Effects of Climate Change on the Livestock Population in Mustang District, Nepal

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ABSTRACT

There is strong evidence to suggest that climate change has affected and will continue to affect the occurrence, distribution, and prevalence of livestock diseases in Nepal. This study investigated how climate change has affected the livestock population in Mustang District. The outbreak of new diseases, changes in disease patterns, increase in cases of external and internal parasites, decrease in the availability of forage and fodder, and deterioration of pasture land were the major climate change effects observed. The number of livestock has decreased, resulting in declining income from livestock-related activities of Jomsom and Kagbeni, two Village Development Committees in the Mustang District where people are seeking alternative occupations. The results revealed that some signs of climate change were experienced by rural communities in the study sites, such as an increasing number of warm days and a decreasing number of cold days. The different measures that people have adopted to lessen the impacts of climate change on the livestock population were also identified.

Keywords: livestock, parasites, pasture, disease

JEL Classification: Q54O, Q1, and Q160

INTRODUCTION

Climate change is the global challenge of the century. It refers to the change in climatic conditions over time due to either anthropogenic or nature-induced causes, which remains for decades or longer and shows distinct variations in its mean (IPCC 2007). Nepal is one of the most vulnerable countries affected by climate change (UNFCCC 2007), wherein the temperature has risen by about 0.41ºC per decade (Government of Nepal (2004a). Warming is high in mountains (0.8ºC) and hills (0.6ºC), and relatively low in the terai regions (0.4ºC).

Nepal is predominantly agricultural country. Agriculture has approximately 33 percent share in gross domestic product, while livestock accounts for 27 percent of the agricultural gross domestic product (MOAC 2011). Livestock is one of the main sources of livelihood, areas of employment, and means of transport in the country. Livestock rearing, which is integrated in agriculture, is the source of milk, meat, and manure. Topographically, Nepal is divided into three ecological zones: mountains, hills, and terai. They cover 15 percent, 68 percent, and 17 percent of the total land area of the country, respectively. The climate in Nepal is characterized by four distinct seasons: pre-monsoon (March–May), monsoon (June-September), post-monsoon (October–November), and winter (December–February).

The study was conducted in Mustang District in the Dhaulagiri Zone of the Western Development Region of Nepal, particularly in the Village Development Committees (VDCs) of Jomsom and Kagbeni (Figure 1). It aimed to investigate the effects of climate change on the livestock population in Mustang District, the connection between climate change and the prevalence of different livestock diseases, the impacts of climate change on different factors in livestock rearing, and the community and institutional responses to climate change in Jomsom and Kagbeni.

Mustang District is situated in the rain shadow area and receives an average rainfall of less than 260 millimeters (mm). The mean minimum monthly air temperature falls to −2.7ºC in winter, while the maximum monthly air temperature reaches 23.1ºC in summer (NTNC 2008). Mustang District has a total land area of 3,573 square kilometers (NTNC 2008). The classification of land use shows an unusually skewed distribution: 39.1 percent of grassland, 28.08 percent of forest land, and 6.19 percent of agricultural land. The majority of people in this region are involved in agriculture and livestock rearing. The primary crops grown are naked barley, buckwheat, maize, and millet. Animal husbandry is the lifeline of the people living here.

Mustang District has a livestock population of 69,000 (DLSO 2010; NTNC 2008), excluding poultry (Table 1). The distribution of livestock varies slightly between Jomsom and Kagbeni (Tables 2 and 3). Livestock, besides providing meat, butter, wool, and hide, are also used for transport. In northern Mustang, livestock is also the major source of dung used for cooking and heating. Cows, sheep, and goats are common in central and southern Mustang, while buffaloes are found only in southern Mustang. Yaks and goats are more popular in upper Mustang and central Mustang. The number of livestock per household is 5–20 cattle and 50 or more small ruminants (NTNC 2008). The lack of adequate grazing area and labor has made it difficult to raise livestock. As a result, the livestock population has been declining gradually.

Climate change has affected the livestock population in numerous ways. With agriculture and livestock rearing as the major sources of livelihood in Nepal, even small and brief changes in climatic conditions could greatly affect the country's food security (Bhandari and Gurung 2008). Climate change is expected

to increase the frequency of weather-related disasters and extreme weather events, such as droughts, heat waves, storms, desertification, and insect infestations (Khanal, Shrestha, and Singh 2010). It is expected to promote the emergence of unpalatable forage species in rangelands, and enhance the scarcity of fodder and forage for livestock.

As a result of climate change, the environment becomes favorable for agents like bacteria and virus. The epidemiological triad between agent, host, and environment becomes imbalanced and the different diseases arise, which were not present in the ecological region. Increase in temperature causes thermal stress, reduces growth, and induces sub-optimal behaviors and reduced immunocompetence in the animals. Climate change may affect infectious animal diseases by increasing the transmission cycle of many vectors.

METHODOLOGY

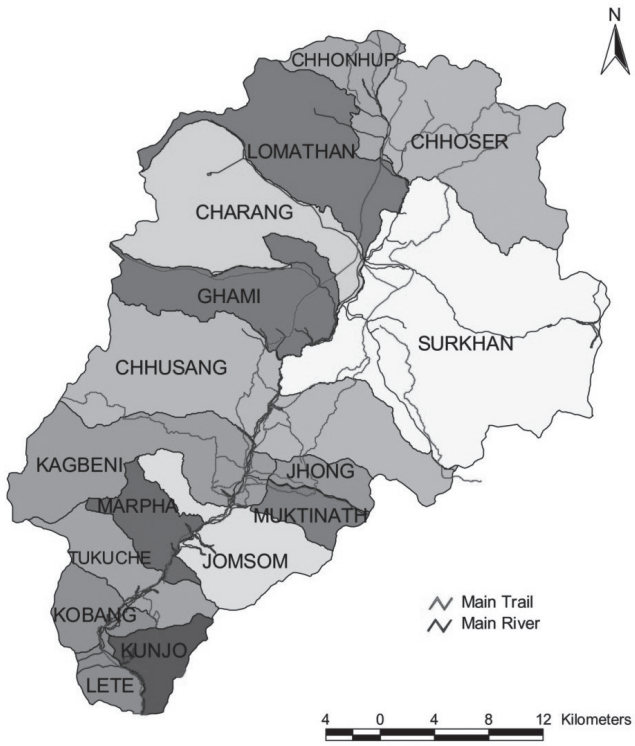
Sample Selection

A total of 71 households, 38 from Jomsom and 33 from Kagbeni, were selected randomly for the study (Table 4).

Data Collection

Jomsom and Kagbeni were chosen randomly among the 16 VDCs in Mustang District. Primary data were collected in June 2012. To develop a better understanding of the study sites, interviews and informal discussions with key informants were conducted. Village heads (Mukhia), model farmers, teachers, elder villagers, and other knowledgeable persons were selected as the key informants. The interviews focused on changes in climate

Figure 1. Map of Mustang District



Source: Bhattarai et al. (2010)

Table 1. Livestock population in Mustang District (2008)

Livestock Species	Livestock Population	
	No.	%
Cow	5,549	7.8
Buffalo	78	0.11
Goat	47,864	68.82
Sheep	7,084	10.18
Yak/Jhopa	4,805	6.9
Donkey/Horse/Mule	4,168	5.99

Source: NTNC (2008)

Table 2. Livestock population in Jomsom and Kagbeni (2010–2011)

Livestock Species	Livestock Population	
	Jomsom	Kagbeni
Cattle	318	422
Yak/Nak	0	347
Jhopa	179	44
Sheep	34	0
Goat	2,026	5,587
Horse	38	48
Mule	89	315
Donkey	55	64

Source: DLSO (2010)

Table 3. Livestock population in selected households in Jomsom and Kagbeni (2012)

Livestock Species	Livestock Population	
	Jomsom	Kagbeni
Cattle	39	126
Yak/Nak	0	10
Jhopa	44	39
Sheep	0	49
Goat	68	854
Horse	8	6
Donkey	0	12

patterns, effects of climate change on livestock, and possible adaptation measures. The survey questionnaire focused on major livestock species reared in the area, cropping patterns, parasitic infestations, feeding patterns, changes in livestock disease patterns due to changes in climate, and possible adaptation measures. For the survey, 12.29 percent and 13.92 percent of the total number of households in Jomsom and Kagbeni participated, respectively. For meteorological data, the monthly maximum and minimum temperatures of the year 2000 to 2010 were taken from the Marpha Agricultural Research Station.

Table 4. Number of households in Jomsom and Kagbeni (2012)

Particulars	Study Sites		Total
	Jomsom	Kagbeni	
*Total number of households	39	126	546
Number of selected households	0	10	71
% of selected households	44	39	26.21

Source: *NTNC (2008)

Data Analysis

All quantitative data were entered in the Statistical Package for Social Science (SPSS). Microsoft Word, Microsoft Excel, and SPSS were used for data processing, analysis, and interpretation of information collected through the key informant interviews and questionnaire survey. Microsoft Excel was used for trend analysis and regression of temperature data.

RESULTS AND DISCUSSION

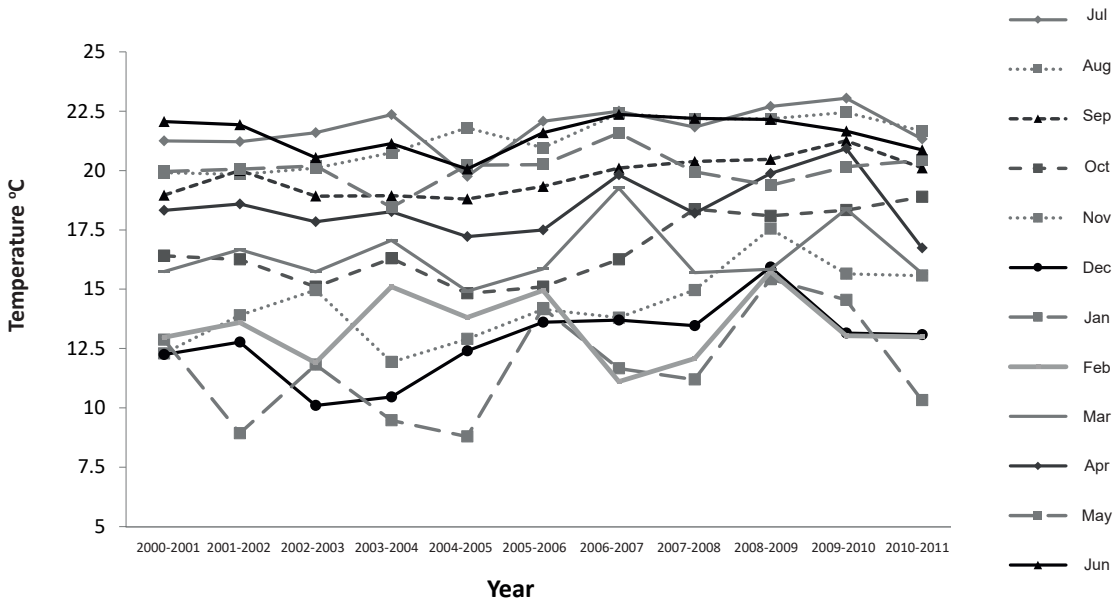
Jomsom (28°47′0″N 83°43′50″E) has an altitude of 2,710 meters (m), while Kagbeni (28°50.294''N 83°47.294"E) has an altitude of 2,866 m. The native peoples living in the two VDCs are mainly Thakali and Bhote. They rely on agriculture and livestock rearing as major sources of livelihood in these areas, where the land is steep and less fertile, and have small holdings. The main crops cultivated in this region are potato, naked barley, and buckwheat. Crops take longer to mature and harvest, with one harvesting done per year. The by-product of these crops is fed to the livestock. Transhumance animal rearing is concentrated in alpine meadows and forests. Chyangra goat, Bhyanglung sheep, Lulu and Kirko cattle, Tibetan horse, and yak/nak are the major livestock species reared in this region, where livestock productivity is lower than in the terai or hills. Livestock rearing is the source of milk, meat, dung, and draft. Farmers in this zone derive their income mainly from livestock, but neither animal nor crop production can meet their basic needs so they are always in feed deficit (DDC 2011). Among the randomly selected respondents of the questionnaire survey, 93 percent engaged in livestock rearing, while 7 percent did not.

Climatic Conditions

There is little variation between the climate patterns in Jomsom and Kagbeni because they are neighboring VDCs (see Figure 1). The mean annual temperature varies between 5ºC–16ºC, but day and night temperature differences are substantial. The mean minimum temperature can be as low as −0.9ºC in January, while the mean maximum temperature can reach 21ºC in July (Figures 2 and 3). The meteorological data obtained from the Marpha Agricultural Research Station show an increasing trend in the temperature of Mustang District in the years 2007 to 2010. The increase in temperature has decreased farm productivity, causing scarcity of forage and fodder; and has caused thermal stress, a decrease in production, disease outbreaks, and an increase in external and internal parasitic infestations.

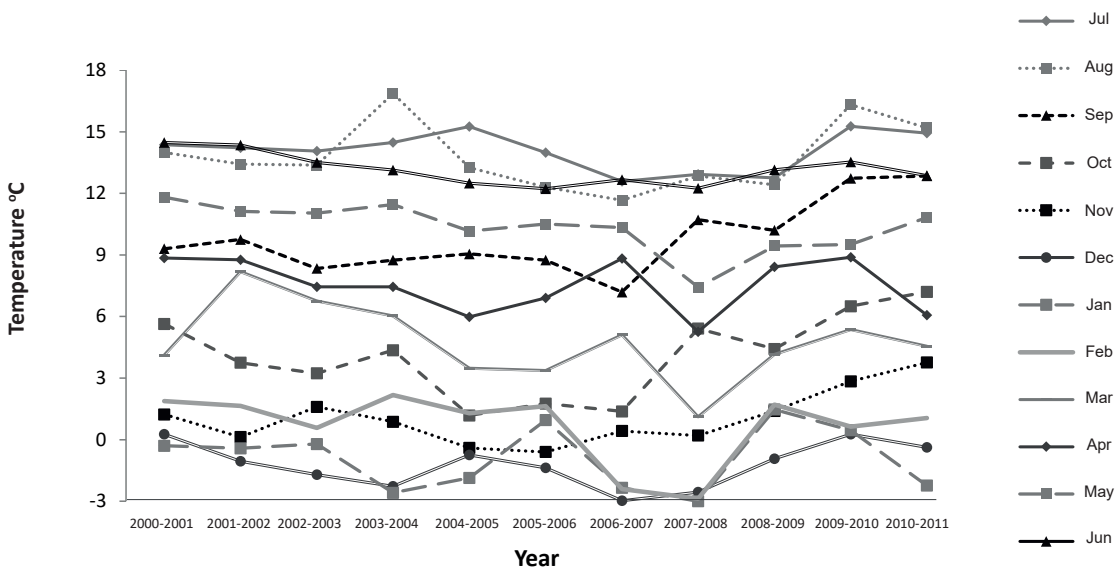
Mustang District receives a lower amount of rainfall than other areas in Nepal because it is a leeward region. However, in recent years, there has been an increase in the amount, intensity, and frequency of rainfall. In July 2011, 44 mm of rainfall was recorded in Jomsom. This surpassed the average rainfall recorded in this region, which is 23 mm.

Figure 2. Annual minimum temperatures in Mustang District



Source: Marpha Agricultural Research Station (2010)

Figure 3. Annual maximum temperatures in Mustang District



Source: Marpha Agricultural Research Station (2010)

Livestock Population and Diseases

The major livestock species reared in Mustang District are cattle, yak/nak, jhopa, horse, donkey, mule, goat, and sheep. Compared to Jomsom, the number of goats and sheep is higher in Kagbeni because it has large rangelands and more cultivable land. Kagbeni is a tourist area, and most of the meat of goats and sheep is consumed in hotels. This is why people in this region prefer to rear goats and sheep, which is a chief source of income generation also because pastureland is widely available. Jhopa, a cross between yak and Lulu cattle, are powerful draft animals used for ploughing and transporting goods. The cattle reared are especially indigenous. Lulu cattle is the smallest breed of Nepal and has relatively low milk production compared to other breeds. Yak is a hardy animal living in this area, reared in transhumance migration pattern. The most common diseases reported in this area are listed in Table 5.

Parasitic Infestations in Livestock

During the survey, the respondents were asked whether the different parasitic infestations in livestock increased or decreased compared to 10 years ago. The results revealed that internal and external parasites became more prevalent in Kagbeni than in Jomsom (Figure 4). According to the respondents, the most common types of diseases were skin infections caused by external parasites (Table 6). The present climate patterns have made the environment more suitable for parasites to grow, develop, and adapt. It has been reported that climate change has caused the emergence of new livestock parasites and diseases, especially skin diseases, in all altitudes (Thakur 2011).

As suggested by Thornton et al. (2007), vector-borne diseases could be triggered by the expansion of the vector population into cooler areas and by the change in climate patterns during wetter years, which could also augment the vector population and cause a large-scale disease outbreak. Helminth or worm infections are greatly influenced by changes in temperature.

Trends in Livestock Diseases

During the survey, the respondents were asked about the trends in livestock diseases, as well as the reasons behind the changes in livestock disease patterns, compared to 10 years ago. Of the 38 respondents rearing livestock in Jomsom, 10 respondents did not observe any changes in livestock disease patterns, 18 respondents observed an increase in livestock diseases, and 10 respondents observed a decrease in livestock diseases. Similarly, of the 33 respondents rearing livestock in Kagbeni, 12 respondents did not observe any changes in livestock disease patterns, 15 respondents observed an increase in livestock diseases, and 6 respondents observed a decrease in livestock diseases.

According to the respondents, the increase in livestock diseases was caused by (1) decrease

Table 5. Common livestock diseases reported in Mustang (2010)

Livestock Species	Major Diseases
Cattle	Foot-and-mouth disease, Hemorrhagic Septicemia, liver fluke, roundworm, tympany, fleas, mites, pyrexia, and other skin infections
Sheep and goat	*Peste des petits ruminants*, diarrhea, tympany, fleas, mites, and lice infestation
Horse, donkey, and mule	Colic

Source: DLSO (2010)

Figure 4. Different parasitic infestations in Jomsom and Kagbeni (2012)

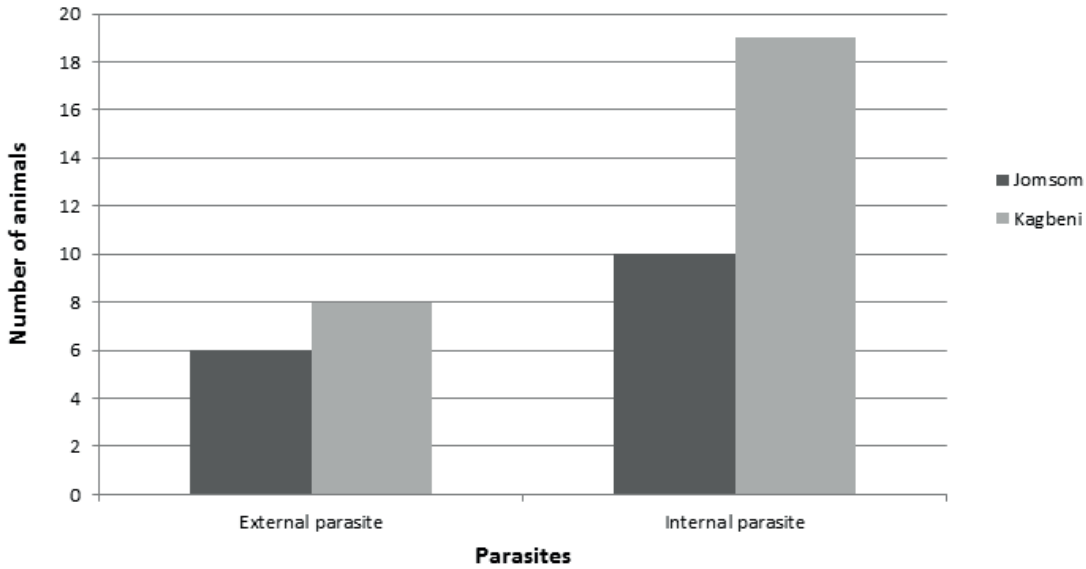


Table 6. Major parasitic livestock diseases in Jomsom and Kagbeni (2012)

Livestock Species	Parasitic Infestations in Jomsom	Parasitic Infestations in Kagbeni
Cow	Lice, liver fluke, and roundworms	Lice, liver fluke, and roundworms
Jhopa	Liver fluke, and roundworms	Lice, liver fluke, and roundworms
Goat	Mange, mites, lice, and mosquitoes	Mange, mites, lice, and fleas
Sheep	Mange, mites, lice, and fleas	Mange, mites, lice, and fleas
Horse	Mange	Strongyles

in the availability of forage and grass due to adverse climate; (2) decrease in agriculture productivity resulting in competition between human and livestock for food, (3) increase in the prevalence of livestock parasites and vector-borne diseases, (4) lack of regular veterinary checkup, (5) overgrazing of native pastures and consequent land degradation, (6) lack of information on pasture development and utilization as well as the nutritive value of grass in pasture, and (7) high mortality rates in the migratory flocks of small ruminants. The decrease in livestock diseases can be attributed to (1) livestock owners' proper care, management, and feeding of animals; (2) availability of the veterinary facilities; (3) proper management and disposal of dung; (4) suitable temperatures; and (5) increase in people's awareness.

Livestock Feeding Management

Livestock feeding management in Jomsom and Kagbeni included stall feeding, free grazing, and mixed type (Table 7). Mixed feeding was the most common practice among the surveyed livestock-rearing households. Ruminants, which usually graze for 6–8 hours, and monogastric animals were fed cereal by-products after they were brought home from grazing. Concentrate feed was given to lactating and growing animals. A total stall-feeding was practiced only when one or two animals were

kept. Kundo (a homemade cooked concentrate) was fed to lactating animals only. Salt mixed in kundo was given once a week or once every two weeks. Oxen were given better care during cultivation time. Yaks and chauries graze longer than other ruminants. They were mostly left to graze in pastures, forests, and along streams when the land was not covered with snow. They were let loose in such areas continuously for several days. A fixed system of rotational grazing prevailed in the kharkas (pasture land), with 15–30 days in one kharka depending on the availability of forage and strength of the herd.

Changes in Livestock Feeding Patterns

People in this region have changed their livestock feeding patterns over time. The free grazing system was common in the past, but now the mixed feeding system is the preferred method. Livestock owners allow livestock to graze when there is grass in the pasture land. In the absence of nutritious grass due to adverse climatic conditions, livestock are stall-fed crop by-products; hay from native species, such as furcha (*Elymus nutans*), dhimchi (*Pennisetum flaccidum*), kote (*Medicago sativa* spp.), and other local grasses available. These local grasses are very expensive so extra investment in the livestock sector is required.

As a source of concentrate, potato is given to livestock in both winter and summer. Livestock are usually fed twice daily in stall feeding. Young calves and lactating females are taken care of and fed with better hay, khole, and some potatoes. Calves less than a year old are given some pida prepared from uwa (naked barley), potato, peas, wheat, and maize flours. Some straws of naked barley, buckwheat, and wheat, are stored as feed after harvest during periods of scarcity. Due to adverse climatic conditions, the grass species that grow in pasture land decrease gradually. Forage and grass for feeding livestock have become scarce in the region, causing livestock-rearing households to invest more in livestock feeding. They buy grasses, hay, straw, and crop by-products to feed the animals.

Climate change is expected to affect feed crops and grazing systems negatively. Climatic conditions brought about by changes in atmospheric carbon dioxide and pasture composition have a strong impact on herbage

Table 7. Livestock feeding management (2012)

VDCs	Stall Feeding (%)	Grazing (%)	Both (%)
Jomsom	13 (37.15)	2 (5.71)	20 (57.14)
Kagbeni	15 (51.8)	1 (3.44)	13 (45)
Total	28 (43.75)	3 (4.7)	33 (51.57)

Table 8. Change in livestock feeding pattern

VDCs	Stall Feeding			Free Grazing			Both		
	5 Years Ago	2012	% Change	5 Years Ago	2011	%	5 Years Ago	2012	%
Jomsom	12	13	8.33	8	2	-75	15	20	33.33
Kagbeni	5	15	200	14	1	-93	10	13	30
Total	17	28	64.70	22	3	-86.3	25	33	32

growth (Devekota 2010). Climate change leads to decrease in the quality of grass and slow emergence of new grass in the pasture of Mustang (Sherpa and Kayastha 2009).

Major Fodder Plants in the Region

Due to the topography, texture, and quality of the soil, only a few species of fodder trees are grown, namely, Bish (*Aconitum spicatum*) and Bhote papal (*Populus ciliate*). Although some improved varieties of forage have been introduced by the District Livestock Service Centre (DLSO) of Mustang. The lack of land area for cultivation of forage deterred this practice. Major forage/grass species introduced by DLSO were oat (*Avena sativa*), Teosenty (*Euchlaena mexicana*), Ryegrass (*Lolium perenne*), and White clover (*Trifolium repens*).

Climate Change Impacts on Livestock in the Region

Changes in temperature; changes in the pattern and amount of rainfall, snowfall, and drought; a decrease in water sources; and an increase in mosquito population were the major changes in climatic conditions people observed in this area. In Jomsom, 35 of 38 households observed changes in climate. In Kagbeni, 25 of 33 households observed changes in climate. The prevalence of new livestock diseases, increase in mortality, decrease in quality of forage, changes in animal breeding behavior, and decrease in animal productivity were observed as the major effects of climate change on the livestock population.

Livestock rearing is the major occupation of people living in this area; it is a source of income and nutrition for the people. The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that affect livestock production systems, such as rapid population and economic growth, rising demand for food (including livestock) and products, and conflict over scarce resources (e.g., land tenure, water, and biofuels). For rural communities, losing livestock assets could trigger a collapse into chronic poverty and have a lasting effect on livelihoods.

Table 9. Overall impact of climate change on livestock in Jomsom and Kagbeni

Variables	Effect of Climate Change
Change in temperature and precipitation	Winters become less cold and frosty, resulting in frequent deaths of calves, sheep, and goats.
	Post-winter rainfall and snowfall become more frequent, resulting in loss of animal life.
	Rainfall becomes intense during summer.
Weather hazards	Droughts and floods become more frequent, causing a decrease in pasture land.
	More livestock in pasture are lost.
Vegetation	Snowfall is reduced, resulting in deteriorating grass quality and grasslands becoming less green.
	Cereal productivity is reduced, depriving livestock of nutritious feed.
Livestock	Fodder becomes less available.
	Internal and external parasitic infestations become more frequent.
	Different disease epidemics become more frequent.
	Milk and meat production of the animal is directly affected by the climate.
	Animal treatment becomes more costly.

The direct effects of climate change will include, for example, higher temperatures and changing rainfall patterns, which could translate into the increased spread of existing vector-borne diseases and macroparasites, accompanied by the emergence and circulation of new diseases. In some areas, climate change could also generate new transmission models.

Due to extreme climatic conditions, there is a direct impact on the growth of palatable grass species in pastures, causing shortage in livestock fodder. This has affected milk and meat production.

Climate Change Impacts on Overall Economy of Farmers

More than 82 percent of households in the study sites depended on agriculture and livestock. This indicates that threat of climate change in agriculture and livestock, can cause direct impact on the livelihoods and overall welfare of the people. This may also lead the livestock holders to engage in alternative professions, such as running a hotel business, becoming a tourist guide, and seeking foreign employment, or wage labor.

Climate Change Adaptation Measures

The respondents in Jomsom and Kagbeni adopted the following measures to lessen the impacts of climate change on livestock: (1) preserve forage and grass for the dry season; (2) build a shed to protect the animals from the adverse effects of low temperatures, rainfall, and snowfall; (3) provide livestock with a nutritious diet; (4) adopt the local livestock breeds that can tolerate the stresses caused by climate change; (5) cultivate local species of fodder and forage that can tolerate harsh climatic conditions; (6) apply rotational grazing of pasture; (7) conserve pasture; and (8) deworm and treat livestock regularly.

CONCLUSION AND RECOMMENDATIONS

There is clear evidence that livestock population in Mustang District is adversely affected by climate change. Threats to agriculture and livestock could directly devastate the people in this region, whose meager income is derived primarily from these two sectors. Based on the survey, 93 percent of households in Jomsom and Kagbeni rely on agriculture and livestock for their livelihood. By selling livestock assets, poor and marginalized people fulfill multiple family needs.

The following were the major effects of climate change observed: (1) an increase in the occurrence of livestock diseases, such as *peste des petits ruminants*, foot-and-mouth disease, external parasites, and internal parasites, which were not present in previous years; (2) decrease in the availability of fodder and forage, resulting in lower animal productivity; and (3) heightened vulnerability of livestock systems and the reinforcement of existing factors that affect livestock production systems, farmers' overall economy, demand for food (including livestock) and resource distribution.

The following are recommendations to mitigate the impacts of climate change on the livestock population:

1. Many local breeds, such as Lulu cattle, yak, and Chyangra goat are suited to the harsh climatic conditions of Mustang District. Identifying and strengthening local breeds through natural selection can improve productivity.
2. Improve livestock and livestock product marketing, and promote inter-regional trade to boost market responses.
3. Appropriate institutional and policy changes should be in place. Provide subsidies, livestock insurance, and income diversification practices. Introduce Livestock Early Warning Systems and other forecasting and crisis preparedness systems.

4. Prompt science and technology development by increasing the understanding of cause and effect of climate change on livestock, development of new breeds, and improvement of animal health.
5. Improve the productivity, nutritive value, and utilization of native pasture species and fodder trees, particularly at high altitudes.
6. Evaluate the technical and economic feasibility of improving hay-making within traditional systems.
7. Conserve and propagate important native pasture plants, such as *Medicago sativa* spp. and *Pennisetum flaccidum*.
8. Build the capacity of livestock keepers by increasing their awareness of global changes, and improving their understanding of climate change and possible adaptation measures. This can be achieved by providing training on agro-ecological technologies and practices for the conservation and production of fodder, improving the supply of animal feed, and reducing malnutrition and mortality in herds.
9. For effective livestock management systems, efficient and affordable adaptation practices have to be developed because the rural poor are unable to buy expensive adaptation technologies. Such practices may include providing livestock with shade and water to reduce heat stress from increasing temperatures. Given the current high cost of energy associated with air conditioning, providing natural shade is a low-cost solution that is more practical for rural poor producers.
10. Improve the management of water resources by introducing simple techniques for localized irrigation (e.g., drip and sprinkler irrigation), along with infrastructure to harvest and store rainwater, such as small superficial and underground dams and tanks connected to the roofs of houses.

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