Climate Change Impact on Livelihood and Natural Resources of Upper Mustang

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ABSTRACT

It is worldwide consensus that warming of the globe is responsible for climate to change unprecedentedly which can have a number of direct and indirect threats to mountain environment and livelihood of the mountain dwellers. The study entitle Climate Change Impact on Livelihood and Natural Resources was carried out in the Lomanthang UCO, ACAP aiming to access climate change impact on agriculture, livestock, rangeland, water resource and housing.

Climatic data were collection of local station, Jomsom and Lete analyzed and interrelated. For the collection of social data direct observation, key informant discussion, questionnaire etc. were followed an addition to these expert discussion with climate change specialist has also been carried out. Finally, social perception is linked with finding from the meteorological station to verify social perception technically.

Annual average temperature is increasing at the rate of 0.032 showing increasing temperature trends where as in contrary to temperature trend total yearly precipitation trend is decreasing at the rate of 1.81. There is also temporal shift in precipitation amount from Sep-Nov to Feb-Mar indicating shift in snowfall as well as decreasing its amount.

Questionnaire survey revealed that 65% of respondents believed that said temperature is increasing hotter than before. Majority of respondent said that water resource is decreasing. Almost 82% of the total respondents have said that the amount of snowfall had drastically decreased in last 20 years. These finding were in line with technical finding. Resulted consequences are increased diarrhea disease frequency, scarcity of water resource, increased dryness in rangelands, leaching problem in mud roofed house etc. However, to endorse the present findings, statistically meaningful data to more detailed micro scale is required to take future adaptation and management strategy to combat climate change effect.

Key words: Lomanthang, Climate change, local livelihood, water resource
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Chapter I: INTRODUCTION

1.1 Background Information

Nepal lies between Palaeoarctic and Oriental realms. The collision between the Indian subcontinent and the Eurasian continent, which started in Paleocene time and continues today, produced the Himalaya and the Tibetan Plateau, a spectacular modern example of the effects of plate tectonics. Nepal lies completely within this collision zone, occupying the central sector of the Himalayan arc, nearly one third of the 2,400 km (1,500 mile)-long Himalayas.

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors that include oceanic processes (such as oceanic circulation), variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, and human-induced alterations of the natural world; these latter effects are currently causing global warming, and "climate change" is often used to describe human-specific impacts.

Accelerated emission of Green House gases is primary cause of unprecedented Global warming bringing climate to change. Since the mid-1970s, the average air temperature measured at 49 stations of the Himalayan region raised by 1°C with high elevation sites warming the most (Hasnain 2000). This is twice as fast as the 0.6°C averages warming for the mid-latitudinal northern hemisphere over the same time period (IPCC 2001a) and illustrated the high sensitivity of mountain regions to climate change (Oerlemanns et al. 2000 as cited in WWF 2006). Using current climate change trends, by 2100, the average global temperature may rise by 1.4-5.8°C (IPCC 2001b; Wigley 2005). As through much of its history, the Earth's climate is changing. Right now, it is getting warmer. Most of the warming in recent decades is very likely the result of human activities (IPCC 2007). Climate change is an associated phenomenon of global warming – the average increase in near surface air and ocean temperatures around the world. Climate change is currently taking place at an unprecedented rate and is projected to compound
the pressures on natural resources and the environment associated with rapid urbanization, industrialization, and economic development.

Changes in global climate pose a number of potential risks to mountain livelihood which ranges from agriculture, livestock, water resource, forest resources, health and sanitation and household assets. The term ‘livelihood’ comprises the capabilities, assets (material and social resources), and activities required for a means of living (Carney 1998). Studies on the Tibetan Plateau show inextricable links between rural livelihoods, land use, human health, and climate change (Wilkes 2008; Xu et al. 2008). The impact of global climatic change on agriculture has recently become a subject of increasing importance (Glantz 1988).

People who live in the Himalayas are in generally poor and face special difficulties. The rugged terrain makes road construction difficult, and landslides often damage roads once built, particularly during the monsoon season. Access to essential goods and services is in general difficult. Economic activities in the mountains are often hampered by lack of access to the well-organized market economy of the plains. Educational opportunities in the mountain regions are limited, and unemployment is a major issue. The subsistence economy of the Himalayas varies from shifting cultivation and seasonal farming to nomadic herding, supplemented by petty trade. In some areas, increased road access and other transportation facilities in recent decades have facilitated the marketing of local products and crops/livestock with comparative advantages vis-à-vis the lowlands (Shrestha, 2005). Climate change has made the future of mountain indigenous people and their livelihoods more vulnerable and uncertain. The available scientific evidence suggests that climate change will place significant stress on the rural livelihoods of mountain people.

Although politically part of Nepal, Upper Mustang is linked by religion, culture, and history to Tibet – and now stands alone as one of the last truly pure Tibetan cultures existing today. With its untouched temples, colorful festivals and red-robed lamas, the kingdom preserves not only the daily vernacular of Buddhist ethics, but a unique heritage of Tibetan religious art. In 1992 restrictions were eased, and the long-forbidden kingdom was cautiously unlocked. There are several features that make the Annapurna region a unique place in the world. It contains world’s deepest river gorge - Kali Gandaki Gorge, which is 3 miles long and 1.5 miles wide, a valley with fossils from the Tethys Sea dating 60 million years ago. The region contains world’s largest
rhododendron forest in Ghorepani. Tilicho Lake, located in Manang – north of Annapurna massif, is the world’s highest altitude fresh water lake. The biological diversity of the Annapurna region is equally rivaled by cultural diversity. Gurung and Magar are the dominant groups in the south, whereas Thakali, Manange and Loba are dominant in the north. Each of these groups speaks their own dialect, and has unique cultures and traditions. Besides, there are also Brahmin, Chhetri and other occupational castes although in comparatively smaller numbers. Hindu, Buddhist and pre-Buddhist religions along with a mixture of all these are prevalent across the region. The local people reside in the 5 districts of the 57 Village Development Committees (VDCs) of the Annapurna Conservation Area (ACA). The natural and cultural features of ACA have made it the most popular trekking destination in the country, drawing more than 60 percent of the country’s total trekkers. Tourism, over the years, has been firmly established as one of the most important and competitive sectors of the local economy. There are over 1,000 lodges, teashops and hundreds of other subsidiary services to cater to the thousands of trekkers, pilgrims and their support staff.

Additionally, ACA is the first protected area that has allowed local resident to live within the boundaries as well as own their private property and maintain their traditional rights and access to the use of natural resources. It is also the first protected area, which has refrained from using army assistance to protect the dwindling natural resource base on which the region depends. Instead, it invests whatever financial resources available for community development and social capital building in the region. NTNC receives no regular funding support from the government for the operation of ACAP, but has been granted the right to collect entry fees from visiting trekkers.
1.2 Literature Review

The Annapurna Conservation Area Project (ACAP) is the largest undertaking of NTNC and also the first Conservation Area launched in 1986 and largest protected area in Nepal. It covers an area of 7,629 sq. km. and is home to over 100,000 residents of different cultural and linguistic groups. ACAP is rich in biodiversity and is a treasure house for 1,226 species of flowering plants, 102 species of mammals, 474 species of birds, 39 species of reptiles and 22 species of amphibians (ACAP 2012).

Shift in development activities along with flux climatic factors are more responsible for the changing socio economic trend of the community. These factors are not responsible only for changing socio economic factors but also livelihood of the people in the community. Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain (Adams et al. 1998). The location and area of natural vegetation zones on the Trans Himalayan region will change substantially under projected climate change scenarios. Areas of temperate grassland and cold temperate coniferous forest could expand, while temperate and cold deserts may shrink. Climate change may also result in a shift of the boundary of the farming-pastoral transition region to the south in Northeast China, which may increase grassland areas and provide more favorable conditions for livestock production. However, the transition area of the farming-pastoral region is also an area of potential desertification, and if protection measures are not taken in new transition areas, desertification may occur (Li and Zhou 2001; Qiu et al. 2001). More frequent and prolonged droughts as a consequence of climate change together with other anthropogenic factors may also result in desertification.

Main economical source of higher Himalaya dwelling people is animal husbandry which needs very huge area of rangeland ecosystem owing to low productivity and slow growth. There is significant uncertainty about the effects of global warming on the vegetation and animal productivity of large dry land ecosystems. Although high altitude dry lands might enjoy increases in net primary productivity (NPP), locally, the greatest confidence is in predicting implications for vegetation production, with lesser confidence in implications for vegetation composition, animal production, and adaptation options (Campbell and Stafford Smith 2000).
Climate change has been reported to impact on grassland productivity, ecosystems, and the distribution and composition of plant communities (Wilkes 2008). Some rangelands might suffer from degradation due to the warmer and drier climate (Dirnbock et al. 2003). Degraded rangeland already accounts for over 40% of dry land on the Tibetan Plateau (Zhong et al. 2003; Gao et al. 2005; Eriksson et. al. 2009); and it is expanding at a rate of 3 to 5% each year (Ma and Wang 1999). Increases in evaporation, reduction in snow cover, and fluctuations in precipitation are key factors contributing to the degradation of dry land ecosystems.

Rangelands are those areas of the earth which, due to physical limitations, such as low and erratic precipitation, rough topography or cold temperatures, are unsuited for cultivated agriculture and are a source of forage for wild and domestic animals of the mountain region (Miller 1998). Due to climate change and global warming the snowline in these mountain regions are moving increasingly northward, resulting in the depletion of rangelands and thus creating scarcity of fodder. As the animals have to be moved higher and higher for grazing, this is directly affecting the lives of mountain women: they face shortage of cow dung, the main source of energy, which is also becoming scarce. Ultimately, because of the scarcity of their main source of fuel, people have to resort to chopping firewood from the forests, which lead to further ecological degradation and unsustainable management of rangeland resources, thus adversely affecting the environment of the rangeland areas. Moreover, the shortage of food supply for livestock also leads to malnutrition and ultimate degradation of livestock resulting in decline in commercial activities and thus shortage of food supply for the people themselves, such as yak butter, cheese, meat and wool.

Following effects are expected to livestock and rangeland:

- Expected higher temperatures may increase livestock deaths in some regions unless some kind of shelter is made available.
- Forage production may be expanded as growing seasons lengthen, but this benefit will depend on water availability.
- Shifts in plant species in rangelands, particularly an increase in perennial herbaceous species, will create greater spring water demands.
1.3 Objectives

The general objective of the study is to assess the climate change impact on livelihood focusing on rangeland and rainfall impact on earthen roof.

Specific Objectives

- To understand local’s perception on climate change
- To assess livelihood pattern (rangeland, livestock, farming and roofing) in comparing 20 years
- To assess causes to change in livelihood pattern
- To understand roofing problem
Chapter II: METHODOLOGY

2.1 Glimpse of the Study Area

The Annapurna Conservation Area is Nepal’s largest protected area covering 7,629 km$^2$ (2,946 sq mi) in the Annapurna Range of the Himalayas across the Manang, Mustang, Kaski, Myagdi and Lamjung districts. The area ranges in altitude from 790 m (2,590 ft) to the peak of Annapurna I at 8,091 m (26,545 ft). The Annapurna Conservation Area was established in 1985 and gazetted in 1992. It is managed by the National Trust for Nature Conservation. There are two distinct climatic regions within a span of 120 km (75 miles) and an altitude of 1,000 to 8,000 m (3,300 to 26,000 ft). Annual rainfall averages 3,000 mm (120 inches) in the south, and less than 500 mm (20 inches) in the north.

Upper Mustang, in Nepal's Himalayas, is one of the most remote places on earth. It is also one of the last places with a pure Tibetan Buddhist culture, a culture virtually unchanged since the 14th century until 1992 the kingdom was, apart from a few exceptions, closed to foreigners. The terrain is harsh, almost everything has to be carried by foot or on horseback. The annual Tigi festival is one of the most important Buddhist ceremonies of the year. People from villages across the region come to Lo Manthang’s Chode monastery to attend. The festival commemorates Padmasambhava, the man who brought Buddhism to Tibet in the 8th century - and his triumph over evil. The festival coincides with the end of the dry season. Mustang is a high altitude desert, with temperatures rising up to five times faster than the world average. Due to the effects of climate change the village of Samdzong has become the poorest village in Lo Manthang. After more than 1,000 years the village is basically dead. Every year, as the drought gets worse, the ritual at the festival, where the monks re-enact an ancient story of how Mustang was saved from drought and destruction, becomes more important to the people of Lo Manthang. While people increasingly feel the effects of climate change, there are even more immediate threats to Upper Mustang’s ancient culture. Most people here do not live to see their 60th birthday. There is no hospital in Lo Manthang and despite millions of dollars in tourist revenue; people in Mustang have no access to health services.
2.2 Research Design

Figure showing methodological framework of research process
2.3 Data Collection

Following approaches has been followed for collection of data:

2.3.1 Direct Field Observations
With participation of local key people direct field observations about condition of rangelands and damaged roof was carried out throughout the 14 days stay in upper mustang.

2.3.2 Key Informant Interview
Key people (ACAP staff, local herder, aged local people, climate change specialist from Kathmandu and Institute of Forestry, local teacher etc) had been consulted about shifting of snowline, change rainfall pattern, stream flow, trend of livestock holding, decrease in rangeland quantity and quality, new and invasive plant in rangelands and problem faced on clay roofed houses.

2.3.3 Questionnaire Survey
Because of huge area cluster sampling was applied at first, based on field situation and then adopting purposive sampling (non random sampling) technique aged 105 (>25 year) were people questioned by open and close ended questionnaire because experienced people are able to response more clearly and being well experienced about past and present climatic condition as well as livelihood pattern.

2.4 Data Analysis

Data analysis comprises of two parts social and climate data obtained from the department of meteorology and hydrology.

2.4.1 Social data
Obtained field data have been fed into MS Excel program and analyzed quantitatively and qualitatively. Quantitative data were depicted by chart and diagrams whereas qualitative data were analyzed by description and discussion and linked with meteorological data.
2.4.2 Climate Data

Climatic data had been collected from meteorology department which was used for trend analysis of temperature and precipitation pattern and finally, social data had been linked to technical data viz. precipitation and rainfall. Nearest location for the Upper Mustang is Lomanthang station but most of data were missing and it was already been closed and so, it is difficult to use and interpreted and so, it was linked with other nearest station Jomsom and Lete. Then finally, obtained social data and climatic data from meteorological station were linked to verify people’s perception.
Chapter III: RESULTS AND DISCUSSIONS

3.1 Climate Data Interpretation

For climate data two variable temperature and precipitations were taken. Climate data were collected from Lomanthang, Jomsom and Lete since there is are missing data and some year data were completely missing year around and some are dated to few years. Missing data were calculated fitting trend line. For precipitation Lomanthang, Jomsom and Lete station were used since precipitation is localized can change abruptly whereas regarding temperature only Jomsom station is used because temperature gradient changes with predictable and constant gradient (Pfiefer et al. 2005).

3.1.1 Maximum, Minimum and Average Temperature Trend

Maximum temperature is decreasing trend whereas minimum temperature is increasing trend with the coefficient great than maximum temperature trend and resulted average temperature trend too increasing as shown in Figure 1 with trend line and equations. This common phenomenon in the world that temperature is increasing and linking with Shrestha et al. 1999, they found High Himalayan temperature is increasing with 0.1 centigrade per decade. This result verifies people’s perception that warming is increased than ever before. Similar result has also been obtained by (Shrestha 2009; Bhusal 2009; Poudle 2011). Increased temperature can pose a number of threat mainly to arid environment since it first and the foremost impact on desiccating effect due to accelerated evaporation.
Figure 1: Maximum, minimum and average temperature trend of Jomsom

3.1.2 Annual Rainfall Trend

Upper Mustang is one of the most arid areas in Nepal. Based on observation of 27 year (1974-2000) highest rainfall amounting 275mm recorded in 2000. Since it is arid already climate change impact may have serious result in water resource availability. Observing total annual rainfall trend is decreasing at the rate of 1.81 as shown in Figure 2 whereas Jomsom rainfall is increasing slightly and Lete rainfall is increasing with high rate i.e. 11.77.
3.1.3 Precipitation Trend of Sep-Nov

Is commonly observed and people residing around High Mountain blamed that snowfall is decreasing in comparison to last 20 years. They also reported that snowfall is shifted from Sep-Nov to Feb-Mar. When precipitation data of Lomangthang were interpreted these first three months data revealed that Sep-Nov precipitation is decreasing trend with slope 0.32 as shown in Figure 3. This the time when Patato, Barely, Phaper etc. crops were raised during which they need moisture for germination of seed, this can have serious moisture limitation to raise these crops. During these months precipitation take place in the form of snow which is one of the best moisture supplement to the site since time is the water scarce and snow melt slowly to dampen the ground to supply slow and long term water supply.
3.1.4 Precipitation Trend of Feb-Apr

As shown in Figure 4 meteorological data analysis revealed that precipitation trend of Feb-Apr is increasing at the rate of 0.021. These results verify people’s perception that Sep-Nov precipitation is shifted to Feb-Apr. Actually, this season it time to harvest some crop and high precipitation impeded ease harvest one hand and at the another hand it also, damages crop being ready to be harvested. Moreover, during this precipitation it is common that it take place in the form of hail which can cause the heavy toll of production.
3.2 Social Data Interpretation

Local people are the live witness to climate change owing to global warming since they have good firsthand experience of snowfall pattern, event of coldest and hottest time, erratic rainfall pattern, and heavy hail fall etc which results into their livelihood to affect directly and indirectly. This is only one source for microclimatic trend analysis since there is general paucity of meteorological data in the Himalayan region and so, in which researcher must depend on social data (people’s perception) and requirement he should verify people’s perception with linking other various related and relevant parameter like tree ring, regional climate, vegetation shift etc.

Figure 4: Feb-Apr precipitation trend of Lete, Jomsom and Lomanghang
3.2.1 People’s perception on climate change
At the dawn of the third millennium, a powerful and complex web of interactions is contributing to unprecedented climate change. The impact of climate change has been observed in each and every area (agriculture, air and water, rangeland, forest, livelihood and so on). Children and women are disproportionately vulnerable to and suffer most from the effects of climate change (ICIMOD 2002). Moreover, climate change has long term effects on people and societies and is either difficult or impossible to reverse over the period of one generation.

3.2.2 Perception on temperature trend
Most study carried in Himalayan region revealed that the today’s surrounding environment is being hotter than before. When local people were questioned about temperature trend, 65% of the total respondents had said that the weather of the upper mustang is being hotter and hotter day by day as shown in Figure 5. This has lead to the adverse effect in their occupation, both in agriculture and animal husbandry. Due to hot weather, the snow is melting in an alarming rate. The snow covers in the high hills of upper mustang remains only for very short period of time. Plants and weeds are not growing well so animal husbandry, one of their main occupations is in great threat due to climate change. Due to the lack of grasses, the people in that area are compelled to feed other foods which cost high amount of money. Only 26% of the total respondents had said that the weather is being colder. Since last two years, the snow fall and rain fall is increasing in upper mustang. This might has made the weather somehow cold in upper mustang. 8% of the respondent said that there is no change in the climate before 20 years and now. Only 1% respondents said that they don’t have any idea on the climate of upper mustang.
3.2.3 Perception on water resource availability

Climate change has also adverse effects on the water resource availability. The number of water resources is decreasing day by day. People have to travel long distance to collect water for drinking. This has made their life more difficult. Figure 6 here depicts responses on water resource availability in comparison to 20 years. As people about water resource availability in 20 years trend, out of the total respondents only 8.4% had said that the number of water sources is increasing. Majority of (48.6%) the total respondents had said that the water sources around their vicinity have been deceased in the last 20 years which is technically verified by analysis of meteorological data i.e. rainfall is in decreasing trend based on local meteorological station of Lomanthang. Remaining 43% said that, there is no change in the water source availability in upper mustang.
3.2.4 Perception towards water resource quality
Along with limited knowledge and increased population, tourism and extensive use of foreign resource even most remote areas of Nepal are facing decreased drinking water resource quality owing to several of form of pollution. When people were asked about drinking water resource quality nowadays, 3.7% of the total respondents had said that the available water resources are being polluted day by day. 32.7% had said no idea and remaining 63.4% had said that there is no change in water resource quality now and before 20 years as shown in figure 7.
3.2.5 Perception on change in precipitation trend
Climate change in upper mustang has also an adverse effect on the amount of snowfall. In the one hand, temporal shift in snowfall had been seen and on the other hand, the amount of snowfall had also been decreased. The snow fall has shift from Sep-Nov to Feb-Apr. Less snowfall in the hills of upper mustang had great role in reducing the growth of grasses for their livestock. As shown in figure 8, 82.2% of the total respondents have said that the amount of snowfall had drastically decreased in last 20 years. But since last 2 years, there is maximum amount of snowfall in upper mustang. On this basis, remaining 17.8% of the respondents have said that the amount of snowfall has been increased. Similarly the amount of rainfall had also decreased drastically in upper mustang. The rainfall occurs for very short period of time with high intensity. Heavy rainfall only for a short period of time born calamity to leaching on mud roofed house in upper mustang.

Figure 8: Perception towards trend of snow fall
3.3 Climate Change Impact on Livelihoods

Majority of Upper Mustang peoples’ livelihood is subsistence based which intricately linked farming with forest, livestock, rangeland, climate based water resource etc and so this analysis have been made taking four aspects viz. livestock, farming, rangelands and roofing.

3.3.1 Livestock
Animal husbandry is one of the major occupations of people living in upper mustang. People keep animals like horse, chyangra, sheep, cow, and ox and so on. Diseases like diarrhea are very common in animals mainly in chyangra since last 10-12 years. This indicates increasing temperature in upper mustang. This can also be stems from recent year good rainfall and snowfall leading nutrient rich feeding. Though nutrient rich feeding is preferred by animals, high uptake can cause poor digestion which might result in diarrhea. Still in-depth study is required to verify this. Increasing depredation has also posed great problems in rearing their livestock. Grasses are not growing sufficiently in the hills of upper mustang due to insufficient snowfall and rainfall. This has made their livestock rearing very difficult in upper mustang. Livestock like horses and mulls in upper mustang are decreasing in number due to transportation facility in that area. Chyangra is the major livestock with main source of income of the people living in upper mustang.

3.3.2 Livestock holding information

3.3.2.1 Trend of livestock holding in household number
Animal husbandry is one of the major occupations of the people living in Upper mustang. More than 90% people in this region are found keeping animals in their house. But most of the people in this region are involving in animal husbandry for their subsistence. Animal husbandry is that resource in which they must depend on all from bedding (animal husk) to manure (waste) for agriculture land. Only few people are found doing it occupationally.

As shows in table 1 that 49.5% of the respondents have decreased the number of horse in their house. The number of horse is decreasing day by day mainly due to the road facility. The access of road had touch most of the village of upper mustang. People can easily use trucks as the means of transportation in this region. Lack of grass to feed the horse and depredation and disease is also responsible for decreasing the number of horse. 14% of the
respondent has no horse kept in their house. Since the horses are expensive, they are unable to afford it. The trend of cow holding has decreased by 32.7% in this area. The major cause behind this is the lack of adequate grass to feed the animals and manpower is another cause of decrease. Similarly chyangra, bheda bakhra and chauri are also decreasing in this region. People in this region use animals as a means of transportation. Even today, people of many village use horse as a means of transportation. Also, people use cow, bheda, changra, chauri for meat. Jhopa is used to plough land for cultivation.

Only 3.7% of the total respondents are found keeping chauri in their house. But chaury number is found to be decreasing in entire household. The rate of bheda holding is also decreasing. Only 13.1% of the total respondents are found rearing bheda in their house. Among them, 10.3% of the respondent has decreasing trend of bheda. In comparison to chauri and bheda, more number of respondents has chyangra in their house. 17.8% of the total respondent has decreasing trend of chyangra. But 4.7% of the total respondents have increased the number of chyangra in their house. This chart shows that the number of jhopa/ox is increasing in 8.4% of the total respondent’s house. Similarly 8.4% of the total respondent has decreasing trend of jhopa.

Table 1: Trend of livestock holding in percentage household

<table>
<thead>
<tr>
<th>Type of Livestock</th>
<th>Trend in relative value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increasing</td>
</tr>
<tr>
<td>Horse</td>
<td>22.4</td>
</tr>
<tr>
<td>Cow</td>
<td>28</td>
</tr>
<tr>
<td>Chaury</td>
<td>-</td>
</tr>
<tr>
<td>Bheda</td>
<td>-</td>
</tr>
<tr>
<td>Chyangra</td>
<td>4.7</td>
</tr>
<tr>
<td>Bakhra</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Day by day, people are leaving this occupation due to the scarcity of manpower to take care of the animals. The main result behind this is seemed to be migration to cities and attraction of foreign employment. Problem of adequate grasses to feed the animals is also one of the major causes of decreasing the size (number) of animals. This may steamed from decreasing water availability. Discussing trend of rainfall it found to be at increasing trend.
which seemed to be contradicted with the above statement. But increasing rainfall in the site means decreased snow fall owing to impact of climatic changes. If precipitation was taken in the form of snow it slowly melts and so, perpetuated for long for long term supply of water. This statement also backed by decreasing and shifting snowfall. As such access of road facility in Mustang area leaded them to cut down the size of mule and horse holding.

3.3.2.2 Trend of livestock holding in 20 years in number

Table 2 shows trend of livestock number of interviewed household. Along with the decreasing trend of livestock holding, number of animals in many household is also decreasing. This table 2 shows that the number of all species of livestock in Upper Mustang is decreasing except Jhopa/ox. Till today, jhopa (animal that is used to plough the land by the local farmers) is not replaced by any other source or machine to plough the land. This might be the reason of increasing number of jhopa in Upper Mustang.

<table>
<thead>
<tr>
<th>Type of livestock</th>
<th>Number before 20 years</th>
<th>Number at present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>491</td>
<td>359</td>
</tr>
<tr>
<td>Horse</td>
<td>594</td>
<td>286</td>
</tr>
<tr>
<td>Chauri</td>
<td>157</td>
<td>86</td>
</tr>
<tr>
<td>Bheda</td>
<td>1100</td>
<td>369</td>
</tr>
<tr>
<td>Bakhara</td>
<td>1225</td>
<td>988</td>
</tr>
<tr>
<td>Chyangra</td>
<td>2383</td>
<td>1219</td>
</tr>
<tr>
<td>Jhopa/ox</td>
<td>46</td>
<td>56</td>
</tr>
</tbody>
</table>

3.3.2.3 Frequency of depredation by wildlife

The frequency of depredation is increasing in comparison to 20 years. Similar result was found by Poudel et al. (2011). Many animals are killed by snow-leopard in this region. Out of all respondents 59% response found that depredation by wildlife is increasing whereas about 10% responded decreasing as shown in figure 9. Dogs also kill the calf of bheda and
chauri. This is good news for the ACAP since it indicates increased number of wildlife population but puts more challenges to manager owing to increased human wildlife conflict. But increased wildlife depredation is not necessarily represents indicator of increased wildlife population because decreasing wild resource also force wildlife to come near human settlement in search food and if is the case it can be a critical problem for both protected area manager and local people.

Similarly the problem of grass and epidemic is also increasing with the increasing temperature. Due to fast melting of snow and untimely distribution of snowfall has raised the problem of feeding to the livestock. Diarrhoea is very common in this region. Many livestock are died due to diarrhoea each year.

![Figure 9: Perception on depredation trend by wildlife](image)

3.3.2 Agriculture

After animal husbandry, agriculture is the second major occupation of people in upper mustang. People in upper mustang do substantial agriculture only for themselves. Crops like wheat, uwa, phapar, mustard (*tori*) are major food crops. Along with these, they also cultivate pea, mustard (*rayo*) and different vegetables for their living. The agricultural
production in this area is decreasing with decreasing agricultural land. Migration of the people towards city area and insufficient rainfall had increased fallow land in upper mustang. So the overall production of crops is decreasing due to increasing fallow land. Till today, no epidemic has been seen in agriculture. Practices of apple farming in upper mustang had been done in different villages of upper mustang successfully. This might be resulted from climate change but need to be verified. Report from Bagwani Marpha increased temperature causes decreasing quality and quantity of apple in due to increased fungal disease.

New variety of agricultural products has also been started in upper mustang. They are able to grow different species of vegetables like cauliflower, cabbage, radish, carrot, potato and so on. Some report said it due to climate change without reliable base because if they had no practice of such crop before and right now they practiced and success it should not take as due to climate change without data to verify it which is in line with the finding of Shrestha 2009. The organizations such as Care Nepal, Agriculture and ACAP had promoted much in agriculture in upper mustang.

3.3.3 Rangeland

Rangeland quality establishes the bounds within which subsistence-based animal husbandry systems can operate. Two important components of rangeland quality are

1) Forage availability and
2) Nutritive quality or digestibility of the available forage

These two components are directly related: the amount of forage an animal must ingest to meet a fixed dietary requirement is directly proportional to the losses from digestion and metabolism (Robbins 1993). Total aboveground net primary productivity (ANPP) of the palatable plants represents the available forage. The timing over which live vegetation is available is another important component of forage availability in pastoral systems where supplemental feeding is absent. Higher temperatures generally advance the growing season through earlier leaf bud burst and green-up (Arft et al. 1999, Schwartz et al. 2006), but have had mixed effects on senescence (Arft et al. 1999, Marchand et al. 2004).

The growth of grasses in rangeland depends upon the amount and duration of rainfall and snowfall. The sufficient amount of snowfall favors forthe growth of vegetation in the rangeland. Primarily Upper Mustang is arid zone itself and increasing temperature and decreasing precipitation have multiple effects on rangeland. Very first water replenish is decreased due to decreased rainfall and increased temperature increases desiccating effect due to increased evapotranspiration. Moreover, increased temperature also decrease snowfall which perpetuates for long to continue water supply. Local rangeland species are Ramjhang, Pangecha, Na, Panja, Dorcha, dhojo, Kote, Heuma, Ghyare and many more. More than 90% of the people have not seen invasion species in the rangeland. Though the area of the rangeland
is almost constant, the vegetation is decreasing year by year. The growth of vegetation is
good only in those years when there is sufficient snowfall. Dryness is the major problem in
the rangeland. Snow leopard attack in the rangeland is increasing and do not hesitate to inter
even in the human settlement nowadays. This has increased human-wildlife conflict in this
area. People in upper mustang had noticed *Yarsagumba*(*)Cordyceps sinensis*) since last 4-5
years.

### 3.3.4 Roofing on house

The house in upper mustang is made up of wood and mud roofed. Though precipitation is
decreasing it’s concentrated to limited months and accordingly, it takes place intensely and
erratically. Sometimes during heavy rainfall cause erosion of roofed mud resulting leaching
problem on mud roofed houses. The leakage problem is common both in old and new houses.
But now a day, during construction of new house people keeps plastics on the roof which
have prevent from leaching on mud roofed house. As shown in figure 10 about 86% of the
total respondents have said that the frequency of the problem is more since last 2 years. And
remaining 14% respondents said that the problem is as usual I comparison to 20 years.

![Figure 10: Response on problem of mud roofed owing to intense rainfall](image)

Fire wood is very scarce in upper mustang due to insufficient vegetation. They have to travel
a long distance towards *lek* (a place where yaks are kept) for collection dung which they used
as firewood for cooking. They commented that because of increased dryness firewood is
being scarcer than before and they have to travel much distance to collect even handful of
firewood. Sometimes they even have to buy the dung from the herders.
Chapter IV: CONCLUSIONS AND WAY FORWARD

Analysis of meteorological data from local and nearest station revealed that temperature trend is increasing rate and precipitation of Lomanthang site is decreasing. Pattern of precipitation also found to be shifted from Sep-Nov to Feb-Apr indicating not only changing rainfall pattern but also does the snowfall. Snowfall is very much crucial to the locality for subsistence type of farming and highland rangeland ecosystem. Local people also, perceived that temperature is increasing and snowfall and rainfall amount is decreasing and moreover, they noticed and reported shift in rainfall time which all are technically verified. Local people are the live witness to climate change information and valuable source where meteorological stations are unavailable and long term data are missing. This can have great socio-economic and biophysical concern in Himalayan region owing to high population, marginal agriculture based on subsistence, high dependency on natural resource, seasonal farming, poor and vulnerable life style (Shrestha and Balla 2011).

Diarrhea disease is being very common; especially in Chyangra and increased its frequency cause moderate loss of Chyangra according to them which can be resulted due to increased temperature because diarrhea germ get active at higher temperature. Based on their response there no any apparent problem born by climate change in farming till date this may be due to either there is no climate relate problem yet at all or since effect of climate is insidious it is hard to understand and recognize them. One of the serious problems they are facing is water resource which is being scarcer day by day at an alarming rate. Because of increased temperature it melt permanent source of water-the glacier quickly as well as increase evapotranspiration in rangeland. Moreover, decrease in snowfall also caused decrease in water replenish in the rangeland and resulted consequences is that rangeland are being drier day by day which have multiple impact from decrease water resource availability to feed animal, rangeland forage and fire wood. One of the greatest climate born consequences faced by the local people ever found to be leaching of mud roofed houses owing to increasing frequency of heavy and intense rainfall. Impact of climate change on the local livelihood is increasing and being apparent and noticed. Still there are a number of rooms to verify these finding with sound technical base for in depth analysis which needs long term and statistically reliable data.
REFERENCES


