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Original Article

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Abstract

The study aimed to assess the livestock holder's perception to climate change and its impact and adaptation strategies on the livestock sector of Nepal. Altogether 240 households, 60 from each agro ecological zone, were selected using stratified random sampling. Primary data were collected by household survey using structured and pre tested questionnaire. The results showed that the farmers were aware of climate change. Nearly third fourth respondents, perceived the increase in temperature, more than half, respondents observed decreased intensity of summer rainfall, and nearly half of the respondents experienced the delayed summer monsoon. Major climate induced impact on livestock production were incidence of diseases and external parasites in animal, loss of forages and fodders, heat stress, water scarcity, infertility, decline in the milk yield and lactation period. Major adapted adaptation strategies comprised the integrated farming, change in herd size and composition, depended on veterinary and livestock services, improved feeding practices, institutional arrangement, and weather warning and water harvest technology. Lack of climate information, lack of labor, money, and lack of market access were the major barriers to adaptation. Awareness campaign on climate change is recommended among livestock holders for climate change information to reduce the negative impact of climate change.

Keywords: Climate change, perception, livestock production, adaptation strategies.

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Introduction

Climate change is already being felt and its effects are expected to continue and to increase and rural communities are increasingly vulnerable to climate induced hazards (Gurung and Bhandari, 2008). Due to the fragile ecosystem, which is very sensitive to even slight changes in natural climate, weaker geological situation and complex topography, Nepal is in fourth vulnerable position with regard to climate change (Maplecroft, 2011). The Intergovernmental Panel on Climate Change (IPCC, 2007) suggests that within the agricultural sector livestock are among the most climate sensitive economic areas. Moreover, the smallholder and subsistence livestock holders' of developing countries (in particular, those farming in the marginal regions) are the most vulnerable to livelihood and food insecurity from the effects of climate change (Stern, 2006; Heltberg, 2009).

Agriculture is the major source of livelihood engaging nearly 66 percent of active population and contributing around 35 percent to the country's GDP (MOAD, 2012). Livestock is an integral part of the mixed farming system and socio-economical life in the country, and contributes nearly 26 percent to the total Agricultural Gross Domestic Product (MOAD, 2012). Livestock systems vary along the elevation gradient, from buffalo dominated in the low elevations of the Terai to Chauri and Yaks in the Mountain region. While not definite, it would seem that livestock in Nepal is at par with livestock systems in other developing countries and is changing rapidly in response to many external and internal drivers including climate change which is seen as a negative impact (Thornton *et al.,* 2007).

Livestock keepers' perception of their environment is a factor of climate change. Adaptation to climate change requires that farmers must first notice that the climate has changed and then identify useful adaptations and implement them (Maddison 2006). Adaptation is widely recognized as an important component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture and livestock sector; but with adaptation, vulnerability can largely be reduced (Smit and Skinner, 2002). Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007). Adaptation to climate change requires that farmers first notice that the climate has changed, and then identify useful adaptations and implement them to reduce the negative impact (Maddison 2006). Common adaptation methods in livestock includes use of new livestock species that are better suited to drier conditions, adoption of mixed crop and livestock farming systems (Kurukulasuriya and Mendelsohn, 2006; Nhemachena and Hassan, 2007). Parry *et al.,* (2007) reported that altered grazing and rotation of pasture, feed stock and supplementary feeding for the drought regions and housing and shade provision, develop and rare heat tolerant breeds for warm and hot regions are the adaptation measures followed by the livestock keepers.

Studies on livestock and climate change revealed that climate change adversely affects the animal health and livestock production. An increase in extreme climate events, such as droughts and floods, is anticipated more constraint to profitable livestock production (Christensen *et al.,* 2007). Cool temperate Grassland is projected to shift northward with climate change and net primary productivity will decline (Christensen *et al.,* 2004). The limited herbaceous production, heat stress from higher temperature, and limited water intake due to the decrease in rainfall could cause reduced milk yields in animals and an increased incidence of some diseases. In some areas, climate change may also cause new transmission models; these effects will be felt mostly by developing countries because of lack of resources, knowledge, veterinarian extension services and research technology development (FAO, 2008). Upadhya *et al.,* (2007) also stated that thermal stress on Indian livestock particularly cattle and buffaloes reported to decrease estrus expression and conception rate. Heat stress on animals reduces the rate of animal feed intake and causes poor performance growth (Rowlinson, 2008). The climate change is feared to have impacts on feed crops and grazing systems, for example, greater incidences of droughts can decrease fodder production and rise in temperature can change the species-mix in the pasture (Hopkins and Del-Prado, 2007). Climate change also increases mortality and

morbidity of animals particularly from the climate sensitive infectious diseases (Patz *et al.*, 2005b). Increased temperature and humidity will increase the risks of mortality and morbidity among the livestock and poultry. The effects of climate change on the health of livestock and poultry are reported by many studies (Harvell *et al.*, 2002; Baylis and Githeko, 2006).

Gandaki River Basin, where the research was conducted, is particularly vulnerable because it lies in the Himalayas' rain shadow and relies on river flows from mountain snow and ice cover for water supplies (Manandhar *et al.*, 2012). However, appropriate mechanisms for coping and adapting to adverse effects in the livestock sector are weak or lacking. With this back drop this research focused to analyze the livestock keepers' perception to climate change, and effect of climate change on livestock production and adaptation strategies in the study area and make the necessary policy recommendations.

Materials and Methods

Study Sites, Sampling, Data Collection and Oversight

The gandaki river basin (grb), nepal spreads from 27.21'45" to $28^0$36'36" degree north longitude to $83^0$08'00"- $84^0$53'00" degree east latitude and elevation ranging from about 144 masl to 8167 masl (ddc, 2002). It covers the areas in the mountain zone (mustang, manang, gorakha, rasuwa districts), hill zone (myagdi, kaski, tanahun, lamjung, syangja, parbat, dhading, nuwakot, makawanpur, baglung, gulmi, palpa), and the valley terai zone (nawalparasi, chitwan, kapilvastu). The average temperature of this area ranges from -9 ^{o}c in mustang to 42.5^{O}C in chitwan (dado, 2012; dlso, 2011B). Average annual rainfall is 26.58 mms in mustang to 2500 mm in chitwan (dado, 2012; dlso, 2011B). This research was based on four agro ecological regions namely the tropical region (below 500 meters above sea level) from chitwan district, subtropical (500 -1000 masl) and warm temperate (1000-2000 masl) from myagdi district and cool temperate (2000-3000 masl) from mustang district.

Fig. 1: Shaded regions showing research districts in Gandaki River Basin, Nepal.

These Districts were selected purposively as livelihood of the most of the people has been hinged on the agriculture and livestock sector (DADO, 2012; DLSO, 2011a; DLSO, 2011b). Four agro-ecological regions were selected from Chitwan, Myagdi and Mustang districts of GRB in Nepal. From each region 60 households were selected using purposive simple random sampling technique accruing the total households to be surveyed were 240 households. The primary data was collected through household survey using pretested semi structured questionnaire via face to face interview during October 2012 to January 2013.

As far as Participation goes, two Focus Group Discussions (FGDs) and one Key Informant Interview (KII) were conducted to triangulate the data and to supplement the household survey. Information on the livestock holder's perception on climate change, and major effects on livestock due to changing climatic conditions were assessed through these participatory methods. The Geographical Positioning System (GPS) was used to determine the altitude and latitude of the study areas.

Statistical Analysis

The first stage of analyses was the descriptive analysis of the socioeconomic and household characteristics through frequency count, percent, mean, and standard deviation. Perception of climate change, problems and general impact of climate change were also summarized by descriptive statistics. T statistics, Chi^2 test, F statistics was applied to test the significance of these variables. Data entry and analysis was done by using computer software package, which are Statistical Package for Social Science (SPSS 16 version), and STATA 12.

Prioritization of major climatic hazards was rated using preference ranking scaling technique consisting four point scales. The points consists of strongly agree, somewhat agree, agree, least agree and disagree using score of 1.00, 0.75, 0.50, 0.25 and 0 respectively. The formula given below was used to find the index for severity of climatic hazards.

$$I_{prob}=\sum \frac{S_i f_i}{N}$$

Where,

I_{prob} = Index value for intensity of problem

$\sum$ = Summation

S_i = Scale value of i^{th} intensity

f_i = Frequency of i^{th} response

N = Total number of respondents

Results and Discussion

Perception Towards Weather Parameters

Change in the weather parameters is important factor that determine the farmer's perception about climate change. Nearly all of the respondents (92.1%) had observed the deviation of weather parameters like variation in rainfall, temperature, humidity and snowfall (Figure 2). The Pearson's Chi-Square ($\chi 2$ =8.40) indicate that the perception about the change in the weather pattern was significant (P<0.038).

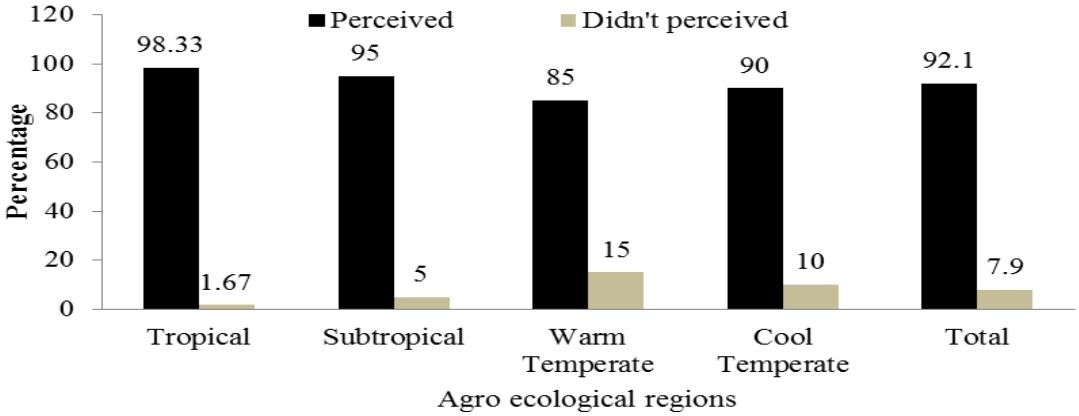

Fig. 2: Perception of respondents towards changing weather parameters across regions.

Similarly, study revealed that nearly 73.0% of respondents perceived the increase in temperature. According to findings, more proportion of respondents in the tropical (78.3%) experienced the increase in temperature across the agro ecological regions. Similarly, 12.5% respondent didn't observe any change in the temperature while 3.3 percent realized the decrease in temperature as compared to last 10 years (Table 3). The chi^2 value (χ^2 =10.46) indicates that the farmers' response towards the temperature variation is statistically not significant.

Table 3: Perception of respondents towards temperature across the regions.

Temperature	Agro Ecological Regions					χ2
	Tropical	Subtropical	Warm temperate	Cool temperate	Total	
Increased	47.00 (78.33)	43.00 (71.67)	41.00 (68.33)	45.00 (75.00)	176.00 (73.33)	10.46
Decreased	3.00 (5.00)	2.00 (3.33)	1.00 (1.67)	2.00 3.33	8.00 (3.33)	
Same	1.00 (1.67)	10.00 (16.67)	9.00 (15.00)	6.00 (10.00)	26.00 (10.83)	
Don't know	9.00 (15.00)	5.00 (8.33)	9.00 (15.00)	7.00 (11.67)	30.00 (12.50)	

Figures in the parentheses indicate percentage.

A majority of respondents (52.5%) observed the decrease in rainfall, 15.4 % perceived the erratic rainfall, while 7.0% experienced the no change in rainfall pattern (Table 4). A large number of respondents experienced the decrease in rainfall in tropical (61.7%), followed by subtropical (55.0%). Similarly, farmer's responses towards onset of summer monsoon were evaluated based on their perception. Nearly half of the respondents (45.0%) of perceived the later initiation of summer monsoon while 19.2% of respondents expressed that the rainfall pattern now days are unpredictable.

Table 4: Perception of respondents towards rainfall across the regions.

Rainfall	Agro Ecological Regions					
	Tropical	Subtropical	Warm temperate	Cool temperate	Total	χ^2
Increased	2.00 (3.33)	5.00 (8.33)	6.00 (10.00)	4.00 (6.67)	17.00 (7.08)	26.17*
Decreased	37.00 (61.67)	33.00 (55.00)	27.00 (45.00)	29.00 (48.33)	126.00 (52.50)	
Erratic	8.00 (13.33)	14.00 (23.33)	6.00 (10.00)	9.00 (15.00)	37.00 (15.42)	
Same	0.00 (0.00)	0.00 (0.00)	9.00 (15.00)	8.00 (13.33)	17.00 (7.08)	
Don't know	13.00 (21.67)	8.00 (13.33)	12.00 (20.00)	10.00 (16.67)	43.00 (17.92)	
Onset of monsoon						
Earlier	1.00 (1.67)	12.00 (20.00)	14.00 (23.33)	12.00 (20.00)	39.00 (16.25)	43.67***
Later	33.00 (55.00)	35.00 (58.33)	20.00 (33.33)	20.00 (33.33)	108.00 (45.00)	
Unpredictable	17.00 (28.33)	7.00 (11.67)	10.00 (16.67)	12.00 (20.00)	46.00 (19.17)	
Same	0.00 (0.00)	0.00 (0.00)	7.00 (11.67)	10.00 (16.67)	17.00 (7.08)	
Don't know	9.00 (15.00)	6.00 (10.00)	9.00 (15.00)	6.00 (10.00)	30.00 (12.50)	

Figure in the parenthesis indicates percentage.

*** and *Indicates significant at 1 percent and 10 percent level of significance respectively.

Major Climatic Hazards or Extremities

Floods, landslide, extreme hot, extreme cold, glacial retreat were five major climatic hazards in the study areas which were identified by the group discussion and based on literature. The value obtained from the preference ranking scale show that extreme hot was the major extreme events in tropical (0.696) and subtropical (0.508). Similarly, landslide was major hazards in the warm temperate (0.629) and cool temperate (0.613) respectively (Table 5).

Table 5: Perception of respondents towards climatic hazards across the regions.

Climatic hazards	Agro Ecological Regions							
	Tropical		Subtropical		Warm temperate		Cool Temperate	
Floods	0.013	III	0.479	II	0.525	II	0.600	II
Landslide	0.004	IV	0.425	IV	0.629	I	0.613	I
Extreme hot	0.696	I	0.508	I	0.444	IV	0.154	V
Extreme cold	0.388	II	0.450	III	0.500	III	0.571	III
Glacial retreat	0.000	V	0.000	V	0.011	V	0.445	IV

Climate Change Impact on Livestock Production

Animal disease, external parasite, unavailability of fodder and forage, unavailability of grazing land, heat stress, unavailability of water, labor unavailability, and climatic extremities and calamities are the problems confronted with the livestock production in the changing climatic context (Table 6). Incidence of animal disease was found as the major problem (43.8%) in the study area. Accordingly, prevalence of animal disease (45.0%) was major problem followed by heat stress (43.3%) in the tropical. Loss and unavailability of grazing land (55.0%) followed by the unavailability of animal feed (48.3%) were major problems in the subtropical. Similarly, Incidence of external parasite (43.3 %) was first ranked as the problem in the warm temperate. Heat stress (61.7%) got first priority and incidence of external parasite (56.7%) problem in the cool temperate.

Effect of Climate Change on Livestock Performance

Changing climatic situation might directly or indirectly affect the animal performance. Infertility was found as the major climatic induced problem in the study area. 47.9% respondents observed that climate change had negative impact on milk production and lactation length and infertility. A majority of respondents 68.3% observed that climate change caused the infertility in the cool temperate. About 46.0 % respondents opined that climate change had an effect on livestock feed intake. Majority of respondents, 51.7%, in the cool temperate observed that there was reduction of feed

Table 6: Perception of respondents towards climatic hazards across the regions.

Problems	Agro Ecological Regions					χ^2
	Tropical	Subtropical	Warm Temperate	Cool Temperate	Total	
Animal disease	27 (45.00)	20 (33.33)	25 (41.67)	33 (55.00)	105 (43.75)	5.87
External parasite	16 (26.67)	22 (36.67)	26 (43.33)	34 (56.67)	98 (40.83)	11.79***
Unavailability of forage and fodder	16 (26.67)	29 (48.33)	21 (35.00)	25 (41.67)	91 (37.92)	6.67*
Heat stress	26 (43.33)	5 (8.33)	16 (26.66)	37 (61.66)	84 (35.00)	41.17***

Water scarcity	9 (15.00)	22 (36.7)	16 (26.67)	24 (40.00)	71 (29.58)	14.27**

Figure in the parenthesis indicates percentage
The sum of percent figures don't hundred
***, ** and *Indicates significant at 1 percent, 5 percent and 10 percent level respectively.

intake by animal due to climate change. Likewise 22.5% respondents observed the declined in the meat production and 16.6 % observed the declined in the egg production (Table 7).

Table 7: Effect of climate change on livestock performance across the regions.

Problems	Agro Ecological Regions				Total
	Tropical	Subtropical	Warm Temperate	Cool Temperate	
Infertility	25 (41.67)	25 (41.67)	24 (40.00)	41 (68.33)	115 (47.90)
Decline in milk	24 (40.00)	28 (46.67)	26 (43.33)	35 (58.33)	113 (47.10)
Reduction in feed intake	25 (41.67)	30 (50.00)	24 (40.00)	31 (51.67)	110 (45.80)
Decline in meat production	8 (13.33)	7 (11.67)	23 (38.33)	16 (26.67)	54 (22.50)
Egg production decline	9 (15.00)	6 (10.00)	10 (16.67)	14 (23.33)	39 (16.60)

Figures in the parentheses indicate percentage
The sum of percent figures is not hundred.

It is evident that (Table 8) integrated farming (multiple cropping mixed with livestock rearing) under changing climatic conditions was the most commonly used method (33.75 percent) in the study area. Integrated farming system was found as the main coping strategies in the subtropical (38.33 percent), and warm temperate (28.33 percent) which may reduce the risk of total failure of livestock farming as farmers at the same time cropping cereals, fruits and vegetables based on the prevailing climatic conditions. Changing herd size and composition was the second best option to get rid of adverse climatic conditions. This includes reducing herd size by selling at extreme conditions specially when there is severe hot drought in the tropical region causing heat stress and extreme cold at the cool temperate regions. This was the main adaptation stategies in the cool temperate region (53.33 percent). Expansion and depending on veterinary and livestock services was the third best adaptation strategy (24.16 percent) in the study area. It was the best adaption strategy (38.33 percent) in the tropical zone.

Table 8: Effect of climate change on livestock performance across the regions.

Adaptation Strategies	Agro Ecological Regions				
	Tropical	Subtropical	Warm Temperate	Cool Temperate	Total
Integrated Farming	15 (25.00)	23 (38.33)	17 (28.33)	26 (43.33)	81 (33.75)
Changing herd size and composition	11 (18.33)	8 (13.33)	12 (20.00)	32 (53.33)	63 (26.25)
Depending on veterinary and livestock services	23 (38.33)	14 (23.33)	5 (8.33)	16 (26.66)	58 (24.16)
Improved feeding practices	18 (30.00)	19 (31.66)	4 (6.66)	11 (18.33)	52 (21.66)
Institutional arrangement	14 (23.33)	9 (15.00)	7 (11.66)	9 (15.00)	39 (16.25)
Weather warning and water	15	5	4	5	29

harvest	(25.00)	(8.33)	(6.66)	(8.33)	(12.08)

Figures in the parentheses indicate percentage.
The sum of percentage figures is not hundred.

Barriers to Adaptation

Around 55.00 percent of respondents had not adopted the adaptation strategies. Those respondents who didn't practice adaptation strategy were asked the reasons for not adapting the adaptation strategy. The analysis of barriers to adaptation to climate change based on the perception of respondents in the study area indicated that there were six major constraints to adaptation. These were lack of information about climate change, lack of knowledge concerning appropriate adaptation strategies, lack of money or saving or poverty, poor market access and transportation link, lack of labor and adaptation technology, lack of institutional arrangement and facilities (Table 9).

Table 9: Reasons for non adopting adaptation strategies across the agro ecological regions.

Reasons	Agro Ecological Regions				
	Tropical	**Subtropical**	**Warm temperate**	**Cool temperate**	**Total**
Lack of climate information	14 (45.16)	29 (82.86)	29 (72.50)	11 (44.00)	83 (63.36)
Lack of labor and technology	13 (41.94)	13 (37.14)	21 (52.50)	11 (44.00)	58 (44.27)
Lack of knowledge	17 (54.84)	10 (28.57)	9 (22.50)	8 (32.00)	44 (33.59)
Lack of money or poverty	5 (16.13)	9 (25.71)	19 (47.50)	4 (16.00)	37 (28.24)
Poor market access and transportation link	1 (3.23)	3 (8.57)	18 (45.00)	9 (36.00)	31 (23.66)
Lack of institutional arrangement	3 (9.68)	6 (17.14)	4 (10.00)	3 (12.00)	16 (12.21)

Figures in the parentheses indicate percentage.
The sum of percentage figures is not hundred.

Conclusion

Climate change is one of the challenges to environment-human security and poses threat to the livelihood of people who rely more in the agriculture and livestock sector since these sectors are more susceptible to the climate induced disasters and calamities. Farmers' perception of climate change in the study area was in line with findings of other researchers around the world. Farmers were able to recognize that temperatures have increased and precipitation has dwindled. Most of livestock keepers had observed the variation on weather patterns and experienced increased temperature, decreased but erratic precipitation and delayed summer monsoon. Landslide, floods, extreme hot, and glacial retreat in the high hill were major hazards and extremities. Major climate induced impact on livestock production were incidence of diseases and external parasites in animal, loss of forages and fodders, heat stress, water scarcity, infertility, decline in the milk yield and lactation period. Awareness campaign on climate change is recommended among livestock holders for climate change information. . Livestock holders in the GRB started different adaptation strategies. The main adaptation measures adopted by livestock keepers were integrated farming,

changing herd size and composition, expansion and depending on veterinary and livestock services, improved feeding practices, institutional arrangement and weather warning and water harvest. Lack of climate information, lack of labor, money, and lack of market access were the major barriers to adaptation.

Government policies should enable farmers have access to extension services adequately as a lack of information has been indicated as a barrier to perception of climate change since variables described here are intricate with the level of knowledge and information to climate change. Information is a very critical variable in farming operations and therefore, cannot be overlooked. Policies should also ensure that farmers through extension services have access to education, encouraging the social network and organizations, establishment of livestock services centre and veterinary and creation of off farm employment is recommended to better informed the climate change and its impact on livestock sector of Nepal which in turn control to counteract adverse impacts to climate variability and change.

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