Report on
Exploring Existing Local Adaptation Practices and Potential Strategic Options to Address Climate Change Impact on Biodiversity and its Dependents of Nepal

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Shambhu Charmakar

Abstract

Though climate change is understood as biggest threat to biodiversity and local livelihoods, the studies relating to climate change and biodiversity are currently found to be insufficient. This has caused uncertainties on how climate change is affecting communities directly dependent upon natural resources for their livelihood, and what could be the appropriate coping strategies. This study is hence carried out in two biodiversity dependent communities of Nepal, viz: Thami in Suspa of Dolakha district (High Mountain region) and Chepang in Shaktikhor of Chitwan district (Terai region) with the objective to explore the existing and potential adaptation (technological and institutional) options to combat climate change impact on biodiversity and forest resources and its dependents. The study carried out the methodologies like household survey, key informants interview, focused group discussion, hazard mapping, socio-resource mapping, and biodiversity survey using plot study, transect walks and direct observations. In overall the study found that both communities, dominated by illiterate and poor population, were found to be affected by climate change. Though they felt that climate change is affecting their livelihood, they realized largely effects and change in climatic hazards but unaware for cause of the change. Different existing non-climatic parameters and newly observed different factors induced by climate change were found to be having coupling effect to the biodiversity sector of the study areas. To minimize the effects, the communities were found to be adopting different strategies which were more traditional rather than scientific. Thus this study recommends for capacity building and awareness of the communities along with strengthening of the institution regarding climate change as well as scientific studies and testing of the appropriate adaptation practices, so as to build long term strategies.

Key words: Biodiversity, climate change, vulnerability, livelihoods, biodiversity dependent indigenous community

Table of contents

List of Tables

List of Figures

List of Annexes

Acronyms and bibliography

CBFEs	Community based Forest Enterprises
CBNRM	Community based Natural Resource Management
CF	Community Forest
Cu.ft.	Cubic feet
CFUGs	Community Forest User Groups
DDC	District Development Committee
DFO	District Forest Office
GOs	Governmental Organizations
Ha.	Hectare
I/NGOs	International/Non- Governmental Organizations
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometer
LSU	Livestock Unit
MoE	Ministry of Environment
NAPA	National Adaptation Plan of Actions
NTFPs	Non-Timber Forest Products
PRA	Participatory Rural Appraisal
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee

Chapter one: Introduction

1.1. Background

Changing climate is now a biggest environmental worry to the scientists and government of both developing and developed countries. The 2005 Millennium Ecosystem Assessment (MEA) reports that by the end of this century, climate change will be the main driver of biodiversity loss, and Inter-governmental Panel on Climate Change (IPCC)has entailed that temperature increase up to 3 °C are also very likely to trigger substantial changes in the structure and functioning of all ecosystems.

Nepal is are reservoir of variety of species and ecosystem and provides valuable services in the form of carbon sequestration, water conservation, watershed protection and ecotourism among others. But with poverty, poor governance and more people being directly dependent upon these resources, degradation is inevitable. Climate change has added extra pressure to the already in threat resources of the country, leading to the increased vulnerability of the ultra-poor putting extra socio-economic burden they are already facing. Furthermore, recently being ranked 4th in new global ranking of the most vulnerable countries on the context of climate change by Maplecroft[1], suggests that the country has to put effort for reducing the effects caused to its resources and people.

Mitigation and adaptation are two major identified ways of tackling against the climate change. But regardless of the efforts to reduce GHG emissions, the effects of climate change are already visible and are unavoidable because of the GHG level that is already in the atmosphere and the slow process in the climate system. Hence, adaptation is the best and appropriate option for a country to make their community able to fight against the impacts they may face due to the increased change in climate.

Nepal, as per the UNFCCC framework in COP10, has come up with National Adaptation Program of Action (NAPA) under the Ministry of environment (MoE)/Government of Nepal for addressing adverse impacts of climate change and reducing vulnerability to climate stimuli including extreme events in order to assess climatic vulnerability, and systematically respond to climate change adaptation issues by developing appropriate adaptation measures (NAPA, 2010). So, this study is carried out in two different biodiversity dependent indigenous communities (those who collect varieties of products from forest for their households energy, food and bedding material for livestock, compost for agriculture, shelter making for human and livestock and believe NTFPs are one of income sources for their livelihoods) for gathering scientific and traditional knowledge in climate change adaptation and helping in finding and applying appropriate adaptation strategies in the field of forest and biodiversity.

[1] http://www.newscientist.com/article/mg20827832.400-asia-tops-climate-changes-most-vulnerable-list.html

1.2. Research problem

Climate change in different parts of Nepal is already being experienced by the local community in the form of erratic rainfall, increased temperature, increased drought period and biodiversity loss, etc.; forcing communities to adapt against the measures. But those adaptation measures have been neither documented properly, nor have been checked scientifically to build upon those practices. In the context that NAPA has been prepared and being implemented in the country, the existing adaptation practices should be studied and analyzed scientifically so as to find out the gap in the practices, build upon the traditional knowledge, and develop the more practical and cost efficient newer adaptation strategies.

In Nepal, there are large numbers of indigenous community who are highly dependent on forest and biodiversity resources for fulfillment of daily needs of timber, fuel wood, fodder, grass, leaf litter, wild animals and water resources. In addition, majority of mountain people are generating their income by sole collecting and trading the timber and non-timber forest products. In this scenario, it is crucial to explore the impact, existing adaptation practices of those communities and potential adaptation strategies to enhance the resilience of biodiversity and its dependents to fight with negative impact and institutionalize the positive impact of climate change. This study is intended to carry out in the context of poor scientific studies of effects of climate change in biodiversity and the adaptation practices being applied by two biodiversity dependent indigenous *Chepang* and *Thami* communities in high mountain and low land ecological region respectively to reduce the impacts. This study will be highly supportive to NAPA and other scientific communities for bringing community based adaptation into reality, as the nature of adaptation differs from one community to another with the change in microclimate.

Therefore, this study is considered as a key to add knowledge on better climate change understanding of the locals by exploring perceptions and perspectives of locals to climate change, most vulnerable class of forest dependent people to climate change effects and types of adaptation practices adopted by these indigenous people in the rural area of mountain and low land region. The findings of this study may be useful to extend to other vulnerable areas of the mountain region. In addition to that this study supports to develop comprehensive policy related to climate change including the special provision focusing the poor forest dependent people in the Mountain region.

1.3. Research questions

This study is considered as a key to add knowledge on better climate change understanding of the locals by exploring perceptions and perspectives of locals to climate change, most vulnerable class of forest dependent people to climate change effects and types of adaptation practices adopted by these people in the rural area of mountain region.
The main research questions of the study are:

1. What understandings do locals (biodiversity dependent indigenous communities) holds on climate change and its impact?

2. At which magnitude they are vulnerable from climate change and its impact?
3. What are the major adaptation strategies of locals to climate change impact on their livelihood strategies?

1.4. Study objectives

The major objective of this study is to explore the existing and potential adaptation (technological and institutional) options to combat with climate change impact on forest and biodiversity resources and its dependents of Nepal. The specific objectives of this study are as follow:

- To identify major climatic hazards experienced in the mountain region;
- To explore the major impacts of climatic hazards on biodiversity resources and in its dependent livelihood;
- To assess the existing adaptation practices adopted by local people;
- To explore potential community based adaptation strategic options.

1.5. Limitation of the study

The main limitations of this study are as follows:

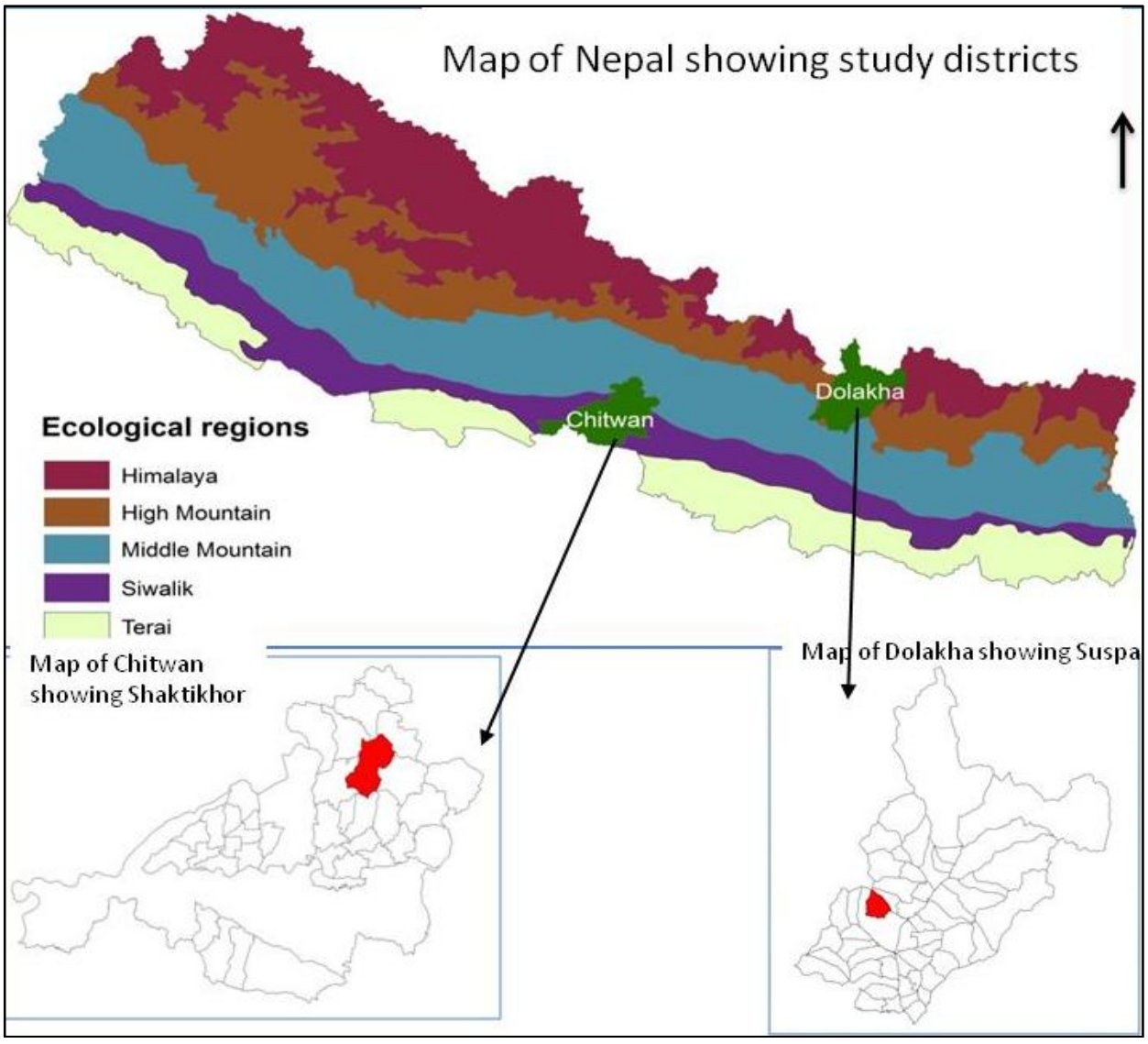
- This study centered only in two VDCs focusing two indigenous communities of Nepal
- Only Single station climatic data calculated for last 21 years
- The available time was short for this research study

Chapter Two: Study Area and Methods

2.1 Study area

The study is carried out in the one village development committee from two different districts: Chitwan and Dolakha of two different ecological zones: Tarai and high mountains respectively. These two VDCs are selected as they are the home of two most biodiversity dependent ethnic communities: *Chepang* in Chitwan and *Thami* in Dolakha. Also these districts are the home of good biodiversity with ample interventions in the past in relation to the biodiversity conservation and other aspects, but with less studies and work relating to climate change and biodiversity conservation together. The overview of each of the districts and VDC in brief are provided below:

Figure 1: Map of Study area



a. Geographic location and climate of study districts

Particular/Districts	Chitwan	Dolakha
Latitude	830 54'45" E to 840 48'15" E	850 50' E to 860 32' E
Longitude	270 21'45" N to 270 52'30"N	270 28' N to 280 00'N
Elevation from msl	141-1945m	900-7146m
Climate	Tropical-Sub-tropical	Sub-tropical-alpine
Average annual rainfall (mm)	2636.5	2043.5
Area in ha	218000	214287
Population	470713	247634
Cultivated Land, ha	46814 (14.95%)	56683 (26.45%)
Forest, Ha	142422 (45.48%)	101500 (47.37%)
Non Cultivated Land, ha	8465 (2.70%)	13740 (6.41%)
Pasture Land, ha	104147 (33.25%)	29500 (13.77%)
Others (including water and snow) ha	11336 (3.62%)	12864 (6%)
Percentage of Irrigated area %	68.79	31.22
No. and area (ha) of CFUG in the district	44 (7453)	345(40089.37)

Source: DDC profile 2002 and DFO, 2010

b. Study VDCs (Suspa and Shaktikhor)

Suspa VDC in Dolakha, covers 984 ha and extends in sub-tropical to upper temperate ecological region and lies on northern part of the district. This VDC contains 7 community forests including 1040 ha one Forest Stewardship Council (FSC) certified forest. Similarly, Shaktikhor in Chitwan lies on northern belt of the districts and situated in low land. A total of nine CFUGs have been formed including 1190.28 ha in Shaktikhor. Thus, both VDCs are home of indigenous communities and mosaic of forest, biodiversity and ecosystem. Irrigated flat land (khet) cultivated for rice is found at lower elevations and on the valley floor. Steep, terraced agricultural land (bari) cultivated for maize or millet dominates the rest of the study area.

c. Population and source of livelihoods

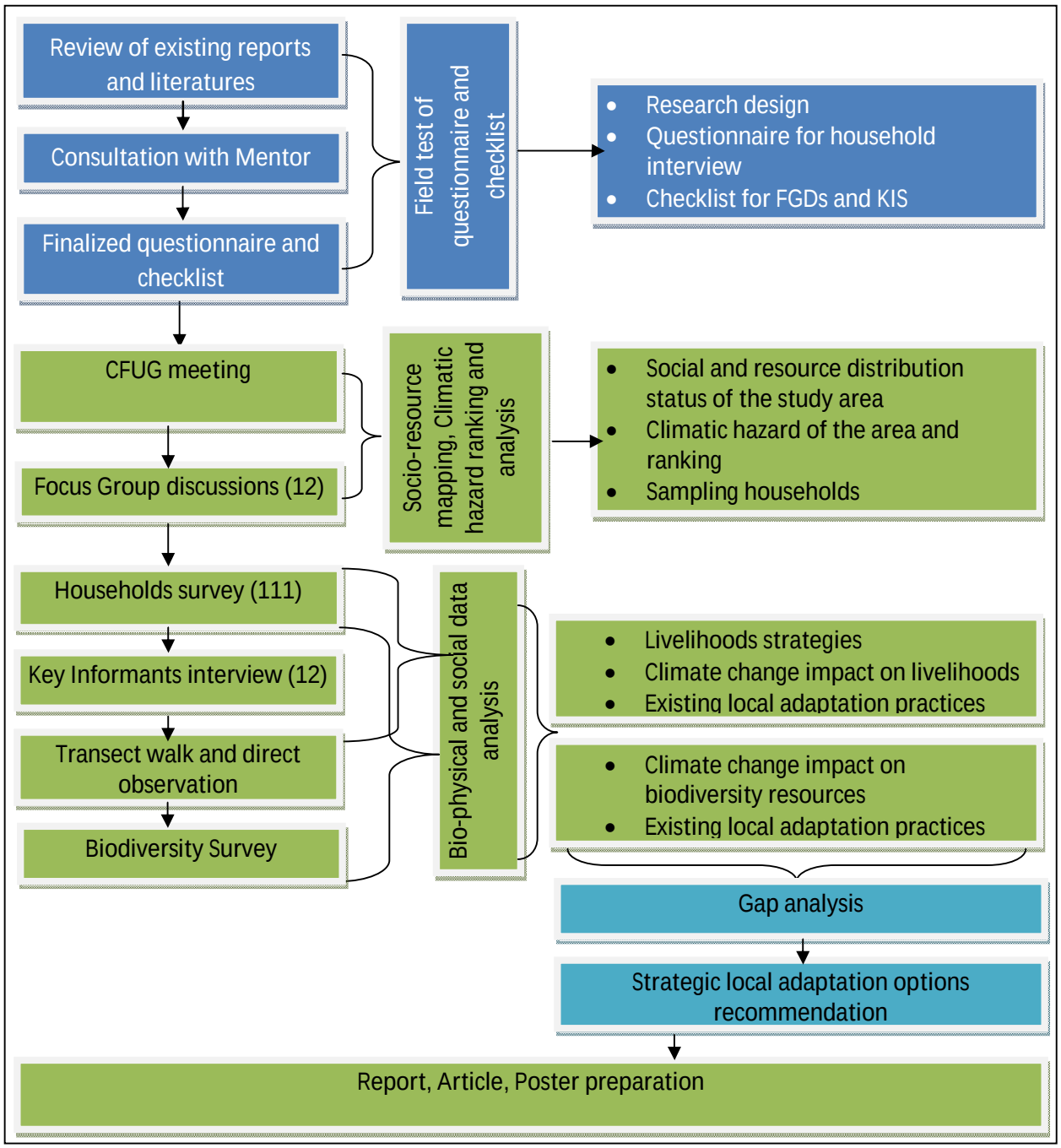
The study area (Shaktikhor and Suspa) is a cultural mosaic comprising different castes and ethnic groups such as Chepang, Thami, Tamang, Sherpa, Kshetri, Bramin and socially excluded communities. Accordingly, they have diverse cultural patterns, languages, festivals, food habits. Above 85% of the total population is engaged in farming, predominantly for subsistence (UNDP, 2009). Because of limited farming land the population is dependent on livestock, forest, and seasonal wage labour in the district or in outside of the district. In case of Shaktikhor, majority of the Chepang has been practicing the shifting cultivation (*Khoria Phadani*) for their livelihoods. These two study areas are repository of non-timber forest products, critical biodiversity and ecosystem services over which local livelihoods depend. Major valuable tree species in Suspa are ThingreSalla (*Tsuga dumosa*), GobreSalla (*Pinus wallichiana*), Chirpine (*pinus roxburghii*), Chilaune (*Schima wallichi*), Utis (*Alnus nepalensis*) etc and NTFPs: *Argeli*, *Lokta*, *Wintergreen*, *Chiraito*, *Nigalo*, *Mushroom* and *Niuro* whereas Sal

(*Shorea robusta*), Karma (*Adina cardifolia*), Botdhayero (*Largestromia parviflora*) are major timber and *Chiuri, Amala, Harro, Barro, Gittha, Bhyakur* are the major NTFPs in Shaktikhor.

2.2 Study framework

In order to explore local adaptation options to climate change effects, this study has applied various climatic hazards, impact and adaptation analysis tools including other PRA tools for completion of this research study.

Figure 2: Study framework



2.3 Study methods

Both quantitative and qualitative information regarding to climate change impact and local adaptation practices were collected. To complete the research, below methods and tools were used.

2.3.1 Literature review

The published and official documents so far available on climate change and biodiversity were reviewed. In addition, thesis developed by university students and district profile prepared by district development committee of the study area were reviewed. Based on that, a set of questionnaire and checklist developed. Similarly, study methods and overall framework was developed.

2.3.2 Consultation with mentor

The developed study framework, methods and questionnaire and checklist was shared with Mentor and some other climate change experts and taken their valuable suggestion and inputs. Incorporating their valuable input, the methods and tools of study was further polished.

2.3.3 Field test of questionnaire and checklist

The developed questionnaire tested in a community forest user group of Dolakha interviewing with three households. Then, some minor change made in the questionnaire and finalized. The finalized version of the questionnaire and checklist are given in Annex 1 and 2 respectively.

2.3.4 Study site selection

Suspa, a high mountain VDC of Dolakha and Shaktikhor-a low land VDC of Chitwan were selected for study because it was home of biodiversity dependent indigenous Thami and Chepang communities. They are indeed dependent on forest and other natural resources. They collect the firewood from forest for their household energy; harvest fodder and grasses for livestock from forest; collect timber for house building; dry leaflitter for making compost; and harvest NTFPs for medicinal, food and income of the family. Furthermore, these study area covers two completely different ecological regions.

2.3.5 Sampling design

Sampling unit was individual household of the VDC. In this study, stratified random sampling was used as the study area included economic class group. A total of 111 households (53 Thamis from Suspa of Dolakha and 58 Chepangs households from Shaktikhor of Chitwan) were selected from study area which is 10 percentages of the total households of the selected community groups. During the household selection process, economic class, community forest user groups in selected VDCs. At the same time, gender was also considered. The overall design was done with consulting mentor and few experts nevertheless it was finalized only after consultation with CFUG executive committee presence in the study VDCs.

2.3.6 Data collection

Household survey and participatory methods like participatory resource mapping, social resource mapping, focus group discussion, and key informants' interviews and transect walk were used to collect data to understand people's views, experience and knowledge on climate change. Further direct observation and CFUG record study were done to verify the data and information. In addition, stakeholders' consultations in concerned districts were conducted in order to collect information regarding climate change impact and local adaptation practices in biodiversity dependent *Thami* and *Chepang* communities.

Similarly, secondary data were also collected from relevant literature and reports prepared by various organizations. The details of the methods and tools are explained as follows:

a) Participatory socio-resource mapping

Participatory resource mapping is crucial steps to explore the information about the forest and ecosystem resources and communities. Accordingly, a participatory socio-resource mapping of study VDC was prepared which provided the idea of resources distribution, community locations and habitat of indigenous community was noted during the mapping.

b) Household interviews

Household survey was mainly conducted to draw the historical information, knowledge, perceptions to climate change and adaptation strategies being applied. The survey was carried out in 111 sampled households. As per objective of this research, the household interview was conducted with household head or the adult person above 25 years of age. The questionnaire was developed incorporating input from mentor and other experts' and was pre-tested for language simplicity, clarity of the questions to respondents, validity/relevance of the questions, missing questions if any.

c) Key informant interviews

Key informants such as local teachers, natural resource based entrepreneurs, local leaders who have been living in that area since long time, were selected and interviewed about the climate change scenario in the area and the adaptation practices the communities are following. The interview was highly important to collect additional information that could be helpful for the study, and was also useful for triangulate the information. During the interview, a well developed checklist was used.

d) Focused group discussion

Focused group discussions (FGDs) were conducted to supplement and triangulate information gathered from the household interviews and other sources. Three group discussions were organized in each district. It was conducted particularly with *Thami* and *Chepang* community. Further to explore the impact on study area, some other discussions were also organized focusing other community of study area. During the FGDs, hazard mapping, Hazards ranking,

impact and adaptation analysis was done that supported to find the major climatic hazards, their impacts and adaptation condition of the study area were analyzed.

e) Transect walks

Transect walk was also carried out to record the climatic hazards and their impacts. During this walk, researcher and local people directly observed the climatic hazards (such as forest fire, drought, landslides and floods) and discussed their impact. It helped to explore more information regarding climate change impacts and local adaptation measures.

f) Meeting with CF executive committee

A meeting was organized with executive committee members of five different community forest user groups (CFUGs) in the study area. Some other key informants were also involved in the meeting. During the meeting, all the executive members were cleared about the study and consent was taken from all of them. In this meeting, forest area, forest users, floral and faunal species, management activities, benefit sharing and sampling household's related information were recorded.

g) Biodiversity survey

Plot study was carried out in 0.1% fired and non-fired area of 16 community forests in both districts to find out if there is any significant change in the regeneration, composition, and biomass of the timber and non-timber species. The fire affected and not affected forests were taken from similar altitudinal range, slope and aspects in both regions. For the tree measurement a plot of 250 square meters (radius 8.92m) was laid out and within that plot, a sub-plot with a 5.64m radius is established for sapling and a sub-plot with a 1 m radius is established for counting regeneration; and a sub plot with a 0.56 m radius is established for sampling leaf litter, herbs, and grass. In case of Chitwan, the biodiversity data was shared from ANSAB biodiversity survey conducted in September, 2010. This study was very much valuable to verify the perception of local people with the real field situation.

h) Data analysis and presentation

The data collected during the field works were analyzed using both quantitative and qualitative methods. Quantitative data were analyzed using computer programs like SPSS, MS-Excel. Statistical analyses are carried out wherever possible and relevant. Qualitative data are presented in the form of simple tables, charts, and graphs and in other pictorial forms.

Chapter Three: Results and Discussion

3.1 Socio-economic condition

The household survey revealed the socio-economic condition of the study area. As the targeted community was Thami in Dolakha and Chepang in Chitwan, the survey was carried out in their household. Of the respondents, 37% were female. In the study area average family size of Thami community was 5.87 and 6.45 of Chepang community. Some 60% of the Chepang communities were uneducated compared to 32% of Thami communities. More than 95% of both communities are dependent upon agriculture integrating it with livestock and forest resources for their livelihood. They rear the buffalo, cow, goat and sheep as a major livestock. Thami has reared the goat (95%), cow (85%) and buffalo (38%) and while Chepang community reared by less households than Thami but the average livestock number is larger than Thami. Further, people of both study area collects and sales non-timber forest products for income generation but few people in the Shaktikhor are traditionally dependent upon Khoria Phadani (Shifting cultivation) for their food production and as well as cash generation.

Economically, both communities have very low earning, majority (94%) of Thamis fall under poverty line (Per capita income = below than 1USD) and which is highest in Chepangs (97%). The major livelihood sources of both communities are rain fed agriculture, livestock, forest and labour. According to field survey, only negligible people are employed locally at non-governmental and governmental organization for both communities but higher in Thamis. Though, the average per capita income of *Chepang* is higher (115USD) than *Thamis* (95USD).

a) Food sufficiency and land holding

A total of 27.59% households in *Chepang* community had food surplus while 22.41% had food sufficiency for whole year, while none of the Thami households had food surplus, only five households had food sufficiency for 12 months. In total, more than 80% households had no food sufficiency for their livelihood. This was justified for having less landholding. Thami communities were found to have average landholding of 0.35 ha per household with about 2% of households to be landless. In case of *Chepangs*, the average landholding was about 0.1 ha per households.

b) Dependency on forest and biodiversity resources

Forest has a complex and inseparable relationship between agriculture and human subsistence and an integral part of the daily subsistence of the biodiversity dependent indigenous community (Subedi, 2003). Community forests were main sources of fuel wood, timber, leaf litter and non-timber forest products (95%) and fodder (75%). The local communities throughout the area are heavily dependent upon a wide variety of natural resources to support

their livelihood. Firewood is the only source of household energy in all the settlements. The livestock also directly depend upon forest resources and grazing in the forest. But they have less dependent on wild animal products has been noticed in the area in comparison of plant resources. However, few households of *Chepang* in Shaktikhor hunt the bats and generate the small income. Thus, the detail of the dependency of *Thamis* and *Chepangs* is provided in Table 1.

Table 1: forest production collection in study area

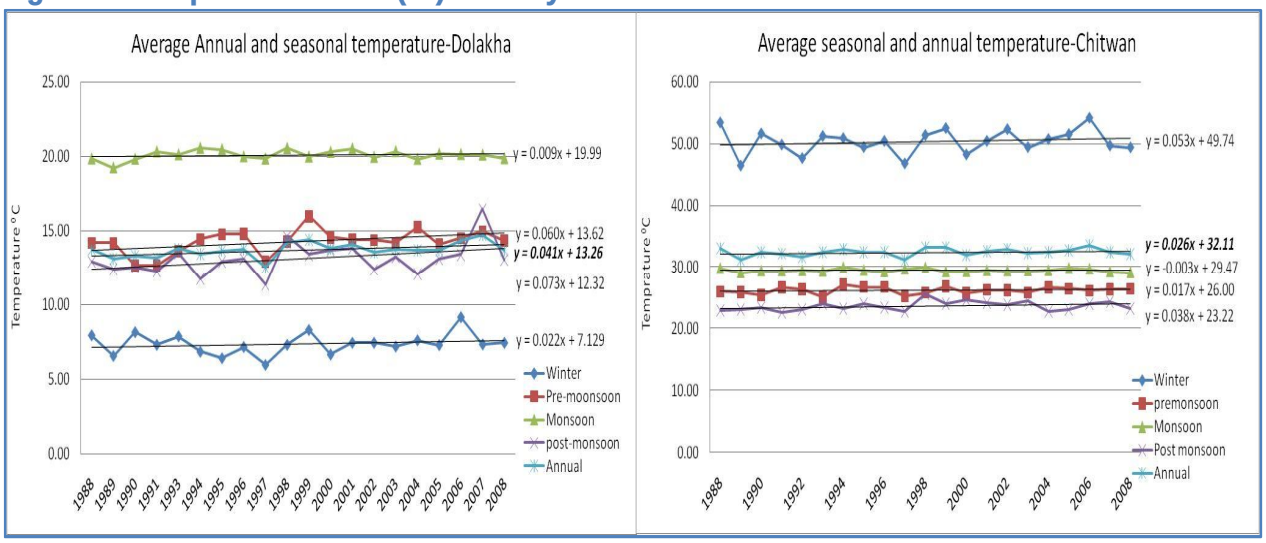
Forest products	Descriptions	Dolakha	Chitwan
Fuelwood	Dependent household (%)	100	100
	Annual collection (kg/hh)	4500	4745
Timber	Dependent household (%)	88	87
	Annual collection (cu. ft/hh)	20	26
Fodder	Dependent household (%)	98	62
	Annual collection (kg/hh)	2850	3600
Agri-implements	Dependent hh (%)	89	50
Leaf litter	Dependent household (%)	85	67
	Annual collection (kg/hh)	2800	6450
NTFPs: vegetable-Morchella and & Fern species	Dependent hh (%)	36	40
	Annual collection (kg/hh)	144	294
Forest food-Dioscorea species in Chitwan and *Symplocos pyrifolia* in Suspa	Dependent household (%)	4	71
	Annual collection (kg/hh)	150	163
Medicinal plants (Chiraito, Thulo Okhto)	Dependent hh (%)	22	60
NTFPs collection for sale*	Dependent hh (%)	26.41	44.43
	Annual collection (kg/hh)	70	65
	Local earning (NRs/hh/year)	2714	1321

**Dioscorea* species, *Gaultheria fragrantissima*, *Danphe bholuwa*, *Edgeworthia gardnerii, Emblica officinalis, Terminalia chebula, T. belerica, Morchella* species and *Aesandra butyracea*.

3.2 Climatic condition

The overall climatic condition showed that the overall temperature and rainfall of the study area is increasing. The mean annual temperature for the last 21 years increased by 0.041 degree Celsius in Dolakha and by 0.026 degree Celsius in Chitwan (Figure 3). Though the average maximum temperature didn't increase in Chitwan, minimum temperature was found to be increasing.

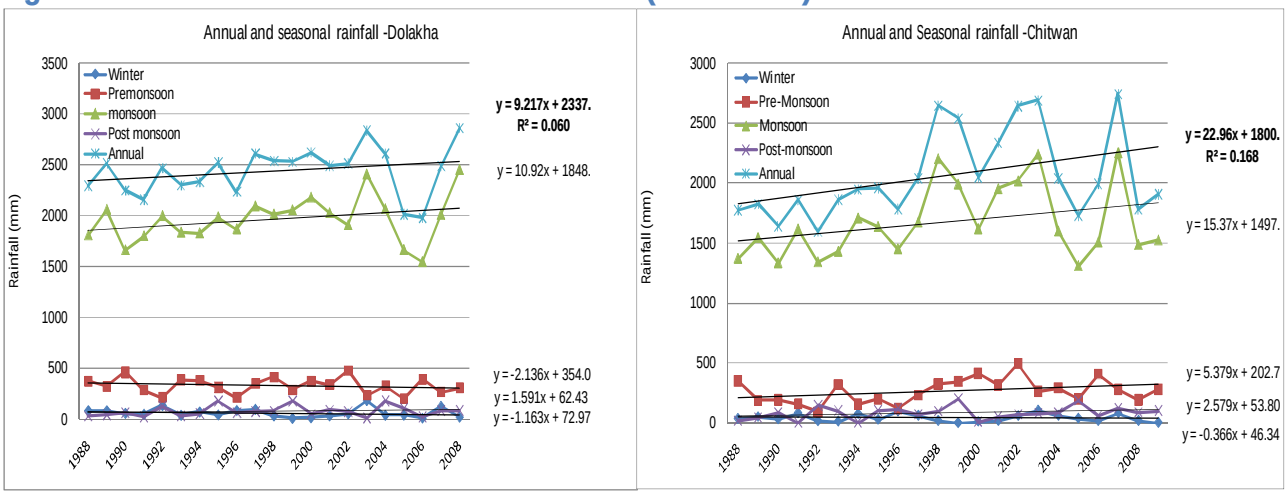
Figure 3: Temperature trend (^{0}C) in study area from 1988 to 2008



As shown in figure 4, annual and seasonal temperature is in increasing trend in both study districts except monsoon in Chitwan. Though the temperature is in increasing trend; trend is high in Dolakha (high altitudinal area) but winter temperature was encountered high in Chitwan.

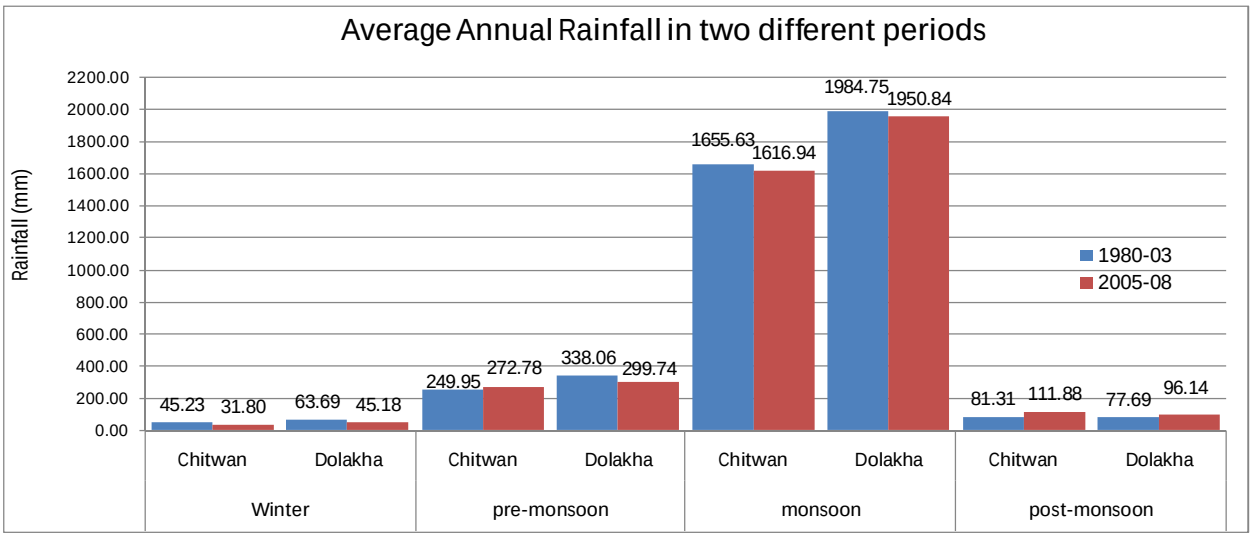
The overall rainfall in both the districts has increased in last 21 years. But, the seasonal analysis showed that rainfall in Dolakha district had increased in monsoon and post monsoon season while it had decreased in other seasons, while in Chitwan the rainfall had increased in all seasons except winter (see Figure 5 for the details). Similarly, the value of R2 is 0.06 and 0.168 for Dolakha and Chitwan respectively which indicates that the annual rainfall pattern is unpredictable. The literatures and expression of the locals had shown flooding and erosion/landslides are also a climatic hazards in the study area. This may be caused by the flash floods occurring in the research sites.

Figure 4: seasonal rainfall in two different sites (1988-2008)



Analysis of rainfall in different periods shows the average annual, winter, pre-monsoon and monsoon rainfall in last five year (2004-08) receives very low in comparison of last 16 years (1988-2003) in Dolakha but post-monsoon rainfall was high whereas annual, monsoon and winter rainfall was low and rest of the season received high in Chitwan than average rainfall of last 16 years (1988-2003). The detail is given in Figure 5.

Figure 5: Average annual rainfall of two different ecological regions in different time periods



This fact shows that the prolonged drought, erratic rainfall and unseasonal rainfall is increasing in last five years even average annual rainfall has been increasing in pattern.

3.3 Major Climatic hazards in the area

Communities were queried on the different impacts of above changes in climate. Community responded that they have observed impacts from different climatic hazards in different scales and levels. The communities during questionnaire survey, FGD and Key Informants interview presented different hazards because of the climate change. The hazards presented by them were categorized and ranked based on their degree of severity, intensity of damage, area coverage and difficulties in handling so as to obtain the following list of hazards (see Table 2).

Table 2: Major climatic hazards in study area

Hazard	Rank (I-high to V- low impacts)				
	I	II	III	IV	V
Drought	√				
Unseasonal rainfall		√			
Forest Fire			√		
Insects and diseases				√	
Floods					√

3.4 Perceived changes in climate

Some 97% of the respondents described that they have perceived changes in the natural phenomenon like erratic rainfall, increased temperature, snow fall, drought etc. But they explained that they are unaware of the cause of such anomalies in climate system. Only about 30%of the respondents (2% Thamis and 28% Chepangs) told that they have heard about climate change and may have been making such impacts. Similarly, majority of *Thami* communities and *Chepang* communities had realized the increased warm summer, drought and intensity of rainfall and decreased length of rainfall, frost in winter and snowfall. But these communities have realized different for cold winter. Other factors also differ, mainly because of difference in ecological zone.

3.5 Impact of climate change

3.5.1 Impacts on different system and monetary loss

The identified climatic hazards have affected to various systems in the study area, mainly agriculture, livestock, forest and biodiversity, human health. These impacts have caused a total monetary loss of NPR 1390700.00 (USD 19867) per year. The detail is given in Table 3.

Table 3: Impacts of climate change hazards to different systems

Area of impact	Major Climatic hazards and affected households%				
	Drought	Unseasonal rainfall	Forest fire	Floods/ landslide	Insect and disease
Agriculture	78	75	35% of total area affected*	54	67
Livestock	49	11		43	
Forest	47	15			67
Human health and disease	3	0		51	47
Horticulture	1	15		--	45
Monitory loss-NRs/year	714100	27400		567700	37600

*: Total monetary loss in case of forest fire was not possible to be calculated through household's survey

3.5.2 Impacts on forest and biodiversity

Two third of respondents observed sprouting, flowering and fruiting of Gurans (*Rhododendron* species), Paiyun (*Prunus cerasoides)*, Kaphal (*Myrica esculenta) and* Chiuri *(Aesandra butyracea)* have been changed in Dolakha. According to their observation, the flowering and fruiting season has shifted 15-30 days before. Most of the respondents state that the forest ground remains without green grass for long period from winter to spring season. Similarly, the regeneration of the species having recalcitrant seed type and species having the germination time from January to June has been reduced.

The locals kept different view on change on forest and biodiversity resources and their distribution. The ecological knowledge of farmer used to sow and reap the agriculture crop

such as flowering of *Painyu* indicates for the *wheat* sowing season, *Champ (Michalia species)* for *Maize* sowing season, *Karangkurung* birds indicates the season of sowing cucumber and summer fruits but nowadays it does not matched with their indigenous ecological knowledge. Thus this study presents perceived change in biodiversity resources as local respondents are given in Table 4.

Table 4: perception of the locals to biodiversity

Factors	For Thami community		For Chepang community	
	Perceived change	% of respondent	Perceived change	% of respondent
Regeneration	Decreased	62	Decreased	65
Invasive species	Increased	67	Increased	71
Composition change	Same (except fired area)	87	Same	89
Flowering and fruiting	Changed	63	Changed	59
Grasses	Decreased	87	Decreased	57
Fuel wood	Increased	83	Decreased	72
Fodder	Decreased	87	Decreased	50
Timber	Increased	70	Decreased	67
NTFPs (in-situ condition)	Decreased	89	Decreased	71
Pest/disease in forest	Increased	98	Increased	58
Forest fire risks	Increased	52	Increased	56

Majority of the respondents expressed that prolonged drought, forest fire, outburst of insect and disease and unseasonal rainfall are responsible for changes in forest and biodiversity. Further, they added over grazing and high pressure over the resources is the other factors.

Regeneration: The Suspa (high altitudinal region) is characterized by diverse landscape, rocky and steepy area with thin soil layer. Further, this region has been receiving high temperature than global and lowland average (Shrestha et al. 2000) provides shelter and food for globally endangered plants, animals and livelihood sources for indigenous communities. Similarly, Shaktikhor of Chitwan lies on low land including Mahabharat range which has fragile landscape. As respondents, this area has highly exposed to prolonged drought, low snowfall, forest fire, and insect and disease outburst. Due to these persistently change in climatic events and fragile nature of Nepalese mountain, the local noted that the regeneration, growth and distribution of plants have been perturbed.

Biodiversity survey found difference in regeneration in fire affected and non-affected forest. Table 5 shows that the number of regeneration (tree species) was found low in fire affected forest at Suspa of Dolakha where as regeneration was low however status was found good in Chitwan. Similarly, sapling was found low in fire affected forests of both regions.

In suspa, regeneration, sapling and biomass found sharply low in fire affected forest which might be due to ground and crown firing together and presence of resinous species with thick

Parmalia in its stem and branches. Thingure salla (*Tsuga dumosa*) and Pahele *(Corydalis chaerophylla) are highly affected* which are limited in specific areas whereas, the sapling and biomass at Shaktikhor was found slightly low but regeneration was very low in forest which has been affected by fire last year than the forest which has not been affected by fire in last year that might be due to the fire occurred within last three years in other most of the forest areas therefore fire is beneficial for regeneration of certain species like Sal in low land forest. The forest where fire occurred before three and fifteen years in high altitude forest, there were no live tree of *Tsuga dumosa*, and *Pahele* and the area was covered by bushy species-*Piptanthus nepalensis* (18200/ha) and *Berberis mucrifolia* suggesting change in forest composition at 1800-2700m. From the study, it is clearly marked that high temperature and prolonged drought have prompted concern about increasing intensity and frequency of forest fire which has directly affected to regeneration and availability of other forest products in the study area.

Table 5: Stock in fire affected and non affected forest in two ecological regions

Particulars	Temperate region (Suspa)					Tropical region (Shaktikhor)			
	Fire affected forest		Forest not affected-fire			Forest affected by fire		Forest not affected by fire	
	TS	BS	TS	BS	Lokta	TS	BS	TS	BS
Regeneration/ha	1500	4000	5133	1200	750	8013	1859	60423	8004
Saplings/ha	1633	18200	2400	1600	243	1773	119	1810	141
Number of tree/ha	600	----	825	---	----	1005	---	1455	---
Tree Biomass-MT/ha	65.00	----	256.02	---	----	395.25	---	571.57	---
Species richness	24		31			80		89	
Note: *TS: Tree species, BS: Bushy species*									

Forest Cover: Forest cover represents to ground, shrub and tree crown cover which found high in low land forest than high altitudinal forests. Similarly, the forest cover in fire affected forest was very low in Suspa but slightly low in Shaktikhor. Specifically, in Suspa, there was high ground cover however there was low shrub and crown cover in fire affected forest whereas Shaktikhor comprises low ground and shrub cover but no significant difference in tree crown cover (Table 6). It might be due to nature and time of forest fire. Other factors might be fragile geographic condition, high population pressure and over grazing in the forest.

Table 6: Forest cover in two ecological regions

Forest cover	Temperate region (Suspa)		Tropical region (Shaktikhor)	
	Fire affected forest	Forest not affected-fire	Forest affected-fire	Forest not affected-fire
Ground cover (%)	50	34	36	56
Shrub cover (%)	20	44	34	48
Crown cover (%)	25	55	55	60

Fodder and ground grass: The respondents of both area state that there is decreasing fodder and ground grass since last seven years. As their realization, increased temperature created

favorable condition to outburst leaf eater in Khasru (*Quercus micarpifolia*), liso (*Ilex depyrina)*, Silinge, Jhigane (*Eurya cerasifolia)*, Banset, Gagan and Utis (*Alnus nepalensis*) and stem borer in Dudhilo (*Ficus nemoralis*) in high altitudinal area. Similarly, leaf eater, stem borer and Red Ant in the low land forest have increased which has affected in growth and productivity of fodder species. During the biodiversity survey, fodder and ground grasses were estimated in participatory manner which shows low in fire affected forest (Table 7). As respondents, the forest floor remains with no more green grasses during winter and spring which is due to prolonged drought, forest fire and other factors might be over human pressure. As a result, grass deficit in these seasons encountered in the study area and fodder is prominent source of green grass during these seasons but frequent outburst of insect and disease has highly affected in its leaf biomass. Thus, people especially female who collect the grasses from the forest and livestock rearing practices has been highly affected.

Non-Timber Forest Products (NTFPs): NTFPs is a source of Thami and Chepang communities. They collect it for curing human and livestock sickness (as medicine), food and sources of earnings (See Table 2). Majority of respondents expressed that the NTFPs have been decreasing sharply in the forest. Mainly Bantarul (*Dioscorea deltiodea*) and Githa/bhyakur (*Dioscorea bulbifera*), Chiuri (*Aesandra butyracea*), Amala (*Emblica officinalis*), Harro (*Terminalia chebula*), Barro (*Terminalia belllirica*), Kurilo (*Asparagus recemosus*) and other varieties of wild vegetables found in the forest area which have an immense food security value in Shaktikhor. Similarly the respondents of Suspa stated that the availability and distribution of non-timber forest products like Nigalo, Lokta (*Danphe bholuwa*), Argeli, Wintergreen (*Gaultheria fragrantissima*), Chiraito (*Swertia chirata*), *Satuwa*, *Niuro* in in-situ condition are significantly gone down except mushroom species in fire affected forest (see Table 7).

Flowering and fruiting habit of certain species like *Chiuri* have been changed. Plants give sufficient number of flowers but the year of prolonged drought it rots and leads to less fruiting. Local *Chepangs* believe that it is due to over maturing of *Chuiri* tree. While they claim that they do conserve *Chuiri* saplings however the pace of regeneration is slow. Similarly, the *Niuro* is a source of income for *Thami* community of Suspa but prolonged drought has affected this plant and dependent because rainfall is a source of moisture for its sprouting. The summer rainfall used to start normally from end of Jestha but in the past 5 years it has shifting to one month later. Therefore, it gives shoot in very low quality and quantity during the droughty days and people are compelled to collect 150-200 kg less *Niuro* and loss of NRs. 4000-6000 per year by a *Niuro* collector.

Box 1: Climate hazards affected to entrepreneurs of wintergreen enterprise Suspa

Gaultheria fragrantissima is an evergreen shrub which is prominent source of income generation in rural area. CFUGs collaboration with private investors has established wintergreen processing enterprise which has provided income and employment in rural areas. It is one of the income sources of Thami for 30 households (including 75% Thamis). These

households earn NRs 2000-9000. But in the past few years, this plant and enterprise has been affected from various climatic hazards such as long drought, unseasonal rainfall and forest fire.

This plant requires moist soil for quality sprouting but frequent prolonged drought has affected in its quality growth. As respondents, wintergreen gives less quality of shoots in dry places than in the moist areas. Further it gives quality shoots in fired area but the sprouting and stock in dry areas decrease significantly. As a result, the local people expressed that they have to spend 1-1.5 hour more time to get 50 kg leaves of wintergreen than last 3 years.

Similarly, local people collected 90% less quantity of leaves and lost some earnings in September. It affected directly to the enterprises because if 600kg leaves processed within September it would give 2.5 kg oil while same amount of leaves processed in October gives only 2.2-2.3 kg oil due to low temperature. So these hazards has directly affected to enterprises with net loss of NRs 6-9000/-last time.

Fuelwood and timber: Fuelwood is an important sources of household energy for all respondents (Table 2) and income sources for few Thami and Chepang communities but there is gap in demand and supply of fuelwood and timber except some well managed and large community forests. Community forest is one of the globally recognized community based forest management system applied in Nepal since three decades. Respondents state that the CF management system has been improving forest conditions. Though the resources condition improving, increasing population and low capacity to afford alternative energy (such as LP-gas, solar and bio-gas) suggesting to high pressure on forest resources. On the other hand, 35 percentage forest areas have been affected from forest fire since 10 years. Majority of respondents' response was the risk of forest fire has been increasing year by year. But certified forest in Dolakha reported that, there occurred devastating forest fire before 15 years then that forest did not encountered with forest fire due to high understanding of forest users however there is risk of fire from other forest area. As majority of respondents, forest fire has affected to fuel wood, timber and fodder species which has also proved by biodiversity survey conducted in both area considering forest fire as a major variable (Table 7). According to respondents, the tree and branches burned during forest fire, do not use as a fuel wood so when the forest fire occurred then the forest dependent people becomes more vulnerable.

Table 7: Stock of fuel wood, fodder, ground grass and few NTFPs per hectare

Forest altitude	Fuel wood (kg)		Fodder (kg)		Grass (kg)		Leaflitter (kg)		Mushroom (kg)		No. of Species		Nigalo (no./clump)	
	Fired	non-fired	Fired	non-fired	Fired	non-fired	Fired	non-fired	Fired	non-fired	Fired	non-fired	Fired	non-fired
Temperate (Suspa)	3325	6875	3150	4550	4935	2800	1225	3500	38	16	34	41	2000/66	3000/75
Tropical (Shaktikhor)	6250	8750	4375	6125	8190	7420	2030	6895	25	15	81	85	N/A	N/A

Fuelwood: 1 Bhari=25 kg, Fodder/grass/leaflitter=35 kg=1 bhari

From the above facts, therefore, we can clearly claim that the forest fire, increased pest and disease and prolonged drought are severely affected to the forest species, ecosystem, products and their services.

Invasive species: The respondents observed increased invasive species in the study area such as *Mikania micrantha* in Chitwan and *Lantana* species, *Piptanthus nepalensis* and *Berberis mucrifolia* in Suspa of Dolkha. Before 1957 there was no *Lantana* species in Suspa but time and again it distributed over the forest, now it is available everywhere and affecting to germination of other valuable forest species respondents added. Similarly, *Piptanthus nepalensis* and *Berberis mucrifolia* are high in fire affected forest in high altitude region. This has indication of drought and increasing temperature. Similarly, the Shaktikhor *Mikania micrantha* was found high and covered the tree, shrubs and herbs and incidence of *Lantana* species was high in low land forest which has directly affected to the germination, growth, flowering and fruiting of the species. Further it has affected to fodder species, grasses and to some extent fuel wood species. Increased temperature and prolonged drought might be the triggering factor for spreading of invasive species in the study area. However this needs further verification through research in detail.

3.5.3 Impacts on wildlife and birds

As respondents, wild animals and birds were found to be largely decreasing except Jackle (*Canis aureus*) and wild boar-*Pigmy* species (see Table 8) .Despite the success in community forestry, the numbers of birds, fishes, toad and some mammals appeared less to the communities. They depicted that the birds *Jureli* and *Chibe*, *Bhadrai*, *KaloBangali and Karangkurung* have highly decreased.

Table 8: Locals perception on situation on birds and wild animals

Category	Species	Impacts on Birds and wild animals	
		Dolakha	Chitwan
Birds	Kalij pheasant	Increased	N/A
	Dhukur	Decreased	Same
	Bhadrai	Decreased	Same
	Jureli	Decreased	Decreased
	Chibe	Decreased	Decreased
	Bhyakur	Decreased	Decreased
	Bat	Decreased	Decreased
	KaloBangali	N/A	Decreased
	Parrot	Decreased	Decreased
	Bhageri	Decreased	Same
	Kyaki	N/A	Decreased
Wild animal	Deer	Decreased	Decreased
	Syal	Increased	Increased
	Badel	Increased	Increased

Wetland diversity	Fish	Decreased	Decreased
	Toad	Decreased	Decreased

Climatic hazards might be major causes of declining the species and their number. As respondents increasing temperature, unseasonal rainfall and long drought and forest fire has significantly affected to wild animals and birds. Particularly, forest fire has destructed the habitat and directly to the birds and wild animals; unseasonal rainfall has affected to its nesting and reproduction system; long drought has declined the water sources in the forest which has threaten them to survive in the area. Similarly, the species found to be largely affected due to flood was toad, regarded as the medicine and dietary vegetable for *Thami* communities. Though the number of wild animal and bird species are decreasing, the *Jackal, badel* and *Kalij pheasant* has been increasing in the area. Its major cause might be increased bushy species and their food in the forest and agricultural land.

3.5.4 Impact on water resources

Locals of research area have observed drying of water resources. According to the 84% respondents, the water sources and their amount of flow has decreased by 42%. In both study area, almost all the wells went dry due to the continued drought since many years. The locals emphasized that it is due to the long drought and lack of water conservation strategies. Since 7 years, the respondents of both study area observed the water sources and ponds in forest and outside of forest during winter and spring season very dry. Further 10 years before, the water sources used to suddenly come out during first week of July but it does not become so and shifted to end of August or sometimes it does not appear during last 7-10 years. As a sequel, the wild animals and birds' habitat, their migration for food and their reproduction might be highly affected.

Further it has hit to the gender affecting to the women who involves in daily households activities. Most of the respondents expressed that they have to spend about 15% extra time to fetch the same amount of water. In case of few households they have to walk long distances to fetch water and sometimes they (respondents of Shaktikhor) have to bring water from river when long drought prevailed. At the same time, the regeneration of plants and growth might have been greatly affected from low moisture content in soil and high temperature in the atmosphere.

3.5.5 Impact on agriculture

Climate change was found to be affecting agriculture system directly or indirectly. In Suspa of Dolakha, as local people are completely dependent upon compost as a fertilizer, agricultural system was found to be hampered because of erratic rainfall, long drought, decreased snowfall and increased forest fire. Similar was the case of Chitwan. As respondents, forest fire has reduced dry leaf litter in the forest which was source of compost in both study area and suggested less manure preparation that has directly hit to the agriculture crops production. Similarly, the locals added that prolonged drought and unseasonal rainfall has severely

affected to the subsistence agriculture farming during seedling production, flowering and maturing period and led to decreased production. The mostly affected crops in Dolakha were potato, wheat, maize, barley, mustard and rice while those in Chitwan were rice, maize and mustard.

3.5.6 Impact on human health

Changes in climate and increase in temperature are creating favorable environment for pests, and diseases to develop and spread into human settlements. Flooding and contamination of water is increasing the risk of water borne diseases. According to people, frequency of diseases like fever, jaundice, common cold, malaria and Dengo etc have increased. One of the main reasons for the increase in health hazard is increase mosquito number in the study area. Majority of the respondents (97%) reported that there have been a missive increase in mosquitoes and houseflies in the past 7 years in Suspa. It was low in number in the past due to low temperature. Similar case was found in Shaktikhor. According to the respondents, the main reason behind the increase in mosquitoes and houseflies is rise in temperature of the local area.

3.6 Existing local adaptation practices

Locals were found to be applying the different adaptation practices for reducing the impacts being faced by them. The adaptation practices applied by the locals are more traditional approaches whereas some approaches are based on the support of different governmental and non-governmental programs. Below has been provided abridged version of the different adaptation practices being applied by the locals and the details is given in Annex-1.

Forest fire management: Forest fire is one of the major climatic hazards identified by the locals. Therefore, there is no any adaptation measures applied in individual level. However, majority of the *Thami* (92.45%) and *Chepang* (89.66%) community involves extinguishing fire in appeal of CFUGs but there were no modern extinguishing equipments applied. Similarly, 52.83% people of Suspa have aware about the fire hazard area but it is less in Shaktikhor even though 65.52% households *Chepang* have trained on fire management. But there are very few practices of fire line preparation and early group formation and preparation for fire management in both study sites.

Insect and disease management: As Figure 3, temperature is continuously increasing which has supported to create the favorable environment to outburst the insect and disease in forest species and agriculture farming. Similarly the mosquitoes in Suspa appeared since 10 years and increased frequency of fever in both sites and Dengo in Chitwan. Mainly insect and disease have been increasingly affecting to the forest fodder and tree species however they have not applied any measures to reduce those effects in both sites except shifting the species when one species affected more. In agriculture farming, 92% *Chepang* households have used the insecticides whereas only 3% *Thamis* have treated the disease appeared in their vegetable farming and very majority of *Thamis* have used *Titepati* for controlling the insect in the crops

but in these days it does not work properly to prevent the insect and disease even in the agriculture crops.

Landslide and flood management: In both study sites, 81.03% Chepang and 86.79% *Thami* have planted perennial crops where the floods and landslide risk prevailed. Similarly, *Thamis* have formed loose dam for control small landslide and flood management but they in both areas have nothing done for large size of landslide and floods management. But CFUGs have provisioned to support providing timber and loan without interest for those households who have affected from landslide and floods extremes.

Fuel wood deficit: the suspa holds more forest area and increasing forest condition than in Shaktikhor but the forest comprises large biomass, regeneration and good condition of forest in Shaktikhor (low land forest) then Suspa (high altitude forest). However, there in both areas fuel wood deficit has been noticed except some community forests user groups. Community forests have controlled haphazard collection and considered sustainable forest management. Therefore, the majority of *Thami* (96.23%) have reduced haphazard use of the fuelwood and used agriculture residue (83.02%) as an alternative sources during the fuelwood deficit time. Similarly 47.17% of Thami households have used improved mud cooking stove but due to low land holding size, they have not planted the fuel wood tree in their private land except 1.89% households. Similarly, reduction of haphazard use of fuelwood, use of agriculture residue, promotion of good agro-forestry practices are the major adaptation strategies of *Chepang* community except very few households use the improved cooking stove. Of 96.55% *Chepang* have reduced haphazard use of the fuel wood and agriculture residue is next strategies to fulfill fuel wood deficit of 18.97% households in Shaktikhor. A good long term adaptation was noticed in *Chepang* community is promotion of agro-forestry practices planting the fuel wood tree species in their private land which has followed by 43.10% households.

From this analysis shows that, low land forest has rich diversity and good condition of forest even it has suffered from frequent forest fire and the *Chepang* community have practices of good agro-forestry practices which is insufficient but was a good initiation to adapt with fuel wood deficit in long run than in *Thami* community.

Grass and fodder deficit: Increased drought, forest fire and outburst of insect and disease have affected to the regeneration and growth of grasses and fodder during the winter and spring season. According to the locals, the over and unsustainable harvesting and over grazing are the next triggering factors leading to low production and regeneration of palatable species for livestock and wildlife. Therefore, Thami Community in Suspa used corn (N=98.11%), kanla conservation (96.23%) grazing control and stall feeding (92.45%), agriculture residue (90.57%) but there was no plantation of improved variety of grasses in their private land and in forest land. At the same time, 89.66%, 84.48%, 75.86%, 79.31%, 67.24%, Chepang households fulfills the grasses and fodder deficit using kanla conservation, grazing control, stall feeding, agriculture residue and corn. One important practice was promotion of agro-forestry system in Shaktikhor and fulfills their fodder deficit. But all these adaptation practices are based on indigenous knowledge.

NTFPs management: NTFP is major sources of food, medicine and income in both study area but since 7-10 years, the many species are declining as we discussed above. In this context,

90.57% Thami in Suspa have harvested the NTFP products based on skill provided by district forest office and some other NGOs and sell it to locally established enterprises. Of 79.25% Thamis collects the NTFPs when it becomes mature so they have to shift 15 days before or sometimes later. Similarly, 26.42% of Thamis have involved in plantation of NTFPs (Argeli and Lokta) in CF area in support of CFUG especially in FSC certified forest and very few households have planted Argeli and Nigalo in their private land. However, its germination and success rate have been lowered when the prolonged drought occurs. At the same time, research team did not notice any special measures in Shakitkhor considerably from households' level. Only 39.66% households involved in conservation of NTFPs habitat and very few 10.34% people have planted Chiuri in their private land. Thus, very few households have aware about NTFPs' harvesting methods otherwise all people have followed same season and indigenous methods for harvesting.

Water source management: There were no visible adaptation practices in both areas to conserve water resources though the forest area is a major source of water for human beings, livestock, wildlife and birds. In Suspa, most of the people established cemented tap except pro-poor households in support of governmental and non-governmental organizations whereas the Chepang community at Chitwan are using cemented and stone tap and still majority people use the water from well. Except those measures, majority of the respondents (90.57%) in suspa considered water source conservation which is low in Shaktikhor. During the year of prolonged drought, 75.86 % respondents harvest the water from river and 8.62%r store water harvesting rainfall whereas Thami community are conserving trees around the sources and has developed reservoir. However the water source becomes dry and affected livestock rearing practices more. To deal with this problem, they temporarily made small pond to feed water for their livestock but they are not making conservation pond to reserve the water for wildlife/birds and livestock in the forest area.

Agriculture farming: Agriculture is mainstay of livelihoods in both sites therefore they have done various local adaptation practices to fight against extreme climatic events. Mainly 94.34% of Thami and 60.34% Chepangs have imported food from market when food deficit occurs. Similarly, 90.57% Thamis used traditional food and seed storage practices i.e. storage in *bhakari* -bamboo and hey made baskets and *Dhokro* whereas 81.03% Chepangs used bamboo made baskets. Rest of the households do not store in basket they put all the production in *Dhokro* only.

In both study areas, there is no improved compost making practices applied to fulfill the deficit of leaf litter. They just shift to next forest blocks (not affected from forest fire) for collecting leaf litter. Of 96.55% Chepangs have developed irrigation channel which have supported for cultivating rice whereas 64.15% households of Thamis have developed rainfed irrigation channels. Majority of households have followed traditional cropping calendar.

Community forests in climate change mitigation and adaptation: The pressure on forest is high in both districts since it consists only 0.82 hectare in Shaktikhor while 1.24 hectare forest

per households in Suspa. The stock rate is very high in Shaktikhor than Suspa. At the same time, researcher visited and consulted with Suspa, Jhareni and Damarthami CFUG in suspa and Jharana and Jana Pragati CFUGs in Shaktikhor. Most of the CFUGs have developed comprehensive management plan and have conducted various in-situ and ex-situ management activities linking with income generation. Here are highlighted the some key activities carried out by some of the CFUGs which might be important from the perspective of climate change mitigation and adaptation (Table 9).

Table 9: CFUG activities in forest and biodiversity management and local livelihood promotion

Major areas	Suspa	Shaktikhor
Forest and biodiversity management		
CF operational plan and constitution	Yes	Yes
Detail provision of forest product distribution, forest management, and penalty and rewarding system in operational plan and constitution	Yes	Yes
Detail provision of biodiversity management (threat identification and mitigation), enterprise development, and pro-poor sub-group formation	Yes	Not clear
Identification of the area having the importance from regeneration, biodiversity, erosion/landslide prone areas, plantation areas	Yes	Not clear
Resources inventory of tree species	Yes	Yes
Detailed inventory of NTFPs and management	Yes	Not clear
Forest management (harvesting, silviculture, firewood, grazing)	In detail	Not in detail
Biodiversity conservation methods and assessment of biodiversity threats	Yes	No
Promotion of nursery and plantation of NTFPs and endemic species	Yes(in few)	Not significantly done
Identification the fire hazard area	Yes	Yes
Construction of fire line in fire hazard prone areas	No	Yes
Extinguishing practice if fired	Yes	Yes
Conservation of important forest area of regeneration and important NTFPs	Yes	Not significantly done
Silvicultural activities (annual bush clearing, singling, thinning and pruning)	Yes	Yes
Identification of the biodiversity threats and development of the mitigation plan	Yes	No
Community development and poor focused program		
Promotion of biogas and improved cooking stove using CF fund	Not significantly done	Initiated by few CFUGs
Support to toilet construction and goat rearing	Yes	Yes

Support to establish wooden and cemented bridges in flood affected area	Yes	Yes
Sub-group formation and poor forest management linking with income generation	Yes	Initiated but not continued
Community based forest enterprises development in local area for controlling the unsustainable collection of non-timber forest products	Few CFUG	Not yet
Forest product collection and distribution system	Equity based	Equity based
Economic support and forest products (timber, fuel wood) supply to hazard affected households	Yes	Yes
Representation of all caste in executive committee and CF activities	Yes	Yes

Thus, CF management system has supported for forest management and livelihoods upliftment. Most of the CFUG executive members in both study area were somehow familiar with climate change but they were still less familiar with its causes. They have conducted in-situ and ex-situ forest management, community development and forest enterprising work in collective way which has certainly supported to mitigate and adapt with changing climate situation nonetheless they need to be aware and trained for ecosystem based integrated adaptation and management being sensitive with climate change scenario.

Chapter Four: Discussion, Conclusion and Way forward

4.1 Discussion

The indigenous Thami and Chepang communities are dependent on forest and biodiversity resources, agriculture farming and livestock and water resources of the area. With the increased pressure on the natural resources due to climate change coupled with unsustainable harvesting, poaching and other illegal activities, both communities are further vulnerable to climate change as they are exclusively dependent on climate sensitive sector such as forest and biodiversity resources, water resources, agriculture farming, livestock rearing and labour. Only 1 percentage people from the Chepang and 3 percentages of Thami communities are engaged in government and non-government employment. At the same time, they both communities hold high illiteracy, low land holding and high family size than national average. National Adaptation Plan of Action (NAPA) report also shows that the Dolakha and Chitwan are very high and high vulnerable districts respectively to climate change effects.

Similarly, the communities lack resource enterprising knowledge, appropriate harvesting technological knowledge and scientific climatic knowledge and its prediction capacity in both. They are continuously practicing indigenous knowledge in agriculture farming, forest products including harvesting and water resource conservation. Institutionally, the study area consist few CFUGs, mother groups, cooperatives and few local clubs and non-governmental organizations. But, they have no awareness on climate change effects and its causes, technologies to adapt, resources to capitalize local human, natural, social capital in the area. Though, the CF area per households is large in suspa, the forest comprises less stock and small number of species than Chitwan. As biodiversity survey, the regeneration, sapling and biomass is low in fire affected forest than in forest not affected by fire. It shows that the high altitudinal forests and ecosystems are highly vulnerable in comparison of low land forests and ecosystems to climate change.

Responses of the communities are based on the seasonal calendars, they are practicing. Snow and frost in high mountain area were said to be decreasing which is the sources of moisture for various agriculture crops. High intense and frequent rainfall has led to the flash floods and landslide in the area. Similarly, long drought has led to the devastating forest fire in all ecological zones but it is highly devastating in High Mountain due to its terrain and unique geographical features. These extreme climatic events have directly affected to livelihoods strategies and natural system in both study areas.

As communities, besides climate change other factors like increasing population and unsustainable and over harvesting might be other triggering factors for negatively affecting

forest and biodiversity resources. As analyzed, the collected information from household's survey, key informants interview and focus group discussions, it is found that the local people have applied certain indigenous coping and adaptation practices through community forestry users groups, farmer groups, mother groups and cooperatives. They have made effort in resource conservation, plantation, community based natural resource enterprise development, community awareness and community mobilizations which has certainly supported to cope and adapt with changing climate situation. However, the CFUGs and other local groups have limited knowledge on climate change effects and its causes and way of solution. Therefore, they are compelled to follow indigenous crops, traditional farming methods and imposing new harvesting rules to various non-timber forest resources even in changing climate situation. As mentioned in practical action, Nepal report, climate change is affecting to all the resources where people depend for our livelihoods. The impacts are more visible among *Chepang* and *Thami* community that have made them more vulnerable due to their weak coping and adaptation mechanisms and capacities. Climate change makes it easier for falling into poverty trap, and harder for the poorest biodiversity dependent *Thami* and *Chepang* communities to escape from it.

4.2 Conclusion

Following conclusions can be drawn from the study:

1. Both communities are highly vulnerable to climate change amid their lack of knowledge on climate change, high dependency on natural resources directly and low adaptive capacity
2. High altitude ecosystems are more vulnerable than low land ecosystem because of geographical conditions and marked more climate (high temperature and low precipitation rate) induced events
3. Natural hazards like fire and drought have increased in recent time which has played crucial role in reducing the forest stock and cover especially in the high altitude region
4. Agricultural productivity and profit to small enterprises are hampered because of erratic climatic events
5. To reduce the effects, adaptation practices are being carried out in the sector of agriculture, water and forests, which are more traditional in approach and based on local level knowledge
6. Other factors like illegal poaching, unsustainable harvesting etc. have coupled with climate change to negatively affect the biodiversity and livelihood of local people

4.3 The way forward

The study has been focused to biodiversity dependent indigenous Thami and Chepang communities. They are highly dependent on climate sensitive sector and are poor and most vulnerable from climate change effects. Therefore, to save the natural resources, biodiversity and linked livelihoods of those communities from above identified climatic induced hazards,

there is urgent need to take better actions as given below:

1. **Education and Awareness raising programs for both communities**: In order to secure the good future, children of both communities need education programs. And there is need of proper awareness program for both communities on how the climate change can affect their livelihood and the resources they are dependent. This will be highly helpful in planning longer term community based adaptation strategies and also coupling different environment (like forest, agriculture etc.) in one strategy making it more cost effective and practical.

2. **Vulnerable area, species and ecosystem identification:** The forest area, species and ecosystems which are vulnerable to climate change effects need to be identified in participation of the locals. Along with identification, a participatory habitat, species and ecosystem management plan should be developed; accordingly, the local people need to be technically and financially strengthened for well implementation. For example, the *Chiuri, Giththa, Bhyakur* and Bat are cultural foods (non-timber forest products) of Chepang community and toad and frog are the cultural food and medicine of Thami communities. Though its great cultural importance, they have been severely affected in these days so it should be conserved and managed sustainably.

3. **Policy for vulnerable species, ecosystem and livelihoods:** In order to insure the sustainable biodiversity and standardize the rural livelihoods even in changing climate, the policy, strategies and guidelines need to be developed and implemented focusing the biodiversity dependent indigenous communities.

4. **Capacity building of vulnerable *Thami* and *Chepang* communities:** The communities need capacity building programs like trainings in climate adaptation and sustainable resource management practices in changing climate situation, so as to minimize the effects of climate change. Integrated development and related capacity preparation is a prominent way to reduce vulnerability in the study area. Therefore, the locals need to be capacitated to fight with climate change effects and reap the benefits obtained from positive consequences of climate change. Further, there should be Enhanced local institutional capacity which contributes to create the united efforts to combat negative consequences of climate change.

5. **Strengthening of existing institutions and establishment of new institutions:** The capacity of current institutions like community forest user groups, few financial institutions, mother groups, local clubs, *Thami* Samaj in Dolakha and Praja cooperative in Shaktikhor needs to be strengthened with the view of climate change mitigation and

adaptation. They should be oriented for identification of climatic hazards and their impacts, causes of impacts and way for fighting with them. In addition, new forest user groups, agriculture farming groups, water conservation groups, income generating groups and financial institutions targeting *Thami* and *Chepang* needs to be formed and strengthened to deal in the context of climate change and to create a win-win mechanism. So as to, they can prepare for reducing effects of climate change.

6. **Infrastructure and Technological development, and collaboration**: To adapt with marked change of climate, there is urgent need to develop required infrastructure like conservation pond, tank, well managed tap and conservation of water sources and well for drinking water; promotion of community forestry (with certification), identification of biodiversity important area, plantation and conservation for good forest and ecosystem health linking them with livelihoods of the biodiversity dependent indigenous communities; introduction of new and variety of seed and technology of farming and irrigation facility development for agriculture farming even in long drought and heavy and unseasonal rainfall context. Also the collective efforts is crucial to address the multiple issues of climate change, biodiversity loss and poverty of study area and country in an integrated way is synergistic solutions in global change context. Further, in Shaktikhor, there is needed to be developed bridges over the river for travel and transportation.

7. **Testing of traditional and indigenous adaptation practices:** The adaptation practices being applied needs to be tested economically, scientifically and environmentally so as to ensure they are applicable for long term strategy. The good practices needs to be adopted while other practices should be improved in changing climate situation.

8. **Promotion of improved varieties of grass:** To fulfill the green grass and nutritional deficit to the livestock rearing, there is need to introduce and promote different varieties of grass species in the private land and community forest area which will fulfill the deficit nutrition at the dry season and increase the livestock rearing capacity of the indigenous biodiversity dependent communities.

9. **Action research and harvesting technology development:** More studies need to be conducted focusing in-situ conservation and ex-situ conservation of forest and biodiversity resources to adopt with risk and disaster posed by climate change. Further, appropriate forest resource harvesting technologies need to be tested and implemented.

10. **Diversification of livelihood/income sources:** The resources in local area are being collected unsustainably. Therefore, the local institutions like CFUGs and farmer groups need to be supported to develop community based forest enterprise such as briquette making, essential oil production, *Chiuri* processing and other promotion of underground

forest fruits in local area which generates and diversify the income in local area as well as it leads to the sustainable management of the natural resources.

11. **Nursery management and promotion of agro-forestry:** In both study sites many fodder and NTFPs species are increasingly declining such as *Champ, Lothsalla* and *Thingure Salla* in Suspa and *Chiuri* in Shaktikhor and so many NTFP species. Therefore to fulfill the need of fodder, fuelwood and NTFPs, there is crucial to support CFUGs to establish nursery and plantation of many endemic and improved varieties of species and their plantation. Furthermore, agro-forestry system including kitchen garden need to be developed in both study site but high crucial in Suspa targeting *Thami* communities.

12. **Agriculture farming:** Agriculture is interconnected with forest and livestock. Therefore to improve agriculture farming, there is crucial to test improved variety of crops and their replication. The forest fire has been affecting for compost making process by reducing the amount of leaflitter in the forest so there is need to transfer the knowledge of integrated compost making process along with integrated pest management technology. Especially, the *Chepang* community has been practicing the shifting cultivation in highly marginalized land and farming the agriculture crop that affected from various climatic events so they have to robust promoting them high value perennial crops in the area.

13. **Promotion of Payment of Ecosystem Services:** In the study area, there are opportunities to reap benefit from are large number of ecosystem services available in the area like eco-tourism promotion, forest carbon trade, forest certification and sustainable marketing of forest products, upstream and downstream linkages, incentive based biodiversity conservation and etc could be adapted at national, regional, watershed and local level.

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Annex 1: Local adaptation practices of local people

Area	SN	Adaptation practices	Households involved in %	
			Dolakha	Chitwan
water resources deficit	1	water source conservation	90.57	58.62
	2	water harvests from river	22.64	75.86
	3	Rain water harvesting	1.89	8.62
	4	shifting to new sources	1.89	12.07
	5	Water filtration and segregation	0.00	17.24
Fuel wood deficit	1	reducing haphazard use	96.23	96.55
	2	using agriculture residue	83.02	18.97
	3	Alternative energy introduction (solar, improved stove.....)	47.17	3.45
	4	Plantation of fuel production species	1.89	43.10
Grass/ fodder deficit	1	User of corn	98.11	67.24
	2	Kanla conservation	96.23	89.66
	3	grazing control	92.45	84.48
	4	Stall feeding	92.45	75.86
	5	Supply to agriculture residue (hey, straw..)	90.57	79.31
	6	Use of Improved watering system	73.58	10.34
	7	plantation of improved variety of species	0.00	5.17
Forest fire control	1	Extinguishing forest fire when occurs	92.45	89.66
	2	Fire hazard area identification	90.57	29.31
	3	Introduction of early warning system (local mechanism)	52.83	10.34
	4	training and awareness	0.00	65.52
	5	Preparation of extinguishing equipment	0.00	8.62
	6	fire line preparation	0.00	18.97
Pest and disease	1	Shift to new species (forest)	72	62
	2	Use of pesticide and insecticide (agriculture)	3	92
NTFPs management	1	use of improved harvesting technology	90.57	8.62
	2	local processing and marketing of NTFPs	86.79	0.00
	3	harvesting season changed	79.25	6.90
	4	conservation of NTFPs habitat	27.55	39.66
	5	Plantation of NTFPs (ex-situ management)	26.42	10.34
landslide and	1	relief group formation	92.45	91.38
	2	formation of check-dam and loose dam	90.57	3.45

Area	SN	Adaptation practices	Households involved in %	
			Dolakha	Chitwan
	3	perennial crop plantation	86.79	81.03
	4	Provision of insurance	0.00	5.17
Agriculture production	1	Import of food from market	94.34	60.34
	2	Storage of agriculture products	90.57	81.03
	3	Introduction of drought resistant species	75.47	74.14
	4	Irrigation facility developed	64.15	96.55
	5	Shifting cropping season	3.77	17.24

Annex 2: Some photos of field study and livelihoods strategies of communities

Focus Group discussion

Household interview

Biodiversity survey

Forest product collection

Marginal agriculture farming

Forest product collection and selling

Livestock rearing

Nigalo collection and handicrafts making

Annex 3: Some photos of Impact of climate change on biodiversity and livelihoods

Fire affected forest

Insect on forest (Red ant)

Water source drying and livestock searching water for drinking

Piptanthus nepalensis in high mountain forest

Micania micrantha in low land forest

Drying well in study area

Women bringing drinking water from a distance

Annex 4: Some photos of local indigenous adaptation practices

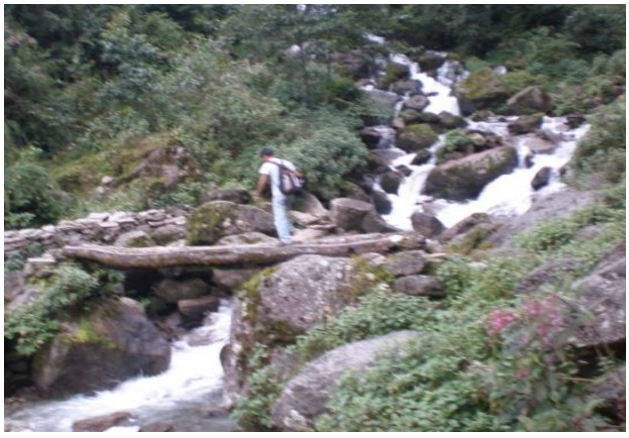
Use of agriculture residue in fuelwood deficit

Storing agriculture residue for grass deficit time and *kanla* conservation

Fencing of regeneration area in CF

Plantation of Argeli (NTFPs)

Agro-forestry practices in Shaktikhor



Wooden bridge for crossing the river during the flooding period

Small water pond construction for livestock