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Livelihood Vulnerability to Climate Change based on Agro Ecological Regions of Nepal

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I. Introduction

Nepal, with a population of 26.6 million (CBS, 2011) the world's fourth most vulnerable country to climate change due to the fragile ecosystem, which is very sensitive to even slight changes in natural climate, weaker geological situation and complex topography (Maplecroft, 2011). 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). Around 87 percent of the country's total population keeps some form of livestock at home (IRIN, 2013). Although, Nepal has one of the highest ratios of livestock and poultry to humans (5.8 animals per household) in Asia, the country's livestock sector is declining (IRIN, 2013). 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).

The Intergovernmental Panel on Climate Change (IPCC, 2007) suggests that within the agricultural sector livestock are among the most climate sensitive economic areas. Studies on livestock and climate change revealed that climate change adversely affects the animal health and livestock production. 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 poor livestock performance and an increased incidence of animal diseases. These effects will be felt mostly by the smallholder and subsistence livestock holders' of developing countries are the most vulnerable to livelihood from the effects of climate change (Stern, 2006; Heltberg, 2009) because of lack of resources, knowledge, veterinarian extension services and research technology development (FAO, 2008). This indicates that the livestock sector is the most vulnerable to any adverse impacts of climate variability and extreme events that might result from climate change.

According to the IPCC (2007), vulnerability is defined as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. According to Raut (2006), the most vulnerable ecological and socio-economic systems are those with the greatest sensitivity to climate change and the least ability to adapt. Nepal's major natural resources, biodiversity and water, are at the forefront of climate vulnerability. Moreover, Nepal posses less coping and adaptive capacity to address the additional impacts of climate change.

There is increasing important to understand the likely impacts of climate change on livestock production and their vulnerability. The degree of vulnerability to climate change among the different groups of people is different based upon agro ecological regions. It was necessary to identify likely hotspots that were already vulnerable and that are likely to suffer substantial

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impacts as a result of climate change. In this backdrop, this study aims on the assessment of livestock vulnerability to climate change based on agro ecosystem elevation, along with other relevant biophysical and social factors and possible adaptation measures.

II. Research Methodology

a) Study sites, sampling, data collection

The Gandaki River Basin (GRB), Nepal spreads from 27.21'45" to 28036'36" degree north longitude to 83008'00"- 84053'00" 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 °C in Mustang to 42.5°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). 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 to December 2012.

Fig.1 : Shaded regions showing study area in Gandaki River Basin, Nepal. 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 regions (1000-2000 Masl) from Myagdi District and cool temperate region (2000-3000 Masl) from Mustang District

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.

b) Integrated vulnerability assessment

Livestock based livelihood vulnerability to climate change in the study areas was accessed by an integrated vulnerability assessment approach. The integrated vulnerability approach is superior over other approaches and is particularly useful for policy decision making (Deressa et al., 2008). Integrated vulnerability approach comprises socioeconomic and biophysical indicators of vulnerability and classified these indicators into adaptive capacity, sensitivity, and exposure. The data on adaptive capacity and sensitivity were obtained from primary and secondary sources of data while dichotomous variables namely river flooding, landslide and drought on climate extremes captured exposure. Principal Component Analysis (PCA) was performed to compute the component score to weigh the variables to calculate the vulnerability indices. The purpose of using weights obtained from the PCA is to avoid the uncertainty of unequal weighting, given the diversity of indicators used (Deressa et al., 2008). Vulnerability was calculated as defined by IPCC (2001).

Vulnerability= Adaptive capacity - Sensitivity - Exposure……1.1

Equation 1.1 can be expressed as follows:

$$V_k = \sum_{i=1}^{n} W_{ki}.X_{ki} - \left(\sum_{i=1}^{n} W_{ki}Y_{ki} + \sum_{i=1}^{n} W_{ki}Z_{ki} \right) \ldots 1.2$$

Where

i = 1, 2, 3, … n Households

k=1, 2, 3, and 4, representing ecological regions

V_k =Vulnerability index for kth region

W_{ki} =Weight obtained from first principal component scores of i^{th} variable for k^{th} region

X_{ki} = Adaptive i^{th} for k^{th} region

Y_{ki} = Sensitivity i^{th} for k^{th} region

Z_{ki} = Exposure i^{th} for k^{th} region

While calculating the direction of relationship in vulnerability indicators (i.e., their sign), negative value was assigned to both exposure and sensitivity. The justification is that areas that are highly exposed to damaging climate are more sensitive to damages, assuming constant adaptive capacity (Deressa et al.,

2008). The implication is that a higher net value indicates lesser vulnerability and vice versa (Madu, 2012).

III. Results and Discussion

a) Livestock Holding

Livestock is an important asset on which livelihood of majority people hinged on. Livestock holding depicts the picture about farmers' economic condition and it also gives the idea about the total farm yard manure availability in the households. Selected household were observed to raise various kind of livestock species in different number especially Chauri, Chyangra, cattle, buffalo, pig, goat, sheep and poultry.

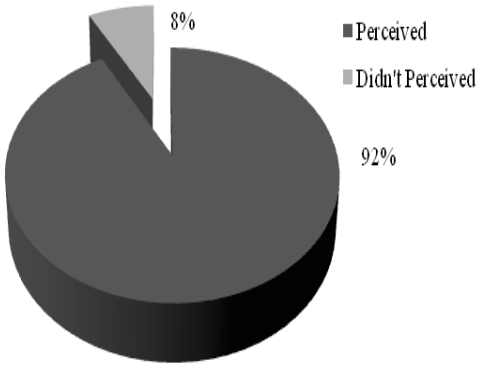
Table 1 : Livestock holding of respondents across the regions

	Agro Ecological Regions					χ^2
	Tropical	Subtropical	Warm Temperate	Cool Temperate	Total Mean	
LSU	54.07	22.25	8.12	18.82	25.81	
S. E.(±)	19.76	7.74	0.94	5.16	5.54	

b) Perception to climate change

Change in the weather parameters is important factor that determine the farmer's perception about climate change. Nearly all of the respondents (92%) had observed the deviation of weather parameters like variation in rainfall, temperature, humidity and snowfall (Figure 2).

The average livestock holding was 25.81 Livestock Standard Unit (LSU)[1]. Livestock holding was greater in tropical (54.07 LSU) among the agro ecological zones under study while least livestock holding was found in warm temperate (8.12 LSU) (Table 1). The highest LSU in tropical may be due to large number of poultry in cluster production and commercial cow production and Chitwan is emerging as the commercial pocket area for livestock sector and contributed more in the household annual income. There was significant differences ($\chi 2 = 7.27$, $P > 0.1$) in the distribution of LSU in households across all agro ecological regions.



Source: Field Survey, 2012

Fig. 2 : Livestock holders'perception of climate change in the study area

Similarly, study revealed that nearly 73.0% of respondents perceived the increase in temperature. According to findings, 10.8% respondent didn't observe any change in the temperature while 3.3 % realized the decrease in temperature (Table 1). The result also showed the decreased and erratic rainfall trend in both summer and winter monsoon in the recent years. More than half of the respondents opined the decreased winter monsoon. Delayed initiation of summer monsoon has noticed as in the case of winter monsoon but quite unpredictable onset of winter monsoon was experienced.

[1] LSU= 1 (Cow/Bull) + 1.5 (Buffalo) + 0.4 (Goat/Sheep) + 0.6 (Swine/Pig) + 0.2 (Poultry)

Table 2 : Perception of respondents towards temperature across the regions

Temperature	Agro Ecological Regions					χ^2
	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)	
Rainfall						
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)	

Source : Field Survey, 2012

*Indicates significant at 10 percent level of significance.
Figure in the parenthesis indicates percentage.

c) *Livestock holders' vulnerability*

The result of statistical description and classification of variable indicate (refer Table 3 and Appendix 1) that the socio-economic characteristics vary widely within the agro ecological regions with the highest being recorded for electricity, toilet, mobile or cell phone, and television, radio, access to road, access to market, access to credit, saving, and member of organization. The variation in the adaptive variables is remarkable. The adaptive capacity variables were categorized in to two groups, household assets; social services and facilities. Average number of household assets possessed by the sampled respondents in the tropical was highest (12.07), followed by subtropical (8.82) and least in the warm temperate (8.00). The F value indicated that the distribution was more heterogeneous and they were significant ($P<0.01$). There was more disparity in the ownership of assets. Analysis of access to the services and facilities indicated that sampled respondents in the tropical had more access to these services with the mean of 7.68 followed by the subtropical (7.050) and least in the warm temperate region (5.00). Similarly, there was high variation in the exposure variables like drought, flood and landslide within the agro ecological regions. The mean of drought, flood and landslide, being all of these variables Binary, indicated that cool temperate region was found more exposed followed by the warm temperate while tropical zone was least exposed to these climatic extreme events. Moreover, sensitivity variables in the study area included annual temperature variation and annual rainfall variability.

Table 3 : Summary of assets, services exposure and sensitivity variables across the regions

Agro ecological regions						
Variables	Tropical	Subtropical	Warm temperate	Cool temperate	Total	F- value
Total assets	12.07	8.82	8.00	8.25	9.28	24.072***
Services	7.68	7.05	5.00	5.40	6.28	30.574***
Exposure	0.03	0.40	0.92	1.02	0.59	27.765***
Rainfall	170.39	129.86	129.86	33.46	117.4	130.080***
Temperature	24.35	19.25	19.25	10.98	18.52	98.932***

Source : Field Survey, 2012

*** Significant at 1 percent level of significance

Analysis of annual temperature range showed that warm temperature (Beni Bazar station) had experienced the highest range of 24.50 percent while lowest annual range of 2.60 percent was recorded in tropical (Rampur station). Analysis of annual rainfall variation showed that the coefficient of variation of 26.04 percent in the annual rainfall was highest in the warm and subtropical (Beni Bazar station) while lowest variation was found in the tropical.

The result of Principle Component Analysis (PCA) showed that nine components with the Eigen value of 1 or greater accounting for 67.85 percent of total variance. The first component had an Eigen value of 6.06 and accounted for 21.66 percent followed by the second component with an Eigen value of 2.71 and percent explanation was of 9.91. The analysis also revealed that the components scores as earlier stated only the component score of the first component were used in weighing the variables for the construction of vulnerability indices. The components score are shown in the Appendix 2.

Table 4 : Vulnerability indices across the regions

Agro Ecological Regions	Vulnerability Index
Tropical	8.11
Subtropical	5.62
Warm temperate	3.29
Cool temperate	3.62

The calculation of vulnerability indices showed that all agro ecological regions had positive values implying that they were less vulnerable. However, some regions were in better position to withstand climate change than others. Accordingly, tropical, subtropical, cool temperate and warm temperate region with the indices of 8.1, 5.62, 3.62, 3.29 respectively in the order of increasing vulnerability (Table 4). It could be concluded that warm temperate by its least indices was most vulnerable while tropical region with highest indices indicates less vulnerable to climate change. According to the GIEC report (2007), mountain ecosystems are considered extremely vulnerable to climate change.

Tropical region experienced low vulnerability to climate change because the rural households have high literacy rate, high household income, and have more access to infrastructure and technology. They are characterized by the high degree of nonfarm employment. The diversification of economic activities and access to the infrastructure technology make the household less reliant on livestock which is more sensitive to climate change. It should also be noted that although drought occasionally occurs, flood rarely occurs and landslide hasn't noticed in this region. Temperature variation and rainfall variability was least over last thirty one years and all these explain why tropical is experiencing low vulnerability. A major reason for high vulnerability of the warm temperate region is the low level of technology and infrastructure development. There is also higher incidence of poverty in more vulnerable region. The high degree of vulnerability in the warm temperate region can in addition be explained by the higher variation in the annual rainfall and temperature variation and more frequent occurrence of occurrence of floods and landslides.

IV. Conclusion

Most of livestock keepers had observed the variation on weather patterns and experienced increased temperature, decreased but erratic precipitation and delayed summer monsoon. The result revealed that highly impoverished livestock keepers from the fragile mountain with limited access to basic services, wealth and assets, are most vulnerable to extreme climatic events than those with better access to services and wealth.

Policies should focus on: the investment on basic services; the inception of livestock insurance, provision of agroecology based technology package to enhance their specific adaptation potential; the strengthening of productive safety net programs through the involvement of governmental and Non Governmental organization. Tackling the problem of vulnerability to climate change among the regions in the Nepal which from the differences in a number of physical and socioeconomic factors requires climate change adaptation policies that implemented within the framework of integrated rural development specially focusing on,

a. Creation of off farm employment opportunities.
b. Provision of credit, training and extension exposure opportunities and climate information.
c. Establishment of cooperatives and agricultural group in the rural areas.
d. Tackling the climate induced hazards like floods, drought and landslide.
e. Water harvest scheme.
f. Rural poverty alleviation program.
g. Income diversification.
h. Improvement in farming practices.

V. Acknowledgement

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Appendix 1 : Description of variables used in vulnerability assessment through PCA

Variables	Tropical	Subtropical	Warm temperate	Cool temperate	Total	F-Value
Upper caste	0.92	0.68	0.10	0.03	0.43	107.52***
Radio	0.70	0.60	0.70	0.60	0.65	0.87
TV	0.92	0.82	0.57	0.60	0.73	9.48***
Mobile	1.00	0.93	0.87	0.83	0.91	4.07***
Cycle	0.97	0.15	0.02	0.03	0.29	233.37***
Computer	0.32	0.25	0.02	0.02	0.15	13.21***
Toilet	0.98	0.97	0.85	0.92	0.93	3.354**
Organization	0.57	0.63	0.28	0.48	0.49	5.84***
Access to credit	0.78	0.92	0.72	0.63	0.76	4.96***
Saving	0.45	0.72	0.48	0.50	0.54	3.65**
100 LSU	0.54	0.22	0.08	0.19	0.26	3..27**
Off farm income	0.15	0.07	0.02	0.15	0.10	1.50
Total income	0.32	0.29	0.12	0.28	0.25	2.59*
Economically active members	4.18	3.63	3.82	3.55	3.80	1.44
Food sufficient	0.93	0.17	0.25	0.53	0.47	44.31***
Land	0.97	0.98	0.92	0.88	0.94	2.18*
Access to road	0.95	0.98	0.75	0.73	0.85	9.03***
Access to market	0.80	0.78	0.72	0.68	0.75	0.95
Access to agrovet	0.27	0.12	0.02	0.00	0.10	11.22***
Educated family	3.37	3.43	1.90	1.78	2.62	10.98***
Quality of house	0.38	0.02	0.07	0.07	0.13	17.72***
Cooking source	0.85	0.33	0.20	0.28	0.42	28.63***

Literacy rate	0.90	0.82	0.68	0.70	0.78	1.85
Rainfall	0.17	0.26	0.26	0.18	0.49	130.08***
Temperature	0.03	0.25	0.25	0.07	0.32	98.93***
Drought	0.03	0.07	0.03	0.17	0.08	3.54**
Flood	0.00	0.15	0.30	0.33	0.20	9.86***
Landslide	0.00	0.18	0.58	0.52	0.32	28.05***

***,** and * Indicate significant at 1, 5 and 10 percent level of significance.

Appendix 2 : Component scores of coefficient for component first through PCA

Indicators	Types of variables	Component scores
Higher caste	Adaptive capacity	0.742
Ownership of radio	Adaptive capacity	0.247
Ownership of TV	Adaptive capacity	0.471
Ownership of cell phone/telephone	Adaptive capacity	0.279
Ownership of cycle	Adaptive capacity	0.761
Ownership of Computer	Adaptive capacity	0.641
Ownership of Toilet	Adaptive capacity	0.265
Member of organization	Adaptive capacity	0.159
Access to credit	Adaptive capacity	0.128
Saving	Adaptive capacity	0.051
Livestock standard unit (100 LSU)	Adaptive capacity	0.375
Off farm income in NRs	Adaptive capacity	0.443
Total income in NRs	Adaptive capacity	0.445
Economically active family members	Adaptive capacity	0.242
Food sufficient	Adaptive capacity	0.442
Ownership of land	Adaptive capacity	0.301
Access to road	Adaptive capacity	0.341
Access to market	Adaptive capacity	0.186
Access to agrovet	Adaptive capacity	0.560
Educated family member	Adaptive capacity	0.512
Quality of house	Adaptive capacity	0.447
Improved cooking source	Adaptive capacity	0.642
Literacy rate	Adaptive capacity	0.108
Rainfall variability	Sensitivity	0.707
Temperature variation	Sensitivity	0.700
Drought	Exposure	-0.390
Flood	Exposure	-0.610
Landslide	Exposure	-0.555

Extraction method: Principal component analysis. Nine components were extracted
Rotation method: Varimax with Kaiser Normalization.