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Assessment of Climate Change Impact and Vulnerability to Climate Change among Livestock holder in Chitwan District, Nepal

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Abstract:

The research was done in order to assess vulnerability to climate change for livestock raising households in Chitwan district of Nepal. The six different villages namely, Gitanagar, Patihani, Padampur, Megauli, Gunjanagar and Ayodhyapuri of Chitwan district were purposively selected for the study. The 60 households from each VDC and altogether 360 household were randomly selected. The descriptive statistics as well as trend analysis was used to study the different socio-demographic variables and climatic pattern. The integrated vulnerability assessment approach was used to assess the climate change vulnerability to the livestock holders in the study area. Annual incremental the temperature and rainfall over the past 30 years were 0.043^{0}C and 0.93 mm respectively. All of the respondents perceived about the climate change to some extent. Self-experience was sufficient (about 58 % of the respondent) to know about the climate change. The various adaptation strategy adopted by the farmer were livestock diversification livestock feed supplement, shifting to off farming activities, changing herd composition , taking credit , maintaining and enhancing genetic breed , growing fodder and storing of hay silage and improving pastures or grazing land. There were various barriers to the adaptation strategy for the households.

The major barriers were lack of information about the climate change and appropriate tools and techniques for adaptation. The own farming experience and knowledge was the major minimizing tools against the adverse climate in the study area. The Principal Component Analysis (PCA) was fitted in the integrated vulnerability approach to find out the index that was 10.99 for the study area. This results shows that the study area is less vulnerable to climate change as the adaptive capacity is high.

Key words: Adaptation, Barriers to adaptation strategy, Livestock holder, Principal Component Analysis and Vulnerability

1 INTRODUCTION

Nepal enjoys a wide variety of climate from the tropics to the alpine regions due to its topographical variability The country witnesses hot and rainy season from June to September; warm and moist cold from October to January; and dry and hot from February to May. (Mool, Bajrachaya and Joshi 2001). Agriculture is the major occupation with more than 66% of peoples involvement and contributing about 35 % of GDP (MOAD 2012) and livestock raising is the most integral part of earning livelihood and mixed farming system , these sectors are heavily affected by climate change. The changing climate affect the livestock in many ways like unavailability of pastures and enough feed, prone to heat stress due to increasing number of hot days, decreasing the availability of the water and water resources and increasing number of vector borne diseases. These all make the livestock-raising household vulnerable to climate change. At the same time, livestock production is a major contributor to greenhouse gas emissions. Therefore, livestock keepers will have to mitigate emissions as well as adapt to change. The adaptation and mitigation that are necessary may require significant changes in production technology and livestock production systems, which could affect

productivity, incomes and livelihoods. Livestock production systems are highly heterogeneous, however, and different production systems have different capacities to adapt or to take on board the policy and regulatory changes that may be required in the future. In developed countries, livestock systems are generally adaptable and resilient. In developing countries, in contrast, households that are dependent on livestock keeping maybe much more vulnerable to changes in climate and climate variability, with the potential for increased poverty and decreased food security. Mitigation is the human intervention to reduce the sources or enhances the sinks of greenhouse gases (IPCC 2007 b) and adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC 2007c). Adaptation to climate change has emerged as a challenge to achieving and sustaining the development outcomes as mitigation is not taking place as needed (Eriksen 2011). Successful adaptation reduces vulnerability to an extent that depends greatly on adaptive capacity the ability of an affected system, region, or community to cope with the impacts and risks of climate change. Enhancement of adaptive capacity can reduce vulnerability and promote sustainable development across many dimensions (IPCC 2003). For that, it is firstly essential to identify vulnerable places, communities and magnitude and aspects of livelihood vulnerability (Regmi and Adhikari 2008). Except very few qualitative vulnerability assessments, integrated vulnerability assessment has not been done yet in Nepal. Indeed, livelihood vulnerability assessment in quantitative way is very new approach in Nepal even for many organizations working in this field (Lama and Bhupendra 2009). Least developed and developing countries are more vulnerable to the climate change induced impacts and they face the great

difficulties due to the lack of proper adaptation efforts (Orindi and Eriksen 2005) . This research primarily focuses on to study an adaptation and mitigation strategy for livestock raising household vulnerable to climate change.

2. RESEARCH METHODOLOGIES

The study was conducted in the central region of inner Terai of Nepal. Chitwan district was purposively selected for the study. The study focused on vulnerable climate change for raising livestock and farming purpose in six different villages namely, Gitanagar, Patihani, Padampur, Megauli, Gunjanagar and Ayodhyapuri purposively.

Source: (CBS 2012)

Figure 1. Map of Nepal showing the study district

In each VDC, there were random selections of 60 household as a sample of study. Thus altogether, samples were 360 household. In this study both, the primary and secondary data were collected and analyzed. Fieldwork was conducted mainly through semi-structured interviews and pre-tested questionnaires using the face to face interview. Information on various aspects of climate change as perceived by the farmers' raising livestock were collected. Information regarding the farm and household characteristics, their feelings and perceived impacts as compared to the past, changes in farming practices and new adaptation strategies were collected through face-to-

face interview. The progressive farmers and local leader were interviewed with the preparation of checklist and their perceptions were collected. Information obtained from the interview was crosschecked during the FGD. Additional information on various community based adaptation strategies, difference observed in the present and past regarding the farming practices were collected through FGD. The major variables included in interview schedule were farmers' perception and their adaption strategies for livestock production. A comparative climatic pattern for last 30 years period to the present was obtained from the metrological station Rampur. The analysis was also done by making graph, pie chart, counting frequency and many other methods.

Empirical models for calculating vulnerability of climate change

The integrated assessment approach combined both socioeconomic and biophysical approaches as this study is exploratory, the selection of indicators or themes is based on the analysis of responses from local society and previous vulnerabilities, how and why they are vulnerable. Vulnerability assessment of the people to the impacts of climate change will be carried out by using Principal Component Analysis where:

$$\text{Vulnerability} = (\text{adaptive capacity}) - (\text{sensitivity} + \text{exposure})$$

Which is, $V = (wA_1+wA_2...wAn) - (wS_1+wS_2...wSn - wE_2+wE_2...wE_n)$
Where, V is vulnerability index, w is the weight for each variable,
A_1-A_n the adaptive variables, S_1-S_n sensitivity variables and
E_1-E_n exposure variables.

Here, both exposure and sensitivity will take negative signs but adaptive capacity takes positive sign.

Indexing

The intensity of problems and reasons were identified by using five point scaling technique comparing most important, somewhat important, important, and less important and least important using scores of 1.00, 0.80, 0.60, 0.40, and 0.20, respectively. The formula given below was used to find the index for intensity various problem/reasons.

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

I_{prob} = Index value for intensity of problem S_i = Scale value of i^{th} intensi
f_i = Frequency of i^{th} response N = Total number of respondent

3. RESULTS AND DISCUSSION

Description of the study area

Chitwan district is located at the central part of the country with an area of 2238.39 square kilometer ranging from 144 to 1947 m AMSL (DADO 2013). Therefore, all types of climate are prevalent in Chitwan. Annual rainfall was recorded 2666.3 mm; maximum temperature of 42.5ºC and minimum 7ºC with 83 % relative humidity (DADO 2013). The district consists of three major topographic divisions; Mahabharata hills in the north, Siwalik Hills in the south and in between lay the inner Terai valley region. The livestock holding in Chitwan district is hereunder.

Table 1. Livestock holding Chitwan District 2012/2013

S.N.	Types of livestock	Number
1	Cattle	72970
2	Buffalo	113609
3	Goat	188101
4	Sheep	3374
5	Pig	9824
6	Poultry	5406020

Source: (DLSO 2013)

Average livestock holding in the study area

The major livestock and birds reared in the study area were cow, buffalo, poultry, sheep, goats and pig. To study the total livestock holding by common unit, Livestock Unit (LSU) was used converting all the livestock species in a single unit. The aggregated LSU was calculated as explained by (Adhikari 2009). LSU = 1 (cattle) + 1.5 (buffalo) + 0.6 (pig) + 0.4 (goat/sheep) + 0.02 (poultry). Average livestock holding was 3.61 LSU with standard deviation of 1.41.

Trend of Climatological data in the study

The trend analysis showed an increase in the minimum, average and maximum temperature significantly over 35 years period with 0.077, 0.043, and 0.010 ^{0}C respectively (Figure 2). According to (Baidhya, Regmi and Shrestha 2007), the national average temperature increase in Nepal is 0.042 ^{0}C per year, which is less than the average maximum temperature in the study area. The detailed analysis (Practical Action 2009) looking over a period of 30 years (1976-2005) reports that maximum and mean temperatures are rising. This evidence is sufficient to prove that the farmers perception of hotter summer and less colder winter. The equation for temp was hereunder

$y_{maxtemp}$= 0.0103x+ 10.252 (R^2= 0.0319).....1
$y_{avegtemp}$= 0.0438x-63.043 (R^2= 0.5308).....2
$y_{mintemp}$=0.0772x-136.34 (R^2= 0.5308).....3

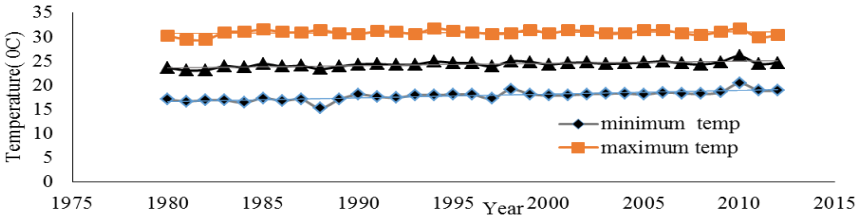

Figure 2. Trend of temperature (^{0}C) in Rampur Station (1980-2014)

Trend of rainfall in Rampur Station

It was found that there is remarkable variation in the rainfall pattern. The rainfall in 2007 was found to be highest with 228.55 mm and lowest in 1980 with 132.6 mm annually. The annual rainfall decreased from mid-eighties to mid-nineties, which then raise up to 2010 with yearly fluctuation and ultimately dropped around the same level of rainfall of 1980s' in 2012. These findings are in line with the farmers' perception about increase in drought and short and late monsoon these days. Average annual rainfall is approximately 1800 mm (GON 2010); the trend line shows that the total rainfall increased with 0.93mm per year in the Rampur station which is less than the national annual rainfall 5.17 mm.

The estimated equation of rainfall for 30 year was hereunder

$$Y_{rainfall}=0.932x-1690\ (R^2=0.098)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

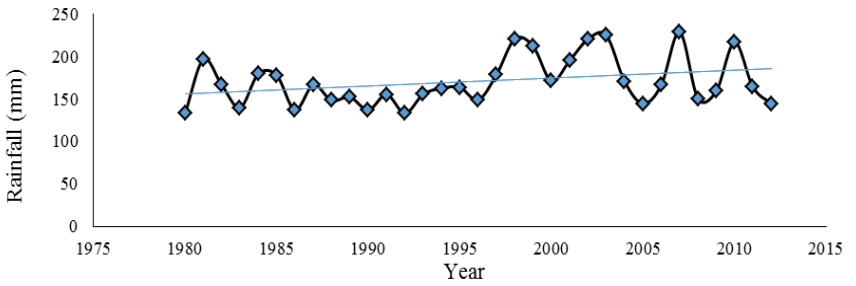

Figure 3. Trend of rainfall in (mm) in Rampur Station (1980-2014)

Farmers level of knowledge about climate change in the study area

The study revealed that, all of the respondents obtained information about climate change. It was found that about 18% were more clearly known about climate change whereas majority of people were least known (45.83%) about climate change and about 36 % were clearly known about climate change.

Table 2. Level of knowledge about the climate change in the study area

Level of knowledge	Frequency
More clearly	66(18.33)
Clearly	129(35.83)
A little bit	165(45.84)

Figures in parenthesis indicate the percentage

Source of information about climate change in the study area

It was revealed that the self experience (58.33%) was primary source of information about climate change. The newspaper and radio were equally used by population in the study area with 15.83% each. Television ,organization and neighbours or colleagues were least used as source of information about 10%.

Table 3. Source of information about the climate change in the study area

Source of information	Frequency
Self-experience	210(58.34)
Radio	57(15.83)
TV	21(5.83)
Newspaper	57(15.83)
Neighbors / colleagues	9(2.50)
Organization	6(1.67)

Figures in parenthesis indicate the percentage.

Perception about the change in various parameters related to climate and the livestock management

The study revealed that the hot weather was mostly at serious level (63.33%) in present but it was intermediate in the past (54.17%). The hailstorm was found to be equally serious and less serious by the households (32%) in present, and less serious in the past by 33.33% of household. The extent of coldness in winter was expressed as serious by 37.50% in the present days but it was felt less serious by about 31% household in past. The cloudy weather was persistent in past in comparison to present. The drought of spell in present was found to be more

pronounced than the past. The incidence of disease and pest in the present was expressed as serious (54.17%) than in the past that was less serious (53.33%). The incidence of parasite in the livestock was less serious in the past (54.17%) as compared to present which was found to be serious (43.33%). While talking about the loss of forage and pasture land, the households opined that the trend was serious (60.00%) in the present than past which was intermediate (55.83%).

Table 4. Perception about the change in various parameters related to climate and the livestock management

Change in parameter	Time	Extreme	High	Intermediate	Low	None
Hailstorm	Present	0(0.00)	84(23.33)	72(20.00)	120(33.34)	84(23.33)
	Past	13(10.83)	114(31.67)	72(20.00)	114(31.67)	28(5.83)
Hot weather	Present	66(18.33)	228(63.34)	63(17.50)	3(0.83)	0(0.00)
	Past	15(4.16)	126(35.00)	195(54.17)	24(6.67)	0(0.00)
Extreme cold	Present	36(10.00)	93(25.84)	90(25.00)	111(30.83)	30 (8.33)
	Past	72(20.00)	135(37.50)	60(16.67)	93(25.83)	0(0.00)
Cloudy weather	Present	6(1.67)	27(7.50)	138(38.33)	171(47.50)	18(5.00)
	Past	135(37.50)	117(32.50)	72(20.00)	36(10.00)	0(0.00)
Drought spell	Present	153(42.50)	156(43.33)	45(12.50)	6(1.67)	0(0.00)
	Past	0(0.00)	6(1.67)	102(28.33)	204(56.67)	48(13.33)
Disease pest incidence	Present	99(27.50)	195(54.17)	57(15.83)	9(2.50)	0 (0.00)
	Past	6(1.67)	9(2.50)	111(30.83)	192(53.33)	42(11.67)
Parasite in livestock	Present	120(33.33)	156(43.33)	84(23.34)	0 (0.00)	0 (0.00)
	Past	0 (0.00)	3(0.83)	99 (27.50)	195(54.17)	63(17.50)
Grassland and forage loss	Present	102(28.33)	216(60.00)	39 (10.84)	3(0.83)	0 (0.00)
	Past	3 (0.83)	102(28.33)	201(55.84)	51(14.17)	3(0.83)

Figures in parenthesis indicate the percentage.

Sectors affected by climate change

The study revealed that the climate change had serious impact in the various sectors. The majority of the affected sector was crops, livestock and fish farming about 66% and 29% respectively. According to respondent the fruits and vegetables production was least affected by climate change (5%).

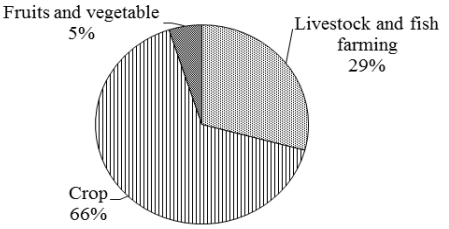

Figure 4. Climate change severely affected sectors

Perception of respondent on change in livestock performance

Infertility in livestock

The study related to infertility status was found to be higher in all the livestock. More than 50% of the respondent expressed that infertility problem is ever increasing. Less than a half of the respondent expressed that they had not yet noticed the infertility in the livestock but surprisingly, less than 10% of the respondent said that infertility is decreased due to climate change in cattle and goat.

Table 5. Perception about the livestock infertility by household in study area.

Livestock	Increased	Decreased	Don't Know
Buffalo	312(86.67)	0 (0.00)	48 (13.33)
Cattle	204 (56.67)	30 (8.33)	126(35.00)
Goat	192 (53.33)	12 (3.33)	159(44.17)

Figures in parenthesis indicate the percentage

Perception about production performance of livestock

From the study, the respondent perceived that production performance sharply decreased in buffalo (80.00%) and cattle (61.67%). However, many households were still unknown about the impact of climate change in production performance. Only few of the respondent said that the climate change increased production performance in buffalo (6.67%) ,cattle (3.33%) , goat (24.17%) and poultry (15.83%). More than 84% of the households said that they were not known about climate change

impact in the poultry production as only few households had reared the poultry for the household and commercial purpose.

Table 6. Respondent Perception towards production performance of different livestock

Livestock	Increased	Decreased	Don't Know
Buffalo	6 (6.67)	288(80.00)	48 (13.33)
Cattle	36(3.33)	232(61.67)	126(35.00)
Goat	87(24.17)	114(31.66)	159(44.17)
Poultry	57(15.83)	0 (0.00)	303(84.17)

Figures in parenthesis indicate the percentage

Reasons for declining livestock performance

The primary cause leading to decline in the livestock performance were heat stress (87.50%), fodder and grazing land unavailability (94.17%), high disease prevalence (90.83%) and decrease in labor force (66.67%) whereas lack of market (36.67%) and water shortage (31.67%) were less responsible for the decline.

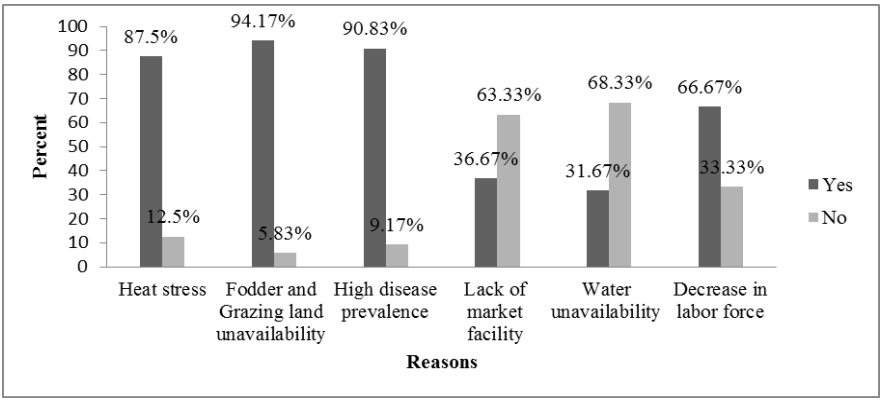

Figure 5. Reasons for declining the livestock performance

Various adaptation strategy adopted by farmer in the study area

The adaptation strategies were not adopted by the entire household due to various reasons. It was found that 35% of households had the barrier to adaptation whereas 65% of households had followed various adaptation strategies.

Adaptation strategies followed in the study area

The various adaptation strategies were adopted in the study area. Livestock diversification (93.59%) was the most adopted adaptation strategy among all the strategy. The livestock feed supplement, changing herd composition, and taking credit was adopted almost equally (about 59%). Shifting the livestock farming to other off farm activities were adopted by almost half of the adopters. About 43% of the households grew fodder and stored the hay silage, improved pastures or grazing land and maintained and enhanced genetic breed as adaptation strategies. The various adaptation strategy followed are shown in Table 8.

Table 7. Various adaptation strategies followed in the study area (n=234)

Adaptation strategies	Frequency
Livestock diversification	219(93.59)
Livestock feed supplement	174(74.36)
Shifting from livestock farming to off farming activities	144(61.54)
Changing herd composition	168(71.79)
Taking credit	180(76.92)
Maintaining and enhancing genetic breed	120(51.28)
Improving pastures or grazing land	126(53.85)
Growing fodder and storing of hay silage	132(56.41)

Figures in parenthesis indicate the percentage

Barriers to adaptation strategy

The households expressed that they had various barrier to adaptation to climate change. Majority of respondent strongly agreed that lack of information was one of the prime causes to adapt against climate change. Poor access to water and unwillingness (i.e. no barrier to adaptation) almost equally were barrier to the adaptation. Lack of the credit and the technology remained least barrier to cope against the adverse climate change.

Table 8. Various barriers against the adaptation strategy

Reasons	Index	Rank
Lack of information about climate change	0.69	I
Lack of knowledge concerning appropriate adaptation	0.59	II
Lack of credit or poverty	0.56	III
No barrier to adaptation	0.55	IV
Poor market and transport facility	0.53	V
Lack of technology	0.46	VI
No access to water	0.41	VII

Source of techniques to minimize the adverse impact of climate change in the study area

The primary source of effect of the technique to minimize the adverse effect of climate change were own knowledge and farming experimenting for about 47% households. The other sources of the techniques were from the other farmer and neighbor (16.7%), media (15%), and training and education (14.2%). The contribution from developmental organization and agriculture and livestock service center in the adaptation to adverse climate was least with 4.2, and 3.3 percent respectively.

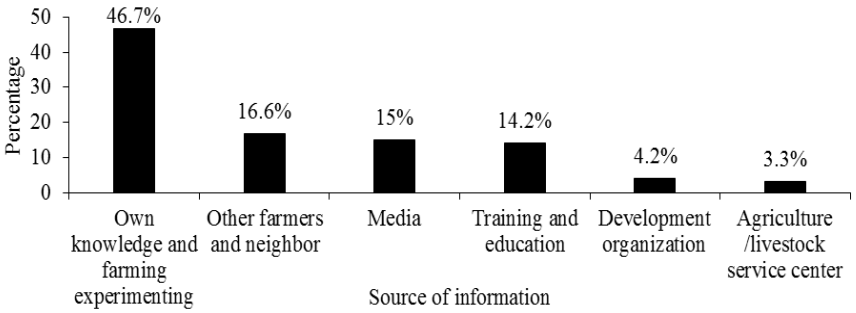

Figure 6. Source of techniques to minimize the adverse impact of climate change in the study area

Assessment of the climate change vulnerability in the study area

The vulnerability was calculated using the integrated vulnerability assessment approach. The Principal Component

Analysis (PCA) calculated using SPSS showed that ten components with Eigen Value 1 or greater accounted the 66.75 percent of the total variance. The first component had the Eigen Value of 2.83 with variance of 11.82 percent followed by second component with Eigen Value 2.15 and total variances of 8.97 percent. Similarly, other components are shown in the table 9.

The vulnerability index of the study area was found to be 10.99, which implies that the study area was less vulnerable. The similar result was found in the tropical region of Nepal with vulnerability index of 8.1. The tropical region are found to be less vulnerable to climate change as the households have high literacy rate, more income source and earning and hi tech technology and proper access to infrastructure. The populations in the tropical area have better employment and earning off farm income. This expansion of the economic undertakings and access to the infrastructure technology make the households less dependent in the livestock that is more sensitive to climate change. The least occurrence of the drought and floods and no presence of the landslides lead to less vulnerability. The provisions of the more adaptive factors are responsible for reduction of vulnerability (Dhakal, et al. 2013).

Table 9. Principal component score of the variable used for the vulnerability

Indicators	Score	Types of variables
Social background of the household	0.49	Adaptive capacity
Family type	0.62	Adaptive capacity
Education status of household	0.77	Adaptive capacity
Primary (major) occupation	0.67	Adaptive capacity
Total cultivated land	0.65	Adaptive capacity
Land ownership	0.64	Adaptive capacity
Radio	0.62	Adaptive capacity
Television	0.66	Adaptive capacity
Bus truck vehicle	0.66	Adaptive capacity
Toilet	0.80	Adaptive capacity
LPG stoves	0.65	Adaptive capacity
Monthly expenditure	0.47	Adaptive capacity
Source and technique minimize climate change effect	0.67	Adaptive capacity
Member organization	0.79	Adaptive capacity

Indicators	Score	Types of variables
Training on agriculture and livestock management	0.78	Adaptive capacity
Access to subsidy	0.59	Adaptive capacity
LSU	0.71	Adaptive capacity
Years of schooling	0.85	Adaptive capacity
Types of household	0.71	Adaptive capacity
Information source about climate change	0.70	Adaptive capacity
Barrier to adaptation	0.61	Sensitivity
Flood	0.56	Exposure
Temperature	0.66	Sensitivity
Rainfall	0.68	Sensitivity
Vulnerability index	10.99	

CONCLUSION

Based upon the study about vulnerability to the climate change for the livestock raising households, the following conclusions were made. Most of the households perceived the change in climate at present in terms of change in rainfall pattern, duration, and change in summer and winter temperature in terms of hotness and coldness. The performance of the livestock decreased due to climate change promoting the heat stress, high incidence of the disease and the pest, loss of biodiversity and the pastureland, infertility, etc. The various adaptation strategy were adopted against the adverse climate change like farm diversification, shifting to the off farm activities, maintaining the improved genetic breed, improving the feed quality and institutional management and training. There were various barriers for the adoption adaptation strategy like lack of information and the appropriate technology, training, the poverty, transport and market facility and water shortage. The various variables like asset possessions, income and saving, training, schooling, and social background were principal component of the adaptive capacity while the extreme variables were barrier to adaptation, flood, and rainfall and temperature pattern.

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