# Adapting Livestock Production Systems to Climate Change in Nepal: Challenges and Opportunities

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## Presenter Information

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**Abstract.** To assess climate change impacts and identify challenges and opportunities for livestock climate change adaption, we conducted a comprehensive study in the Thulokhola watershed of Nuwakot district in Nepal from June 1, 2011 to January 31, 2013. We established nine community livestock groups (CLGs) consisting of 51 members and trained the CLG members in daily livestock record keeping and monitoring surface water quality. Monthly fecal samples from 50 cattle, 50 goats, and 50 buffaloes were collected for the determination of gastrointestinal parasites. Soil and fodder samples were also collected and analyzed. Group discussions, Participatory Rural Appraisals, and full-fledged household survey of 97 households were done. A survey of 41 water sources in the watershed was also conducted. While 85.3 % of the water sources have either dried up or decreased in flow in recent years, drought conditions had great toll on agricultural production. Prevalence rates of helminthes on goats, cattle, and buffalo was 53.8%, 31.32%, and 23.52%, respectively, and animal deaths were remarkably high. Declining pregnancy rates on livestock along with waning supply of fodder and forages and poor soil quality were additional major problems. Although local communities have undertaken several measures including adding new breed, destocking, purchasing fodder and forages, and planting grasses for livestock climate change adaptation, the problems of animal health, breeding conditions, soil fertility, forest degradation, increasing women workload, and water shortages were largely unaddressed. Opportunities for livestock climate change adaptation in Nepal include agroforestry intervention, groundwater utilization, rainwater harvesting, enhancing feed efficiency, and community capacity-building.

**Keywords:** Livestock climate change adaptation, challenges, opportunities.

## Introduction

The mixed farming livestock production system is the dominant agricultural production system in Nepal. Traditionally, this system consisted of strong linkages between livestock, crop production, soil quality and forest resources (Abington 1992). While forests supplied fodder, fuel wood, grazing land, and balanced hydrology; the livestock converted fodder, grasses, and agricultural by-products to milk, meat, manure, and household income. The soil fertility of agricultural land was maintained by manure application. Agricultural crops provided food to the families, and fodder, straw, and grains to the livestock. Livestock provided milk, butter, meat and household income to the families. Estimated livestock population for the year 2009/2010 in Nepal includes 7,199,000 cattle, 4.83 million buffaloes, 797,000 sheep, 8.76 million goats and 1.06 million pigs (MoF 2010). In recent years, climate change impacts such as degradation of resource and ecosystem services, shrinking water storehouses, earlier snowmelt and shorter winters, and natural hazards (Schild 2007), as well as rise in mean maximum temperature and change in the dates for the beginning and the end of the monsoons (Hua 2009) have impacted heavily on the farming system. According to MoF (2010), the untimely rain in mid-September in 2009 destroyed about 19,000 ha of land by inundation, riverbank erosion, and sand deposition, and 75,000 ha of paddy could not be planted due to abnormal rainfall.

The changes in the reliability of stream flow, erratic monsoons, and flooding have caused a decline in crop and livestock production in Nepal (Timsina 2011). Complex problems related to deforestation and forest degradation, opening of new unfertile land for agricultural production, increased cropping intensity, soil erosion, land degradation,

low agricultural productivity, food scarcity, and climate change impacts (Abington and Clinch 1992; Shrestha 1992; Regmi and Zoebisch 2004; Dhital 2009; MoF 2010; Feed The Future 2011) have resulted in a deterioration of livestock-based mixed farming systems in the region, and adaptation to climate change has become one of the major concerns in Nepal (Feed The Future 2011).

The specific objectives of this study were to: (1) assess vulnerability of the mixed farming livestock production systems to climate change in the mid-hills of Nepal, and (2) assess opportunities and challenges for livestock climate change adaptation.

## Methods

The study area, the Thulokhola watershed, is located 2.5 km south of Devighat in the Nuwakot district of Nepal. The elevation of the Thulokhola watershed which extends from <440 m asl at the Trishuli River to 1,585 m asl, faces north and drains directly into the Trishuli River. The watershed has an estimated area of 10 km$^2$ and contains 359 households. Buffalo, goats, and cattle are the major livestock in the watershed. Based on the historical precipitation data available from a nearby weather station, total annual precipitation peaked in 2000 (2,573 mm), started declining in 2001 and reached as low as 882 mm total annual rainfall in 2009 (Fig. 1).

Nine informal Community Livestock Groups (CLGs), consisting of 26 men and 25 women, were formed across the Thulokhola watershed in June 2011. The CLG members were invited to a workshop on July 3, 2011, where they learned about the goals and the objectives of the project, as well as their roles. In the workshop, the CLG members were trained for monthly water quality monitoring and livestock record keeping and were provided with record forms, weighing machine, and a portable LaMotte GREEN Water Monitoring Kit. We collected monthly fecal samples for one year from 50 cattle, 50 goats and 50 buffalo which were analyzed for the prevalence of gastrointestinal parasites. We also collected soil and fodder samples from the watershed for laboratory analyses.

By dividing the CLG into six groups, an interdisciplinary team of eight scientists performed group discussions in January 2012. A wide range of questions related to climate change impacts, natural resources, agricultural production and governmental services were asked and discussed in each group meeting, and the responses were analyzed and synthesized considering the climate change exposure, sensitivity, adaptation and limitations. A total of 97 households were surveyed in May 2012. The survey questionnaire contained questions about the livestock composition, fodder and forages, exposure to climate change, climate change impacts, awareness and perceptions of farmers on climate change, women's empowerment, capacity-building, and livestock climate change adaptation. Free style Participatory Rural Appraisals (PRAs) in each of the three elevations (the upper, middle and lower) and a survey of 41 water sources in the three elevation levels were also conducted in May, 2012 in the watershed. For data analyses, simple statistics such as mean, standard deviation, frequency, and range were calculated in JMP 8.0.

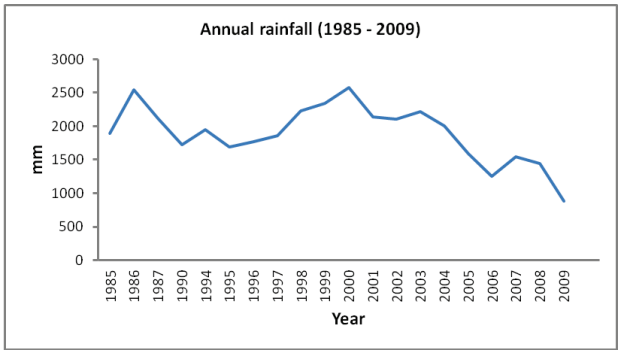


**Figure 1. Annual rainfall (1985-2009) in Nuwakot, Nepal.**

## Results

### *Livestock climate change impacts*

Drought conditions in recent years have taken a great toll on agricultural production in the Thulokhola watershed as farmers are unable to plant their crops in time resulting in crop failures, poor harvest, and overall decline in agricultural productivity. Spring survey results showed that almost 85% of the water sources have either dried up or decreased in flow over the past 10 years. In light of poor agricultural production due to drought conditions and the lack of irrigation water, farmers fear severe problems in their future food security and food availability. Because of shortages of irrigation water, farmers in the Thulokhola watershed are reducing or abandoning rice cultivation during winter months, which has resulted in decreased grain production. Lack of irrigation water has also impacted vegetable production which is critical for family health, nutrition, and household income. Diminishing water sources has also negatively affected washing clothes and maintaining general cleanliness in the family. Overall, farming has become more unstable and costly, and due to limited chances for increasing household income from farming, youths are leaving the villages for outside employment, resulting in labor constraints for livestock production.

Loss of animals due to emerging new diseases and parasites is remarkably high and is having serious negative impacts on the household economy. Almost all members in the six focus groups said that they have suffered animal deaths due to diseases and parasites in recent months. Group no. 3 in the middle elevation succinctly summarized the impacts of animal death as "Our agricultural produce from lands is just enough for food; when animals die we cannot even afford schooling of our children, we will need 10 years to pay the debt because of the death of our large animals."

Out of 1,467 fecal samples of animals examined, goats showed the highest prevalence of helminthes (54%), while buffalo showed the lowest prevalence (24%) followed by (31%) cattle (Table 1). In buffalo, the major parasites found were Trematode parasites (Fasciola and paramphistomes) followed by few cases of stongyle and Moneizea. The losses caused by the trematode parasites are more severe than other nematode parasites in buffalo. Similarly, the major parasites found in cattle were Trematode parasites (Fasciola and paramphistomes). The most common para-

**Table 1. Prelalence of helminthes parasites in buffalo, cattle and goats in the Thulokhola watershed, Nuwakot, August 2011 to July 2012.**

| Elevation | Animals | Number of samples | Positive samples | Negative samples | Prevalence % |
|---|---|---|---|---|---|
| Lower | Buffalo | 165 | 37 | 128 | 22.4 |
| | Cattle | 140 | 41 | 99 | 29.3 |
| | Goats | 151 | 78 | 73 | 51.6 |
| Middle | Buffalo | 154 | 30 | 124 | 19.5 |
| | Cattle | 129 | 36 | 93 | 27.9 |
| | Goats | 145 | 89 | 56 | 61.4 |
| Upper | Buffalo | 204 | 56 | 148 | 27.5 |
| | Cattle | 186 | 65 | 121 | 35.0 |
| | Goats | 193 | 96 | 97 | 49.7 |
| All elevations | Total buffalo | 523 | 123 | 400 | 23.5 |
| All elevations | Total cattle | 455 | 142 | 313 | 31.2 |
| All elevations | Total goats | 489 | 263 | 226 | 53.8 |

sites of goats in the Thulokhola watershed are gastro-intestinal parasites (Stongyles) and Tape worms (Moniezea). The strongyles worms have been reported to be highly pathogenic, causing severe diarrhea and weight loss in goats. Based on information collected from the CLG members, the goat morality rate in this watershed was 22%; this rate was high enough to cause economic hardships by itself. Major causes of goat death included gastrointestinal parasites, peste des petits ruminants (PPR), a highly contagious and infectious viral respiratory disease of domestic and wild small ruminants, Orf (also known as "sore mouth"), a virus that causes sores but typically not death, Foot and Mouth Disease and flukes. Many of these diseases were exacerbated due to very poor living conditions, high parasite loads and poor nutrition for goats. We observed goat pens which were very poorly ventilated, foul smelling, and in many cases the cows and goats were penned together.

Declining fodder and forages was one of the major concerns of livestock producers. Rice straw, corn products (green fodder, stover, corn husk, and grain), wheat straw, finger millet straw, legume residue, fodder, green grasses, and concentrate were the major sources of dry matter (DM) for livestock. The DM supply decreased from January until July when green corn forages, corn stovers, and natural grasses become available for livestock. A significant amount of feed supplied to livestock was wasted due to its low quality, poor feed preparation and handling.

A large number of livestock producers in the Thulokhola watershed have experienced declines in the pregnancy rates of their livestock over the past 10 years. Livestock breeding difficulties in the Thulokhola watershed included the need for repeated breeding, prolonged anestrous, infertility and abortion. Abortion in goats was another major problem as over a half of the respondents in the upper elevation and about 40% of the respondents in the middle and lower elevations reported abortions in goats as an emerging problem in recent years. Poor animal health due to parasites, diseases, and nutritionally inadequate diets (Poudel *et al.* 2012a, b) have negatively impacted the pregnancy rates of livestock in this watershed.

The support systems for livestock production (*i.e.*, forest, soils) are also spiraling downward in the Thulokhola watershed. Deforestation and forest degradation have caused serious problems with regard to fuel wood, leaf-litter, fodder, forages, and timber supplies. Seventy six percent respondents in the upper elevation, 82% in the middle, and 77% respondents in the lower elevation mentioned that the condition of their community forests had been degraded in recent years. Local communities have to travel further and spend more time gathering even small amounts of forage for their livestock. The degradation of pasture lands has further reduced forages for animals. Soils in farm lands are acidic (Table 2) and in most cases were highly compacted. Soils of irrigated lands showed lower fertility levels compared to the non-irrigated lands. The suboptimal pH in all samples and the low level of phosphorus in irrigated lands are not sufficient to support desired productivity. Water quality monitoring data showed positive fecal coliform results all the time, acceptable pH all the time, and excellent dissolved oxygen values all the time. Phosphate, nitrate, and turbidity values indicated poor water quality especially during the months of agricultural activities and rainy season.

## *Livestock climate change adaptation*

Various measures undertaken by local communities for coping livestock climate change impacts in the Thulokhola watershed include: adding new breed, destocking, purchasing fodder/forages, concentrates, rice straw for their animal, planting grasses, collecting fodder and forages from forest and community forest, collecting small grasses from terrace risers and edges of the fields (if available), and bringing animals (especially cattle and goats) to graze on more distant pastures. Figure 2 presents major changes

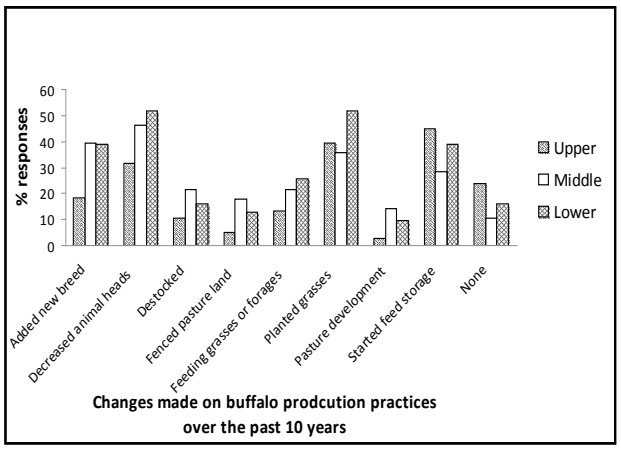


**Figure 2. Major changes made by buffalo producers in past 10 years in the Thulokhola watershed, Nuwakot, Nepal.**

**Table 2. Chemical properties of soils (0-15 cm) for the three elevations of the Thulokhola watershed, Nuwakot, Nepal.**

| Elevation | n | pH | OM (%) | N (%) | $P_2O_5$ (kg/ha) | $K_2O$ (kg/ha) |
|---|---|---|---|---|---|---|
| Un-irrigated land | | | | | | |
| Upper | 7 | 5.3 | 5.5 | 0.19 | 191 | 430 |
| Middle | 11 | 6.0 | 4.2 | 0.15 | 187 | 463 |
| Lower | 3 | 5.3 | 3.6 | 0.14 | 68 | 378 |
| Irrigated land | | | | | | |
| Upper | 7 | 5.2 | 3.4 | 0.14 | 54 | 258 |
| Middle | 7 | 5.6 | 2.3 | 0.10 | 54 | 357 |
| Lower | 11 | 4.7 | 4.9 | 0.16 | 55 | 165 |

made by the buffalo producers in the watershed in past 10 years. With some degree of variation, adding new breed, decreasing animal heads, stall feeding, planting grasses and feed storage appear to be the major adaptation strategies undertaken by the buffalo producers. Napier (*Pennisetum purpureum*), stylo (*Stylosanthes guianensis*), and oats (*Avena sativa*) were major grasses recently introduced in the watershed. They admitted that they had to feed low quality feed to their livestock especially during feed-deficient seasons. With regard to animal health, farmers have administered drugs to animals, given frequent baths to buffalo to protect against heat, developed shaded areas for daytime resting, and collected fecal samples for animal parasite testing. To cope with climate change impacts on agricultural production, farmers in the Thulokhola watershed have implemented several adaptation measures including the construction of ponds for irrigation water storage, application of herbicides, chemical fertilizers, and pesticides on crops; introduction of hybrid seeds, application of chemicals against rodents, snakes, and other organisms; chasing away monkeys from their crop lands, guarding crops at night against wildlife, started planting wheat crops, and not planting corn due to drought conditions.

In relation to irrigation water sources, they have tried (in limited scale) pumping water and drip irrigation. For drinking water they have dug shallow wells and have installed pipes for drinking water supplies. These adaptation measures are at a limited scale and apparently have not been able to impact the production system sufficiently to compensate for climate change impacts in any significant way. At the community level, residents in the Thulokhola watershed have accomplished a number of community improvements to the water supply (*e.g.* constructing community ponds and water storage tanks, installing pipelines for water supplies), as well as managing community forest, planting trees in public spaces, and raising community awareness.

## *Challenges for livestock climate change adaptation*

Diminishing water sources constitute the major climate change adaptation problem in the Thulokhola watershed which is not only causing increased labor for fetching drinking water and health and sanitation problems but also affecting the decisions farmers make in relation to growing vegetable crops, number of livestock heads, and planting agronomic crops. Farmers are experiencing frequent crop failures due to lack of irrigation water. The local communities have found it even more difficult to ameliorate livestock issues like diseases, parasites, delayed pregnancies, and breeding difficulties. Appropriate responses to livestock issues are limited at best, and in some cases non-existent. Based on the responses and perceptions of local communities in the watershed, there exists a range of adaptive responses to livestock climate change impacts in this watershed, in the following order (from least response to greatest): *Animal health/animal breeding < soil fertility management < landslides and flooding < deforestation/forest degradation < decline crop yields and crop production < water shortages.* This observed order of adaptation indicates that the livestock aspect of the mixed farming system will be the most difficult to adapt to climate related changes, particularly the animal health and breeding issues. Certainly, a working knowledge of the epidemiology and prevalence of emerging diseases and parasites, optimal feeding and nutrition regimes, and adequate access to veterinary services at the village level are necessary for sound animal health and productivity. Based on the PRAs results, the lack of knowledge and the lack of financial resources constitute the two major limitations for the implementation of climate change adaptation measures. Effective coordination of village level climate change adaptation activities such as reforestation, water resource conservation, soil conservation, animal health improvement and fodder and forages is another major challenge. Moreover, overcoming farm labor shortage as well as improving degraded forest and pasture lands are additional challenges for livestock climate change adaptations.

## *Opportunities for livestock climate change adaptation*

Ground water utilization and rainwater water harvesting present major opportunities for climate change adaption. For groundwater utilization, it is important to explore the possibilities of groundwater development in the region and characterize groundwater in terms of its availability, occurence, local topography, rocks (water-bearing or non water-bearing), recharge characteristics, and groundwater flow. It is also important to explore the possibility of artificial recharge of the water sources. Rainwater harvesting is another opportunity which needs to be explored for addressing water scarcity due to climate change impacts.

Agroforestry intervention and enhancing feed efficiency offer other opportunities for livestock climate change adaptation. Farmers are willing to plant fodder trees, grasses, fruit trees and grow vegetable and cereal crops in their farm lands while raising their livestock. Growing fodder trees on private land can compensate for the fodder and forage supply from forests meanwhile saving labor and time for collecting fodder and forages. As

**Table 3. Percentage crude protein (CP), organic matter (OM), total ash (Ash), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), hemicelluloses (HC) and cellulose content of major fodder species in the Thulokhola watershed, Nuwakot, Nepal.**

| Species | n | CP | Ash | OM | NDF | ADF | ADL | HC | Cellulose |
|---|---|---|---|---|---|---|---|---|---|
| *Ficus cunia* | 24 | 13.0 | 17.7 | 82.3 | 56.0 | 47.8 | 26.7 | 15.7 | 21.1 |
| *Ficus hispida* | 18 | 11.9 | 23.0 | 76.0 | 42.4 | 34.1 | 16.8 | 15.8 | 17.3 |
| *Litsea polyantha* | 23 | 13.2 | 7.1 | 92.9 | 717 | 63.5 | 42.4 | 14.9 | 2.1 |
| *Bauhinia purpurea* | 2 | 11.2 | 16.5 | 83.5 | 54.1 | 39.8 | 20.0 | 34.2 | 19.9 |
| *Artocarpus lakoocha* | 1 | 8.1 | 4.9 | 95.1 | 83.7 | 80.6 | 60.2 | 23.5 | 20.4 |

a matter fact, the nutritional analyses of major fodder trees in the watershed indicated that the local fodder plants are quite nutritious (Table 3), therefore, they will sufficiently contribute to animal nutrition if promoted. Planting fodder trees in farm land will also enhances the regeneration of forests which will enhance watershed hydrology and biodiversity. Similarly, diversification of household incomes presents another opportunity for climate change adaptation. Major sources of household income in the recent years include selling agricultural products, selling livestock products and livestock, earning daily wages, setting up small businesses, and pursuing part-time employment.

Existing communication media and the presence of community organizations in the watershed present other opportunities for climate change adaptation through information dissemination. The survey results showed that 94.8% of the surveyed respondents owned a mobile phone, 88.7% owned radio, 47.4% owned television, and 6.2% owned computers. In addition to radio, TV, village meetings, newspapers, school meetings, friends and families as well as the neighbors were important sources of information relevant to livestock production and management. Various community groups mentioned in the watershed included community forest groups, cooperatives, road construction committees, irrigation and drinking water management group, mother's group, women's group, and school board members.

## Conclusion

Nepal's rural livestock enterprise is struggling for its survival in the face of climate change impacts and declining resources such as forests, water supply, crop production, soil quality, and farm labor. As animals represent the peak of the food pyramid, declines in any of these supportive resources will eventually impact the animals. With new/emerging diseases and parasites and declining fodder and forages and pasture lands, cows, goats, and buffaloes are suffering higher incidences of diseases, parasites, and mortality. In addition, delayed pregnancies as well as anestrous and repeat breeding conditions in cows, goats and buffaloes represent a significant financial loss for the owners. Although farmers can relate the problems that they have been experiencing in the system pretty well, there is a lack of scientific understating and explanation of the problems they are facing. Formation of community livestock groups and involving these groups in the livestock climate change adaptation research result in the generation of a large set of multidisciplinary dataset which help researchers in effectively assessing and understanding the vulnerability of livestock production system and livestock climate change adaptation. The resiliency of the mixed farming livestock production system in the mid-hill region of Nepal revolves primarily around animal health, fodder and forages, forest resources, farm labor, water sources, and crop production. Therefore, sufficient consideration should be given to these factors while developing programs and policies for livestock climate change adaptation in this region.

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