mixed broad-leaved forest of *Acer campbellii, A.pectinatum, Sorbus cuspidate, Magnolia campbellii*
Lower subalpine	3000-3500	*Abies spectabilies* forest with *Rhododendron hodgsoni* and *R.barbatum*
Upper subalpine	3500-4000	*Betula utilis* forest with *Rhododendron hodgsoni, R.barbatum* and *Abies spectabilies*
Lower alpine	4000-4500	*Rhododendron-Juniper* shrubland with patches of abundant *Rhododendron anthopogan, R.setosum, R.nivale*
Upper alpine	4500-5000	Alpine slopes with Gramineae and Cyperaceae
Nival	Above 5000	Permanent snow and ice

Source: Dobremez and Shakya (1975)

4.3 Biomeridian Monitoring Sites

The Barun valley biomeridian pilot project aimed to install nine monitoring sites with scientific instrumentation from the base of the watershed (Barun Dovan; 1100m) to treeline (about 4000m) at 500 m altitudinal intervals. Due to topographic constraint, degraded natural vegetation, and weather conditions, a total of five devices were installed (see Appendix B, Map 6) along the Yeti Trail. Two additional devices were installed at Lingum and Syaksila villages and will be used for educational purposes as well as collection of scientific data.

Detail information about monitoring stations locations is included in Tables 8 and 9. Of the five devices along the Yeti Trail, one device was installed in private land at 1265 m altitude and one in community forest at 1822 m while rest were installed in National Park property.

Due to the lack of forest patch, it was difficult to select an ideal place to install a monitoring station at an altitude below 1500m. Similarly, it was also difficult to select a monitoring station between 1500 and 2000 m altitude where the occurrence of slash and burn practice, felling of logs, grazing of goats and cattle, field of Cardamom, and the presence of cattle shed were observed.

Table 8: Biomeridian monitoring sites

Date	GPS's Way point no	Longitude (ddmmss)	Latitude (ddmmss)	altitude (m)	Land owner	Forest type
9-Mar-18	15	87^{O}21'52.8"	27^{O}41'24.0"	1265	Private land	Mixed broad leaf
10-Mar-18	22	87^{O}20'44.5”	27^{O}41'32.9"	1822	Community forest	Mixed broad leaf
11-Mar-18	29	87 ^{O}20'07.8"	27^{O}41'42.5"	2101	National park	Mixed Phalant forest
12-Mar-18	33	87^{O}18'47.6"	27^{O}42'02.5"	2287	National park	
13-Mar-18	36	87^{O}17'05.6"	27^{O}43'10.9"	2786	National Park	Mixed broad leaf

Table 9: Trail benchmarks near monitoring sites

Trail	GPS's Waypoint	Longitude (ddmmss)	Latitude (ddmmss)	Altitude (m)	Bearing to device	Distance to device (m)
Barun Dovan to Syaksila	13	87^{O}21'49.8"	27 ^{O} 41'23.4"	1302	N80 ^{O}E	100
Yeti Trail	21	87^{O}20'44.7"	27 ^{O} 41'31.9"	1825	N335 ^{O}W	50
Yeti Trail	27	87 ^{O}20'08.6"	27 ^{O} 41'43.2"	2094	N195 ^{O}W	100
Yeti Trail	32	87 ^{O}18'47.6"	27 ^{O} 42'03.3"	2284	N185 ^{O}W	21
Yeti Trail	35	87 ^{O}17'05.6"	27 ^{O} 43'11.1"	2783	N330 ^{O}W	14

4.4 Monitoring Site Ecological Study

At each of the instrumentation monitoring sites along the biomeridian, a more extensive ecological study was conducted. The status of some key species and their presence at the monitoring stations is included in Table 10.

Table 10: Key species and observed locations

Botanical Name	Local Name	Syaksila	Hinju	Deaurali	Tuting	Ramitay Danda
Acer cappadocicum	*Yalli*					Ok
Acer csesium	*Yalli*				Ok	Ok
Aconogonum campanulatum			Ok			
Aconogonum molle	*Nallu*				Ok	Ok
Aeschynanthus sikkimensis			Ok			
Agrostophyllum callosum				Ok		
Ainsliaea aptera		Ok	Ok	Ok		
Ajuga lobata		Ok				Ok
Alnus nepalensis	*Ushuma*	Ok				Ok
Amomum cardamomum			Ok			

Arisaema costatum		Ok				Ok
Arisaema flavum	*Tha lungo*	Ok				
Arisaema griffithii	*Phi Dhuwa*					Ok
Asparagus filicinus						
Astilbe rivularis			Ok			
Berberis wallichiana					Ok	
Brassaiopsis hainla	*Bukaak*	Ok			Ok	
Brassaiopsis mitis					Ok	
Campylandra aurantiaca					Ok	
Castanopsis tribuloides		Ok				
Clematis buchananiana						Ok
Clematis montana						Ok
Cythula tomentosa		Ok				
Daphne bholua					Ok	Ok
Debregeasia longifolia			Ok			
Disporum cantoniense		Ok				
Elaeagnus parvifolia		Ok				
Elatostema platyphyllum	*Dilima*				Ok	Ok
Elatostema sessile					Ok	Ok
Elsholtzia flava		Ok				
Elsholtzia fruticosa		Ok				
Engelhardia spicata	*Khong la*	Ok				
Euonymus echinatus			Ok	Ok		
Eupatorium adenophorum		Ok				
Galium verum						Ok
Gastrochilus calceolaris			Ok			
Girardinia diversifolia	*Yangguwa*	Ok	Ok			
Gynura cusimbua		Ok				
Hedera nepalensis			Ok	Ok	Ok	
Holboellia latifolia					Ok	
Hydrangea anomala			Ok		Ok	Ok
Ilex dipyrena				Ok	Ok	
Impatiens stenantha			Ok			
Jasminum dispermum			Ok	Ok	Ok	
Leucosceptrum canum		Ok				
Lyonia ovalifolia	*Sangay*					Ok
Maesa chisia		Ok				
Melastoma normale		Ok				
Neolitsea pallens				Ok	Ok	
Nephrolepis cordifolia		Ok				

Paris polyphylla	*Gyambu tingdin*					Ok
Phytolacca acinosa	*Hang gayayppo*	Ok				
Pieris formosa						Ok
Pilea scripta		Ok				
Piper mullesua			Ok			
Plantago major				Ok		
Polygonatum cirrhifolium	*Hen Dayakpa*					Ok
Polygonatum oppositifolium	*Thack chik*			Ok		
Primula listeri						Ok
Primula petiolaris						Ok
Quercus glauca				Ok	Ok	
Ranunculus diffusus			Ok			
Raphidophora decursiva			Ok			
Remusatia hookeriana	*Thaksiki Mendok*	Ok				
Rhododendron arboreum	*Khem Mendok*					Ok
Rhododendron arboreum var. roseum						Ok
Rhododendron fulgens						Ok
Rhododendron triflorum						Ok
Rhus wallichii			Ok			
Ribes griffithii						Ok
Rohdea nepalensis				Ok		
Rubia manjith	*Chook*				Ok	
Rubus ellipticus				Ok		
Rubus lineatus					Ok	Ok
Rubus paniculata	*Anggo rokma*				Ok	
Sabia campanulata					Ok	
Saurauia napaulensis			Ok			
Schefflera impressa	*Bokakak*		Ok		Ok	
Senecio cappa		Ok				
Smilacina purpurea					Ok	
Smilax rigida				Ok	Ok	
Symplocos paniculata			Ok	Ok	Ok	
Thalictrum foliolosum			Ok			Ok
Urtica dioica	*Sadukpa*	Ok	Ok			
Viburnum erubescens	*Lakmalung*	Ok			Ok	Ok
Viburnum nervosum						Ok
Viola canescens		Ok	Ok			Ok
Zanthoxylum oxyphyllum				Ok		

4.5 Temperature and Humidity Data

At installation, the HOBO loggers were set to record surface temperature and humidity data at 15-minute intervals and to wrap data when full for recording data indefinitely. Data from six of HOBO loggers was downloaded in early May 2018. Three stations had not been correctly started at the time of installation and had recorded no data. These loggers were restarted and are now collecting data. Results from the three stations that were recording include more than 30,000 temperature and relative humidity measurements. Results are shown in Figures 2-5.

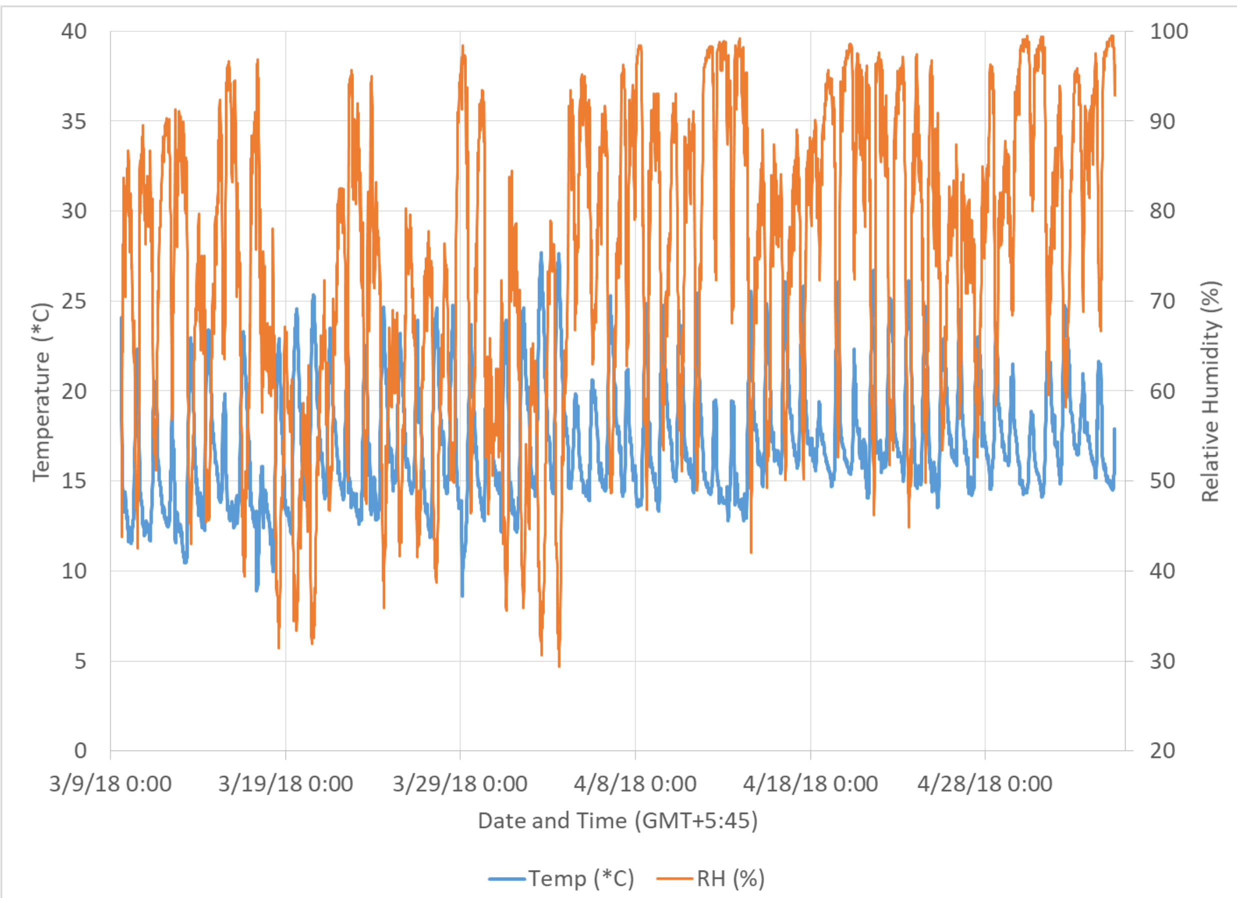


Figure 2: Temperature and Relatively Humidity Recorded at Lower Barun Site (approximately 1500m elevation)

As expected, 15-minute time series of temperature and humidity show strong diurnal cycles. Differences can also clearly be seen between the stations at different elevations (Figure 5). Long-term records of surface temperature and humidity at different elevations will allow better climatological characterization of the Barun Valley.

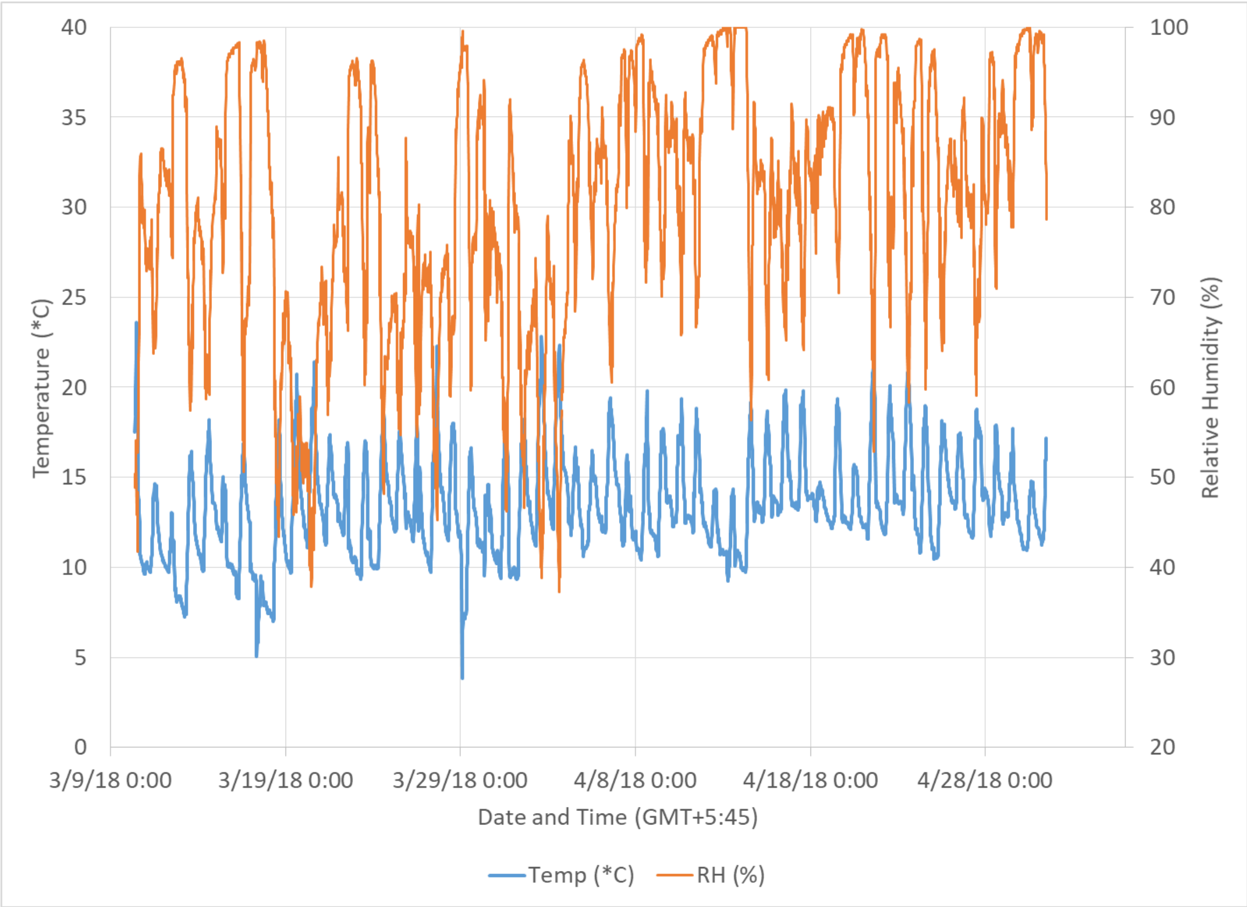


Figure 3: Temperature and Relatively Humidity Recorded at Hinju Site (1809m elevation)

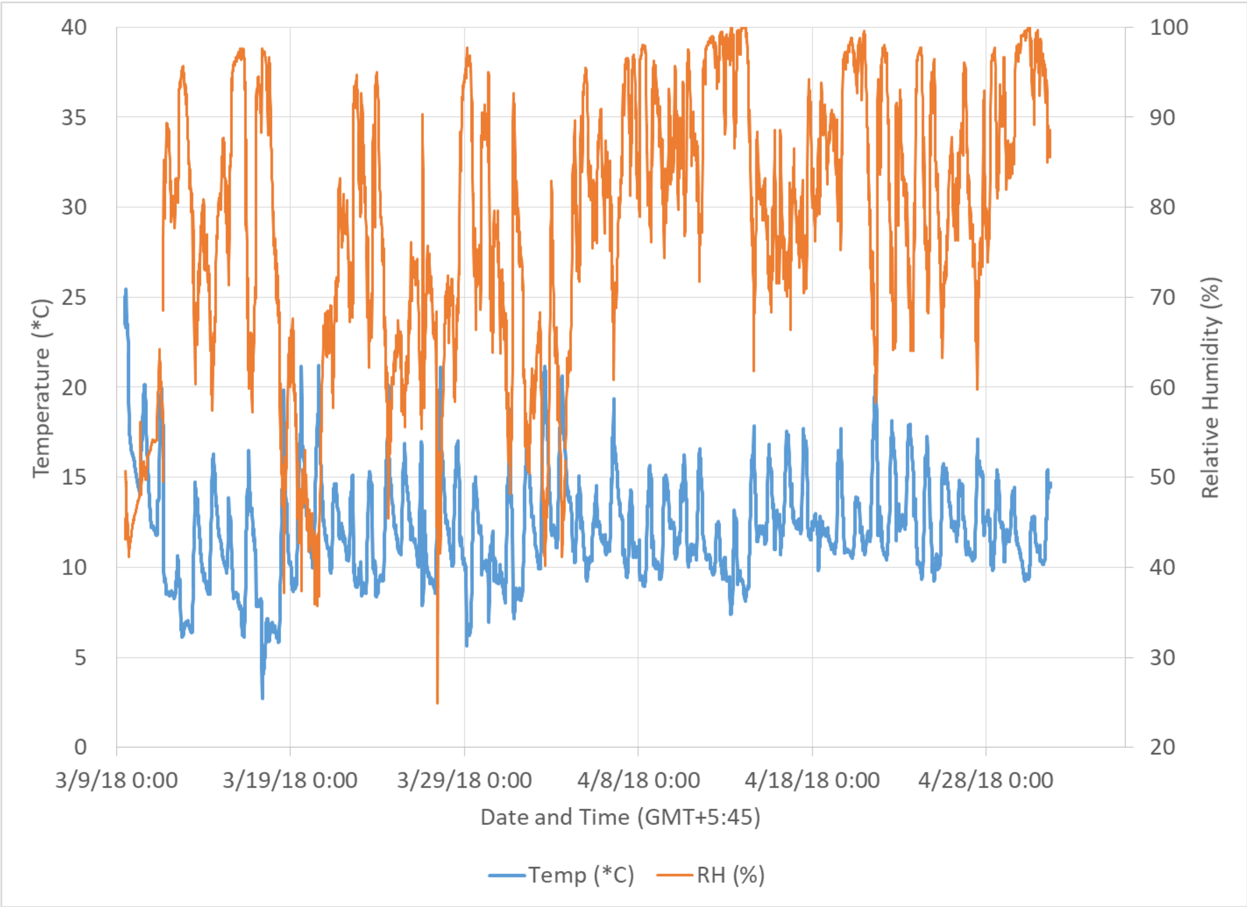


Figure 4: Temperature and Relatively Humidity Recorded at Deaurali Site (2100m elevation)

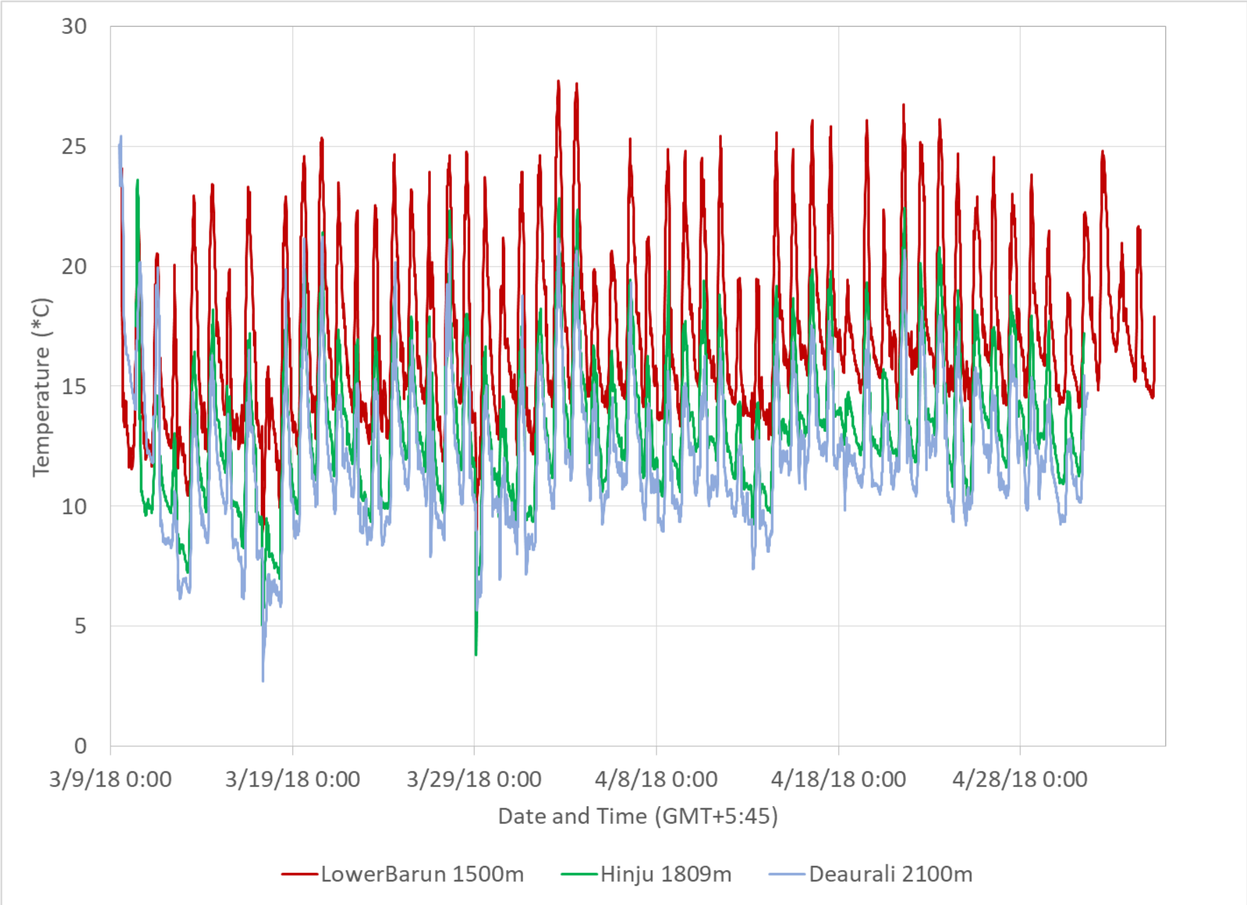


Figure 5: Temperature Comparison between Sites

4.6 Audio Recording and Wildlife Camera Traps

At each of the monitoring stations Wildlife Acoustics SM4 acoustic recorders were installed to monitor birdsong. Detail information of the locations along with the information of the benchmark on the trail to the device were presented in Tables 8 and 9. The devices were set to record continuous data three times a day:

- one hour before sunrise to two hours after sunrise
- from 11:00 to 13:00
- one hour before sunset to one hour after sunset

At all other times, day and night, the device was set to record data continuously for 5 minutes and then sleep continuously for 10 minutes.

The acoustic recorders were downloaded in April and in May. During the May download, a solar panel and battery were added to three of the sites to allow longer duration of recording between visits. A continuing effort is being made to develop a lower cost, more durable solar powering system.

At the time of data download in May, filters were added to several of the audio recording programs to reduce water noise. Ongoing development of a filtering protocol will increase the utility of future data collection.

Of the five sites for which audio data analysis has been begun, over 579 hours (196 GB) of data were collected. This data is being analyzed using Wildlife Acoustics Kaleidoscope software package (see example results in Figure 6). The process of identifying bird species from the data is ongoing. It has thus far been noted that the data is of high quality and will be of great utility in identifying species present at these sites.

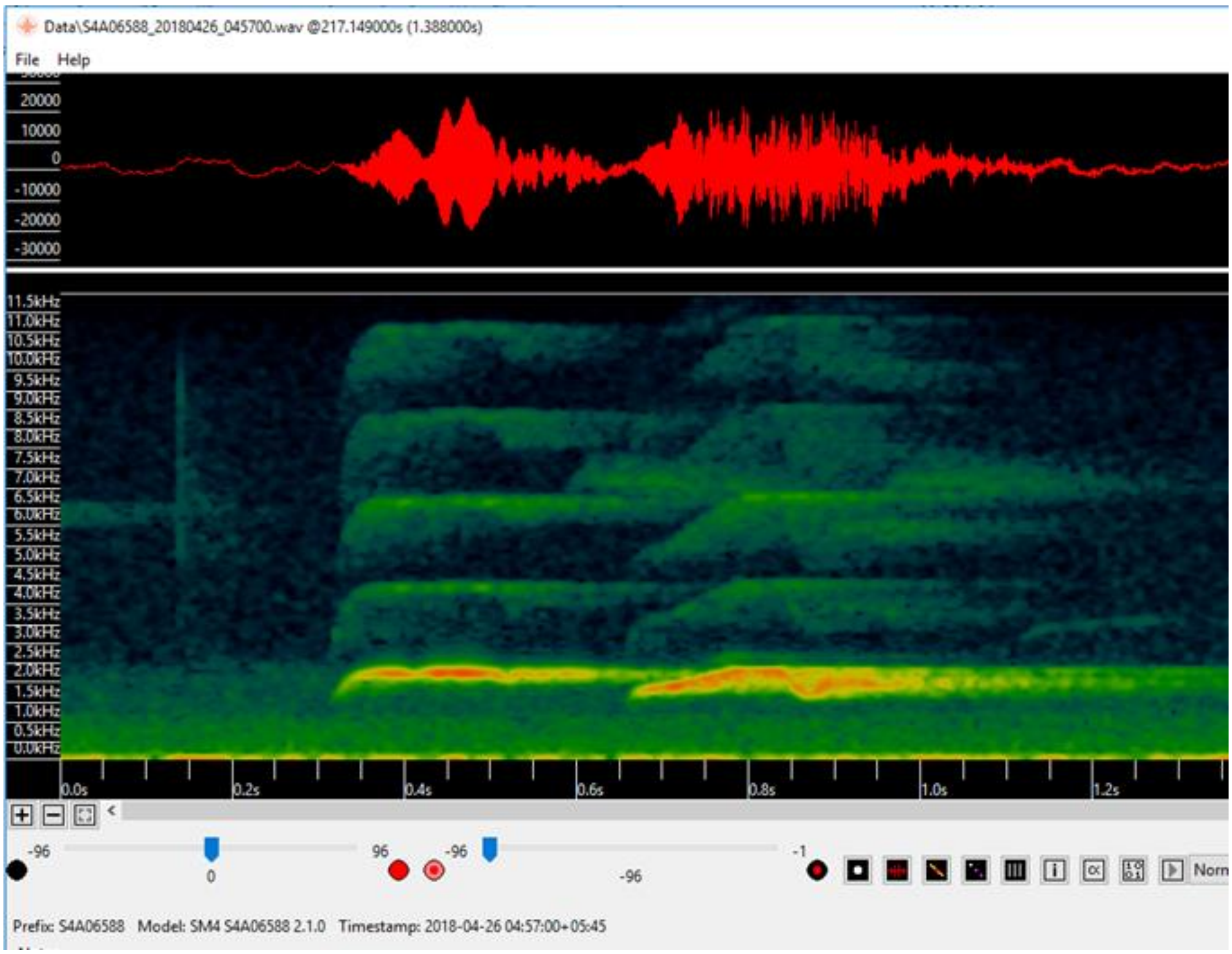


Figure 6: Example Birdsong Analysis from Deaurali Site

Browning Strike Force Pro wildlife cameras were installed at Kali Khola and Ramite Danda to detect passing wildlife. Both installation locations showed considerable sign of wildlife. The camera traps will photograph wildlife during the day and use infrared flash photography to document nighttime wildlife. Two additional cameras are ready to be installed at higher elevations after the monsoon passes.

4.7 Socio-economic Study

This is a preliminary report prepared based on field study in the settlement areas of Barun valley aiming to develop a five year's future project proposal for climate change study with and through the locals in the Barun biomeridian. In the field, the meetings were therefore formally organized with the locals by applying the methodologies of Appreciative Participatory Planning and Action (APPA) and Wellbeing Ranking for the appraisal of existing situation, resources, income generating status and prioritized needs of the local community focusing on future project. Open-ended interviews with the local knowledgeable persons, Makalu-Barun National Park's staff, school teachers, women groups and observation on existing development activities were also done during the field study. The field study was scheduled from March 7, 2018 to March 18, 2018.

Settlements of the People:

Located on eastern flank, the Project Area/Barun Valley encompasses mainly three main villages i.e. Simbung, Syaksila, and Lingam/Magkhim in the upper slopes of the confluences of rivers Barun and Arun, the Arun and the Wangkhola stream and, the Arun and the Thadokhola stream respectively. There are two new settlements also called Gola and Barun Dovan developed for local business purpose on the right bank of the Arun near the confluences of the Arun and the Wangkhola stream and, rivers Barun and Arun respectively below the main villages. The newly constructing track of Koshi highway which will connect India and Tibet, China in the future goes right through these new settlements and Simbung village. The Barun, which comes down from the glacier of Mt. Makalu and meets the Arun at Barun Dovan in the area, separates Simbung and Syaksila villages and the Wangkhola stream divides Syaksila and Lingam/Magkhim villages. The Arun River that comes down from Tibet in the area flows bordering on the east. The elevations of the settlement areas range from 1,100 m at the confluence of the Arun and the Thadokhola stream to 1,750 m at Simbung village.

These settlements of Simbung, Syaksila and Lingam/Mangkhim that were previously divided in Wards 5, 6 and 7 of Hatiya Village Development Committee respectively and are now contained in only Ward-4 of Bhotkhola Rural Municipality under the new structure of federal political system of the country. The all settlements are entirely found in the Buffer Zone of Makalu-Barun National Park.

The settlement pattern of Lingam/Mangkhim is found in scatter form and other are found in cluster forms encircling by agricultural lands. Gola is being developed in a small town form. Most of the traditional wooden plank and bamboo-mat roof of two-story stone walled houses of the area has been recently being replaced by blue and green corrugated tin sheets.

The People:

Most of the residents of Simbung and Syaksila villages are the Singsawa who came from Tibet via Ragala pass with their goats in ancient time according to their migration history. The Singsawa ethnic group is generally known as Bhote or Kath Bhote in the region. Some of them have recently begun to call Lhomi also by themselves specifying the meaning of Southerners in Tibetan language. Besides, Lingam/Mangkhim and other small hamlets namely Gola and Adima include the ethnic groups of the Gurungs, the Sherpas, the Rais, the Tamangs and two families of the Newar.

There is one landless Dalit family of Kami in Syaksila village who survives on iron smithy-work traditionally and there is another Dalit family of Damai at Gola who came to settle recently for his traditional tailoring job. The ethnic groups of the Singsawas, the Sherpas, the Rais and the Tamangs of the area speak their own mother languages separately, though they speak Nepali as well to keep the communication to one another.

The area holds 235 household and 1,172 people in total of all ethnic and caste groups comprising 584 male and 588 female. Among them, one family of Syaksila and two families of Simbung owned houses in Khandbari municipality. A number of families of Lingam/Mangkhim and Gola have lands and houses in Khandbari area. A person of Lingam who is involved in tourism business has a house in Kathmandu also.

The Culture:

The Singsawas follow the Ningmapa, an old sect of Tibetan Buddhism, albeit they practice shamanism as well. They need both monk and shaman to perform their rite and rituals. They use to call Lhaven for male shaman and Khendoma for female shaman. Likewise, the Sherpas, the Gurungs and the Tamangs also follow the same sect of Buddhism and shamanism as the Singsawas. The Rais are the followers of animism/Muddumism, a primitive religion that believes on nature. There are ten monks, three Lhaven and one Khendoma in Syaksila. Likewise, seven monks, six Lhaven and one Aamchi (a person who practices medical treatment by using medicinal plants) are found in Simbung. Rai Bijuwas (Shamans) are also found in the area.

Gyalbo Loshar, Tamu Loshar and Sonam Loshar, which fall basically in the months of January and February, are the main festivals of the Singsawas, the Gurungs and the Tamangs respectively. Buddhist people go to the Gombas every month to light the lamps and to worship the god, Buddha along with other deities. The Singsawas organize a big worship celebration traditionally in their Gomabs on each full-moon day of Mangsir (November/ December) each year which is called Jayaman. Likewise, the Rais worship the earth deity two times each year. Besides, all the households of each village together worship forest deities such as Singha Devi, Jala Kannya, Sansari and Jalapa in Ashoj (September/October) and in Chaitra (March/April) in each settlement area each year. At that time, they sacrifice chicken and, male goats and sheep to the shrines of forest deities. And they celebrate the festivals of Maghe Sankrati, Saune Sankrati and Tihar as well cheerfully.

Ethno-cultural System of Bhote Ethnicity:

The northernmost area of Sankhuwasabha district is well known by the name of Bhot Khola area. The word "Bhot" denotes to the Trans-Himalayan region and the "Khola" to the river. There is no river that is called as Bhot Khola but the area is, however, called as Bhot Khola. And the people who live in the Bhot is known by Bhote. People of Bhot Khola area are known to be migrated from Trans-Himalayan region, the Bhot. As such, Bhot Khola area has been inhabited by Bhote community from long time. Till now, the community is the dominant in the area.

The Bhote celebrate various cultural events at different times for a specific period in a year (Table 11). In each cultural event, burning of batti (cotton thread dipped in oil or ghee) and worshipping of gods are carried out in Gumba (religious site of Buddhism religion like temple in Hindu ethnicity). Lama (the Buddhist priest) worships in the Gumba. In special events, Dhoja (timber of certain tree species) is erected in front of the Gumba.

Each and every cultural event requires/uses certain biological resources such as timber of certain species of trees, wild animal's body parts, flowers and fruits of certain plant species, products of plants and animals etc. (Table 11). The cultures are known to have been celebrating as usual till now. There are seven Buddhist monasteries in the area. Among them, Samling Gomba and Nukchheling Gomba are in Syaksila village and Mendung Gomba and Membung Gomba are in Simbung village. Likewise, Khempalung Gomba and Imjung Gomba are found at Barun Dovan, a sacred confluence site of rivers Barun and Arun. And another one named Barun Shikhar Gomba is found in Ligam village.

The Kiduk, a traditional social association found in each Singsawa and Sherpa village is a very effective institution of these communities. This institution keeps harmonious social unity and relationship within the community. Under Kiduk, each household provides physical and financial helps to each other in scarcity. They donate food grains, money, utensils and even land, and help to build houses.

Table 11: Ethno-culture system of Bhote, Gurung, and Rai ethnicity

Name	Celebrating Month	Duration	Activities carried out	Needed plants/animals and their products
Buddha jayanti	Jestha	1 day	Burning light in Gumba, Dhoja erected, Lama reading and meeting at Gumba	Champ, Utis, Kharane, Patle katus, Choya (bamboo)
Gyalbo Loshar	1st Falgun	At least 5 days otherwise one week	Lama worships for 3 consecutive days in Gumba, dances wearing mask, eating and drinking thukpa and chhyang	Kodo (Millet), available flowers

Shrawan sankranti	sharwan 1	One day	Worship in Gumba, new dhoja erected	Fish, bird, Paha, legs of wild animals (deer, musk deer) Tail of laicharo
Dasai	Asoj	5 days	Celebration with food and dances	
Tihar	Kartik		Lightening by burning cotton thread, eating feast and drinking	Kodo, Cow's ghee
Maghe sankranti	Magh 1	One day		Worship in Gumba
Lohsar	Poush 15	1 day	Celebration with food and dances	Tarul (dioscirea sps)
Chaitra dasai	Chaitra	One day		Worship in Gumba
Mukhya puja (Major worship)	Kartik	3 days	worshipping in Gumba, Dancing with mask and beating tarma for music	Ghoge champ, Rani champ, Aule champe, Pahelo champ
Marriage ceremony	Mangsir, Magh and falgun		Doors of rhododendron, champs constructed, Burning Titepati for smoke to get bride into house, Feast and drinking	Titepati, Champ, Gurans, Tori, Sag
Naming ceremony of newly birth baby (Nwaran)		3rd day of birth	Dhup of sallo, Sunpati, Bhairav pati, Kapoor, Kasturi, Chirmiri, wild cock, Bakulla, Saur	
Death mourning		3 days	Lama worships. Dead body is burnt. Titepati is used for clearing (chokyawune Dhup of juniper is burnt	Titepati, Sallo, Flower of Gurans, Nigalo, Paiynu
Chinta	During child birth and death of man			Chichilkote, Fish, Nigalo, Musure katush, Patle katush, leaf of Kera (Bannana), skin of Deer or Ghoral
Ubhauli pooja- Plantation	Chaitra- Baisakh		Worship of god and goddess	Patha (Pig), Kukhura (Chick) available flowers
Udhauli pooja- harvesting main crops	Kartik Mangsir		Worship of god and goddess	Patha (Pig), Kukhura (Chick) available flowers

Ethno-botanical species of Barun Valley's Community:

Communities of Barun valley have been traditionally using various species for various purposes such as culture, medicinal, timber, fodder etc. A total of 36 species of plants that are used by the communities have been recorded during present field work. Their corresponding scientific names were identified based on the local names reported in various books and reports but the scientific name of one species, locally called as “khanakpa" remained unknown. However, 35 species of plants belonging to 25 families have been sorted out (Table 12). Among them, 16 species are of tree lifeform, 11 of herb (including herbaceous climber), 6 of shrub (including woody climber) and two species of bamboo life form.

Distribution wise analysis of the species revealed that the altitudinal zone between 2000m and 2500 m had larger number of ethno-botanically significant species (20 species) whereas the zone of 1500m to 2000m and the zone of 2500m to 3000m had 15 species in each zone. The number of ethno-botanical species was found gradually decreasing while moving up to higher elevation (Figure 7). Most of the plants (more than 10 species) flower during April to July whereas 5 to 7 species flower during March, August and September (Table 12).

Table 12: Ethno-botanical species and their ecological features

Local name	**Scientific name**	**Family**	**Life form**	**Flowering -fruiting time**	**Altitudinal distribution (m)**	**Status**	**Habitat**
Bhairavpati	*Rhododendron lepidotum*	Ericaceae	Shrub	Jun-Jul	2100-4700		Forest, shrubberies
Bhakiamilo	*Rhus javanica*	Anacardiaceae	Tree	Aug-sept	1300-2400		Forest
Bhoj patra	*Betula utilis*	Betulaceae	Tree	Apr-May	2700-4300		Forest
Bikh	*Aconitum spicatum*	Ranunculaceae	Tall Herb	Aug-Sept	1800-4200	Commercially threatened	Forest/ shrubberies
Bojho	*Acorus calamus*	Araceae	Herb		1700-2300		
Boke timur	*Zanthoxylum oxyphyllum*	Rutaceae	Shrub	Apr-May	2100-2800		
Champ	*Magnolia campbellii*	Magnoliaceae	Tree	Mar-Apr	2250-2700	Rare	Forest
Chilaune	*Schima wallichii*	Theaceae	Tree	May-Jun	900-2100	Decreasing	Forest
Chinde	*Pentapanax leschenaultia*	Araliaceae	Tree	May-Jul	1600-3700		
Chiraito	*Swertia chirayita*	Gentianaceae	Annual Herb	May-Oct	1500-2500	Vulnerable	Open moist place
Dhupi	*Juniper sps*	Cupressaceae	Evergree shrub/ small Tree		2700-4600		
Gurans	*Rhododendron arboreum*	Ericaceae	Tree	Feb-May	1500-3300		
Harjor/Harchur	*Viscum album*	Loranthaceae	Evergreen Parasitic shrub on tree	Mar-May	600-2300		
Indrayani	*Trichosanthes tricuspidata*	Cucurbitaceae	Woody climber	May-Aug	1200-2300	Common	Shruberries
Kapoor	*Cinnamomum camphora*	Lauraceae	Tree	Apr-May	1300-1500		
Kaulo	*Persea odoratisssima*	Lauraceae	Tree	Mar-Apr	1000-2000		
Kharane	*Symplocos ramosissima*	Symplocaceae	Tree/shrub	May-Jul	1400-2600		
Majitho	*Rubia manjith*	Rubiaceae	Climbing herb	June-Nov	1200-2100		Forests and shrubberies
Malingo	*Arundinaria manling*	Poaceae	Bamboos		2500-3000		

Musure/Kalo katus	*Castanopsis tribuloides*	Fagaceae	Tree	Mar-May	450-2300	Abundant	Forest
Nigalo	*Arundinaria aristata*	Poaceae	Bamboo		2200-3100		Forest, shrubberies
Padamchal	*Rheum austral*	Polygonacae	Perennial Herb	Jun-Jul	3200-4200		Open slopes
Painyu	*Prunus ceracoides*	Rosaceae	Tree	Oct-Nov	1300-2400	Decreasing	forest
Panchaule	*Dactyloriza hatigeria*	Ochidaceae	Herb	Jun-Jul	2800-3960	NG protected/ CITES-II	Shruberries, open slopes, marshes
Pashanvedh	*Bergenia ciliate*	Saxifragaceae	Perennial Herb	Mar-Jul	900-1700		Forest rock edge
Patle/seto katus	*Castanopis hystrix*	Fagaceae	Tree	Apr-May	1000-2500	Abundant	Forest
Satuwa	*Paris polyphylla*	Liliaceae	Perennial Herb	Apr-May	2900-3100	Vulnerable	Forest
Saur	*Betula alnoides*	Betulacease	Tree	Nov-Dec	1200-2600		
Sil timur	*Lindera neesiana*	Lauraceae	Small tree		1800-2700		
Sunpati	*Rhodondendron anthopogon*	Ericaceae	Shrub	May-Jul	3300-5100		Shrubberies /open slope
Tarul	*Dioscorea alata*	Dioscoreaceae	Herbaceous climber		600-1200		Forest
Thulo okhati/ budho okhati	*Astilbe rivularis*	Saxifragaceae	Herb	Jul-Sept	2000-3600		Shrubberies
Timur	*Zanthoxylum armatum*	Rutaceae	Small tree	Apr-May	1100-2500		Shrubberies
Titepati	*Artemisia*	Asteraceae	Tall herb	Jul-Sept	300-2400	Common	Open place
Utis	*Alnus nepalenis*	Betulaceae	Tree	Oct-Dec	500-2600	Abundant	River gullies, damp forest

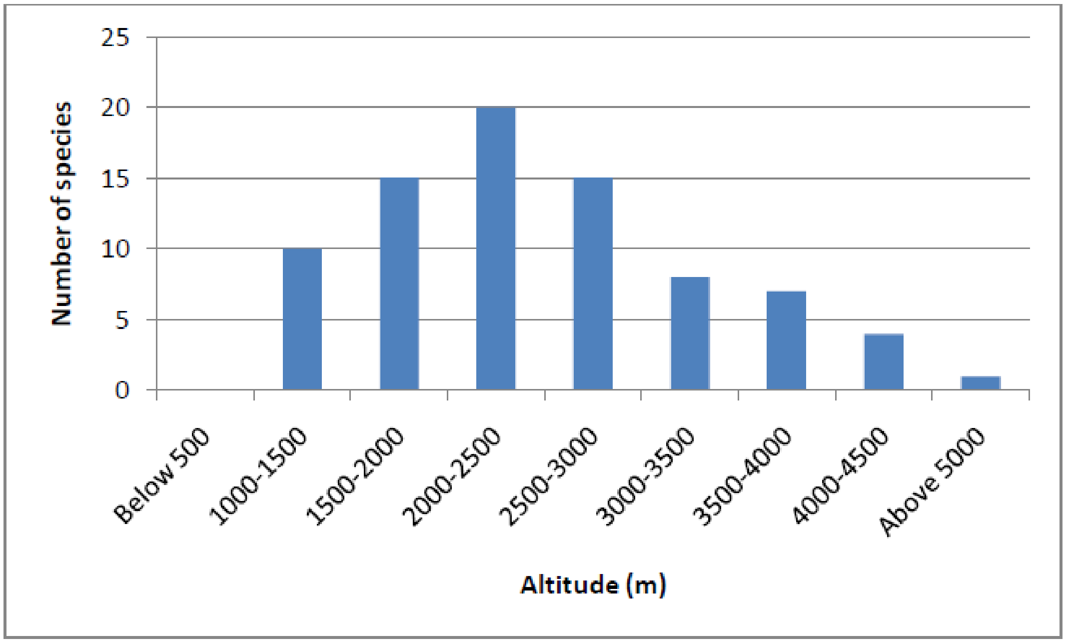


Figure 7: Altitudinal Distribution of Ethno-botanical Species

Income-Generating Activities of the Area:

Agriculture is the primary occupation practiced in the area. The staple crops of the area include maize, finger millet, rice, barley, wheat, and naked barley followed by potato and buckwheat. Big sized soybean of Syaksila is a very demanding item even down to Khandbari bazaar, the headquarters of Sankhuwasabha district. Besides, mustard, garlic, red chili, radish, tomato and other seasonal vegetables are grown in the area. A few families recently introduced cabbage and cauliflower for their own diet. Besides that horticulture and big cardamom plantation has been adopted to generate income in the sloped areas of the villages. Secondary occupations were animal husbandry and trade while some youth are engaged in labor jobs within and outside Nepal.

Climate Change:

According to the locals, rainfall and snowfall do not occur timely as before in the area. In the past, snowfall came near to the villages. Sometimes, it came to cover the village houses also. But now it happens unevenly and creates more floods. For instance, a glacier lake outburst flood frighteningly occurred in the Barun on May 21, 2017 and it damaged and washed down the virgin gorge of the Barun along with the rice field at Barun Dovan.

Table 13: Climate change in Barun valley

	Before (10/15) years ago		Now	Impact
Temperature	Snow fall occurred		No snow fall	Increase of hotness
Rainfall	**Duration**	Every month	Irregular	Increase of drought / landslide
	Amount		Plenty	Not plenty
	Pattern		Homogenously	Heavy when hot
Spring water sources		Yes	Dried	Deterioration of Irrigation system, drinking water to be brought from very fa
Pond		Yes	No	

The water sources are also drying up in the area. The people of Simbung village reported that the water sources of Aagongjen, Thongde, Takachen, Lumbungchen and Dingang which are found in their village are remarkably drying up. In the past, people fetched the water from these sources for family use and their animals also quenched thirst from the ponds of these sources. Similarly, the water source of Takpa Kharka in Lingam is also drying up in where the people and their animals depended throughout the year. Instead, they have now a water supply from the Sisne Muhan. People feel a little bit warmer also than before in the area.

4.8 Community Engagement and Development

A training program was held at Barun Dovan to share information about the utility of the temperature and humidity loggers and acoustic recorders, along with their technical matters such as installation, setting parameters, and downloading recorded data with the local communities. Local community members, game scout (represent from the National Park), local police, TEF's staff, and team's experts participated in the meeting. The objective of this program was to involve local communities in collecting the climatic data and birds' sound, and to make them aware about the direct or indirect impact of climate change on their livelihoods.

Community participation has been adopted for conservation and development initiatives by the government and working line agencies, believing that without community engagement and participation it is impossible to do conservation. Community based conservation is the most effective solution and sustainable according to Future Generations experience working in international border with the Qomolangma National Nature Preserve of the Tibet Autonomous Region in the north.

Future Generation University has initiated community development work based on the concept of “by the community and with the community” and first to support eco-tourism helped in maintain the Yeti Trail which is yet to be recognized as a trail route to Makalu Base Camp. In 2011 Future Generations staff conducted a baseline study for community development and to support them partnership was signed with Share & Care Nepal, TEF and financial support to constructing Yeti Trail and community training.

Community development work previously completed in the past few years by the same partners in the Barun Valley area:

1. Yeti Trail construction.
2. Six local volunteers trained 3 month residential, 9 month online and community lab project.
3. Ten local community volunteers trained 15 days training cum exposure visits.
4. Technical skills:
    a. One carpenter
    b. One mechanic
    c. Two electronic maintenance (Mobile, TV, Radio etc.)

After the above training, participants applied learning from training and started following activities:

d. Formed various groups such as women group, farmers group, Youth group, Social welfare committee and strengthened community forest user groups.
e. Group started sanitation around the villages,
f. Every group collected funds for income generations and social projects.
g. Participants supporting and teaching in school
h. Started Home stay and shops by participants after the training.
i. Built Toilets by every house help of local government and mentoring by volunteers.
j. Starting kitchen gardens and horticulture.
k. Cardamom production cross the Barun Valley

As part of this pilot study for the biomeridian project, the following community meetings were conducted. In these meetings, people were asked to dream for their future projects and prioritize them to implement in requirement basis. The list of prioritized projects is as follows:

<u>Prioritized projects of Syaksila village:</u>

1. Protection of Okti Nagthan water source
2. Hybrid male goat and pig
3. Development of horticulture along with orange, Rudrakchhe, Bhodhi Chitta, apple, walnut, grape, kiwi, coffee and other marketable fruits
4. Development of home-stay program
5. Cultivation of Satuwa and Chireto
6. Development of vegetables cultivation
7. Training on Allo
8. Training on management of cooperative/saving & credit
9. Training on conservation awareness

10. Installation of improved oven
11. Development of bee Keeping
12. Training on carpentry
13. Establishment of electric mill
14. Development of private forests

Prioritized projects of Simbung village:

1. Hybrid male goat and pig
2. Plantation of orange, walnut, Rudrakchhe, Bhodhi Chitta, apple, grape, kiwi, coffee, tea, paulonia and other marketable fruits
3. Cultivation of Satuwa, Chireto and Taxes
4. Training on Allo
5. Establishment of Lokta paper factory
6. Bee-Keeping
7. Training on black cardamom processing
8. Installation of improved oven
9. Development of home-stay program
10. Village drinking water supply maintenance
11. Conservation of Aagongjen, Thongde, Takachen, Lumbungchen and Dingang which are going to be dried up
12. Training on carpentry

Prioritized projects of Lingam/Mangkhim village:

1. Hybrid male goat, pig and buffalo
2. Drinking water supply maintenance
3. Cultivation of medicinal plants such as Satuwa, chirto and Taxes
4. Development of kitchen garden
5. Barun Shikhar Gomba maintenance
6. Training on Allo
7. Bee-keeping
8. Training on electricity wiring
9. Training on carpentry
10. Training on conservation

Assistance was provided to begin addressing these priorities.

4.9 Lessons Learning from Pilot Study

Scientific Survey

- Setting up monitoring stations at 250 m to 500 meters was difficult, especially in the village areas as most of the sites were heavily disturbed. Difficulties also arose due to long travel times to higher elevation sites.
- Replacing the battery for sound recorders with solar panels will support extension of the biomeridian transect to higher elevations. Filters on sound recorders near streams/rivers will decrease background noise and increase utility of the data.
- Only one side of the Barun River valley is currently covered and results obtained here cannot be generalized for the other slope sides. Additional work should include extension to the entire Barun watershed.

Community Survey

- Barun Valley community exposure visits, leadership training and community development support has boosted the moral of the villagers to support conservation initiatives, but as not all villages are covered, further planning is needed
- Ward level initiation to be mainstreamed with our project initiations for sustainability
- Yeti Trail to be explored by National Tourism Board and give recognition so eco-tourism can be started by the Barun people only
- Future Generations already building network now with DNPWC, Share & Care Nepal, Nepali academic institutions, and local governing bodies for sustainability of the projects
- Local farmers yet to be trained and promoted for commercial farming then subsistence farming for income generation and stop shifting cultivation practices
- Community development courses to be supported throughout the project period to ensure that the youth are involved in the conservation and development issues
- Homestay initiation in Syaksila and Gola needs to be scaled up and more training to be provided in future
- Support more improved cooking stoves to minimize the pressure in fuel wood consumption

5. Conclusion and Recommendations

The subtropical zone (1000m-2000m) in the Barun Valley area is largely covered by cultivated land, private forest and community forest. As such, this zone is under heavy anthropogenic pressure. As a consequence, the intact natural vegetation is lacking in the zone, and this must be taken into consideration for planning of long-term monitoring efforts.

The original plan was to install Acoustic Recorder along the Yeti Trail in each bioclimatic zone at 500 m altitudinal interval. Due to the low overall gradient of the Yeti Trail below 2000m (2-3 days walk to cover this distance) the complete transect was not yet completed. The difficult terrain, frequent precipitation, and long travel times to elevations above 2000m pose difficulties in changing the batteries of the audio recording devices. In May the team began testing solar power for the powering of the audio recording devices and that testing continues. The installation of the device above 2000m altitude will be completed after further testing of equipment and the passing of the monsoon.

Initial results of temperature and relative humidity monitoring collected more than 30,000 measurements between March and May 2018 at three sites. Continued monitoring at these and other sites will create a rich dataset which can be used to study climate change.

Analysis of audio data collected at monitoring locations has begun. Data collection was successful and resulted in more than 579 hours of audio data from five sites. This data is being analyzed to identify bird species and to inform refinement of the experimental design and instrumentation methodology. This pilot data collection was quite informative both on practical and scientific levels and will lead to increased quality of data collection as the biomeridian project moves forward.

It is anticipated that using of ethno-botanical species on climate change monitoring will help local communities understand about climate change and its impact upon their subsistence production, and consequently will help to develop their capacity on informed decision making to cope with the threats. Most of the ethno-botanically significant species belong to tree and herb life forms, and the upper subtropical. Since, collinean and montane zones are relatively more sensitive to climate change and these zones have larger number the species that are of interest to and familiar to locals, involving of the locals in climate change monitoring in these zones would help to achieve anticipated outputs.

Recommendations:

This pilot project resulted in the following recommendations for continued work

- Awareness programs on ethno-culture, ethno-botany and ethno-agriculture to maintain the traditional knowledge and practices.
- Awareness of climate change and its impact upon the communities' daily livelihood requires be increased.
- Detailed studies of pollinator dependent plants and their pollinators should be conducted with people participation.

- Many scientifically identified species may be known even by a single local name and vice versa. They might differ not only at species level but also at family level too. Without studying the specimens, the scientific names identified based on local names might be wrong. This prompts the need for reconfirming the ethno-botanical species identified based on the local names through specimen-based studies.
- Permanent plots should be established in national park i.e. beyond the community forestry, most probably above 2000m where natural vegetation is intact. The vegetation of temperate zone (2000m - 3000m) is relatively sensitive to climate. Permanent plots should be established in both north and south facing slopes in this zone.
- Since the HOBO temperature and humidity loggers can operate for 5 years without changing battery, these devices could be installed in remote places where permanent plots could be established.
- It is recommended that solar power be added to SM4 acoustic recorders due to the labor and time intensive nature of changing batteries at far locations monthly.
  During the current project period, a short training on the scientific instrumentation was given to limited persons. Such training should be extended to a wider group of community members and stakeholders.
- It is necessary to conduct integrated training programs which would help to raise awareness of the local communities to the climate changes and the direct or indirect consequences upon their livelihood including in agricultural product.

Overall the **Walking Trees along Lifezone Ecotones in Barun Valley, Nepal** pilot project to develop key indicators for monitoring Biomeridians - *Climate Response through Information & Local Engagement* was a success. Community engagement and scientific data collection were begun. Already this information informs moving forward in both sustainable development and research.

It is recommended that this project continue with the further development of key-indicators for climate change, the installation of scientific instrumentation, and community engagement and development. A 5-year framework outlining this continued work will be presented in a separate document.

This valuable work contributes to long-term sustainable development in the Barun Valley Region and also to scientific knowledge of climate change in the region. It also positions the Barun Valley Biomeridian as a showcase project for future global expansion of the biomeridian project.

Reference:

Adger, W.N., 2000. Social and ecological resilience: are they related? Prog. Hum.Geogr. 24, 347e364. http://dx.doi.org/10.1191/030913200701540465.

Begossi, A., Hanazaki, N., Tamashiro, J.Y., 2002. Medicinal plants in the Atlantic forest (Brazil): Knowledge, use and conservation. Hum. Ecol. 30, 281e299.http://dx.doi.org/10.1023/A:1016564217719.

Benz, B.F., Cevallos, E.,J., Santana, M.,F., Rosales, A.,J., Graf, M.,S., 2000. Losing knowledge about plant use in the sierra de manantlan biosphere reserve, Mexico. Econ. Bot. 54, 183e191. http://dx.doi.org/10.1007/BF02907821.

Berkes, F., Colding, J., Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. Ecol. Appl. 10, 1251e1262, 10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2.

Durant, J.M., Hjermann, D.Ø., Ottersen, G. &Stenseth, N.C. (2007). Climate and the match or mismatch between predator requirements and resource availability. *Clin. Res*., 33, 271–283.

Dobremez, J.F. and Shakya, P.R. (1975). Carte Ecologique du Nepal. Biranagar-Kanchenjunga 1:250,000 *Cahiers Nepalais Documents* No. 7 CNRS, Paris.

Hegland, S.J., Nielsen, A., Lazaro, A., Bjerknes, A. & Totlan, O. (2009). How does climate warming affect plant-pollinator interactions? *Ecology Letter*, 12, 184-195.

IPCC (2000) *Special Report of the Intergovernmental Panel on Climate Change: Emissions Scenarios. Summary for Policymakers,* Cambridge, GB, Cambridge University Press.

IPCC (2001a) *Climate change 2001. Impacts, adaptation, and vulnerability,* Cambridge, GB, Cambridge University Press.

Keller, F., Kienast, F. & Beniston, M. (2000) Evidence of response of vegetation to environmental change on high-elevation sites in the Swiss Alps. *Reg. Environ. Change,* 1**,** 70-77.

Kullman, L. (2007) Tree line population monitoring of Pinus sylvestris in the Swedish Scandes, 1973-2005: implications for tree line theory and climate change ecology. *Journal of Ecology,* 95**,** 41-52.

Mazepa, V. S. (2005) Stand density in the last millennium at the upper tree-line ecotone in the Polar Ural Mountains. *Canadian Journal of Forest Research-Revue Canadienne De Recherche Forestiere,* 35**,** 2082-2091.

Meshinev, T., Apostolova, I. &Koleva, E. (2000) Influence of warming on timberline rising: a case study on Pinus peuce Griseb. in Bulgaria. *Phytocoenologia,* 30**,** 431-438.

Motta, R. & Nola, P. (2001) Growth trends and dynamics in sub-alpine forest stands in the Varaita Valley (Piedmont, Italy) and their relationships with human activities and global change. *Journal of Vegetation Science,* 12**,** 219-230.

Motta, R., Morales, M. & Nola, P. (2006) Human land-use, forest dynamics and tree growth at the treeline in the Western Italian Alps. *Annals of Forest Science,* 63**,** 739-747.

OCCC (2002) Das Klima ändert - auch in der Schweiz: die wichtigsten Ergebnisse des drittenWissensstandsberichts des IPCC aus der Sicht der Schweiz. Bern, CH, Beratendes Organ fürFragen der Klimaänderung.

Pauli, H., Gottfried, M. & Grabherr, G. (2001) High summits of the Alps in a changing climate. The oldest observation series on high mountain plant diversity in Europe. IN WALTHER, G. R., BURGA, C. A. & EDWARDS, P. J. (Eds.) *Fingerprints of climate change. Adapted behaviour and shifting species ranges.* NY, US, Kluwer Academic/Plenum Publishers.

Paulsen, J., Weber, U. M. & Körner, C. (2000) Tree growth near treeline: Abrupt or gradual reduction with altitude? *Arctic Antarctic and Alpine Research*, 32**,** 14-20.
Rebetez, M. & Reinhard, M. (2007) Monthly air temperature trends in Switzerland 1901-2000 and 1975-2004. *Theor. Appl. Climatol.,* in print.
Ruiz-Mall_en, I., Corbera, E. (2013) Community-based conservation and traditional ecological knowledge: implications for social-ecological resilience. Ecol. Soc. 18, 12.
Sharma E., Chettri N., Tse-ring K., Shrestha A.B., Jing F., Mool P. and Eriksson M. (2009). Climate Change Impacts and Vulnerability in the Eastern Himalayas. ICIMOD, Kathmandu.
Shrestha, T.B. (1989). Development Ecology of the Arun Basin in Nepal. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal.
Stenseth, N.C. &Mysterud, A. (2002). Climate, changing phenology, and other life history and traits: nonlinearity and match-mismatch to the environment. *Proc. Natl Acad. Sci. USA*, 99, 13379–13381.
Suwal M.K., Shrestha, K.B., Guragain, L., Shakya R., Shrestha, K., Bhuju, D.R. and Vetaas, O.R. (2016)Land-use change under a warming climate facilitated upslope expansion of Himalayan silver fir (*Abiesspectabilis*(D. Don) Spach. Accepted in 2016 by Plant Ecology, An International Journal.
Sturm, M., Racine, C. & Tape, K. (2001) Climate change - Increasing shrub abundance in the Arctic. *Nature*, 411**,** 546-547.
Walther, G.-R., Beissner, S. & Burga, C. A. (2005) Trends in the upward shift of alpine plants. *Journal of Vegetation Science,* 16**,** 541-548
Visser, M.E. & Both, C. (2005). Shifts in phenology due to global climate change: the need for a yardstick. *Proc. R. Soc. B-Biol. Sci*., 272, 2561–2569.
Yao, TD; Guo, XJ; Lonnie, T; Duan, KQ; Wang, NL; Pu,JC; Xu, BQ; Yang, XX; Sun, WZ (2006) ‘δ18O record and temperature change over the past 100 years in ice cores on the Tibetan Plateau’. *Science in China: Series D Earth Science*49(1): 1-9

Appendix A: List of community survey data

Table A 1: Village-wise population of the area

Name of Village	Household	Population		
		Total	Male	Female
Simbung	50	233	117	116
Syaksila	136	663	336	327
Lingam/Mangkhim	49	276	131	145
Total	235	1,172 (100%)	584 (50%)	588 (50%)

Source: Central Bureau of Statistics, Nepal 2012

Table A 2: Name of school and number of student by sex in the area

SN	Name of School	Student			Address
		Boys	Girls	Total	
1	Shree Popti Bhanjyang Adharbhut School (up to grade-vi)	59	79	138	Syaksila
2	Shree Bal Kalyan Adharbhut School (up to grade-v)	13	27	40	Simbung
3	Jorsalle School (up to grade-iii)	5	11	16	Mangkhim
4	Krishna Secondary School (up to grade-v)	26	27	53	Lingam
5	Krishna Secondary School (from grade vi to grade -x)	99	81	180	Gola
Total		202 (47%)	225 (53%)	427 (100%)	

Table A 3: Status of education obtained by the people in the area

Village	SLC		10 + 2		BA		MA		HA		CMA		Total
	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	
Syaksila	5	4	5	2	1	0	0	0	0	0	0	0	17
Simbung	5	2	1	0	1	0	0	0	0	0	0	0	9
Lingam	16	1	4	1	2	0	0	2	1	0	0	1	28
Grand Total	26	7	10	3	4	00	00	2	1	00	00	1	54

Table A 4: Agriculture calendar of Barun Valley from lower belt to upper belt

Crops/Vegetables	J	F	M	A	M	J	J	A	S	O	N	D
Maize			Sowing			Weeding			Harvesting			
Millet						Planting			Harvesting			
Rice						Planting			Harvesting			
Barley	Sowing				Harvesting						Sowing	
Wheat	Sowing				Harvesting						Sowing	
Naked barley	Sowing				Harvesting						Sowing	
Potato	Sowing			Harvesting								
Buckwheat	Sowing			Harvesting					Harvesting			
Soybean				Sowing					Harvesting			
Black cardamom					Planting		Weeding		Harvesting			
Mustard	Sowing								Harvesting			
Chireto				Sowing					Harvesting			
Radish	Harvesting								Sowing			
Beans				Sowing					Harvesting			
Cabbage and Cauliflower	Harvesting						Planting					

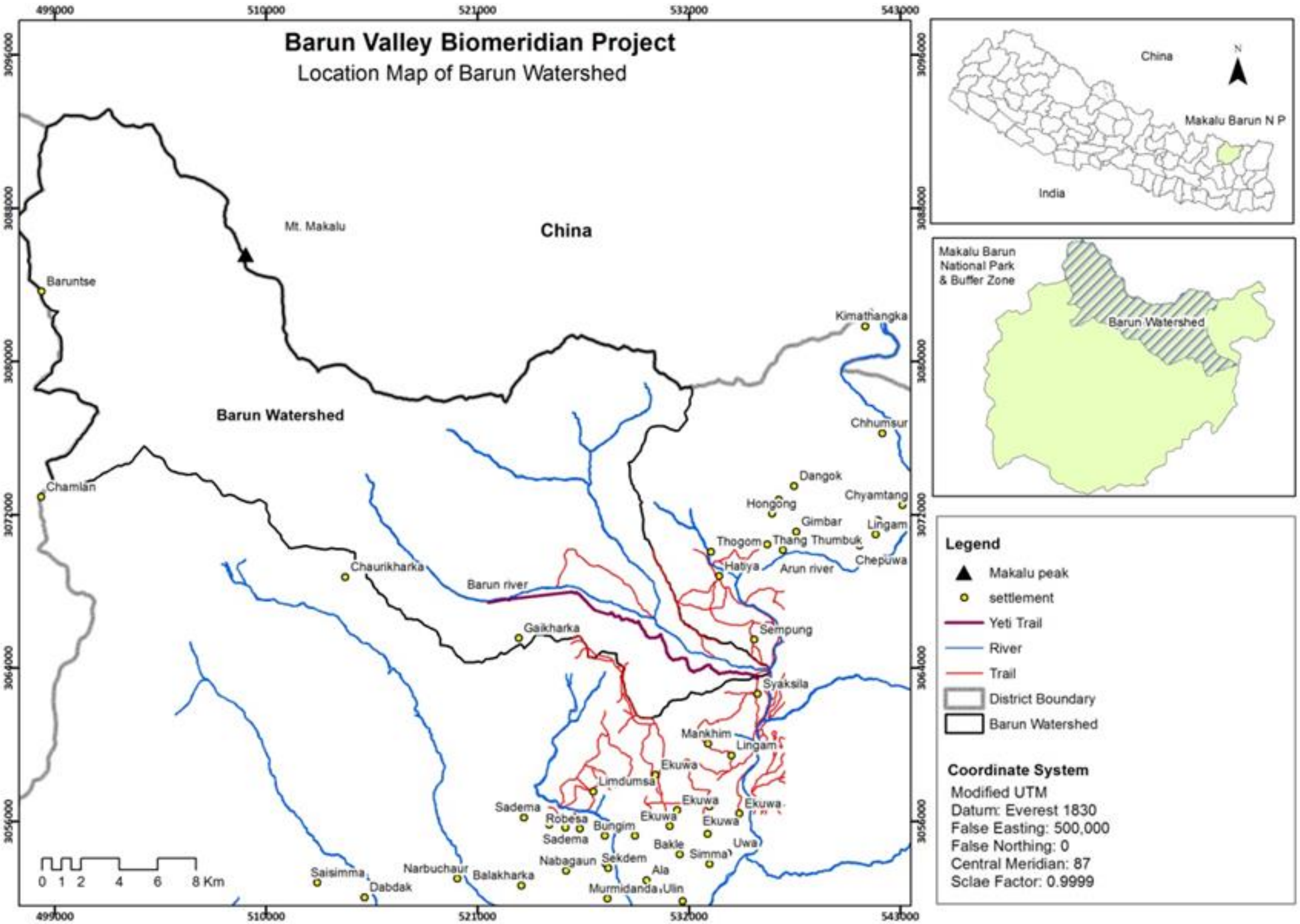
Table A 5: Name of development groups, their address, area of work, and funds

SN	Name of Groups	Address	Area of Work	Fund
1	Women Health Mother Group	Syaksila	Women health	00
2	Kopila Women Group	Syaksila	Sanitation and livestock	30,000
3	Okti Women Group	Syaksila	Sanitation and livestock	70,000
4	Arun-Barun Club	Syaksila	Sport and sanitation	00
5	Dungsing Self-help Group	Syaksila	Physical contribution on social affairs	00
6	Barun Self-help Group	Syaksila	Saving & credit	70,000
7	Thalima Self-help Group	Syaksila	Saving & credit	70,000
8	Makalu Self-help Group	Syaksila	Saving & credit	120,000
9	Jorkhanbe Self-help Group	Syaksila	Saving & credit	00
10	Star Bal Club for under 20	Syaksila	Relief in trouble	50,000
11	Simbung Samaj Yuwa Club	Simbung	Sport and social affairs	00
12	Janahit Ama Samuha	Simbung	Saving & credit	55,000
13	Mendung Gomba Self-help Group	Simbung	Saving & credit	450,000
14	Takachen Self-help Group	Simbung	Saving & credit	500,000
15	Dungsing Self-help Group	Simbung	Saving & credit	250,000
16	Simbung Kiduk Samuha	Simbung	Relief in trouble	17,000
17	Gramin Bachat Ama Samuha	Lingam	Saving & credit	60,000
18	Lali Gurans Yuwa Club	Lingam	Saving & credit	90,000
19	Bal Club for between 5 and 16 age	Lingam	Sport	70,000
20	Barun Agriculture Group	Barun Dovan	Agriculture	00
21	Barun Women Group	Barun Dovan	Saving & Credit	30,000
	Total			1,932,000

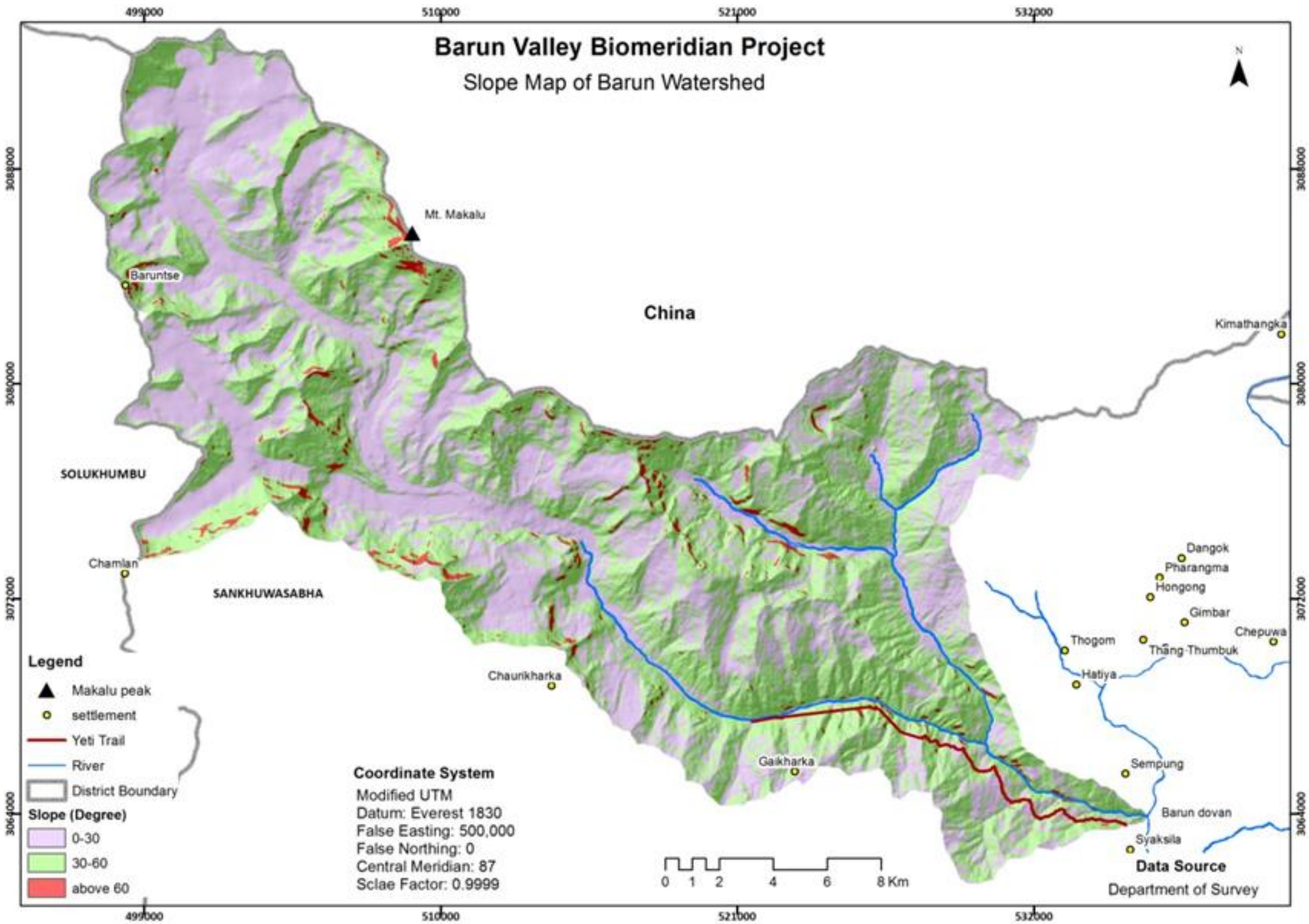
Table A 6: Wealth ranking of local people

Village	# of very poor household	# of poor household	# of Middle class household	# of Higher class household	Total
Syaksila	22 (16%)	47 (35%)	49 (36%)	18 (13%)	136 (100%)
Simbung	15 (30%)	28 (56%)	6 (12%)	1 (2%)	50 (100%)
Lingam/Mangkhim	8 (16%)	26 (53%)	10 (20%)	5 (10%)	49 (100%)
Grand Total	45 (19%)	101 (43%)	65 (28%)	24 (10%)	235 (100%)

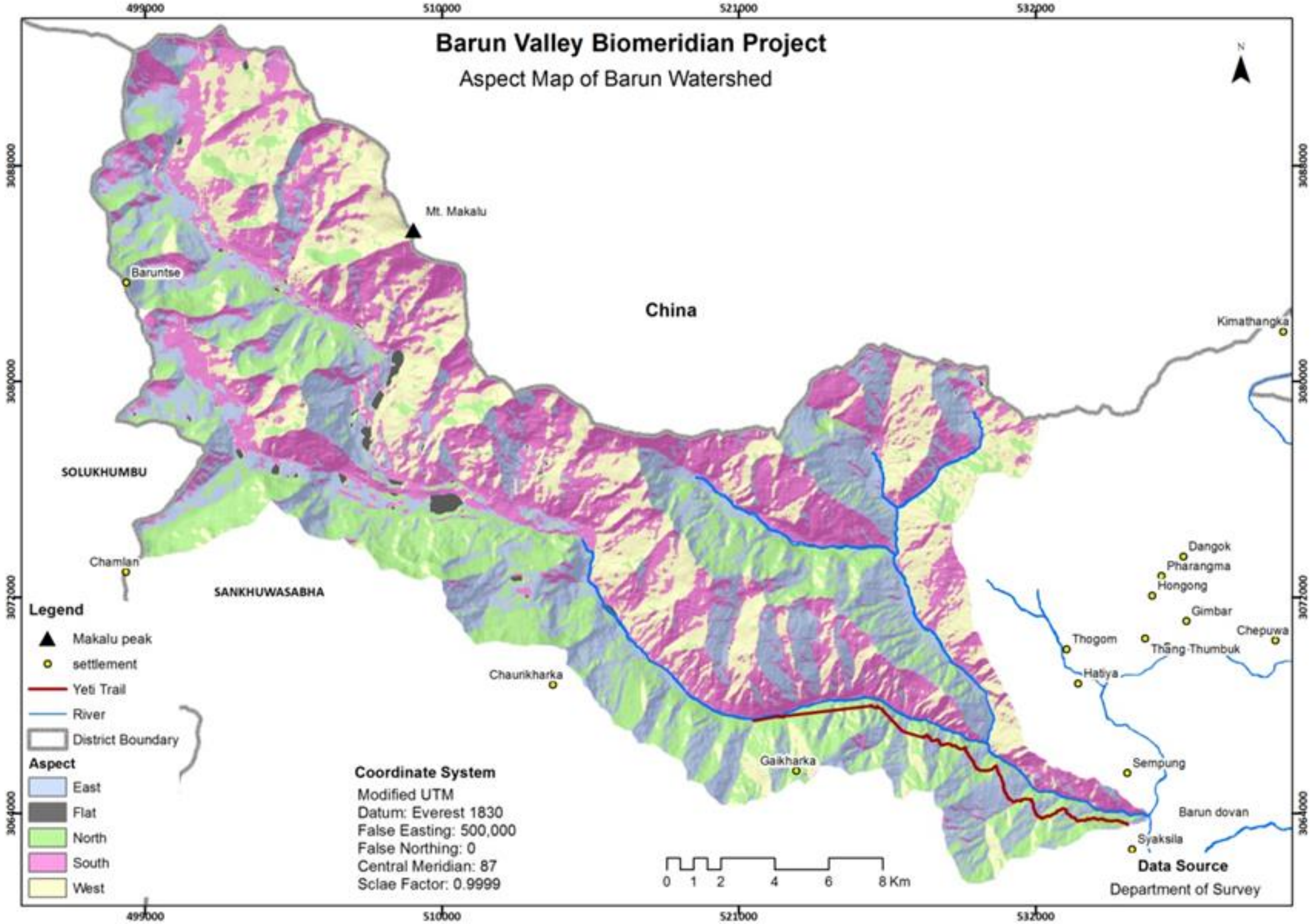
Appendix B: GIS Maps



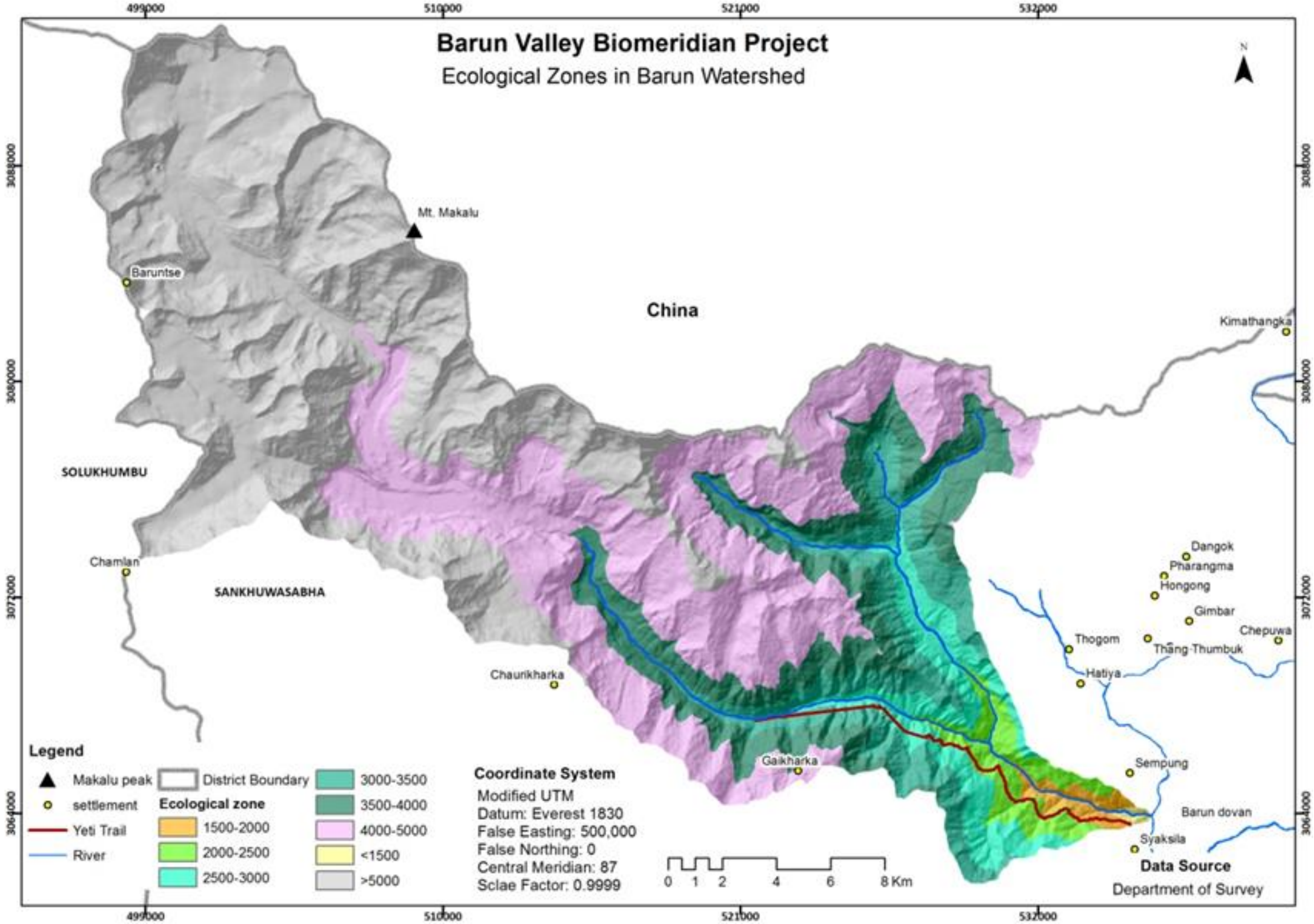
Map 1: Location map of Barun Valley/watershed



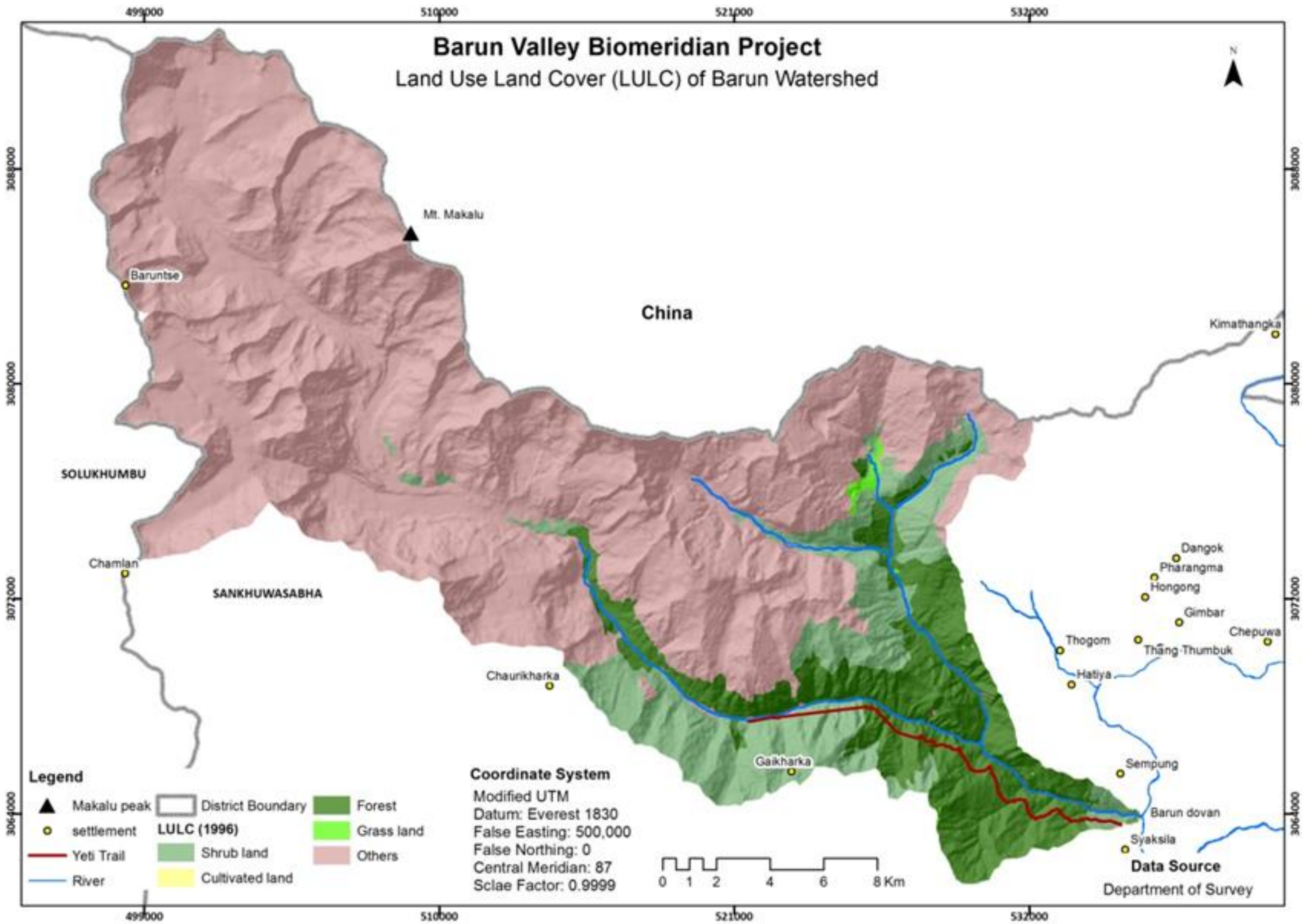
Map 2: Slope map of Barun watershed



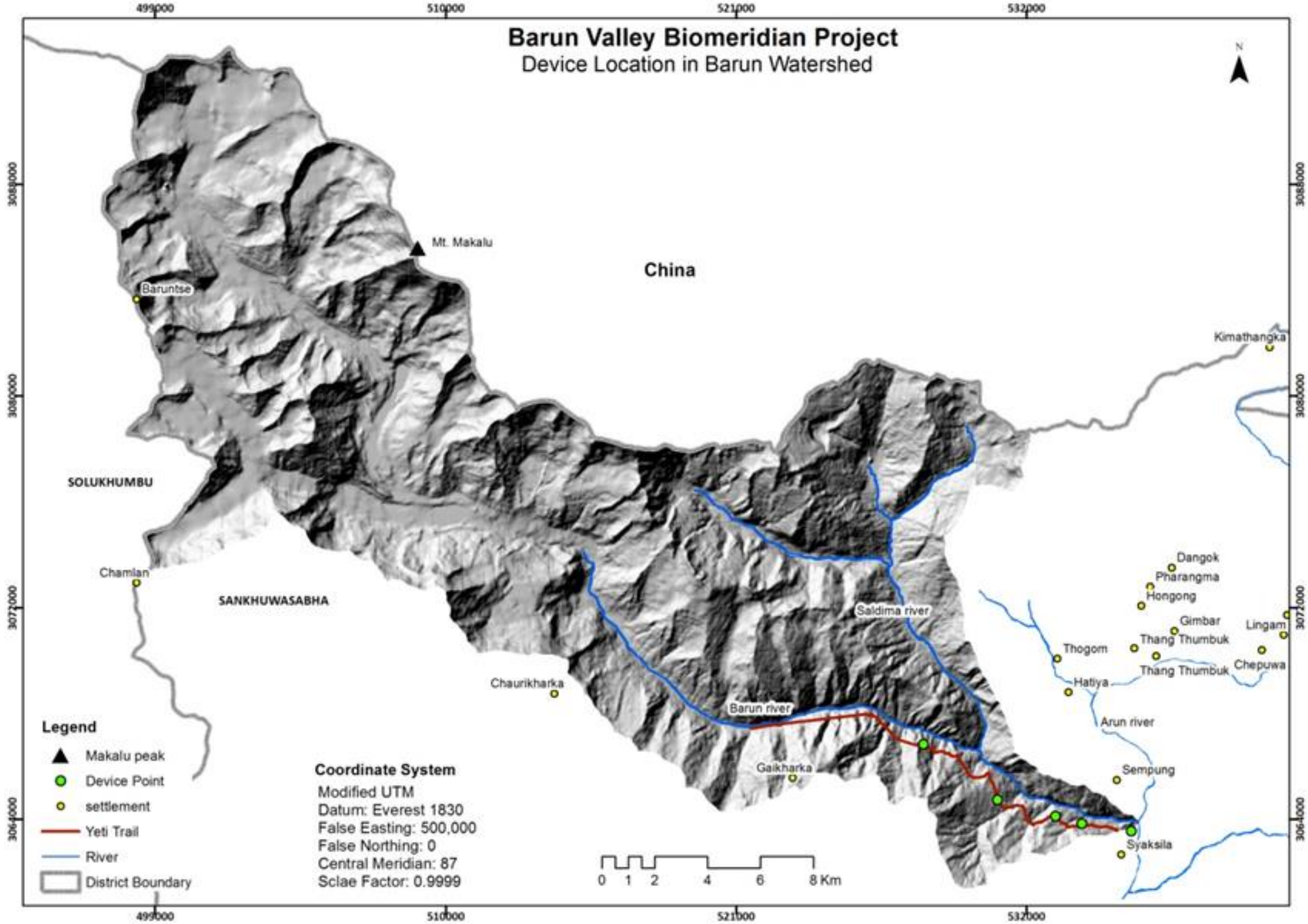
Map 3: Aspect map of Barun watershed



Map 4: Ecological zones in Barun watershed



Map 5: Landuse/landcover in Barun watershed



Map 6: Location of HOBO Logger and Acoustic Recorder in Barun watershed