Livelihood Strategy under Climate Change Stress

Assessing Climate Vulnerability and Preparing an Adaptation Framework with Communities in Kangchenjunga Conservation Area, Nepal

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RESOURCES HIMALAYA

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Acronyms and abbreviations

AFU	Agriculture and Forestry University
BS	Bikram Sambat
CBS	Central Bureau of Statistics
CDO	Chief District Officer
DBH	Diameter at Breast Height
DFO	District Forest Officer
DHM	Department of Hydrology and Meteorology
ECDF	Environment Conservation Development Forum
FGD	Focus Group Discussion
FMD	Foot and Mouth Disease
HH	Household
HIMALICA	Rural Livelihoods and Climate Change Adaptation in the Himalayas
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
KCA	Kangchenjunga Conservation Area
KCAP	Kangchenjunga Conservation Area Project
KCAMC	Kangchenjunga Conservation Area Management Committee
KII	Key Informant Interview
masl	metres above mean sea level
NAST	Nepal Academy of Science and Technology
NPR	Nepalese Rupee
PI	Principal Investigator
RHF	Resources Himalaya Foundation
SLD	Shared Learning Dialogue
TU	Tribhuvan University
UN	Unidentified
VDC	Village Development Committee

Executive summary

A research study titled 'Kangchenjunga Livelihood under Climate Stress' was undertaken to assess climate change impacts on vulnerable mountain ecosystems and people of Olangchung Gola in eastern Nepal and to prepare an adaptation framework involving the local community. In keeping with the principles and ethics of action research, the project shared the findings with the local people to make them aware of the changes and their consequences with the objective of strengthening their adaptive capacity. The research was a part of the HIMALICA (Rural Livelihoods and Climate Change Adaptation in the Himalayas) Initiative under the International Centre for Integrated Mountain Development, implemented by Resources Himalaya Foundation.

For assessing climate change vulnerability and risk, the framework suggested by IPCC-AR5 was followed. The climate change trend was evaluated using temperature and precipitation data recorded by the Taplejung weather station covering over 50 years. Taplejung is Nepal's most landslide prone district; further, the evidence of extreme events and disasters were discussed during interaction with local communities. The study included high mountain agriculture and rangeland, livelihood strategies and any adaptation or mitigation actions taken. The field methods included household surveys, key informant interviews and focus group discussions. The vegetation survey was carried out in four transects at elevations between 3750 and 4500 masl. Tree cores of standing juniper (*Juniperus squamata*) were collected to estimate their year of establishment and upper altitudinal limit for the species was determined to detect any change or shifting of the treeline.

The findings of the study were discussed with the local communities through shared learning dialogues (SLDs). Over 150 people of Fungling, Olangchung Gola and Lelep area in Kangchenjunga Conservation Area (KCA), Taplejung actively took part and shared information and the knowledge. For understanding the issues, a landslide education poster was specially prepared for the local situation and perception based seasonal calendars were also used. The outcomes of the dialogues and field survey are presented here in brief.

Climate trend

A general trend of temperature rise and precipitation decline was shown by the trend analysis of meteorological data of the Taplejung weather station.

An increment of 1.62 °C in mean maximum temperature was noted in the last 50 years (1962–2012), while there was a high fluctuation of rainfall with decreasing trend. The rainfall has decreased by 44.1 mm for the period between 1948 and 2013. In their interviews, the local people stated that they have been experiencing increase in temperature and decrease in winter days. However, they varied in their perceptions of rainfall and snowfall, indicating erratic and localized nature of precipitation. There was unanimity regarding the problem of landslide; everyone agreed that have increased and have been worsening in recent years.

Agriculture based livelihoods

Majority of inhabitants (87.5%) in Lelep and its vicinity depend on agriculture and cattle herding. The conventional crops are potato, maize, millet and barley; however, cash crops like large cardamom and chiretta have become popular in recent decades. Majority of the farmers are worried about declining crop productivity. They pointed out eight different factors that included disease and pests, newly arrived weeds, erratic rainfall- all indicating climatic variation. They have recorded 13 different pests such as aphids, red ant, chirke, furke and marua on major crops including cardamom. Similarly, at least five species of weeds new to the area such as abijalo (*Drymaria diandra)*, udase (*Galinsoga parviflora*) and halhale (*Rumex nepalensis*) were reported. As a way-out, the locals were found testing various practices: i) changing crop calendar (31%), ii) using more fertilizer (31%), iii) opting for cash crops (19%), and iv) applying sprinkler irrigation (69%).

Livestock based livelihoods

For the large proportion of the people (89%) in Olangchung Gola, livestock rearing is a major livelihood option. The traditional transhumance system is still practised, with family 'goth' and grazing units at various altitudes from 3000 to 5000 masl. In recent years, the number of yaks and goats has increased while that of Bhelang bulls has decreased. As there is an increasing trend of young people out-migrating from the villages and improvement in road transport (for example Gola-Tiptala, Tibet), a shift from the livestock dependent livelihood is expected. Moreover, local people have reported increased livestock mortality and diseases, declining grazing area, spread of unpalatable plant species. Local people perceived that such conditions could be linked to climate change. In response to the impacts, they are practicing rangeland management based on their traditional knowledge and training they participate at times. As such the most popular practices are rotational grazing, controlled burning, bush clearance, plantation, landslide control, etc.

Vegetation composition

Altogether 88 plant species were recorded in four transects (at 3750, 4000, 4250 and 4500 masl) in 60 sampling plots at herb/ground stratum (height < 1 m). The species found in all four transects were *Bistorta* sp., *Cotoneaster* sp., *Gentiana* sp., *Potentilla coriandrifolia* and *Primula* sp. The local herders identified at least one fifth of the rangeland plants as either poisonous or unpalatable. These include *Pieris formosa, Berberis* sp., *Juniperus* sp., *Rhododendron anthopogon*, *Gaultheria* sp., *Incarvillea* sp., *Lancea* sp. and *Rumex nepalensis*. Notably some of these are gradually shifting upward and invading the rangeland, while some of the most favoured species seldom occurred in the sampling plots, such as charamba, khoda, *Lonicera* sp., *Potentilla* sp.

Local people in Olangchung Gola and Lelep have observed that at least 11 plant species have shifted to higher elevations compared to previous years. In Olangchung Gola, nine such species were found which were limited to lower elevation in the past years. In Lelep area, six species were noticed which have shifted to higher elevation compared to the past years, and five species, formerly growing in lower altitudes were successfully planted. Tree species shifting upslope include *Betula utilis*, juniper and rhododendron. A plausible reason for such upward shift of the plant species could be the temperature rise in the area.

The standing junipers (*Juniperus squamata*) were taken as a case example of treeline species. The study recorded the treeline at 4070 masl with old growth of juniper, established in 1779 in Singjema, Deuma; the seedlings of the juniper, however, were found above 4200 masl, indicating an upward shift of the species. The rate of upslope shift of the species, calculated in the sampled belt transect was 8.4 m per decade. Examination of 17 juniper tree cores from the site revealed that the minimum and maximum growth were 0.39 mm per year and 1.746 mm per year respectively. The growth rate, as calculated by node (whorl) count was found to be 7 cm per year on average.

1. Introduction

Climate change is transforming the environmental and social landscape of the Himalaya. The impacts of environmental change in the Himalaya are being conspicuously noticed in the livelihoods of its people which has increased their economic and environmental vulnerability (Singh *et al.* 2011). Nepal is located almost in the middle of the Himalaya; its average temperature is increasing at 0.06 ˚C/year, which is disproportionately high at higher altitudes (Shrestha and Aryal 2011) with severe impacts on mountain ecosystems. The rural mountain people depend greatly on ecosystem services, specifically wild plants and animals, which make a significant contribution to their livelihoods (Vira and Kontoleon 2013). Similarly, the biological resources contribute some 20–25% of income in these communities (Vedeld *et al.* 2007). But the ecosystem services are being threatened owing to climatic change. Treelines are shifting upward (Gaire *et al.* 2014) with potential effects on alpine rangelands, and agricultural production has declined, making livelihoods of communities vulnerable.

Several studies in different parts of the world show that climate change has impacted various sectors of the socio-ecological system. Rising temperature due to climate change and altered precipitation patterns causing summer droughts has influenced the spread of weeds in Europe (Tubiello *et al.* 2007; Gillett *et al.* 2011; Bloomfield *et al.* 2006; Lobell and Burke 2008; Robinson and Gross 2010). Wetter and milder winters influence the growth of annual winter weeds and warmer summers and longer growing seasons have been the reason for the growth of thermopile summer weeds (Blomfield *et al.* 2006; Wack *et al.* 2011; Hanzik and Gerowitt 2012). Studies in different parts of the Himalaya show that there is definite reduction in the number of snowfall days in the high Himalayan region over the past years (Tiwari *et al.* 2010; Vedwan and Rhoades 2001; Chaudhary *et al.* 2011; Bhutiyani *et al.* 2010; Shekhar *et al.* 2010). Soils are affected by climate change both explicitly (effect of temperature on soil organic matter decomposition) and implicitly (changes in soil moisture due to evapo-transpiration) (Karmakar *et al.* 2016).

Climate change impacts agricultural productivity. Global production of maize and wheat was observed to have declined by 3.8% and 5.5% respectively between 1980 and 2008. This change was estimated to be due to climate change (Lobell *et al.* 2011). It was also observed that there was 17% decrease in both maize and soybean yields in the United States for each degree increase in growing season temperature, indicating a higher observed sensitivity of agriculture to temperature than studies had previously predicted (Lobel and Asner 2003). A change in growing season precipitation by one standard deviation can be associated with as much as 10% change in production, for example millets in

South Asia (Lobell and Burke 2008). Agricultural production has been affected by newly introduced diseases and pests in Nepal (Anderson *et al.* 2004). These emerging infectious diseases in crops caused by climate change are threats to conservation and public health.

More extreme weather events are due to increased energy within the climate system. Already, in the past decade, weather-related natural hazards have been the cause of 90% of natural disasters and 60% of related deaths and have been responsible for 98% of the impacts on disaster-affected populations, the majority in areas of developing countries (IFRC 2005). The World Meteorological Organization reported in December 2005 that the year gone broke dozens of weather records all over the world, from drought in Brazil, to cold spells in Pakistan to hurricanes in the Atlantic Ocean. Except for 1996, all of the past 10 years rank among the 10 hottest years since 1850 (Helmer and Hilhorst 2006).

Relationships between changes in climate and changes in human migration patterns can be considered in the context of this representation of vulnerability. It is suggested that, especially among the poor, the lack of capacity to adapt to environmental risks or hazards is interconnected with population displacements (Kates 2000). Different studies throughout the world have documented the migration of people as a result of climate change. People living in rural areas have practiced adaptation tactics including migration to other places to cope with recurring drought. For instance, in Western Sudan, it was found that most of the male population migrated to Khartoum, in search of wage labour when agricultural production was hindered due to low rainfall (Afolayan and Adelekan 1999).

The Himalayas have always been venerated for their magnificent elevation and biological and cultural richness. Besides mountaineering, scientific expeditions and surveys have generated a good amount of information on the Himalayan region. Yet, scientific studies encompassing recent environmental degradation, climate change in particular are few. The Intergovernmental Panel on Climate Change (IPCC) 2007 Fourth Assessment Report designated the Himalayan region a "white spot" because of the limited number of scientific studies conducted in this region, including Nepal. A review of literature on Kangchenjunga included a few but recent scientific reports, which covered climate change issues (for example, Chaudhary and Bawa 2011; Chettri 2009; Chettri *et al.* 2012; Devkota *et al.* 2012; Gaire *et al.* 2017; Racoviteanu *et al.* 2014; Shukla *et al.* 2016). They provide some understanding of the problems in the area and more importantly are helpful in identifying gaps and opportunities in furthering rigorous studies while avoiding duplication of the sites and/or works.

As an attempt to fill the above mentioned gap, albeit on a small scale, an action research was carried out in the Kangchenjunga Conservation Area (KCA) of Nepal. The purpose of the study was to find and document evidence of climate change impacts on ecology and livelihoods in the mountainous region of the Nepal Himalaya, more specifically in the high altitude settlements of KCA. It was further expected to build research capacities of the institutions, investigators and relevant stakeholders to assess climate vulnerabilities of mountain ecosystems, local communities, and their livelihoods, and thereby identify policy options for framing relevant adaptive measures. Traditional transhumance involving yak and chauri, crop cultivation and local business are the primary sources of livelihood, which in case of KCA are further constrained due to changing climatic conditions.

Keeping the Kangchenjunga area in focus, the overall objective of the project was to undertake an action research study and produce knowledge based adaptation measures involving local communities for securing their livelihood options in the climate vulnerable high mountains of Nepal. The specific objectives of the project were: i) to assess the impact of climate change on overall livelihoods of mountain community, where agriculture is the major livelihood option ii) to assess climate change induced treeline shift in high altitude and its effects on livelihoods of local communities, and iii) to determine possible adaptation and livelihoods options for the mountain communities based on the knowledge generated by this project.

2. Research framework and methodology

2.1 Research framework and questions

2.1.1 Research activities

This study of livelihoods and environment consisted of three major activities: i) pre-field visit, ii) field visit, and iii) post-field visit (Figure 1). The pre-visit activities included team formation, securing permission and approval from the concerned authority, the Department of National Parks and Wildlife Conservation, finalization of methodology, and orientation cum training of the research team. The field visit involved meetings with stakeholders, questionnaire survey, focus group discussions, shared learning dialogues, and key informant interviews. The activities during the field visit also included vegetation survey and tree core collection at defined transects in the study area. Similarly, the post-field visit activities included secondary data collection, data entry and analysis, interpretation and report preparation.

Assessment of vulnerability and risk is a pre-requisite for adaptation planning. As this research study was intended to support such planning, a framework to assess the vulnerability and risk was prepared (Figure 2). It is based on the framework suggested by Intergovernmental Panel on Climate Change (IPCC) in its Assessment Report 5. The framework has been adapted for the mountain communities under climate change stress in Kangchenjunga Area, Nepal. In addition to looking at temperature and precipitation trends to understand climate trends, three hazards were also examined: landslides, crop pests and livestock diseases. The system of concern was the mountain community, their environment of mountain farms and alpine rangelands. The variables for sensitivity were herbaceous diversity, new weeds with invasive characteristics, treeline species and upward moving plants, and livestock diversity. In terms of adaptive capacity, crop calendar, introduction of new varieties of crops, irrigation or other technologies, school education, specifically science and people's occupation were assessed.

It was expected that such information of climate trends leading to exposure, sensitivity and adaptive capacity together would help assess the vulnerability and risk, and constitute a basis for adaption planning.

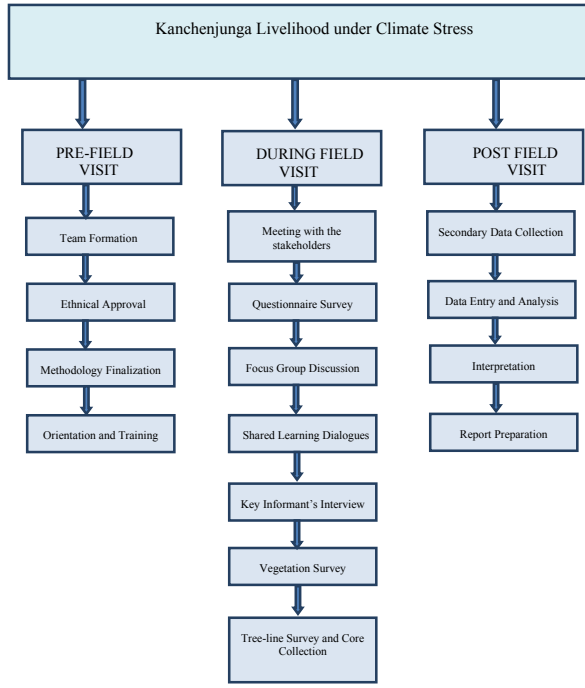

Figure 1: Research activities

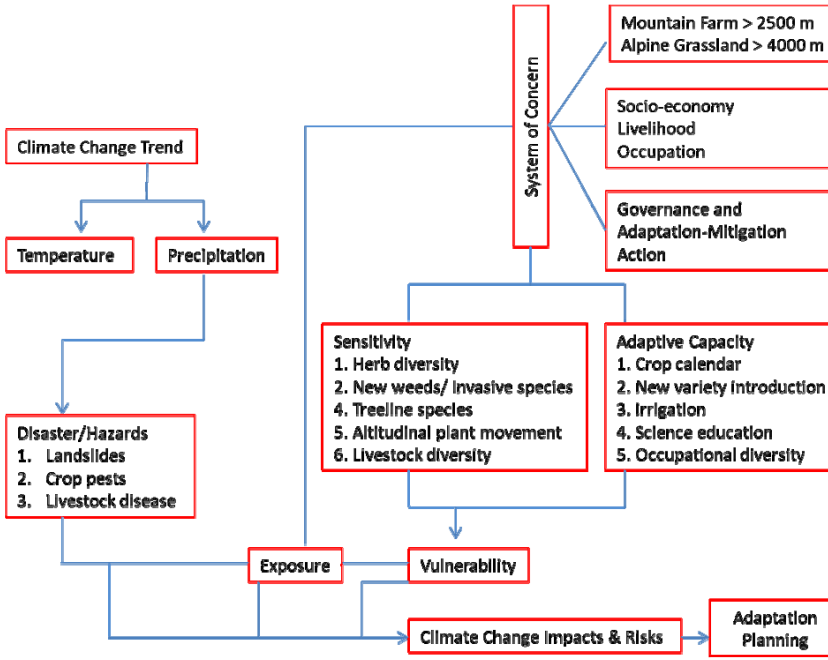

Figure 2: Framework to assess vulnerability and risk in mountain communities under climate change stress in Kangchenjunga Area, Nepal. Reference: IPCC AR5 2013 Framework

2.1.2 Research questions

The research questions were framed under the various objectives of the project.

2.1.2.1 Climate trend

- Are there any significant changes in the climatic parameters over the past years in the study site?
- Do the local perceptions about the changes correspond with the scientific data?

2.1.2.2 Agriculture based livelihoods

- Are there any changes in agricultural production during the past years in the study area?
- Is climate change responsible for the change or are there some other factors?

2.1.2.3 Livestock based livelihoods

- Are there any changes in the livestock herding practices during the past years in the research site?
- Is climate change responsible for the change or are there some other factors?

2.1.2.4 Vegetation composition

- What is the vegetation composition of the rangelands in the research site?
- Which alpine grasses do the livestock prefer and what is their condition?
- Is there any shift in the treeline of the study area and what is the growth rate of the species making the treeline?

2.2 Research methodology

The study adopted both qualitative and quantitative methods to address the above mentioned three specific objectives. The household (HH) survey and shared learning dialogues (SLDs) were conducted in two major communities of the research area. Vegetation surveys were conducted in three transects, including alpine grassland; the measurements of plant species were taken at treeline of juniper (*Juniperus squamata* Buch.-Ham. ex D.Don).

2.2.1 Primary data collection

Questionnaire survey

A semi-structured questionnaire survey was carried out for both agriculture related livelihoods and livestock related livelihoods in the study sites of Lelep and Olangchung Gola, respectively. Altogether, 32 respondents were interviewed for agriculture and 33 for livestock related livelihoods in order to assess the livelihoods of the study site under climate stress.

Focus group discussions

Two FGDs were carried out in both study sites with representative members of the community. Based on the FGDs, perception based seasonal calendars were prepared for general understanding of climate trends and their effects.

Shared learning dialogues

Two SLDs were conducted in Olangchung Gola and in Gobatar which were focused on a few important questions related to local knowledge and livelihood

and to share the research findings with the local community. During the SLDs, the educational posters on landslide control, especially prepared for KCA were displayed and discussed.

Key informant interviews

Altogether five KIIs were carried out in the settlements of KCA mainly focused on the primary research questions related to local knowledge and livelihood.

Vegetation survey

A vegetation survey was conducted to record the plant species diversity in the pastureland at four different altitudes (3750, 4000, 4250 and 4500 masl) of the study site using quadratic measurements aimed to assess the impact of climate change on vegetation pattern by comparing results of the research with secondary empirical data. At each altitude, transects were laid consisting 15 plots (size 1 m x 1 m), and all the plant species under 1 m were noted, their mean height (cm) and coverage (%) were measured.

Treeline survey and core collection

For treeline study, the standing juniper (*Juniperus squamata*) was selected at Singjema Khola, Deuma at an altitude of 4050 masl. The oldest tree of juniper was located, and a belt transect was extended up to the most recent seedling towards the mountain top. The plot measured 20 m in width and 120 m in length. The measurements of all individuals of juniper were taken which included in height (m), node (whorl) count, crown diameter (m) or diameter at breast height (DBH) where applicable. The location of the site was recorded by GPS (Etrex). Tree cores were collected from the large size Junipers, using core borers (Haglof, Sweden). The samples were taken to the Dendrochronology Laboratory of Department of Forest Research and Survey in Kathmandu for further analysis.

2.2.2 Meteorological data

The meteorological data of temperature and rainfall of Taplejung weather station were collected from Department of Hydrology and Meteorology (DHM) in order to validate local perceptions of climate change. The temperature data covered 50 years (1962-2012) and the rainfall data covered over 64 years (1948-2012).

2.3 Study area

The study area is located inside the KCA in Taplejung district in eastern Nepal. Field studies were carried out in Olangchung Gola and Lelep villages of

Phaktalung Rural Municipality; previously, they were called Olangchung Gola and Lelep Village Development Committees (VDCs), respectively. The site was selected because of the following specific socio-ecological features:

i. The area is a global biodiversity hotspot and local communities are heavily dependent on biodiversity for their livelihoods,

ii. The communities represent typical rural high mountain settlements,

iii. These villages are situated along traditional trade routes to Tibet from Nepal, and the traders are still using it, and

iv. KCA is a model landscape for trans-boundary conservation spearheaded by the International Centre for Integrated Mountain Development (ICIMOD).

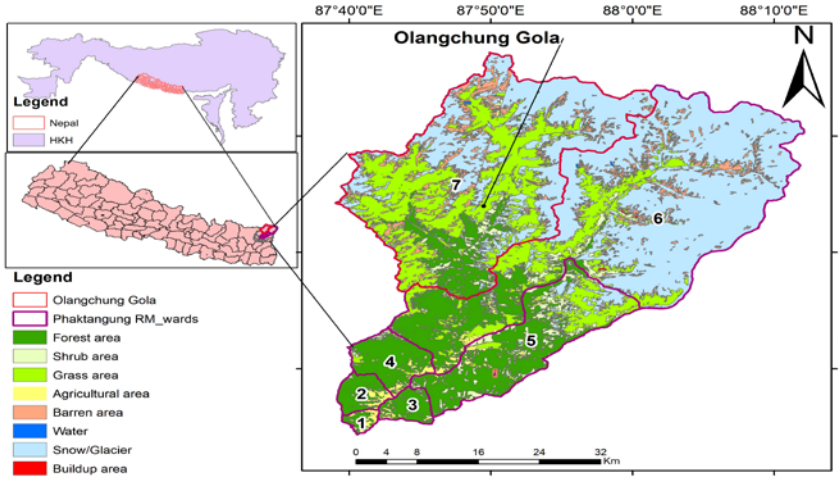

Figure 3: Location map of the research sites in Taplejung district, eastern Nepal

2.4 Project activities

2.4.1 Team formation

A project office was set up on the premises of the Resources Himalaya Foundation (RHF) in Kathmandu. A research team was formed comprising of one principal investigator (PI), one vegetation expert, one livelihood expert and two master's degree students. The team members had expertise in climate change adaptation,

vegetation, ecology, sociology and livestock and environmental science. The details of the team are presented in Annex 7.1.

2.4.2 Research ethics and accountability

The project strictly adhered to research ethics and norms practiced internationally and governed by national regulatory framework. All necessary official permissions and clearances were taken before start of research activities, and communities were duly informed and familiarized with the research objectives before its commencement. Verbal consent was obtained from the participants before conducting the HH survey.

The project funds were duly audited as per the prevailing legal norms and institutional arrangements to ensure transparency and optimal utilization of funds towards reaching the project objectives.

2.4.3 Methodology finalization

The methodology was finalized in consultation with ICIMOD experts in October 2016.

2.4.4 Orientation and methodology training

Prior to the field survey, an orientation programme was organized for the study in November 2016.

2.4.5 Field visits

Two field visits were conducted in the research sites. During the first field visit between 4 and 17 November 2016, the research team focused on obtaining data regarding livestock and agricultural practices in the area. After analyzing the collected data, the research team conducted a second field visit between 12 and 24 May 2017. The preliminary findings from the first visit were shared with community members during SLDs. The detailed schedule and activities during the first and second field visits are presented in Annexes 7.2 and 7.3.

2.4.6 Meetings with stakeholders

Before initiating the field activities, meetings were organized with concerned authorities from different organizations in Kathmandu and Taplejung (Table 1).

Table 1: Meetings with stakeholders in Taplejung

SN	Name	Organization	Designation	Place
1	Dan Bahadur Shrestha	District Forest Office (DFO)	Forest Officer	Fungling
2	Chakra Pani Pandey	District Administration Office	Chief District Officer	Fungling
3	Khagendra Phembo Limbu	Kangchenjunga Conservation Area Management Committee	Chairperson	Fungling
4	Harish Chandra Chilwal	HIMALICA/ Environment Conservation Development Forum (ECDF)	Programme Co-ordinator	Fungling
5	Kumar Siwa	Environment Conservation Development Forum (ECDF)	Chairperson	Fungling
6	Tekendra Pradhan	SUAAHARA II	District Co-ordinator	Fungling
7	Dilli Paudel	District Administrative Office	In-charge, Olangchung Gola	Fungling
8	DEO	District Education Office	District Education Officer	Fungling
9	Vice Principal	High School, Fungling	Vice Principal	Fungling
10	Ram Bahadur Tamang	High School, Lelep	Principal	Fungling

2.4.7 Questionnaire survey for agriculture based livelihoods

The semi-structured questionnaire survey on agriculture related livelihoods was carried out in Lelep and surrounding villages of KCA. Altogether 32 HH surveys were conducted in ward numbers 2, 3, 4, 5, 6 and 7 of Iladanda, Gobatar, Lumthung, and Lelep villages, out of a total of 303 HHs (Central Bureau of Statistics, CBS 2012), with the objective of obtaining information on the climate change stress on cultivation practices along with the practiced and possible adaptation measures. List of informants is presented in Annex 7.6 and the questionnaire used for the HH survey in Annex 7.8.

2.4.8 Questionnaire survey for livestock based livelihoods

Semi-structured questionnaire surveys on livestock related livelihoods were conducted in 33 HHs out of 62 at Olangchung Gola (CBS 2012) on 10 and 11 November 2016. Informants included both male and female from 27 to 70 years of age. List of informants is presented in Annex 7.4. The survey was done with an objective of obtaining information on the climate change stress on livestock practices including rangeland and the practiced and possible adaptation measures. The questionnaire used for the HH survey is in Annex 7.5.

2.4.9 Shared learning dialogues

The research team conducted two SLDs in Olangchung Gola and Gobatar during the second field visit. The SLDs were focused on a few important questions related to local knowledge and livelihood, such as (i) to what extent are community members aware of the impact of climate change (ii) how do local people perceive the changes (iii) how do they identify the changes (iv) what are the institutional mechanisms to manage their resources (v) what are the alternate livelihood options that communities have identified given the impacts of change and (vi) are there any opportunities they can identify under the changed circumstances? Additionally, the issues of future risks to low income groups was discussed. Mainly, farmers and sheep and yak/chauri herders have lower resilient capacity. The means of livelihood were discussed under three broad categories i.e. herding and tourism, herding and farming, and herding and off farm activities in general. The list of participants in both SLDs at Olangchung Gola and Gobatar are presented in Annexes 7.8.1 and 7.8.2 respectively.

2.4.10 Focus group discussions

Two FGDs were held with community representatives to gather their opinions on climate change and the stress due to it. The issues discussed in the SLDs were also discussed in FGDs. The FGDs were also centered on the variation that exists in the community in terms of their experiences and adaptation practices. Guiding questions for the FGD at Olangchung Gola and Lelep are presented in Annexes 7.9.1 and 7.9.2 respectively. The list of participants of FGDs in Olangchung Gola and Lelep is in Table 2.

Table 2: List of participants involved in focus group discussion

SN	Date	Site	Name	Gender	Age (Yrs)
1	11-Nov-16	Olangchung Gola	Dorjee Bara	Male	60
2	11-Nov-16	Olangchung Gola	Bhujung Lama	Male	33
3	11-Nov-16	Olangchung Gola	Chetten Sherpa	Male	35
4	11-Nov-16	Olangchung Gola	Tenzing Sherpa	Male	27
5	11-Nov-16	Olangchung Gola	Chetten Sherpa	Male	33
6	11-Nov-16	Olangchung Gola	Tashi Sherpa	Male	35
7	11-Nov-16	Olangchung Gola	Chetten Sherpa	Male	35
8	13-Nov-16	Lelep-3	Lakpa Chiring Sherpa	Male	55
9	13-Nov-16	Tapethok-7	Dil Bahadur Limbu	Male	50
10	13-Nov-16	Lelep-3	Khagendra Limbu	Male	37
11	13-Nov-16	Lelep-3	Pasang Buti Sherpa	Female	60
12	13-Nov-16	Lelep-3	Nurpu Sherpa	Male	66

2.4.11 Key informant interviews

Altogether five KIIs were carried out in the VDCs of KCA that were located on the way to the research site, Olangchung Gola. Interviews were mainly focused to the primary research questions, related to local knowledge and livelihood. Guiding questions for KII are in Annex 7.10. The name and other details of key informants are presented in Table 3 below.

Table 3: List of participants in key informant interviews

SN	Date	Site	Name	Gender
1	6-Nov-16	Mitlung	Purna Karki	Male
2	7-Nov-16	Tapethok	Buddha Lal Limbu	Male
3	8-Nov-16	Lelep	Bishnu Limbu Phembo	Male
4	8-Nov-16	Lelep	Narayan Prasad Phembo	Male
5	8-Nov-16	Iladanda	Bharat Limbu	Male

2.4.12 Vegetation survey

A vegetation survey was conducted to record the plant species diversity in the pasturelands at four different altitudes using quadratic measurements. It included two alpine grasslands: Rolep (4500 masl) and Flauma (4200 masl), one near the treeline at Singjema Khola of Deuma (4000 masl) and one below the treeline

at Dhingasamba (3750 masl). The sites were located en-route to Tiptala border from Gola along the Tamor River valley. At each altitude, there were three line transects at a difference of 20 m and had five quadrats (size 1m x 1 m) each. Thus, there were 15 quadrat plots at each altitude. The aim of these quadratic measurements was to assess the impact of climate change on vegetation pattern by comparing results of the research with secondary data.

2.4.13 Treeline survey and core collection

The treeline comprised three different species: juniper (*Juniperus squamata*), silver fir (*Abies spectabilis*) and birch (*Betula utilis*). Among these, the juniper treeline was considered for the study, because this species has not been studied earlier, while that of fir and birch have been studied by previous researchers (see Gaire *et al.* 2014). A well grown treeline of juniper was chosen at Singjema Khola, Deuma at 4050 masl for detail measurements and core sampling. A belt transect of 120 m x 20 m was plotted at the treeline covering mature trees of juniper (4050 masl) and newly established seedlings and saplings at the highest accessible position of 4200 masl. Measurements of all individuals of juniper inside this plot were taken. The measurements included height, node (whorl) count, crown diameter or diameter at breast height (DBH) (where applicable) and their position.

In order to understand the impact of changing climate, tree cores were collected from juniper marking the treeline at 4000 masl in Deuma. Swedish tree core borers (Haglof Co.) were used to collect the tree cores from breast height. Two core samples were collected from each tree where possible. The collected tree cores were taken to the laboratory of Department of Forest Research and Survey in Kathmandu for further analysis using Lin-Tab.

2.4.14 Meteorological data

Climatic data (temperature and precipitation) were obtained from the Department of Hydrology and Meteorology (DHM) for Taplejung weather station (index no. 1405). The meteorological station (Type: synoptic) is located at 1723 masl with coordinates 27^0 21' latitude and 87^0 40' longitude. Precipitation records from 1948 to 2013 and 50 years long temperature (mean monthly minimum and mean monthly maximum) data from 1962 to 2012 were obtained for Taplejung weather station.

2.4.15 Data entry and checking

The data collected during the field visits were entered in an Excel Sheet for detailed analysis.

3. Results and discussion

The results of the study project are presented here under the four major sub-headings: 1) temperature and precipitation trend, 2) agriculture related livelihoods, 3) livestock related livelihoods, and 4) vegetation analysis. In the backdrop of climate information, three domains of the study, namely a change in agricultural practices, change in transhumance herding and a shift in vegetation pattern, in and around the research sites were covered in details in this report. These domains have been discussed through the lens of climate change in this research.

3.1 Climatic variability

Climatic variables (temperature and precipitation recordings) for the period 1948 to 2012 and 1962 to 2012 respectively were studied from the Taplejung meteorological station data. The result of the analysis is presented in Figures 4 and 5.

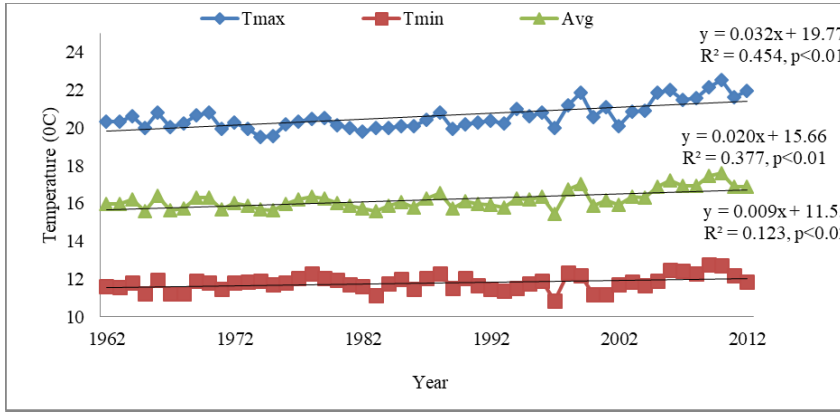

Figure 4: Temperature trend of the study area, Taplejung. Data source: DHM

3.1.1 Temperature

The mean maximum temperature of the area was found to have increased by 1.62^0 C from 20.35^0 C during 1962 to 21.97^0 C in 2012 (*n=50, R^2=0.0.45, p<*

0.01), and the mean minimum temperature by 0.22^0 C from 11.61^0 C during 1962 to 11.83^0 C during 2012 (*n=50, R^2=0.123, p< 0.02*). Similarly, annual mean temperature showed 1.0^0 C increase from 15.9^0 C in year 1962 to 16.9^0 C during 2012 (*n=50, R^2=0.377, p< 0.01*). The result showed that the difference in mean minimum and maximum temperature has increased by 1.39^0 C from the mean maximum and minimum values of 10.13^0 C and 8.74^0 C in 2012 and 1964 respectively.

3.1.2 Precipitation

The analysis of precipitation showed (Figure 5) a high fluctuation with decreasing trend with 203.6 mm mean rainfall in 1948 to 161.5 mm in 2013. The rainfall has decreased by 44.1 mm for period 1948 to 2013 (*n=65, R^2=0.007, p*) a high fluctuation with decreasing trend from year 1948 with 203.6 mm mean rainfall to 161.5 mm in 2013. The rainfall has decreased by 44.1 mm for period 1948 to 2013 > *0.05*). The highest mean rainfall recorded was 208.8 mm in 2003 while the minimum was 117 for 2009. 130. Likewise, high rainfall was recorded during 1948 (203.6 mm), 1985 (206.1 mm) and 1990 (203 mm) and low records were seen for 1964 (130.6 mm), 1992 (124.8 mm) and 2011 (119.6 mm).

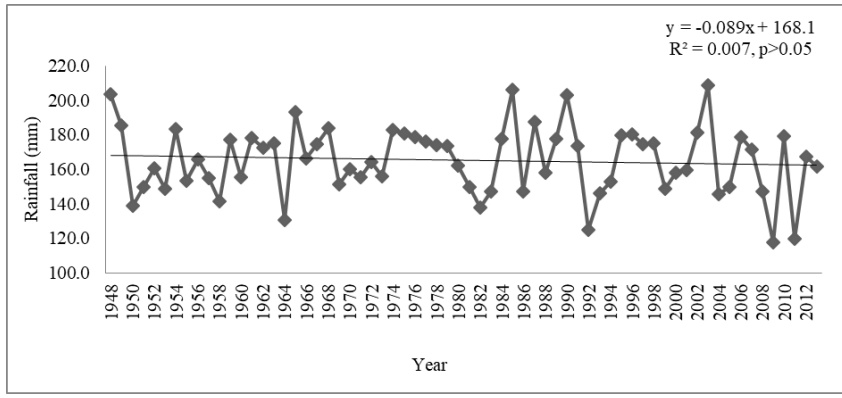

Figure 5: Rainfall trend of the study area, Taplejung. Data source: DHM

3.2 Agriculture based livelihoods

3.2.1 Main occupation of inhabitants of villages in Lelep

All inhabitants of Iladanda, Gobatar, Lumthung and Lelep villages involved in the HH survey (n=32) were dependent on agriculture. Major crops grown included potato, maize, millet, barley and buckwheat, and some seasonal fruits

and vegetables. A significant population, i.e. 53.12%, depended solely on agriculture, followed by agriculture and livestock herding (34.37%). There were two HHs dependent on agriculture and wage labour for their survival. However, one HH was found involved in agricultural production, livestock herding and also daily wages. Finally, one member from a HH worked for the government and was also involved in agriculture. Table 4 shows the number of HHs with their main occupation as well as other occupations.

Table 4: Occupation and number of informants from various villages in research site

SN	Occupation	No. of HHs	Percentage (%)
1	Agriculture	17	53.12
2	Agriculture and livestock	11	34.37
3	Agriculture and government service	1	0.03
4	Agriculture, livestock and daily wages	1	0.03
5	Agriculture and daily wages	2	0.06

Although all the HHs surveyed raised traditional crops, the study found that there was a shift from traditional crop varieties to cash crops, such as large cardamom (*Amomum subulatum*) and chiretta (*Swertia chirayita*). A significant number of informants, 26 (81.25%), mentioned that they cultivate large cardamom in addition to traditional crops. Some have been cultivating cardamom for more than 25 years and some had recently started cultivating it.

Nupu Bhote (67) from Lelep stated: "I started cultivating cardamom 25 years ago. The selling price of it has hugely reduced. I sold one *man* [40 kg] of cardamom at the rate of NPR 100,000 in 2072 BS [2015]. Now its price is NPR 40,000" (HH Survey, 14 Nov 2016). Three informants mentioned that they recently started cultivating cardamom and their cardamom was not ready to harvest yet.

Four informants said that they started chiretta farming in their agricultural lands as well as on lands which were used to graze cattle. Some had fence off the previous grazing land for chiretta farming. Asaran Kumar Rai (60) from Lelep said: "I practiced slash and burn in my own forest. The first year I cultivated maize and next year I cultivated chirayito [chiretta]" (HH Survey, 13 Nov 2016). One respondent was also involved in chiretta trade.

3.2.2 Changes in agricultural production

During the HH survey, inhabitants were asked about the trend of productivity, i.e. increasing or decreasing or same, in the last five years for individual food

and cash crops. In case of potato, 12.5% farmers said that productivity has been decreasing. In contrast, 6.25% said that it was increasing and 21.87% mentioned that the trend remained same. Maize is another main food crop. Only 6.25% farmers said that its productivity has been increasing while 46.87% said that it has been decreasing. About 15.62% farmers mentioned that the trend was same as before.

In case of cash crops, such as cardamom, 25% farmers said that there was a decreasing trend of productivity while 18.75% farmers said productivity had increased. A majority of farmers, i.e. 56.25%, were either cultivating on a small scale or had recently started cultivation, still wishing for better productivity.

3.2.3 Factors affecting the agricultural production

There were eight major factors that informants felt were responsible in declining agricultural production. These included: i) diseases and pests, ii) newly arrived weeds, iii) declining soil quality, iv) changes in water availability, v) increasing natural disasters, vi) migration, vii) changes in temperature and precipitation, and viii) changes in crop varieties.

3.2.3.1 Diseases and pests

A variety of crop diseases were mentioned by the informants as responsible for the decline crop productivity. Altogether 24 informants mentioned that there were increasing incidence of pests that were hampering the growth of crops. Termites, aphids, *lakha*, *mudha*, *ghun* and various species of butterflies were seen in potato. Similarly, the case of decreasing trend of cardamom productivity mentioned by 25% farmers was due to pests and diseases, such as red ants, aphids, *lapre*, *furkey* (red leaves turn yellow and then die), *maruwa* and caterpillar like insect (since three years). It was also mentioned that the leaves were drying up and the crop could not grow well. Furthermore, people said that they were unaware about the treatment of such diseases.

A significant number of farmers, i.e. 53.12%, mentioned that the decreasing trend of maize productivity was due to increasing number of pests. Insects such as aphids (in roots), green insect, red insect, *fale* (in roots), *ranke* and butterflies were affecting the growth of maize. It was also reported that beetles, caterpillars and butterflies were affecting the growth of food crops. "An ant-like insect has been observed in chilly from this year", said Danke Sherpa (50) from Lelep. Diseases and pests, mentioned by the informants, are listed in Table 5.

Table 5: Pests and diseases in traditional crops and cardamom

SN	Local Name	Vector	Remarks
1	Dhamira	Termites	Potato
2	Khumle	Caterpillar	Potato, maize and cardamom
3	Mudha		Potato
4	Chirke	Red ant	Potato, maize and cardamom
5	Ghun		Potato
6	Lakha		Potato
7	Putali	Butterfly	Potato, maize and cardamom
8	Hariyo kira		Maize
9	Fale kira		Maize
10	Ranke		Maize
11	Lapre kira		Cardamom
12	Furkey		Cardamom
13	Maruwa		Cardamom

3.2.3.2 Newly arrived weeds in the agricultural fields

In addition to the effect of diseases and pests on both food and cash crops, respondents mentioned 21 different weeds that were responsible for decreasing farm productivity. Twenty seven informants mentioned that these weeds were increasing in their agricultural land. All the informants were between 20-30 and 60-80 age groups. Among them, 16 said that they not only observed weeds but also observed newly arrived invasive species. Fourteen informants noted that the time spent in weeding has increased in the past few years because of these new weeds. Table 6 below shows different weeds and newly arrived species.

Table 6: Common crop weeds, number of mentions and newly arrived species

SN	Local Name	Scientific Name	No. mentions	Remarks
1	Dubo	*Cynodon dactylon* (L.) Pers.	4	
2	Siru	*Imperata cylindrica* (L.) P. Beauv.	2	
3	Abijalo	*Drymaria diandra* Blume	3	Newly arrived

SN	Local Name	Scientific Name	No. mentions	Remarks
4	Rataunlo	*Polygonum chinense* L.	12	
5	Banso	*Echinochloa colonum* (L.) Link	3	
6	Udase	*Galinsoga parviflora* Cav.	9	Newly arrived
7	Ilame jhar/Gandhe	*Ageratum conyzoides* L.	9	
8	Kali jhar/Banmara	*Eupatorium adenophorum* Spreng.	8	
9	Titepati	*Artemisia indica* Willd.	5	
10	Kurro	*Bidens pilosa* L.	9	Newly arrived
11	Bhui ainselu	*Fragaria nubicola* Lindl. ex Lacaita	2	Newly arrived
12	Amile jhar Chari amilo	*Oxalis corniculata* L.	1	
13	Arthunge	*Heteropogon contortus* (L.) Beauvois	1	
14	Pani jhar	Unidentified	1	
15	Bikase	Unidentified	1	
16	Unnyeu	Unidentified	1	
17	Neupane jhar	Unidentified	1	
18	Mase lahara	Unidentified	1	
19	Bukiphul	*Anaphalis triplinervis* (Sims) C. B. Clarke	1	Newly arrived
20	Halhale	*Rumex nepalensis* Spreng	1	
21	Sisnu	*Urtica dioica* L.	1	

Among these weeds, a weed *pani jhar* was mainly found in cardamom while another weed *Ilame jhar* was said to be toxic to sheep.

Eleven plant species were said to have shifted upwards, six of them reported to have moved up naturally and five were planted (Table 7).

Table 7: Plant species naturally moving upwards and now planted in higher elevations

SN	Local Name	Scientific Name	Remarks
1	Kutmero	*Litsea monopetala* (Roxb.) Pers.	Naturally moving upwards
2	Amliso	*Thysanolaena maxima* (Roxb.) O. Kuntze	Naturally moving upwards
3	Bans	*Bambusa* sp.	Naturally moving upwards
4	Uttis	*Alnus nepalensis* D. Don	Naturally moving upwards
5	Khursani	*Capsicum annuum* L.	Planted
6	Anp	*Mangifera indica* L.	Planted
7	Syau	*Malus pumila* Miller	Planted
8	Litchi	*Litchi chinensis* Sonner	Planted
9	Aru bakhara	*Prunus domestica* L.	Planted
10	Chiraito	*Swertia chirayita* (Roxb. ex Flem.) Karst.	Naturally moving upwards
11	Simal	*Bombax ceiba* L.	Naturally moving upwards

3.2.3.3 Declining soil quality

Twenty five participants mentioned that there was a change in soil quality. All the respondents from age group 20-30 mentioned that the soil had become harder than earlier. While majority of the respondents agreed to this, there were four who said soil moisture had increased compared to the past. However, 64 year old Nagendra Prasad Rai from Lelep said that the reason for harder soil was due to excessive use of chemical fertilizers, such as urea. He also added that maize had become harder due to excess use of urea.

3.2.3.4 Changes in water availability

Stream flow: Nine informants said that there was an increase in stream flow than before. In contrast, eight informants of age group 50–70 said that there was a decrease in stream flow.

Stream supply: Fourteen informants said that the stream supply had increased while nine said that the supply had decreased. It was interesting to note that of those who said the stream supply was increasing, eight were from age group 30–50, and of those who said stream supply was decreasing, four were from age group 50–60. A majority of informants said that they had observed a decline

in stream flow over the past 3–6 years. However, Gopal Rai (43) and Mingma Gyanje Sherpa (36) said that they observed the decreasing trend over the past 9–10 years.

Changes in water availability: Altogether nine informants said that there was decreasing trend of water availability in the area while five informants said there was an increasing trend. The decreasing trend was mentioned by four informants of the 60–70 age group. However, one informant from the same age group said there was an increasing trend.

3.2.3.5 Increasing natural disasters

Informants had different experiences and opinions regarding natural disasters. Altogether 15 informants said incidence of flood was increasing, 19 said incidence of landslide was increasing and 18 said incidence of drought was increasing. In contrast, 11 said incidence of flood was decreasing, nine said incidence of landslide was decreasing and eight said incidence of drought was decreasing.

3.2.3.6 Migration

Migration was reported as one of the factors affecting agricultural production, albeit on a small scale. Only 11 informants mentioned that some villagers had migrated to other places. Increasing incidence of natural calamities such as floods, landslides and drought was mentioned as the main reason for migration. A farmer, Gyanu Thepe Sherpa (30), from Lelep said that 12 HHs had moved to Tapethok due to landslide in 2006. Another farmer, Ram Prasad Rai (62), from Lelep said that 1-2 HHs had shifted to Taplejung due to flood. It was thus concluded that one of the reasons for decreased agricultural production was due to farmers migrating to other areas.

3.2.3.7 Seasonal calendar

Informants provided mixed responses regarding changes in the seasonal calendar. Altogether 15 informants said that there was an increase in summer temperatures while five of them said that the temperature was decreasing. Majority of informants who shared their experiences were from age group 40-50 who said the rise in temperature was seen during monsoon. Meanwhile, 16 informants believed that winter temperatures were increasing. In contrast, 15 said it was same as before.

A significant number of informants said that rainfall had been decreasing over the years while five said it was increasing. A majority of informants said that they had been experiencing erratic and irregular rainfall which was affecting crop production. Drying of leaves was observed because of erratic rainfall. That had led to a problem in irrigation and failure of the maize crop. Some informants also mentioned that crops were decayed due to excess rainfall. Pemba Sherpa (49) from Lelep said that there had been decline in the productivity of crops by 50% due to less rainfall.

Regarding the amount of snowfall in the area in recent years, a majority of informants, i.e. 25, said that it had been decreasing while only four of them said it had been increasing. This decrease in amount of snowfall led to kill major crops.

Altogether 13 informants said that cloudy days had been decreasing whereas two of them said that it was increasing. Similarly, four informants said that hailstorms were increasing whereas 18 said that hailstorms were decreasing. These 18 informants were from age group 40-60. Sixteen informants also said that windstorms had decreased in recent years while three said that they had increased.

3.2.3.8 Shift in crop varieties

A shift from traditional agricultural farming to cash crops was also observed in the area. Altogether 14 informants said that they had changed their cropping pattern. Seven of them had changed from food crop farming to high value and low weight cash crops such as cardamom. Tensing Sherpa (45) from Lelep said that the change in crops was to earn more money. This helped to boost the economic status of the villagers and hence they were more attracted towards these cash crops. The production of food crops has therefore declined over the past few years.

3.2.4 Local adaptation measures

3.2.4.1 Changes in sowing, planting and harvesting period

About 31% of informants said that they also changed their sowing, planting and harvesting time according to the changes in climatic conditions. The rest said that they just followed their previous traditions and timing of sowing, planting and harvesting.

A farmer, Ram Prasad Rai (62), said: "We used to sow maize on 18 Falgun [1 March]. The maize is now harvested almost 10 to 15 days earlier. Similarly,

we used to harvest potato in Mangsir [November-December]. This is now harvested on Magh [January-February]" (HH Survey, 14 November 2016). Similarly, another farmer Rajan Rai (66) said: "Maize used to be sown in the last week of Magh. Now it has changed. We sow maize in first week of this month [November]" (HH Survey, 14 November 2016). He further added that the harvesting time of maize had changed from the first week of Asar [third week of June] to mid Asar. Chhiiring Thonduk Sherpa (70) had the same statement. Fupu Dhoma Sherpa (39) said that millet used to be harvested in December in the past but has now being harvested in November.

3.2.4.2 Use of fertilizers

Ten informants said that they had been using more fertilizer nowadays than in the past. Rabin Chemjong Limbu (22) from Lelep said that more fertilizer was needed for cardamom cultivation. However, less number of livestock had also decreased the amount of animal manure. Rajan Rai (66) and Santa Bahadur Sherpa (54) said that less animal manure has resulted in declining soil fertility. Futi Sherpa (48) from Lelep said: "Earlier livestock were allowed to graze and animal manure was sufficient but now cardamom cultivation has increased, resulting in less livestock as there is less grazing area" (HH Survey, 14 Nov 2016).

3.2.4.3 Shift to high value crops

There was shift from traditional agricultural farming to high value crops. Six participants mentioned that they had changed their cropping pattern from food crops such as maize, wheat and potato to cardamom. Pasang Sherpa (40) said that he changed the crop due to lack of manure. Rabin Chemjong Limbu (22) and Tenzing Sherpa (45) said they had changed crops because of the higher income from cardamom. Similarly, Lakpa Phuti Sherpa (65) said that since there was no one to nurture the crops she had shifted to cardamom cultivation.

3.2.4.4 Irrigation

Irrigation was one of the adaptation measures in the changing agrarian landscape. Twenty two participants mentioned that there was an increasing tendency in the use of irrigation. All of the participants from age group 40-50 said the same. However, four participants said that the frequency of use of irrigation was same and all of them were agriculturalists. Sprinkler irrigation was mainly used in cardamom cultivation. However, other techniques such as drip irrigation were also used.

3.2.4.5 Food security

Most informants said that they had adopted other livelihood strategies to supplement household income and food security by working as daily wages or trading cash crops. A majority of informants, i.e. 26, mentioned that agricultural production was not sufficient for their family. Only six informants said that the food production was sufficient. Significant number of informants reported that they took up daily wage work to support their families for the rest of the year. Only a few of them said that they were involved in trade of chiretta and cardamom to sustain their livelihoods.

3.3 Livestock related livelihoods

3.3.1 Main occupation of inhabitants of Olangchung Gola

Livestock herding was the main occupation of the people of Olangchung Gola. Traditional transhumant movement of livestock is practiced. Livestock are taken for grazing in high alpine pastures in summer and returned to lower altitudes in winter. The major types of livestock in the research site were yak, chauri (including their hybrids such as urang, dimzo and jhopa), bhelang and sihaal goat. The local people also reared chicken. A survey of 33 HHs in Olangchung Gola showed that a significant percentage of the population depended on livestock herding, i.e. 15 (45.45%), followed by 10 (30.30%) on livestock herding together with other businesses. Out of 33 HHs, 0.09% kept livestock and also worked on a daily wage basis. One HH had livestock and the person also worked as a government employee. Two HHs were completely dependent on business while one single woman had no occupation at all. Table 8 shows the various occupations of the inhabitants of Olangchung Gola.

Table 8: Occupation and number of households in Olangchung Gola

SN	Occupation	No. of HHs	Percentage (%)
1	Livestock	15	45.45
2	Livestock and business	10	30.30
3	Livestock and daily wages	3	9.09
4	Livestock and government service	1	3.03
5	Daily wages	1	3.03
6	Business	2	6.06
7	No occupation	1	3.03

3.3.2 Changes in livestock herding

The study found that there was a change in livestock herding patterns, their numbers and species profile. Although the number of yaks and their hybrids had increased slightly, the total number of livestock reared by local people at present was found to be decreasing as compared to the past. They had 896 yaks and yak hybrids in the past but they now reared 928 yaks which was an increase. In contrast, they used to rear 206 bhelangs in the past, but now reared only 7. However, the number of sihaal goats had increased from 22 to 30. In all, there was a decrease in livestock numbers.

3.3.3 Factors responsible for the changes in livestock composition

The survey revealed several factors affecting the livestock herding pattern, changes in number and species. Some of the major factors included livestock mortality, diseases and pests, efficient birth of some livestock, fluctuation in grassland production, upward shifting of grazing area, growth of unpalatable plants and invasive species, less number of people to look after a large number of livestock, and shifting from transhumance herding to business for better economic opportunities and standard of living. These factors are categorized into four major themes: climatic, economic, migration and food security.

3.3.3.1 Climatic reasons

Changes in climatic conditions have been observed in the research site and corroborated by both local experience and recorded scientific data. The changes in climatic events have had direct and indirect impacts on the livestock economy. The different indicators of the changes in climatic conditions and its impact on livestock and rangelands are described below:

3.3.3.1.1 Seasonal calendar, water availability and disaster

Local experience and perception

A significant number of informants, 22 out of 33, had heard about climate change through a variety of sources such as Kangchenjunga Conservation Area Project (KCAP) training programmes, through radio, television, and from villagers. Four categories—increasing, decreasing, no change and fluctuating—were used to obtain their experience on the changes in climatic parameters and occurrence of extreme events during past years. Change in water availability, stream flow and stream supply were accessed through three categories—increasing, decreasing, and no change.

Information about the changes in occurrence of disaster events such as flood, landslide and drought were also obtained.

There were about 350-370 houses in the village before the landslides and flood of 1963. In 1963, a small landslide occurred and blocked the river at Deurali. The water started flowing back and flooded the upstream places with bed and bank scouring and caused huge landslide with destruction of almost half of the village. The next huge flood and landslide occurred in 1980 at Yangma which swept away the whole village destroying most of the houses and livestock. People do not live there any longer. The most recent significant landslide they remember is of 2011 at Sukepani. They said that the route to Tibet used to be very nice and mules and horses could be used for transportation but now that is not possible because the path is very risky due to landslides. They can't even go to Taplejung during rainy season because the path gets blocked due to landslides. They thus confirmed that landslides events have increased over the past years, making their life difficult.

Climatic parameters: Altogether 70% informants perceived an increase in summer temperatures while 48% perceived an increase in winter temperatures. Similarly, 67% said that there was increasing rainfall frequency and 55% reported increasing rainfall intensity. Regarding snowfall pattern, 67% said that the amount of snowfall was decreasing while 64% said that snowfall volume has significantly decreased over the past years.

Weather and extreme events: Extreme events included cloudy days, hailstorm, windstorm and cloudburst. Altogether 45% of the respondents said that the number of cloudy days had not changed, 33% and 30% said that they perceived hailstorm and windstorm events to be increasing over the past years, whereas 33% of them reported that cloudburst events were increasing.

Representatives during FGD confirmed that summer and winter temperatures were increasing. According to them, the winters used to very severe when they were young and the snowfall has decreased significantly in recent years (Figure 6).

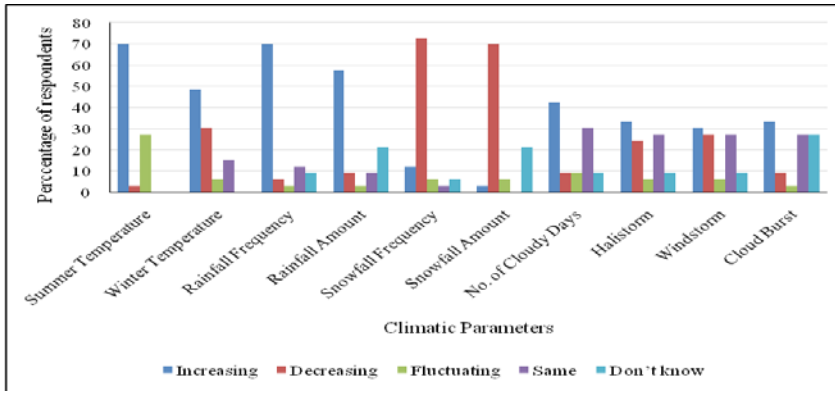

Figure 6: Local perceptions of climatic parameters and extreme events, Gola,
Source: Field Data 2016

Availability of water resources: Altogether 61% informants said that they had observed the stream flow in their place to be increasing over the recent years. Similarly 33% of the respondents said that the stream flow was decreasing whereas 42% said that the water availability in their place had not changed and there had not been any scarcity of water till date. Representatives of FGD said that the stream flow used to be very less as compared to now. They could easily cross the river with the help of one stick but now that was not possible because of much increased flow (Figure 7).

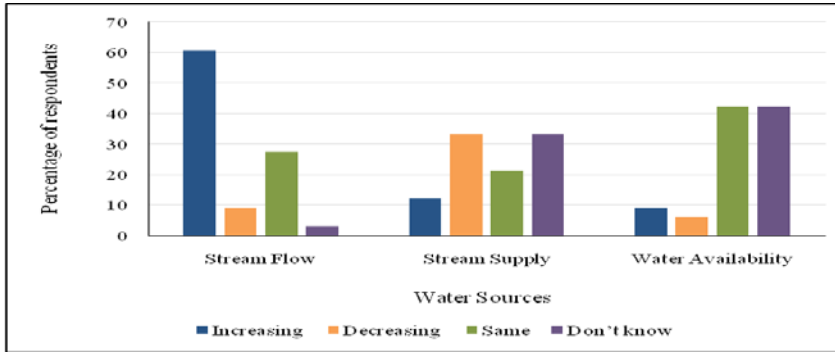

Figure 7: Local perception on change in water resources availability in Gola,
Source: Field Data 2016

Disaster events: Landslides, droughts and floods were reported by the informants. Altogether 73% said that landslides were increasing and 58% said that increasing drought events (Figure 8). Twenty four informants reported that more rainfall and less snowfall were the main causes for change in the

occurrence of disaster events. Most of the respondents were aged 30 and above. This may be because they could clearly remember the climatic conditions from 20 years before. One of them also said that increased deforestation was the cause for increased disaster events while one of the locals said earthquake was the cause.

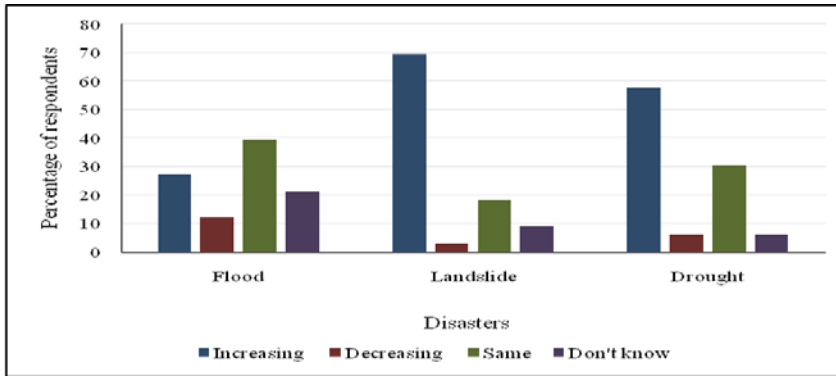

Figure 8: Local perceptions on occurrence of disaster events in Gola, Source: Field Data 2016

Comparison of local perceptions and scientific data

Local perceptions in Olangchung Gola of the change in climatic parameters, water availability and disaster events were found to match to some extent with the results from the trend analysis of data from DHM. The summer and winter temperatures as experienced by the locals were increasing annually. The warming effect was significant particularly during summer than in winter with an increase of 0.0248° C and 0.0246° C per year during summer and during winter respectively. The rainfall change perceived by the locals however contradicts with the result from trend analysis of precipitation data. The locals said that the rainfall was increasing whereas the trend line shows a decrease in precipitation. Similarly, the decrease in snowfall as reported by the local people could not be validated by the scientific data because there is no snowfall data recorded yet.

Local people said that the stream flow in their area had increased significantly over the recent decades. Representatives at the FGD focused on the increase in stream flow said that rivers could be easily crossed when they were young but now it was not possible without a bridge. On the contrary, it was found that the river discharge of Majhitar station in Tamor River was found to be decreasing. However, no scientific data relating to water supply change and water availability could be obtained.

In terms of disaster events, locals responded that there was no increase or decrease in the flood events in their area whereas landslides and drought events were increasing. Informants mentioned that more rainfall, less snowfall, increased deforestation and earthquakes were the major causes for disaster events. The maximum annual flood peak discharge of Tamor River was analyzed and it was found to be decreasing which did not comply with the people's perceptions. This could be because the hydrological data was available only for the river station at lower altitude at Majhitar and the study site was at much higher altitude. Similarly, for landslide events, the data on total annual landslides was accessed from Nepal DesInventar Database, NSET 2015 for comparison to the trend in the study site and it was found that the landslides events were increasing which complied with the local people's perception.

3.3.3.2 Livestock number and species

In total, there was a decrease in livestock numbers. However, the number of yaks and their hybrids were increased because of their efficient birth and people kept them for transportation of goods. The reason for decrease in the total number was due to lack of human resources to look after the huge number of livestock. A decline in grass production was also mentioned by the informants, which can be attributed to the changes in climatic condition. Other reasons for decreasing livestock population included selling of livestock for changing the occupation to business and for better life of the family.

3.3.3.3 Livestock diseases, pests and mortality

Respondents listed various diseases and pests affecting livestock in the area. These included diseases such as diarrhoea, swelling of eye, foot and mouth diseases (FMD), breathing difficulty, *gembu* and pests such as tick, lice, leech, liver fluke, tapeworm, black quarter and scabies. These diseases and pests were affecting livestock numbers and productivity and causing huge losses due to mortality in more expensive livestock such as yak and chauri. The incidence of these regular and new diseases and pests in the livestock could be attributed to the changes in climatic parameters such as increase in temperature or erratic rainfall.

Table 9. Livestock disease and pests reported by locals in Olangchung Gola

SN	Diseases and pests	Livestock
1	Diarrhoea	All
2	Swelling of eye	Sheep
3	Foot and mouth disease (FMD)	Yak and chauri
4	Breathing difficulty	All
5	Tick	All
6	Lice	All
7	Leech	All
8	Liver fluke	All
9	Tapeworm	All
10	Black quarter	Sheep and goat
11	Scabies	Goat

Livestock mortality rate had increased in the area. This could be linked with the increase in incidences of various diseases and pests which in turn could be due to the changes in climatic parameters. The information about diseases and pests was mostly provided by herders which could be attributed to their knowledge about diseases and pests in livestock as a result of being involved in the herding occupation.

3.3.3.4 Grassland production

A majority of informants (52%) said that there was no change in grassland productivity in the area. Altogether 27% said that it was increasing because of more rainfall and increasing hot days. In contrast, 21% said that it was decreasing because of no rainfall during dry season, heavy rainfall during wet season, and growth of unpalatable vegetation. They also noted that the declining trend of grassland production was due to changes in rainfall pattern that provided favourable conditions for the growth of weeds and created sudden and more water logging. Too much rainfall in early rainy season and more rainfall caused the decay of grasses. This directly shows the impact of changes in climatic parameters on grassland production. Among the informants, 83% were either completely or partially involved in herding.

3.3.3.5 Unpalatable plants and invasive species

Informants listed a number of unpalatable and invasive plant species which had been increasing in the area. These are listed in Table 10 below. These

unpalatable and invasive species were affecting the production of palatable grasses. An increase of these unpalatable and invasive plant species had led to the decrease in livestock numbers. This allows these unpalatable and invasive species to grow and invade the area. Climatic changes could also directly cause the growth of unpalatable species and invasion.

Table 10: List of unpalatable and invasive plant species reported from the study area

SN	Local Name	Scientific Name	Remarks
1	Halhale	*Rumex nepalensis* Spreng	Invasive species
2	Chutro	*Berberis aristata* DC.	Invasive species
3	Dhorne		
4	Maleto		
5	Titepati	*Artemisia indica* Willd.	Invasive species
6	Angeri	*Lyonia ovalifolia* (Wall.) Drude	
7	Bolu	*Pieris formosa* (Wall.) D. Don	Invasive species
8	Dhupi	*Juniperus squamata* Buch.-Ham. ex D.Don	
9	Lahare dhupi	*Juniperus recurva* Buch.-Ham. ex D.Don	
10	Uttis	*Alnus nepalensis* D. Don	
11	Sunpati	*Rhododendron anthopogon* D.Don	
12	Kande		
13	Thuturupa		Invasive species
14	Thotne	*Aconogonum molle* (D.Don) H.Hara	Invasive species
15	Chimal	*Rhododendron barbatum* Wall. ex G. Don	
16	Bhuinchuk	*Hippophae tibetana* Schlecht.	
17	Kalijhar	*Eupatorium adenophorum* Spreng.	Invasive species
18	Argeli	*Edgeworthia gardneri* (Wall.) Meisn.	Invasive species
19	Chirayito	*Swertia chirayita* (Roxb. ex Flem.) Karst.	Invasive species

3.3.3.6 Rangeland, treeline and vegetation shift

Local people in Olangchung Gola were found to take their livestock above the rhododendron line to graze. Altogether 48% of the informants said that they had noticed the rangeland shifting towards higher elevation over the past years. Among them, the main occupation of 81% informants was herding.

Informants listed a few plant species shifting towards the higher altitude (Table 11). The shift could be linked to increasing temperatures causing species to shift upwards in elevation.

Table 11: List of plant species shifting towards higher altitudes

SN	Local Name	Scientific Name
1	Halhale	*Rumex nepalensis* Spreng.
2	Thotne	*Aconogonum molle* (D.Don) H.Hara
3	Dhupi	*Juniperus squamata* Buch.-Ham. ex D.Don
4	Utis	*Alnus nepalensis* D.Don
5	Sunpati	*Rhododendron anthopogon* D.Don
6	Maikopila	*Saussurea* sp.
7	Gurans	*Rhododendron* sp.
8	Bhojpatra	*Betula utilis* D. Don
9	Gobre salla	*Pinus wallichiana* A. B. Jacks

3.3.3.7 Migration

Locals have been migrating out from the research site due to climatic changes or disasters. Altogether 19 informants, i.e. 58%, said that some locals had migrated due to different reasons including heavy snowfall, landslides and flood causing the destruction of their livestock.

3.3.3.8 Better economic opportunities

3.3.3.8.1 Livestock species and number

The change in livestock species and number, to some extent, was because of a shift from transhumance herding to businesses for better economic opportunities and securing a better life for their family and children. However, keeping more yaks than before was an economic reason as they were used for transporting goods from one place to another. In contrast, people sold chauris for monetary gain, to secure a better life for their family or to explore other business opportunities.

Altogether 69% informants said that a change in number of livestock was related to exploring better economic opportunities.

3.3.3.8.2 Shift to other practices

Some people had shifted from their traditional occupation to a new occupation such as business, medicinal plant trade and foreign employment. Altogether 48% informants said that local people had shifted from their traditional occupation. The shift to non-agricultural practices could directly be linked to better economic opportunities.

3.3.3.9 Lack of human resources

When asked if they have seen people migrating to other places, 58% said that locals have migrated from the research site due to various reasons mainly climate induced disasters. At the time of the 1991 Nepal census, Olangchung Gola had a population of 422 people living in 82 individual HHs whereas according to the 2011 Nepal census, there were 239 people living in 62 individual HHs. This has now decreased to 52 individual HHs according to the local people. Migration of local people from the research site to other places is also a major reason for the change in livestock number as stated by the respondents.

Among several reasons responsible for the decrease in the number of livestock stated by the respondents, lack of human resources was also one. They said that there is a lack of human resources to take care of the livestock and the herding was becoming unmanageable due to which they sold and decreased the number of livestock.

3.3.3.10 Food security and livestock production

Out of many reasons responsible for the change in livestock number either it be increase or decrease, is the food security or the production of livestock. Out of 33, 55% of the respondents said that the livestock rearing doesn't provide sufficient production for their family for a year whereas 39% said that the livestock production is sufficient for their family. Out of 39% responses with sufficient livestock production, 54% said that they also have surplus production.

The livestock number increases when there is sufficient or surplus production and thus economic benefits to the family whereas it decreases when the production is insufficient and there is no economic benefit from herding. That is when herders shift to non-agricultural practices, such as business and foreign employment. Similarly, food insecurity or decreased livestock production can

also be caused directly by the change in climatic conditions being unfavorable to the livestock or indirectly by the increase in frequency of diseases and pests as well as increase in livestock mortality.

3.3.4 Adaptation measures

Adaptation measures practiced by the local people can also play an important role in coping with the climatic changes and thus avoiding negative impacts to the livestock and rangeland causing either increase or decrease in the livestock number and rangeland production. Local people are found to have practiced different adaptation measures to cope with the changing climatic conditions which are discussed below:

3.3.4.1 Rangeland management practices

Herders have practiced different rangeland management practices such as rotational grazing, controlled burning, bush clearance, dung clearance, clearance of unpalatable species such as chutro and bhimsenpati, slash and burn, route track reformation and making bars and maintaining level of rangeland in order to avoid the negative impacts of climatic changes on livestock herding and rangelands.

Table 12. Transhumance migration in Olangchung Gola area

SN	Month	Grazing site A (Ghele Sherpa)	Grazing site B (Chundak Sherpa)
1	Baishakh	Mauma (4200 masl)	Jongim
2	Jeth	Mauma (4200 masl)	Dangje
3	Asar	Samjung	Mauma (4200 masl)
4	Shrawan	Samjung	Deuma (4000 masl)
5	Bhadra	Khemama, Tiptala (5000 masl)	Mauma (4200 masl)
6	Aswin	Khanglung	Dhingasamba (3750 masl)
7	Kartik	Rolep (4500 masl)	Tangje
8	Mansir	Mauma (4200 masl)	Lamakhana
9	Poush	Dhingasamba (3750 masl)	Babaksa
10	Magh	Dhingasamba (3750 masl)	Sebar
11	Fagun	Syamdo	Selap
12	Chaitra	Ramnesuki	Thomatepsa

3.3.4.2 Landslide prevention measures

Landslide prevention measures such as afforestation, route track reformation, gabion wall construction were practiced in the research site at the local level.

3.3.4.3 Adaptation measures adopted by herders

To cope with the changing rainfall pattern, herders practice early collection of fodder before snowfall, taking livestock to a dry place during rainy season and keeping livestock at the same flat place.

3.3.4.4 Migration

People were asked if they have seen the locals migrating from that place due to the climatic changes or disasters. Nineteen respondents i.e. 58% said that locals have migrated from the research site due to different reasons including heavy snowfall, landslides and flood resulting in livestock mortality. Migration clearly causes a decrease in livestock numbers.

3.3.4.5 Shift to other practices

Locals were found to have shifted from herding to other livelihood strategies, such as business, foreign employment and medicinal plant trade. Sixteen respondents said that they have seen the farmers shifting to non-agricultural practices from livestock herding. The shift directly contributes to a decrease in livestock herders and livestock number and thus also affects rangeland maintenance and production.

3.4 Vegetation analysis

Vegetation analysis was carried out in the rangelands and treeline of the research site. Quadrat sampling and transect methods were followed for rangeland survey and treeline study respectively. Altogether, 130 species were recorded in the four transects at elevations of 3750, 4000, 4250 and 4500 masl. Out of 130 species, 71 species were palatable as stated by the informants whereas nine species were recorded as unpalatable. Twelve species were unidentified.

3.4.1 Vegetation survey

3.4.1.1 Transect I: Dhingasamba; altitude 3750 masl; N 27º 42.952; E 087 º 44.118

Altogether 39 species were recorded in the vegetation survey at 3750 masl in three horizontal transects and 15 quadrats. In total of 15 quadrats, the species

with highest number of occurrence and frequency were chyadukpa and ghodtapre (*Centella asiatica*) with 14 and 93.9% respectively with relative frequency of 8%, followed by *Cyperus* sp. with 80% frequency and 6.9% relative frequency. The species with the lowest number of frequency were mendojyabu, sijyak, thombamikpa, halhale, *Juniperus* sp., mendosingya, *Rhododendron campanalutum* and *Bistorta* sp. with 6.7% and relative frequency of 0.6%.

Table 13: Measurement of species density at herb stratum at Dhingasamba (3750 masl)

SN	Name of plant species	NoO	Freq. %	RF %	Cov. %	RC %	MHt cm
1	*Berberis* sp. (Chemak)	2	13.3	1.1	10	3.2	75
2	*Bistorta* sp.	1	6.7	0.6	10	3.2	6
3	Chyadukpa	14	93.3	8	6	1.9	4.8
4	Chyurukpa	4	26.7	2.3	1.8	0.6	5.8
5	*Cotoneaster* sp. (Thaxema)	2	13.3	1.1	6.5	2.1	20
6	*Cyperus* sp. (Chalep)	12	80	6.9	12.9	4.1	6.9
7	Dhamjyak	3	20	1.7	16.7	5.4	12
8	*Euphorbia* sp. (Homacha)	3	20	1.7	3	1	2
9	Fern	8	53.3	4.6	11.6	3.7	27
10	*Fragaria* sp.	7	46.7	4	4.6	1.5	3.6
11	*Gaultheria* sp. (Munjima)	4	26.7	2.3	23.8	7.6	9.5
12	*Gentiana sp.* (Toriamendo)	3	20	1.7	2	0.6	2.3
13	Ghodtapre jasto (?)	14	93.3	8	4	1.3	2.1
14	*Juniperus* sp. (Pama)	1	6.7	0.6	10	3.2	2
15	Kyukuma	8	53.3	4.6	3.3	1.1	3.5
16	Majudela	2	13.3	1.1	3.5	1.1	19
17	Mendojyabu	1	6.7	0.6	5	1.6	3
18	Mendojyangu	2	13.3	1.1	3.5	1.1	5.5
19	Mendokapu	7	46.7	4	6.6	2.1	3
20	Mendosingya	1	6.7	0.6	15	4.8	12
21	Moss (Yambe)	2	13.3	1.1	7.5	2.4	2
22	*Plantago* sp.	2	13.3	1.1	2.5	0.8	5.5
23	*Potentilla coriandrifolia* (Chyatholo)	2	13.3	1.1	7.5	2.4	3.5

SN	Name of plant species	NoO	Freq. %	RF %	Cov. %	RC %	MHt cm
24	*Potentilla* sp. 2 (Chilun)	5	33.3	2.9	4.2	1.3	2.8
25	*Primula* sp. (Pandema)	6	40	3.4	3	1	4.2
26	*Rhododendron campanulatum*	1	6.7	0.6	10	3.2	2.5
27	*R. setosum* (Bhairungpati)	6	40	3.4	19.2	6.2	47.5
28	*Rumex nepalensis* (Syumakpa)	1	6.7	0.6	1	0.3	2
29	*Saxifraga* sp. (Mandosepu)	2	13.3	1.1	2.5	0.8	4.5
30	Sijyak	1	6.7	0.6	25	8	4
31	Syole	8	53.3	4.6	3.4	1.1	4.4
32	Thaksima	3	20	1.7	11.7	3.8	4.3
33	Thombamikpa	1	6.7	0.6	8	2.6	5
34	UN 03	2	13.3	1.1	11	3.5	3.5
35	UN 04	3	20	1.7	6.7	2.2	3.7
36	UN 05	4	26.7	2.3	6.3	2	2.3
37	UN 08	8	53.3	4.6	5.1	1.6	3.1
38	Upa	9	60	5.1	3.9	1.3	24.4

Similarly, the species with the maximum coverage was Sijyak with 25%, *Gaultheria* sp. with 23.8%, followed by 19.2% bhairangpati with relative coverage values of 8%, 7.6% and 6.2% respectively. The highest species recorded were *Berberis* sp., *Bhairangpati* sp., fern, upa and *Cotoneaster* sp. with 75 cm, 47.5 cm, 27 cm, 24 cm and 20 cm mean heights respectively.

Out of 39 species, 15 species were palatable and 5 species were unpalatable. The preferability of many species were not known. Three of the species could not be identified.

3.4.1.2 Transect II: Singjema Khola, Deuma; altitude 4000 masl; N 27º 45.091; E 087 º 44.221

Altogether 34 species were recorded at 4000 masl in three horizontal transects and 15 quadrats. The species with highest occurrence of 13 out of 15 and frequency of 86.7% were khoda and *Cyperus* sp. with relative frequency of 9.7%, followed by chyadukpa with 73.3% frequency and 8.2% relative frequency. The species with least frequency were *Fragaria* sp., UN 7, *Berberis* sp., *Potentilla*

sp.1 Cherak, UN 2, *Cotoneaster* sp. *Maxima, Primula* sp.*, Potentilla* sp. *3,* thosi, *Saxifraga* sp., pink flower, chandu, moss, UN 5, *Bistorta* sp.*,* khoda, with 6.7% frequency value and relative frequency of 0.7%. The species with maximum coverage was *Cotoneaster* sp. with 50% coverage, followed by 37% halhale and 25% *Potentilla* sp.1 (cherak) with relative coverage values of 15.6%, 11.6% and 7.8% respectively. The tallest species recorded were *Berberis* sp. with mean height of 50 cm, followed by other species such as UN 2, halhale and majedula with 8 cm, 7 cm, and 6.6 cm mean heights respectively. Out of 34 species, 23 species were palatable and 2 species were unpalatable. Five species could not be identified. The preferability of some species could not be known.

Table 14: Measurement of species density at herb stratum at Singjema (4000 masl)

SN	Name of plant species	NoO	Freq. %	RF %	Cov. %	RC %	MHt cm
1	*Berberis* sp. (Chemak)	1	6.7	0.7	15	4.7	50
2	*Bistorta* sp.	1	6.7	0.7	5	1.6	6
3	Chandu	1	6.7	0.7	2	0.6	6
4	Chyadukpa	11	73.3	8.2	5.3	1.6	5.3
5	Chyangoju	2	13.3	1.5	3	0.9	3.5
6	*Cotoneaster* sp. (Thaxema)	1	6.7	0.7	50	15.6	4
7	*Cyperus* sp. (Chalep)	13	86.7	9.7	17.1	5.3	4.2
8	*Fragaria* sp.	1	6.7	0.7	1	0.3	4
9	*Gentiana sp.* (Toriamendo)	2	13.3	1.5	3.5	1.1	3
10	*Gentianella* sp. (Mendogono)	2	13.3	1.5	1.5	0.5	1.5
11	Khoda	13	86.7	9.7	9.3	2.9	2.9
12	Kyukuma	9	60	6.7	8.1	2.5	4.8
13	Majudela	10	66.7	7.5	7.7	2.4	6.6
14	Moss (Yambe)	1	6.7	0.7	5	1.6	1
15	Panjyadallu	4	26.7	3	18.8	5.8	4
16	*Plantago* sp.	6	40	4.5	5.3	1.7	5
17	*Potentilla* sp. (Shepo)	6	40	4.5	3	0.9	4.2
18	*Potentilla coriandrifolia* (Chyatholo)	3	20	2.2	9	2.8	3
19	*Potentilla* sp. (Tholo)	8	53.3	6	8.6	2.7	5.8
20	*Potentilla* sp. 1 (Cherak)	1	6.7	0.7	25	7.8	3

SN	Name of plant species	NoO	Freq. %	RF %	Cov. %	RC %	MHt cm
21	*Potentilla* sp. 2 (Chilun)	3	20	2.2	23.3	7.3	4
22	*Potentilla* sp. 3 (Thosi)	1	6.7	0.7	7	2.2	3
23	*Primula* sp. (Pandema)	1	6.7	0.7	2	0.6	4
24	*Rhododendron* sp. (Thaksuro)	6	40	4.5	20.8	6.5	6
25	*Rumex nepalensis* (Syumakpa)	9	60	6.7	37.3	11.6	7
26	*Saxifraga* sp. (Mandosepu)	1	6.7	0.7	2	0.6	5
27	UN 02	1	6.7	0.7	2	0.6	8
28	UN 03	4	26.7	3	2.3	0.7	3.5
29	UN 04	5	33.3	3.7	4.8	1.5	2.8
30	UN 05	1	6.7	0.7	2	0.6	2
31	UN 06	3	20	2.2	4	1.2	4.3
32	UN 07	1	6.7	0.7	4	1.2	5
33	UN 08	1	6.7	0.7	3	0.9	5
34	UN 09 (Pink flower)	1	6.7	0.7	3	0.9	4

3.4.1.3 Transect III: Flauma; altitude 4250 masl; N 27º 46.497; E 087 º 43.519

In the vegetation survey at Transect III 4250 masl at Flauma, altogether 36 species were recorded. Maximum occurred and frequent species were *Bistorta* sp., with 13 occurrence out of 15 and 86.7% frequency with relative frequency of 11.6%, followed by *Primula* sp., and *Gaultheria* sp. with frequency 60 % and 53.3% and relative frequencies of 8% and 7.1% respectively. The species with least frequencies were *Primula* sp., penji, mapu, *Gentianella* sp., *falu* sp., chalep, pandelamu, *Astralagus* sp., chyadukpa, *Rhododendron anthopogon, Rhododendron lepidotum, Saxifraga* sp., *Dactylorhiza hatagirea, Berberis* sp. and *Incarvillea* sp. with 6.7% frequency and relative frequency of 0.9%.

Similarly, the species with the maximum coverage of 50% was *Juniperus* sp., followed by 40% *Berberis* sp., 35% *Rhododendron lepidotum* with relative coverage values of 10.4%, 9.8% and 8.6% respectively. The highest species recorded were *Rhododendron anthopogon, Rhododendron* sp. and *Juniperus* sp. with 50 cm, 37.5 cm, and 30 cm mean heights respectively. Out of 36 species, 11 species were palatable and three species were unpalatable. The preferability of some species could not be known.

Table 15: Measurement of species density at herb stratum at Flauma (4250 masl)

SN	Name of plant species	NoO	Freq.%	RF%	Cov.%	RC%	MHt cm
1	*Astralagus* sp.	1	6.7	0.9	1	0.2	2
2	*Berberis* sp. (Chemak)	1	6.7	0.9	40	9.8	15
3	*Bistorta* sp.	13	86.7	11.6	18.5	4.5	5.9
4	Chyadukpa	1	6.7	0.9	2	0.5	3
5	*Cotoneaster* sp. (Thaxema)	5	33.3	4.5	19	4.6	6.8
6	*Cyperus* sp. (Chalep)	1	6.7	0.9	35	8.6	2
7	*Dactylorhiza hatageria*	1	6.7	0.9	1	0.2	3
8	*Falu* sp.	1	6.7	0.9	10	2.4	12
9	*Gaultheria* sp. (Munjima)	8	53.3	7.1	22.9	5.6	5.4
10	*Gentiana sp.* (Toriamendo)	2	13.3	1.8	3	0.7	4.5
11	*Gentianella* sp. (Mendogono)	1	6.7	0.9	1	0.2	3
12	Grass	4	26.7	3.6	2	0.5	3
13	*Incarvillea* sp. (Mendojhyango)	1	6.7	0.9	1	0.2	3
14	*Juniperus* sp. (Pama)	4	26.7	3.6	42.5	10.4	37.5
15	*Lancea* sp. (Mendosingya)	4	26.7	3.6	6.8	1.6	14.8
16	*Lonicera* sp. (Maxima)	1	6.7	0.9	10	2.4	15
17	Mapu	1	6.7	0.9	2	0.5	4
18	Pandelamo	1	6.7	0.9	2	0.5	4
19	Pangemendo	3	20	2.7	3	0.7	3
20	Penje	1	6.7	0.9	1	0.2	15
21	*Potentilla* sp. (Shepo)	6	40	5.4	10.2	2.5	3
22	*Potentilla coriandrifolia* (Chyatholo)	7	46.7	6.2	6.1	1.5	3
23	*Primula* sp. (Pandema)	9	60	8	6	1.5	5.3
24	*Primula* sp. 1	2	13.3	1.8	5.5	1.3	4.5
25	*Primula* sp. 2	1	6.7	0.9	6	1.5	3
26	*Rhododendron anthopogan*	1	6.7	0.9	30	7.3	50
27	*Rhododendron lepidotum*	1	6.7	0.9	35	8.6	15
28	*Rhododendron setosum* (Bhairungpati)	2	13.3	1.8	20	4.9	27.5
29	*Rhododendron* sp.	3	20	2.7	15	3.7	30

SN	Name of plant species	NoO	Freq.%	RF%	Cov.%	RC%	MHt cm
30	*Rhododendron* sp. (Thaksuro)	2	13.3	1.8	11	2.7	8.5
31	*Saxifraga caveana*	3	20	2.7	5	1.2	4.3
32	*Saxifraga* sp. (Mandosepu)	1	6.7	0.9	5	1.2	4
33	Shangdima	3	20	2.7	4.7	1.1	3
34	*Tanacetum* sp.	3	20	2.7	5.7	1.4	4.7
35	Thashu (Khar)	7	46.7	6.2	10.3	2.5	4.4
36	Thosi	6	40	5.4	10.3	2.5	7.3

3.4.1.4 Transect IV: Rolep; altitude 4500 masl; N 27º 47.181; E 087 º 44.421

Altogether 37 species were recorded in the vegetation survey of Transect IV (4500 masl) at Rolep, from 15 sample plots. The species with maximum occurrence of 12 and the highest frequency of 80% was *Gentiana* sp. with relative frequency of 10.3%, followed by *Cotoneaster* sp. and *Potentilla coriandrifolia* with 53.3% frequency and 6.9% relative frequency. The species with the lowest frequency were pangajarapo, UN 10, mapu, *Primula* sp.1*, Primula* sp.2*, Tanacetum gossypium, Invarvillea* sp.*,* UN 11, UN 12, *Saxifraga* sp. (mandosepu), *Trifolium* sp.*, Corex* sp., chayadela, UN 2, UN 3, thamo, *Corydalis* sp., chushu with 6.7% frequency and relative frequency of 0.9%.

The highest coverage was of species *Juniperus* sp. with 76.4%, followed by 34.4% *Cotoneaster* sp. and 15.7% thasu (khar) with relative coverage values of 24.8%, 11.1% and 5.1% respectively. The highest species recorded were *Juniperus* sp., *Meconopsis* sp. (shepodhombo) and *Trifolium* sp. with 93.3 cm, 10.5 cm, and 10 cm mean heights respectively. Out of 37 species recorded, 15 species were palatable and two species were unpalatable. The preferability of some species were not known and five species could not be identified.

Table 16: Measurement of species density at herb stratum at Rolep (4500 masl)

SN	Name of plant species	NoO	Freq.%	RF%	Cov.%	RC%	MHt cm
1	*Astralagus* sp.	2	13.3	1.7	3	1	3
2	*Bistorta* sp.	5	33.3	4.3	8.8	2.8	6.2
3	*Carex* sp.	1	6.7	0.9	3	1	7
4	Charamba	6	40	5.2	13	4.2	4.6
5	Chushu	1	6.7	0.9	1	0.3	2
6	Chyadela	1	6.7	0.9	3	1	5
7	*Corydalis* sp.	1	6.7	0.9	1	0.3	3

SN	Name of plant species	NoO	Freq.%	RF%	Cov.%	RC%	MHt cm
8	*Cotoneaster* sp. (Thaxema)	8	53.3	6.9	34.4	11.1	6
9	*Euphorbia* sp. (Homacha)	6	40	5.2	6	1.9	3.3
10	*Gentiana sp.* (Toriamendo)	12	80	10.3	4.2	1.3	4.5
11	*Gentianella* sp. (Mendogono)	3	20	2.6	3.7	1.2	3.3
12	Ghodtapre jasto	1	6.7	0.9	8	2.6	4
13	*Juniperus* sp. (Pama)	3	20	2.6	76.7	24.8	93.3
14	*Lancea* sp. (Mendosingya)	3	20	2.6	3.3	1.1	3
15	Mapu	1	6.7	0.9	7	2.3	2
16	*Meconopsis* sp. (Sepodhombo)	4	26.7	3.5	5.5	1.8	10.5
17	Pandelamo	2	13.3	1.7	6	1.9	5
18	Pangajarapo	1	6.7	0.9	1	0.3	5
19	*Potentilla* sp. (Shepo)	6	40	5.2	10.2	3.3	4
20	*Potentilla coriandrifolia* (Chyatholo)	8	53.3	6.9	10.3	3.3	3.5
21	*Primula* sp. (Pandema)	7	46.7	6	2.1	0.7	3.3
22	*Primula* sp. 1	1	6.7	0.9	2	0.6	3
23	*Primula* sp. 2	1	6.7	0.9	2	0.6	3
24	*Saxifraga* sp. (Mandosepu)	1	6.7	0.9	3	1	4
25	Shangdima	4	26.7	3.5	11.3	3.6	4.3
26	*Silene* sp.	2	13.3	1.7	2	0.6	6
27	*Tanacetum gossypium*	1	6.7	0.9	3	1	3
28	*Tanacetum* sp.	7	46.7	6	8.1	2.6	5.5
29	Thamo	1	6.7	0.9	12	3.9	4
30	Thashu (Khar)	7	46.7	6	15.7	5.1	7.4
31	*Trifolium* sp.	1	6.7	0.9	7	2.3	10
32	UN 01	3	20	2.6	5.3	1.7	3

SN	Name of plant species	NoO	Freq.%	RF%	Cov.%	RC%	MHt cm
33	UN 02	1	6.7	0.9	1	0.3	0
34	UN 03	1	6.7	0.9	3	1	4
35	UN 10	1	6.7	0.9	10	3.2	8
36	UN 11	1	6.7	0.9	3	1	2
37	UN 12	1	6.7	0.9	10	3.2	6

3.4.2 Livestock preference of alpine grass and other vegetation

In-depth interviews were conducted with two herders in Mauma and Deuma to know about the alpine grasses and other vegetation preferred by the livestock in Olangchung Gola. The herders were Ghele Sherpa with over 25 years of livestock grazing and rearing, and Chundak Sherpa with 20 years of experience. The categorizations were: i) most favoured, ii) favoured, iii) seasonally favoured, iv) least favoured and v) not favoured. Of the total 45 species, there were nine species most favoured by the livestock, such as the species of *Bistorta* sp, *Cyperus* sp and *Euphoribia*. Similarly, ten species were least favoured, such as *Salix* sp., *Incarvellia* sp., *Gaultheria* sp., *Saxifraga* sp., *Plantago* sp. and *Lancea* sp. The favoured and seasonally favoured were six and three species respectively. Seven species were never preferred by the livestock, as they are toxic.

Table 17. Livestock preference of alpine grass and other forage species at Gola

SN	Most Favoured	Favoured	Seasonally Favoured	Least Favoured	Not Favoured
1	*Bistorta* पांज्यादलु	*Potentilla* छेरक	*Potentilla* छयाथोलो	स्योमाक्पा (हलहले)	खामा
2	*Cyperus* चालेप	Potentila छिलुं	*Berberis* छेमक	च्यादुक्पा	*Rhododendron anthopogan*
3	चराम्वा	पेन्जे	क्युक्युमा	*Salix* लाँमा	*R. lepidotum*
4	*Euphorbia* होमाचा	चन्दु		*Incarvellia* मेन्दोभ्याङ्गो	*Rhododendron* भैरुंगपाती
5	पांगेमेन्दो	Cotoneaster थाक्सेमा		*Gaultheria* मुन्जीमा	*Juniperus* पामा
6	*Lonicera* माक्सिमा	च्याङ्गोजु		*Gentianella* मेन्दोगोनो	*Meconopsis* सेपोधोम्बो
7	Primula पाँदेमा			*Saxifraga* मेन्दोसेपू	माजुदेला

SN	Most Favoured	Favoured	Seasonally Favoured	Least Favoured	Not Favoured
8	खोड़ा			*Lancea* मेन्दोसिङ्या	
9	*Potentilla* थोसी			*Gentiana* तोरियामेन्दो	
10				*Plantago* इसपगोल	

3.4.3 Growth rate and upward shift of juniper

Examination of 17 tree cores of juniper species from the site revealed that the minimum and maximum growth rates of tree was 0.39 mm/year and 1.746 mm/year respectively (Table 18). The longest time period covered by chronology was 238 years, from 1799 to 2016. Among all the tree ring series the longest and shortest were 238 and 16 years, with an average of 94 years. The overall trend of growth and age of tree was seen to be negative with r2 value 0.4, which indicates that the growth of trees depends upon the age and size of the tree, meaning the older the tree the slower the growth rate.

Table 18. Age and mean growth of juniper at the treeline at Singjema Khola, Deuma (4000 masl)

Series	Cores	Beginning year	Ending year	Age	Mean growth
1	JUSQ001	1993	2016	24	0.721
2	JUSQ003	1979	2016	38	0.77
3	JUSQ003	1991	2016	26	1.06
4	JUSQ004	1963	2016	54	0.675
5	JUSQ007	1978	2016	39	1
6	JUSQ010	1979	2016	38	1.424
7	JUSQ011	1994	2016	23	1.666
8	JUSQ013	2001	2016	16	1.199
9	JUSQ014	1941	2016	76	0.849
10	JUSQ015	1987	2016	30	1.505
11	JUSQ015	1987	2016	30	1.746
12	JUSQ016	1794	2016	223	0.393
13	JUSQ016	1782	2016	235	0.547
14	JUSQ017	1802	2016	215	0.414
15	JUSQ017	1801	2016	216	0.955
16	JUSQ018	1942	2016	75	1.565
17	JUSQ019	1779	2016	238	0.699

* JUSQ = *Juniperus squamata* Buch.-Ham. ex D.Don

The standing juniper formed the treeline at 4070 masl near Singjema Khola at Deuma. The seedlings of the species were observed above 4200 masl, indicating that the species was shifting upwards in recent years. The preliminary calculation showed that there was upslope shift of juniper at the rate of 8.4 m per decade. The measurements of all individuals were done within the belt transect of 120 m x 10 m. Altogether, there were 136 individuals of juniper, which included seedlings and old mature trees (DBH 101 cm; height up to 18 m). The growth rate, as calculated by node (whorl) counts, was found to be 7 cm per year on average.

Table 19. Measurements of all individuals of juniper species in belt ttransect at Sangjema

S.N.	Belt distance (m) from top	Node/whorl counts (no.)	Height of tree (cm)	Average crown width (cm)	Basal diameter (at 1 cm from the ground)
1	0.0	8	20	18	2
2	1.3	7	25	28	3
3	2.3	12	25	22	3
4	3.0	5	31	25	<2
5	3.7	12	22	25	4
6	4.5	6	15	28	<2
7	4.5	6	38	22	2
8	4.6	8	19	22	2
9	4.6	13	75	120	2
10	5.0	11	50	60	4
11	5.0	9	50	60	2
12	7.1	9	40	40	2
13	11.0	6	50	75	3
14	11.0	6	50	40	2
15	12.1	7	50	40	2
16	14.8	11	90	60	6
17	14.9	7	50	125	3
18	14.9	3	25	10	<2
19	16.2	6	40	20	2
20	16.5	7	30	40	3
21	16.5	15	20	60	4

S.N.	Belt distance (m) from top	Node/whorl counts (no.)	Height of tree (cm)	Average crown width (cm)	Basal diameter (at 1 cm from the ground)
22	19.3	9	60	50	4
23	19.3	13	120	80	9.5
24	19.4	9	50	50	3
25	20.7	9	40	30	2
26	22.0	10	50	40	5
27	22.5	7	60	30	3
28	25.0	30	150	135	7
29	26.0	7	45	30	<2
30	26.5	8	50	25	2
31	26.6	8	50	100	2.5
32	27.0	11	110	125	6
33	27.0	12	80	70	3.5
34	27.5	20	145	90	4
35	28.0	7	35	30	2
36	29.0	9	80	85	3
37	29.0	12	40	90	4
38	29.0	4	30	30	<2
39	29.0	3	30	20	<2
40	30.7	20	170	290	15
41	31.4	20	160	90	5.5
42	32.8	20	35	70	4
43	32.8	11	50	110	4
44	33.0	12	65	125	6
45	33.2	5	50	70	2
46	33.5	7	50	50	2
47	33.8	22	130	85	6
48	37.0	4	40	40	<2
49	37.0	6	45	20	<2
50	37.0	4	45	25	<2
51	38.2	6	40	30	2
52	38.2	13	70	130	6.5
53	38.5	6	40	40	4

S.N.	Belt distance (m) from top	Node/whorl counts (no.)	Height of tree (cm)	Average crown width (cm)	Basal diameter (at 1 cm from the ground)
54	39.5	4	40	25	1<2
55	39.6	6	35	50	2
56	40.5	5	40	35	2.5
57	40.6	5	60	40	3.5
58	41.4	7	80	80	6
59	41.5	12	60	110	7
60	42.4	13	60	120	6
61	42.5	5	30	30	<2
62	43.3	14	65	125	5
63	43.4	18	100	80	5
64	43.6	45	210	215	9.8
65	43.6	36	190	120	9.9
66	44.0	6	50	40	2.5
67	45.6	30	250	175	10.5
68	45.6	32	165	140	8.3
69	47.8	20	140	110	7.5
70	49.9	11	65	170	9
71	51.6	23	180	80	12
72	53.6	14	40	120	4
73	54.3	8	25	75	2
74	54.3	14	135	100	6
75	54.3	14	145	85	4
76	55.3	4	40	30	<2
77	57.0	14	60	110	8
78	59.6	4	30	35	<2
79	59.6	5	25	20	<2
80	60.0	16	120	110	6
81	64.9	10	65	35	2.5
82	65.5	7	30	20	<2
83	65.5	4	50	15	3
84	65.6	40	350	220	15
85	67.0	39	140	170	8

S.N.	Belt distance (m) from top	Node/whorl counts (no.)	Height of tree (cm)	Average crown width (cm)	Basal diameter (at 1 cm from the ground)
86	69.0	17	90	65	4
87	70.8	10	25	50	4
88	72.8	9	65	50	4
89	72.8	6	25	25	<2
90	75.8	31	170	130	9
91	77.5	11	140	80	4
92	77.6	6	100	35	3
93	79.0	7	60	30	<2
94	80.7	5	30	25	<2
95	81.7	10	65	30	2
96	81.7	7	55	30	2
97	82.0	41	200	300	14
98	83.6	8	50	35	<2
99	85.0	40	200	175	11.5
100	85.2	14	110	80	6
101	85.3	41	190	125	12
102	85.6	34	225	150	10
103	85.8	31	250	150	12
104	86.9	28	240	150	12
105	90.0	41	450	300	15
106	90.3	NA	450	300	23
107	90.5	21	180	130	13.5
108	92.5	22	400	300	14
109	92.8	5	50	20	<2
110	92.9	7	30	50	3
111	94.3	11	200	175	11.5
112	94.4	NA	175	150	10.5
113	95.0	22	100	300	120
114	98.4	20	75	50	4
115	98.7	6	50	65	<2
116	100.7	27	325	250	15
117	101.0	NA	1800	800	48

S.N.	Belt distance (m) from top	Node/whorl counts (no.)	Height of tree (cm)	Average crown width (cm)	Basal diameter (at 1 cm from the ground)
118	101.0	NA	1600	700	50
119	102.3	NA	NA	200	18
120	103.6	NA	15	800	45
121	103.9	38	250	160	16
122	104.3	37	400	275	18
123	104.4	NA	450	240	24.5
124	105.0	24	300	200	14
125	105.6	30	400	250	20
126	107.1	12	200	150	4
127	107.6	47	500	400	22
128	107.7	NA	375	300	21
129	107.8	NA	450	400	31
130	107.9	22	180	200	6
131	109.3	NA	450	420	31.5
132	113.0	NA	1200	800	47
134	113.0	NA	400	400	22.5
135	115.0	NA	300	175	27
136	117.0	34	300	200	27

Note: NA = Not Available

4. Findings and conclusion

Table 20 presents a summary of the findings from the study sites in KCA. The local people have felt the impacts of climate change through their experiences of temperature rise and changed rainfall pattern. As proxy evidences of the change, they have noticed upward shift of some plant species and new weeds in their farms and other places. The use of simple modern tools such as thermometer and rain-gauge will be much helpful in their scientific understanding of climate/ weather patterns. To verify the changes observed and analyze them quantitatively, core sample collection for dendrochronological studies is proposed. More community consultation and awareness sessions involving the local people are also proposed so as to prepare a framework of adaptation measures.

Table 20: Research objectives, activities and findings

SN	Objectives	Activities	Findings
1	To sensitize local people about the impact of climate change	• Community consultations • Display and distribution of IEC materials	• Changes in temperature, rainfall and snowfall patterns, water availability and landslides
2	To establish a weather station at a school in Lelep	• Establishment of a weather station and set up a rain gauge for regular monitoring • Use thermometer for temperature record.	• School teachers/students have accepted the offer and promised to record temperature and rainfall (Educational materials, stationary and NPR 10,000 supported to the school).
3	To assess climate change induced treeline shift	• HH survey, FGD, KII and SLD • Quadratic measurement for vegetation shift • Collected tree core samples for dendro-climatological study	• Eleven plant species said to have shifted upwards, six of them moved up naturally and the rest planted in Lelep area (Table 7), and nine species moving upwards in Gola area (Table 11) • Nineteen unpalatable plant species said to be grown in rangeland, nine of them were said to be invasive species (Table 10) • Treeline of juniper was found at 4070 masl; its seedlings were found above 4200 masl, indicating upward shift of the species
4	To assess the impact of climate change in agriculture	• Questionnaire survey and KII; Cross-checked and verified during the second field visit	• Major crops include potato, maize, millet and barley • Shift from traditional crops to cash crops • Thirteen different pests and diseases reported on major crops as well as on cardamom (Table 5) • Twenty one weeds reported among them five are new to the area (Table 6)

SN	Objectives	Activities	Findings
5	To assess the impact of climate change in livestock	• Questionnaire survey and KII; Cross-checked and verified during the second field visit	• Total number of livestock decreasing except yak and sihaal goat • Decreased due to less human resources and lack of grass • Decreased because of changing occupation such as business • Increased because of their efficient birth and for transportation of goods
6	To trace the potential adaption and livelihood options	• Questionnaire survey and KII; Cross-checked and verified during the second field visit	• Cultivation of cash crops such as cardamom and chiretta • A few shops with Chinese items and hotels have opened • Opportunity for tourism

5. Way forward

The present research study presents a climate trend of increased temperature and erratic and decreasing rainfall in the Kangchenjunga area of eastern Nepal. Natural disasters and hazards were evident from fresh and continued landslides on mountain slopes throughout the trek. Another area of concern for the local community and their ecosystems, in specific the rangeland and agricultural farms, were being invaded by unwanted weeds and pests. At the treeline, the treeline species was found shifting upwards, while at the settlements and their vicinity, new plant species were noticed which were previously limited to lower elevations. The farmers are most affected as their crops and livestock were infected by pests and disease that have resulted in decreased production. Local farmers have been adopting some quick measures such as shift in crop calendar, introduction of new varieties, and sprinkler irrigation. They were receiving occasional services of livestock treatment and training to enhance their capacity. The effort, however, is far less than what is needed.

The following actions are recommended:

1. **Climate trend study**: The observed trend of climate change, rise in temperature and reduction in rainfall should be further corroborated by expanding the study sites and comparing the findings with similar studies

and data analysis in nearby sites. The impacts of climate change are manifested in treeline dynamics and upslope shift of species limit. Further studies considering more tree species and across different aspects of the mountains could provide a better understanding of these impacts. In the study area of Deuma, Olangchung Gola, at least three more species of trees, *Betula utilis*, *Salix* sp., and *Abies spectabilis* were present. Within the same study site, these species can be studied for a comparative analysis of climate change impacts on treeline shifts.

2. **Livelihood options and knowledge enhancement**: High mountain livelihoods are very vulnerable to climate change as the local people have fewer options to adapt. However, the indigenous knowledge systems that have helped them thrive in most adverse conditions could provide the best solutions. There is a need for more action research on adaptation and mitigation measures, working with local communities to develop site specific and appropriate solutions and generating knowledge to enhance our understanding of the complexities of climate change impacts on the ecosystems and livelihoods.

3. **Permanent research station**: The Himalaya is viewed as much affected by climate change, but the lack of empirical long-term studies have been a major limitation for scenario development. In recent years, some studies have been carried out but there is paucity of experimental studies based on long-term research. Thus, it is highly recommended that permanent monitoring plots be set up in the high altitudes of the Kangchenjunga area and long-term data be generated.

4. **Development projects and sustainability**: A road is being built to link Olangchung Gola with Tibet via Tiptala pass. Also, the road from the district headquarter, Fungling, is being extended to the north. Linking research studies with such projects is important for monitoring impacts of linear infrastructure development and ensuring the sustainability of natural ecosystems.

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7. Annexes

Annex 7.1
Research team, expertise, education, experience and their roles and responsibilities

Name of expert	Education	Experience	Roles/responsibilities
Dr Dinesh Raj Bhuju, Academician (NAST)	MSc Botany, PG Plant Conservation, PhD (Chiba University, Japan)	More than 25 years in research and university teaching	Principal investigator (PI): Mountain ecologist and climate change specialist. Overall supervision.
Dr Kamal Adhikari Research Fellow (RHF)	MSc Botany, MSc Ethnobotany, PhD (University of Aberdeen, Scotland)	More than 15 years in research and field surveys.	Vegetation expert: Ethnobotany and socio-economy, field experiences at KCA during high altitude wetland survey. Assist PI in project execution and report preparation.
Dr Shankar Raj Barsila, Asst. Professor (AFU, Rampur Nepal)	MSc Animal Science, PhD (ETH, Switzerland)	More than 12 years in research and field surveys; Recently in teaching.	Livelihood expert: Mountain agroecosystem and pastoralism, field experiences at KCA during PhD. Assist PI in project execution and report preparation.
Ms Lily Shrestha **Research Assistant**	MSc first year (Golden Gate International College, TU affiliate)	Experience in environmental baseline survey; Volunteer in environmental campaigns	Participate and assist in field survey and data entry; produce master's thesis.
Ms Shubekshya Upadhyay **Research Assistant**	MSc first year (Golden Gate International College, TU affiliate)	Experience in environmental baseline survey; Volunteer/ Social mobiliser	Participate and assist in field survey and data entry; produce master's thesis

Annex 7.2
First field visit (04–17 Nov 2016) to Kangchenjunga

Date	Route	Activities
4-5 Nov-16	Kathmandu-Fungling	Communicated with • Kangchenjunga Conservation Area Management Committee (KCAMC) • District Forest Office • HIMALICA
6-Nov-16	Fungling-Mitlung	Meeting with stakeholders • Kumar Siwa, Chairperson ECDF, Taplejung • Harish Chandra Chilwal, HIMALICA, Taplejung • Khagendra Phembo Limbu, Chairperson KCAMC • Dan Bahadur Shrestha, DFO • Tekendra Pradhan, SUAAHARA • Chakra Pani Pandey, CDO • Three hour walk to Mitlung • Interviewed Purna Karki at Mitlung
7-Nov-16	Mitlung-Tapethok	• Arrangement of a local guide/helper, Dil Bahadur Limbu • Observed cardamom plantation, sprinkler irrigation, solid waste issues, landslides on the way • Interviewed Buddha Lal Limbu at Tapethok
8-Nov-16	Tapethok-Illadada	• Interviewed Mr. Bishnu Limbu Phembu and Mr. Narayan Prasad Phembu • Observed KCAP head office at Lelep • Interviewed Mr. Bharat Limbu at Iladanda
9-Nov-16	Illadada-Olangchung Gola	• Observed several landslides on the way, • Interacted with local people and explained about the research project
10-Nov-16	Olanchung Gola	• Familiarization, formal and informal interaction with the local people • Conducted HH surveys • Met a of the herder who still keeps a goth, in the evening

Date	Route	Activities
11-Nov-16	Olanchung Gola	• Conducted HH Surveys • Conducted a FGD with seven members of the community
12-Nov-16	Olanchung Gola-Lumthung	• Identified and listed a few plant species, including trees, plant species of economic importance, and medicinal and aromatic plants (MAPs) • Jungim area observed as a potential habitat for bear. There was a village in the past but washed away by flood and landslide in 1980. • Conducted HH surveys
13-Nov-16	Lumthung-Lelep	• Conducted HH surveys • Observed ongoing suspension bridge construction and local participation in the nearby river site in Lumthung • Conducted a FGD in Lelep
14-Nov-16	Lelep-Chiruwa	• Conducted HH surveys • Identified and observed more plant species and their habitat
15-Nov-16	Chiruwa-Fungling	• Observed the existing road condition and landslides on the way from Thiba to Fungling
16-17 Nov-16	Fungling-Kathmandu	• Observed plant species of Tarai • Observed the degraded state of Chure range

Annex 7.3
Second field visit (12–24 May 2017) to Kangchenjunga

Date	Route	Activities
12-13 May 2017	Kathmandu-Fungling	• Travel
14 May 2017	Fungling-Chhiruwa	Communicated with • Kangchenjunga Conservation Area Management Committee (KCAMC) • District Forest Office • District Administrative Office • Poster distribution to schools • Poster displaying at Fungling
15 May 2017	Chhiruwa-Iladanda	• Poster displaying on the way • Arrived Iladanda
16 May 2017	Iladanda-Olangchung Gola	• Poster displaying on the way
17 May 2017	Gola-Mauma	• Arranged local guides • Arranged food and utensils • Poster displaying and distribution in Gola • Stayed at Mauma (4200 m)
18 May 2017	Mauma – Rolep – Flauma - Mauma - Deuma	• Met yak herders • Conducted vegetation survey at Rolep (4500 m) and Flauma (4250 m) • Back to Deuma
19 May 2017	Deuma	• Conducted vegetation survey at Singjema Juniper Tree-line (4070 m) • Tree-core collection at tree-line • Stayed at Deuma (4000 m)
20 May 2017	Deuma-Gola	• Conducted vegetation survey at Singjema • Collected tree cores at Juniper forest patch, Singema • Conducted SLD at Gola
21 May 2017	Gola-Lelep	• Poster displaying and distribution • Conducted SLD at Gobatar • Met school teachers • Set up weather station at the school
22 May 2017	Lelep-Fungling	• Poster displaying on the way
23 May 2017	Fungling-Birtamod	• Arrived Birtamod
24 May 2017	Birtamod-Kathmandu	• Arrived Kathmandu

Annex 7.4
List of participants interviewed for livestock related livelihoods

SN	Date	Interviewee	Gender	Site
1	10-Nov-16	Tashi Sherpa	Male	Olangchung Gola-4
2	10-Nov-16	Gombo Sherpa	Male	Olangchung Gola-3
3	10-Nov-16	Pemba Choki Sherpa	Female	Olangchung Gola-7
4	10-Nov-16	Chhunba Sherpa	Male	Olangchung Gola-8
5	10-Nov-16	Bhomu Sherpa	Female	Olangchung Gola-5
6	10-Nov-16	Nima Sherpa	Male	Olangchung Gola-6
7	10-Nov-16	Dandu Sherpa	Male	Olangchung Gola-2
8	10-Nov-16	Tenzing Sherpa	Male	Olangchung Gola-1
9	10-Nov-16	Rejuma Sherpa	Female	Olangchung Gola-6
10	10-Nov-16	Nima Thunduk	Male	Olangchung Gola-2
11	10-Nov-16	Phomu Sherpa	Female	Olangchung Gola-5
12	10-Nov-16	Nurpu Sherpa	Male	Olangchung Gola-1
13	10-Nov-16	Mingma Chokki	Female	Olangchung Gola-4
14	10-Nov-16	Chankhe Sherpa	Male	Olangchung Gola-5
15	10-Nov-16	Chungduk Sherpa	Male	Olangchung Gola-5
16	10-Nov-16	Pema Sherpa	Male	Olangchung Gola-9
17	10-Nov-16	Tamling Gyalzo	Male	Olangchung Gola-9
18	10-Nov-16	Doka Chungdak Sherpa	Male	Olangchung Gola-9
19	10-Nov-16	Changju Sherpa	Male	Olangchung Gola-9
20	10-Nov-16	Phu Chiring Sherpa	Male	Olangchung Gola-9
21	10-Nov-16	Hyonden Sherpa	Male	Olangchung Gola-5
22	10-Nov-16	Cheden Sherpa	Male	Olangchung Gola-7
23	10-Nov-16	Wangya Sherpa	Male	Olangchung Gola-2
24	10-Nov-16	Chettan Phunchok	Male	Olangchung Gola-2
25	10-Nov-16	Fula Yauchap	Male	Olangchung Gola-5
26	10-Nov-16	Chettan Tashi	Male	Olangchung Gola-2
27	10-Nov-16	Chettan Sherpa	Male	Olangchung Gola-4
28	11-Nov-16	Mingma Walung	Female	Olangchung Gola-2
29	11-Nov-16	Fupa Chyungdak Sherpa	Male	Olangchung Gola-5
30	11-Nov-16	Dorje Sherpa	Male	Olangchung Gola-5
31	11-Nov-16	Tsewang Tenzing	Male	Olangchung Gola-9
32	11-Nov-16	Chettan Tashi Sherpa	Male	Olangchung Gola-1
33	11-Nov-16	Nima Kipa Sherpa	Male	Olangchung Gola-3

Annex 7.5
Household survey questionnaire for livestock related livelihoods

Namaste,

I am ……. from RHF/GGIC-Tribhuvan University. This questionnaire is being implemented to provide information on **Kanchanjungha Livelihood under Climate Stress**. It is entirely for an educational purpose i.e. for a thesis as a part of requirement leading to the award of a M. Sc. in Environmental Science from Tribhuvan University, Kathmandu, Nepal. I appreciate your kind cooperation in answering the following questions, which will be very much helpful for carrying out this study. Moreover, information given by you will totally be confidential will only be used for my research study. Your participation is totally voluntary.

A) GENERAL INFORMATION OF RESPONDENT:

1. Date: Time:
2. Name of the respondent:
3. Age:
4. Sex: Male ( ) Female ( )
5. Ethnicity:
6. VDC:
7. Ward No:
8. Village:
9. Occupation:
10. Educational Qualification:

B) HOUSEHOLD PROFILE:

1) Are you native resident of this place?

Yes-1 ( ) No-2 ( )

If yes,

a) How long you have been staying here?

a) Less than 20 years ( ) b) More than 20 years ( )

If More than 20 years: then continue with following questions

2) What are the major sources of income in your family? Among these sources, which is the major source?

a) Agriculture ( ) b) Livestock ( ) c) Government Service ( ) d) Private Service ( )

e) Business ( ) f) Daily wages ( ) g) other specify please……

If livestock, then for how many years you have been practicing transhumance?

……

3) Do you have livestock: Yes/No

If yes, can you provide your livestock holding status?

Types	Before	Now	If changes give reasons
Livestock			

4) Have you noticed any changes in livestock mortality rate?

a) Yes ( ) b) No ( )

If yes,

Livestock	Mortality rate	
	Before	Now

5) Have you witnessed any new diseases and pests in livestock? Yes ( ) No ( )

If yes, which disease is seen in which livestock?

…….....……

6) Where do you take you livestock to graze? Or, from where do you collect fodder for your livestock

…….....……

7) How far take your livestock to graze?

…….....……

8) Is that grazing land being nearer or farther than before?

9) …….....……

C) PEOPLES'S PERCEPTION ON CLIMATE CHANGE:

1. Have you ever heard about Climate change?

a) Yes ( ) b) No ( )

If yes, what is your source of hearing about…….

2. Could you tell your experience on the changes in the following parameter in recent 20 years?

SN	Climatic parameter		Yes-1, No-2	If Yes, Inc-1/ Dec-2/Fluct-3 from when	Remarks
1	Temperature	Winter			
		Summer			
2	Rainfall	Frequency			
		Amount			
3	Snowfall	Frequency			
		Volume			
4	No cloudy days				
5	Hailstorm/ windstorm				
6	Cloud burst				
7	Others, specify please				

3. Have you experienced any of the following

Events	Inc-1, Dec-2, Same-3	Since when	Remarks
Extreme hot summer hot days			
Extreme cold winter days			
Winters are less cold than frosty			
Days are becoming hotter			
Others, specify please			

4. Have you experienced any changes in water availability?

Events	Yes-1, No-2	If yes since when	Remarks
Increase in stream flows/ well/stone spout			
Decrease in stream supply/well/stone spout			
No change in water availability			

5. Any changes in disastrous events in recent years.

Events	Yes-1, No-2	If increase or Decrease Reason for change	Remarks
Flood			
Landslide			
Drought			
Others, specify please			

D) IMPACT OF CLIMATE CHANGE ON RANGELAND

1. Do any changes in rainfall pattern (Erratic and irregular) and temperature affect grassland production?

   Yes ( ) No ( ). If yes how? ……

2. Any there any problem of non-preferable plants? What are the new non-preferable plants that have invaded this place? ……

3. What are the different types of insect pests that you have observed in livestock? Are there any new pests that have been recently discovered? What is the name of that pest? How it affects? ……
   ……

4. What are the different diseases that are hampering the livestock? Which diseases are recently seen? ……

5. Have you noticed any invasive alien species in your area?

   If yes which species is seen…….....

6. Have you taken any adaptation measures to deal with the effects of climate change?

   Yes ( ) No ( ). If No, why? …….....

E) VEGETATION SHIFT

1) Up to which level do you take your livestock to graze**?**
   a) Above tree lines of Bhojpatra (Betula)/Thingre sallo (Abies)
   b) Above Chimal (*Rhododendron campanulatum*)
2) Is that level same or shifted? If shifted, towards a) low level or b) higher level
3) Have you noticed if those trees/shrubs at the same level or moving up?
4) Can you tell/show me the shifted site?
5) Please tell your experience of the grazing site (new plants, shifting, etc.)
   ……
6) Are there any visible changes in the herbage composition of the grazing lands?

   If yes, please indicate the following:

Diminishing or rare species	Impact on livestock	New Species	Impact on grazing	Comments

F) ADAPTATION MEASURES PRACTICED BY FARMERS

Livestock Adaptations

1) Have you changed your transhumant movement plan?

	Yes-1/ No-2	If yes Present	Past
Upward movement			
Top lying period			
Downward movement			

2) Have you made any changes in livestock pattern?

Yes ( ) No ( ) If yes,

	Past	**Present**
livestock pattern		

3) Have you changed the livestock species?

Yes ( ) No ( ) If yes, give the name of the species,

	Livestock species	**Why?**
Past		
Present		

4) Have you carried out any rangeland management practices?

…….....……

5) Is there any change in grassland productivity?

a) Increased-1 ( ) b) Decreased-2 ( ) c) No change-3

What could be the reasons behind increase or decrease in the grassland productivity?

…….....……

6) Are there any changes in pest or parasite management practices?

a) Yes ( ) b) No ( )

If yes, what were the earlier practices? What is the present practice?

…….....……

7) Have you practiced in any changes in landslide prevention measures?

…….....……

8) Have you observed any changes in rangeland soil condition?

a) Yes ( ) b) No ( )

If yes, what is the reason?

a) Hard soil ( ) b) High moisture in the soil ( ) c) Others ( )

9) Have you cleared ever the unwanted or non-preferable herbage species for effective grazing?

a) Past years…….. b) At present……

If there is change what is the reason? .....

10) Have you applied any grassland conservation practices?

	Yes	No
At past		
Present		

If yes what practiced did you have followed?

…….....……

11) Did you have any local innovations to cope with the changing rainfall pattern?

a) Yes ( ) b) No ( )

If yes, who innovated the innovation, when?

a) An individual farmer

b) A community

c) Use since many generations

12) Have you used any water storage or harvesting technique to collect water during rainy season?

a) Yes ( ) b) No ( )

Non livestock adaptation

1) Do you know if any farmers have migrated to other place due to the increasing climatic changes (such as drought, landslide, and flood)?

…….....……

2) Do you know if any farmer shifted to non-agricultural practices from agriculture due to climate change?

…….....……

3) Does anyone have outside employment in your family?

a) Yes ( ) b) No ( )

Changes in production after practicing adaptation measures

1) Are the practiced adaptation measures beneficial in dealing with climate change impacts?

a) Yes ( ) b) No ( )

If yes, what are the changes in the livestock production after the adaptation measures?

	Before adaptation	After adaptation
	Incr-1/ Dec-2	Inc-1/Dec-2
Livestock productivity		

2) Whether the adaptation measures undertaken are satisfactory or not?

a) Satisfactory ( ) b) Not satisfactory ( )

G) FOOD SECURITY:

1) Do you think your livestock production is sufficient for your family?

Yes ( ) b) No ( )

a) If yes, do you have surplus production? Yes ( ) b) No ( )

c) If no, for how many months it will support your family?

d) How do you manage for rest of the year?

…….....……

2) Have you faced food shortage in the past?

a) Yes ( ) b) No

If yes, When? To what extent?

…….....……

3) What were the causes of food shortage?

a) Drought ( ) b) Flood ( ) c) Hailstorm/ Windstorm ( )

d) Others, Specify please……..

4) How did you address the food shortage issues in the past?

…….....……

5) Who was affected most (least) by the problem? Men? Women? Child? Elderly? To what extent?

…….....……

Interviewer information:

Name:

Signature:

Date of Interview:

Thank you for your co-operation!!!

Annex 7.6
List of participants interviewed for agriculture related livelihoods

SN	Date	Interviewee	Gender	Site
1	12-Nov-16	Ram Prasad Rai	Male	Lelep
2	12-Nov-16	Santa Bahadur Sherpa	Male	Lelep
3	12-Nov-16	Sameer Limbu	Male	Lelep
4	12-Nov-16	Mingma Gyanje Sherpa	Male	Lelep
5	12-Nov-16	Gopal Rai	Male	Lelep
6	13-Nov-16	Rajan Rai	Male	Lelep
7	13-Nov-16	Phu Chirri Sherpa	Male	Lelep
8	13-Nov-16	Nar Bahadur Rai	Male	Lelep
9	13-Nov-16	Til Bahadur Rai	Male	Lelep
10	13-Nov-16	Kamala Rai	Female	Lelep
11	13-Nov-16	Indra Gurung	Male	Lelep
12	13-Nov-16	Gyanu Thepe Sherpa	Female	Lelep
13	13-Nov-16	Chirring Thonduke Sherpa	Male	Lelep
14	13-Nov-16	Lakpa Diki Sherpa	Male	Lelep
15	13-Nov-16	Fupu Chiki Sherpa	Male	Lelep
16	13-Nov-16	Rabin Chemjong Limbu	Male	Lelep
17	13-Nov-16	Nima Gyabu Sherpa	Male	Lelep
18	13-Nov-16	Tenjing Sherpa	Male	Lelep
19	13-Nov-16	Lakpa Phuti Sherpa	Male	Lelep
20	13-Nov-16	Asaran Kumar Rai	Male	Lelep
21	13-Nov-16	Uma Gurung	Female	Lelep
22	13-Nov-16	Dani Sherpa	Male	Lelep
23	13-Nov-16	Dil Bahadur Limbu	Male	Tapethok
24	14-Nov-16	Nagendra Prasad Rai	Male	Lelep
25	14-Nov-16	Pemba Sherpa	Male	Lelep
26	14-Nov-16	Futi Sherpa	Male	Lelep
27	14-Nov-16	Fupu Dodma Sherpa	Female	Lelep
28	14-Nov-16	Tenjing Lama	Male	Lelep
29	14-Nov-16	Pasang Sherpa	Male	Lelep
30	14-Nov-16	Dake Sherpa	Male	Lelep
31	14-Nov-16	Nupu Bhote	Male	Lelep
32	14-Nov-16	Machindra Phempu	Male	Lelep

Annex 7.7
Household survey questionnaire for agriculture related livelihoods

Namaste,

I am ……. from RHF/GGIC-Tribhuvan University. This questionnaire is being implemented to provide information on **Kanchanjungha Livelihood under Climate Stress**. It is entirely for an educational purpose i.e. for a thesis as a part of requirement leading to the award of a M. Sc. in Environmental Science from Tribhuvan University, Kathmandu, Nepal. I appreciate your kind cooperation in answering the following questions, which will be very much helpful for carrying out this study. Moreover, information given by you will totally be confidential will only be used for my research study. Your participation is totally voluntary.

A) GENERAL INFORMATION OF RESPONDENT:

1. Date: Time:
2. Name of the respondent:
3. Age:
4. Sex: Male ( ) Female ( )
5. Ethnicity:
6. VDC:
7. Ward No:
8. Village:
9. Occupation:
10. Educational Qualification:

B) HOUSEHOLD PROFILE:

1) Are you native resident of this place?

Yes-1 ( ) No-2 ( )

If yes,

a) How long you have been staying here?

b) Less than 20 years ( ) b) More than 20 years ( )

If More than 20 years: then continue with following questions

2) What are the major sources of income in your family? Among these sources, which is the major source?

a) Agriculture ( ) b) Livestock ( ) c) Government Service ( ) d) Private Service ( )

e) Business ( ) f) Daily wages ( ) g) other specify please…….

If agriculture/livestock, then for how many years you have been practicing cultivation?

…….....……

3) Do you have livestock: Yes/No

If yes, can you provide your livestock holding status?

Types	Before	Now	If changes give reasons
Livestock			

4) Have you noticed any changes in livestock mortality rate?

b) Yes ( ) b) No ( )

If yes,

Livestock	Mortality rate	
	Before	Now

5) Have you witnessed any new diseases in livestock? Yes ( ) No ( )

If yes, which disease is seen in which livestock?

6) Where do you take you livestock to graze? Or, from where do you collect fodder for your livestock

7) How far take your livestock to graze?

8) Is that grazing land being nearer or farther than before?

C) PEOPLES'S PERCEPTION ON CLIMATE CHANGE:

1. Have you ever heard about Climate change?

b) Yes ( ) b) No ( )

If yes, what is your source of hearing about:

2. Could you tell your experience on the changes in the following parameter in recent 20 years?

SN	Climatic parameter		Yes-1, No-2	If yes, Inc-1/Dec-2/ fluct-3 from when	Remarks
1	Temperature	Summer			
		Winter			
2	Rainfall	Frequency			
		Amount			
3	Snowfall	Frequency			
		Volume			
4	No of cloudy days				
5	Hailstorm/windstorm				
6	Cloud burst				
7	Others, Specify please				

3. Have you experienced any of the following

Events	Inc-1, Dec-2, Same-3	Since when	Remarks
Extreme hot summer hot days			
Extreme cold winter days			
Winters are less cold than frosty			
Days are becoming hotter			
Others, specify please			

4. Have you experienced any changes in water availability?

Events	Yes-1, No-2	If yes since when	Remarks
Increase in stream flows/well/stone spout			
Decrease in stream supply/well/stone spout			
No change in water availability			

5. Any changes in disastrous events in recent years.

Events	Yes-1, No-2	If increase or Decrease / Reason for change	Remarks
Flood			
Landslide			
Drought			
Others, specify please			

D) IMPACT OF CLIMATE CHANGE ON AGRICULTURE:

1. Do any changes in rainfall pattern (Erratic and irregular) and temperature affect crop production?

Yes ( ) No ( ). If yes how?

2. Any there any problem of weeds? What are the types of weeds found in the area? What are the new weeds that have invaded this place?
3. What are the different types of insect pests that you have observed? Are there any new pests that have been recently discovered? What is the name of that pest? How it affects?
4. What are the different diseases that are hampering the plant growth? Which diseases are recently seen?
5. Have you noticed any invasive alien species in your area?

   If yes which species is seen
6. Have you taken any adaptation measures to deal with the effects of climate change?

   Yes ( ) No ( ). If No, why?

E) VEGETATION SHIFT

1) Up to which level do you take your livestock to graze**?**
   a) Above tree lines of Bhojpatra (Betula)/Thingre sallo (Abies)
   b) Above Chimal (Rhododendron campanulatum)
2) Is that level same or shifted? If shifted, towards a) low level or b) higher level
3) Have you noticed if those trees/shrubs at the same level or moving up?
4) Can you tell/show me the shifted site?
5) Please tell your experience of the grazing site (new plants, shifting, etc.)

F) ADAPTATION MEASURES PRACTICED BY FARMERS:

Agricultural/Livestock Adaptations

1) Have you changed your sowing, planting and harvesting time of the crops?

	Yes-1/ No-2	**If yes Present**	**Past**
Sowing time			
Planting time			
Harvesting time			

2) Have you made any changes in cropping pattern/livestock pattern

   Yes ( ) No ( ) If yes,

	Past	**Present**
Cropping/livestock pattern		

3) Have you changed the crop/livestock variety?

Yes ( ) No ( ) If yes, give the name of the variety,

	Crop/livestock variety	Why?
Past		
Present		

4) Have you carried out any land management practices?

5) Is there any change in fertilizer use?

b) Increased-1 ( ) b) Decreased-2 ( ) c) No change-3

What could be the reasons behind increase or decrease in the use of fertilizer?

6) Are there any changes in pest management practices?

b) Yes ( ) b) No ( )

If yes, What were the earlier practices? What is the present practice?

7) Is there any change in frequency of use of irrigation water?

a) Increased ( ) b) Decreased ( ) c) No change ( )

8) Have you practiced any changes in land preparation?

9) Have you observed any changes in soil condition?

a) Yes ( ) b) No ( )

If yes, what is the reason?

a) Hard soil ( ) b) High moisture in the soil ( ) c) Others ( )

10) How many times weeding is done for a crop?

a) Past years…….. b) At present……

If there is change what is the reason?

11) Have you applied any moisture conservation practices?

	Yes	No
At past		
Present		

If yes what practiced did you have followed?

12) Did you have any local innovations to cope with the changing rainfall pattern?

a) Yes ( ) b) No ( )

If yes, who innovated the innovation, when?

b) An individual farmer

c) A community

d) Use since many generations

13) Have you used any water storage or harvesting technique to collect water during rainy season?

a) Yes ( ) b) No ( )

Nonagricultural/livestock adaptation

1) Do you know if any farmers have migrated to other place due to the increasing climatic changes (such as drought, landslide, and flood)?
2) Do you know if any farmer shifted to nonagricultural practices from agriculture due to climate change?
3) Does anyone have outside employment in your family?

b) Yes ( ) b) No ( )

Changes in production after practicing adaptation measures

1) Are the practiced adaptation measures beneficial in dealing with climate change impacts?

a) Yes ( ) b) No ( )

If yes, what are the changes in the crop yield after the adaptation measures?

	Before adaptation	After adaptation
	Incr-1/ Dec-2	Inc-1/Dec-2
Productivity		

2) Whether the adaptation measures undertaken are satisfactory or not?

a) Satisfactory ( ) b) Not satisfactory ( )

G) FOOD SECURITY:

1) Do you think your agricultural production is sufficient for your family? Yes ( ), b) No ( )

a) If yes, do you have surplus production? Yes ( ) b) No ( )

c) If no, for how many months it will support your family?

d) How do you manage for rest of the year?

2) Have you faced food shortage in the past?

a) Yes ( ) b) No

If yes, When? To what extent?

3) What were the causes of food shortage?

a) Drought ( ) b) Flood ( ) c) Hailstorm/ Windstorm ( )

d) Others, Specify please……..

4) How did you address the food shortage issues in the past?

5) Who was affected most (least) by the problem? Men? Women? Child? Elderly? To what extent?

6) How much crop did you produce last year?

Crops	Area of farmland (in ropani)	Production (in muri)	Trend of productivity Inc-1, Dec-2, Same-3

Interviewer information:

Name:

Signature:

Date of Interview:

Thank you for your co-operation!!!

Annex 7.8
Participants during shared learning dialogues

7.8.1: Participants of the shared learning dialogue at Olangchung Gola

SN	Name	Gender	SN	Name	Gender
1	Bhomo Sherpa	M	21	Donga Sherpa	M
2	Dawa Sherpa	M	22	Ma Rida Sherpa	F
3	Phupu Lamu Sherpa	F	23	Chheten Sherpa 'Hurri'	M
4	Angmu Sherpa	F	24	Chheten Lawar Sherpa	M
5	Bhomo Sherpa	F	25	Pasang Chhiring Sherpa	M
6	Chanje Sherpa	M	26	Tasi Sherpa	M
7	Kichung Sherpa	M	27	Nupu Sherpa	M
8	Chhering Bhutik Sherpa	F	28	Upa Sherpa	F
9	Jachung Sherpa	M	29	Dik Bahadur KC	M
10	Jomki Sherpa	F	30	Chhewang Tenjin Sherpa	M
11	Minga Bhutik Sherpa	F	31	Topten Sherpa	M
12	Pendup Sherpa	M	32	Gombu Sherpa	F
13	Doma Sherpa	F	33	Chhering Doba Sherpa	F
14	Kusyo Bhula Sherpa	M	34	Donga Sherpa	F
15	Po Dandu Sherpa	M	35	Yang Sherpa	F
16	Chanje Dongma	F	36	Dorje Sherpa	M
17	Tenji Jya Sherpa	M	37	Jiten Limbu	M
18	Dongma Sherpa	F	38	Tansi Sherpa	M
19	Changa Chhering Sherpa	M	39	Nima Kipa Sherpa	F
20	Bhutik Sherpa	M	40	Dawa Phuti Sherpa	F

7.8.2: Participants of the shared learning dialogue at Gobatar

SN	Name	Gender	SN	Name	Gender
1	Kamal Rai	M	11	Phupu Dona Sherpa	F
2	Nar Bahadur Rai	M	12	Gyanu Thebe Sherpa	F
3	Air Kumar Rai	M	13	Pekha Bhuti Sherpa	F
4	Ajaya Rai	M	14	Lampa Bhuri Sherpa	F
5	Kamala Rai	F	15	Kruchhiri Sherpa	F
6	Gopal Rai	M	16	Chhiring Sherpa	M
7	Lampa Bhuri Sherpa	F	17	Chheten Sherpa	M
8	Lampa Dini Sherpa	F	18	Nima Sherpa	F
9	Tenjing Sherpa	M	19	Tosi Sherpa	M
10	Chhiring Phutung Sherpa	M			

Annex 7.9
Guiding questions for focus group discussions

7.9.1: Guiding questions for the focus group discussion at Olangchung Gola

1. To what extent are you aware of climate change?
2. Have you experienced any changes in the climatic parameters, water availability or disastrous events in the recent years?
3. How do you identify the changes?
4. How does climate change affect grassland and vegetation?
5. Have you under taken any adaptation measures?
6. What are the alternate livelihood options you and other community members identify given the impacts of change?
7. Are there any opportunities you can identify under the changed circumstances?
8. What are the institutional mechanisms to manage your resources?
9. What is the status of transhumance in this area? What is the reason behind decrease in transhumance tradition?

7.9.2: Guiding questions for the focus group discussion at Lelep

1. To what extent are you aware of climate change?
2. Have you experienced any changes in the climatic parameters, water availability or disastrous events in the recent years?
3. How do you identify the changes?
4. How does climate change affect the livelihood and vegetation?
5. Have you under taken any adaptation measures?
6. What are the alternate livelihood options you and other community members identify given the impacts of change?
7. Are there any opportunities you can identify under the changed circumstances?
8. What are the institutional mechanisms to manage your resources?
9. Do you think the increase in cardamom production triggers landslide?

Annex 7.10: Guiding questions for key informant interview

1. To what extent are you aware of the impact of the climate change?
2. How do you experience the changes?
3. How do you identify the changes?
4. What are the institutional mechanisms to manage your resources?
5. What are the alternate livelihood options you and other community members identify given the impacts of change?
6. Are there any opportunities you can identify under the changed circumstances?

Annex 7.11
Selected field photographs

Photograph 1: Household survey at Olangchung Gola, Nov 2016

Photograph 2: Household survey at Olangchung Gola, Nov 2016

Photograph 3: A focus group discussion at Olangchung Gola, Nov 2016

Photograph 4: Meeting with local people and sharing at Olangchung Gola, May 2017

Photograph 5: Vegetation survey at Rolep (4500m asl), Kangchenjunga area May 2017

Photograph 6: A local respondent showing a medicinal plant (*Astilbe rivularis*), Nov 2016

Photograph 7: Cardamom cultivation near Tapkethok, Taplejung, Nov 2016

Photograph 8: A landslide on the way to Olangchung Gola, Taplejung, Nov 2016

Photograph 9: Research team walking along the landslide on the way to Olangchung Gola

Photo 10: Handover rain gauge, thermometer and IEC materials to the school, Lelep, May 2017

Photograph 11: Transporting chiretta (*Swertia chirayita*) for sale, Kanchenjunga, May 2017

Photograph 12: A silver fir tree (*Abies spectabilis*) on the way to Gola

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RESOURCES HIMALAYA

Resources Himalaya Foundation

Resources Himalaya Foundation (RHF) is a not-for-profit research institute. It has over 30 years of experience in innovative research and capacity building in biodiversity, environment and livelihood in Nepal, Bhutan and Sikkim through nearly 200 research projects. Notable research projects conducted by RHF include the Formation of Fish Conservation Committees in Karnali, Sustainable Fish Harvesting Guideline, Climate Change Adaptation Plan for Middle Mountain, Treeline and Treering Studies, Post-earthquake Rapid Environment Assessment, Count Rhino '94, Status of the Red Panda in the Himalayas, Hornbill Ecology, Nationwide Database of Chure Ecology, Elephant Conservation Action Plan, Snow Leopard Conservation Action Plan, Nepal Biodiversity Action Plan and Conservation Plan of the Western Tarai and Churiya. RHF also assisted in developing Rapid Biodiversity Survey Framework for all nine protected areas of Bhutan including Phobjikha Conservation Landscape Area Plan.

Bringing contemporary knowledge to deal with issues of natural resources conservation, and mentoring the younger generation to build the conservationists of the future are the two major thrusts of RHF's work. \

ICIMOD

International Centre for Integrated Mountain Development

The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning and knowledge sharing centre serving the eight regional member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues.

ICIMOD supports regional transboundary programmes through partnerships with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. ICIMOD strengthens networking among regional and global centres of excellence. Overall, ICIMOD is working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream, now and for the future.

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