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Determinants of Livestock Holders' Adaptive Capacity to Climate Change in Gandaki River Basin, Nepal

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Abstract

A study was focused to assess the determinants of livestock holders' adaptive capacity to climate change using logistic regression model based in four agro ecological regions of Gandaki River Basin, Nepal. Altogether 240 households, 60 from each agro ecological zone, were selected using stratified random sampling. Primary data were collected by household survey using semi-structured and pre tested questionnaire. A majority of respondents observed the deviation in weather parameters. Nearly half of livestock keepers adapted different adaptation measures that comprised integrated farming, adopted 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. Farming experience, education, training, saving, access to credit, access to road and market, cool temperate, climate information, exposed to extremities, member organization had significant and positive impact on adaptation decision. The awareness creating activities, like education, training, and creation of off farm employment is recommended to strengthen the adaptive capacity of livestock holders.

Key words: Climate change, logistic regression, adaptation strategies, adaptive capacity, Nepal

1. Introduction

Livestock is an integral part of the mixed farming system and socio-economical life in the country, and contributes nearly 26 % to the total Agricultural Gross Domestic Product (MOAD, 2012). Livestock serve many purposes for small farmers in Nepal, supplying meat, milk, eggs, leather, wool, draft power, and manure, among other benefits. 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, 2007). The Intergovernmental Panel on Climate Change (IPCC, 2007) suggests that within the agricultural sector livestock are among the most climate sensitive economic areas. 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). Studies on livestock and climate change revealed that climate change adversely affects the animal health and livestock production. Climate hazards are leading contributors to livestock losses, directly (e.g. animals lost in floods) or indirectly (e.g. loss of feed and fodder crops due to floods or drought resulting in slow growth and vulnerability to disease) (Sharma, 2009). However, appropriate mechanisms for coping and adapting to adverse effects in the livestock sector are weak or lacking.

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. Determinants of adaptive capacity were studied by various scientists al around the world. Off farm employment may present the constraint to the adaptation of technology and because it competes for on farm managerial time (McNamara *et al*., 1991). Tizale (2009) argue that with the large family size there is a possibility that many family members may be forced to divert part of the labor force to off-farm activities in an attempt to earn income to ease the consumption pressure imposed by a large family size. Deressa *et al.* (2009) and Maddison (2006) in Africa also reported that provision of extension facilities and training on crop and livestock increases the probability of practicing different adaptation strategies by farmers. Access to extension services is positively related to adoption of new technologies by exposing farmers to new information and technical skills (Adesina and Forson 1995). Access to extension services increases the likelihood of perceiving changes in climate as well as the likelihood of adaptation (Gbetibouo, 2009). Deressa *et al*. (2009) reported that increase in years of schooling would result in increase in the probability of the adaptation measures. Level of education higher level of education is often hypothesized to increase the probability of adopting new technologies (Daberkow and McBride, 2003). Access to credit has a positive and significant impact on the likelihood of adaptation measures (Caviglia-Harris 2002; Deressa, 2009; Gbetibouo, 2009). Research on adoption of agricultural technologies indicates that there is a positive relation-ship between the level of adoption and the availability of credit (Yirga, 2007; Pattanayak *et al*., 2003). Gbetibouo (2009) and Deressa *et al*. (2009) supported that increase in annual household cash earnings increases the probability of adaptation. Deressa *et al*. (2009) also reported that information on temperature and rainfall has a significant and positive impact on probability of using different adaptation measures. Various studies in developing countries reported that a strong positive relationship between access to information and the adoption behavior of farmers (Yirga, 2007), and that access to information through extension increases the likelihood of adapting to climate change (Maddison, 2006; Nhemachena and Hassan, 2007). Studies by Maddison (2006); Nhemachena and Hassan (2007); and Gbetibouo (2009) indicated that experience in farming increases the probability of uptake of adaptation measures to climate change. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison, 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). With this back drop, the major objective of the study was to determine the local individual and community based adaptation strategies followed by livestock holders' to climate change, and examine the relationship of socio demographic variables with climate change in Gandaki River Basin, Nepal. Specifically, the research based to determine the adaptive capacity of livestock holders', barriers to adaptation and make the necessary policy recommendations as well.

2. Research Methodology

2.1. 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 (south - Chitwan) to 8167 masl (Dhaulagiri Himal of Myagdi) (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 ^oC in Mustang to 42.5^oC 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. 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.

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, major climatic hazards, 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.

2.2. Data management and analysis

The socioeconomic and household characteristics were analyzed by descriptive analysis. Logistic regression model was used for the identifcation of determinants of adaptive capacity of livestock holders in various ecological zones. Maddison (2006), Seo and Mendelsohn (2008) and Hassan and Nhemachena (2008) studied the impact of climate change and factors affecting the adaptation measures in livestock and mixed crop livestock production.There were several factors that affect for the practicing different adaptation strategies in the farm level. Decision to practice different adaptation strategies might be influenced by several socioeconomic, demographic, institutional and financial conditions (Deressa *et al*., 2009; Regmi, 2010). The livestock holders' used to practice various adaptation measures (Table 1). The probability of adopting adaptation strategies was expressed as,

$$P(Y_i = 1) = P_i = \frac{1}{1+exp^{-z}} \quad \ldots\ldots 1$$

This can be operationalized as,

$$Logit \quad P\left(Y_i^*\right) = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i \ldots\ldots 2$$

Logit $(Y_i^* = \text{Adopt} = 1) = \gamma' K + \varepsilon_i$

Thus, the binary logit regression model was expressed as;

$$Y(Adopt = 1) = \beta_0 + \beta_1.sexhh_i + \beta_2.agehh_i + \beta_3.familysie_i + \beta_4.landarea_i + \beta_5.member\_org_i + \beta_6.training_i + \beta_7.caste_i + \beta_8.eduhh_i + \beta_8.credit_i + \beta_{10}\ saving_i + \beta_{11}extreme_i + \beta_{12}info\_climate_i + \beta_{13}farming\_exp_i + \beta_{14}road + \beta_{15}region\,1_i + \beta_{16}region\,2_i + \beta_{17}region\,3_i + \varepsilon_i \ldots\ldots 3$$

$Y_i^* =$ a latent variable representing the propensity of a farm household i to adopt adaptation strategy (1 if farmer adopt, and 0 otherwise)

β_0 = a constant term

X_i = K= the vector of farm households' assets endowments, household characteristics and location variable that influence the adoption decision (Set of variables explaining the adoption decision including respondent's perception on climate change, rainfall and exposure)

β_i = parameters to be estimated.

Exp ($ß_i$) indicates the odd ratio for a household having characteristics i versus not having i

ε_i = error term of the i^{th} farm households

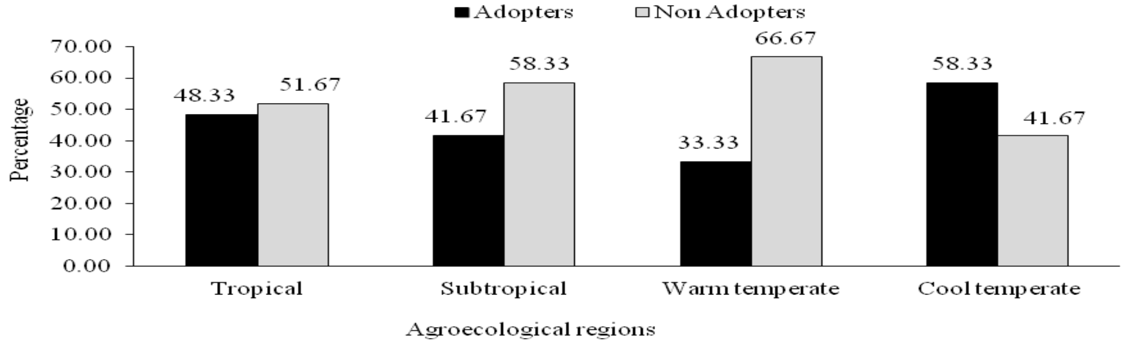
i = 1, 2, 3, … n farm households.

3. Results and Discussion

3.2. Decision on adaptation strategies

Societies are dynamic and they use all possible strategies to reduce the vulnerability to climate change impacts. Coping mechanism are the actual responses to negative impact of climate change on livestock system in the face of unwelcome situations, are considered as the short term responses (Berkes & Jolly, 2001). The respondents reported a diversity of coping strategies that included both modern and traditional methods. Those who responded that they have adapted to climate change indicate different adaptation strategies. It was found (Figure 1) that 45.41 % of sampled households had adopted coping mechanism to reduce the negative impact of climate change on livestock production.

Fig-1. Respondents adopting adaptation strategies across the regions in the study area



It is evident that (Table 1) integrated farming (multiple cropping mixed with livestock rearing) under changing climatic conditions was the most commonly used method (33.8 %) in the study area. Integrated farming system was found as the main coping strategies in the subtropical (38.3 %), and warm temperate (28.3 %) 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 control the 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 strategies in the cool temperate region (53.3%). Expansion and depending on veterinary and livestock services was the third best adaptation strategy (24.2 %) in the study area. It was the best adaption strategy (38.3 %) in the tropical zone.

Table-1. Adaptation strategies practiced by livestock holders against the climate change

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 harvest	15 (25.00)	5 (8.33)	4 (6.66)	5 (8.33)	29 (12.08)

Figures in the parentheses indicate %age The sum of %age figures is not hundred

3.3. Determinants of adaptive capacity of livestock holders

The result from logistic regression model is shown in Table 2. The likelihood ratio statistics was highly significant (LR chi^2 (18) =250.60 with P<0.01). The Pseudo R^2= 0.782 the overall predictive power of the model (91.76 %) and explanatory power (63.64 %) were found high. The goodness of fit test as defined by Pearson Chi^2 (222) was 93.22, value indicating good adequacy and fitted data. Margins, derived from partial derivatives as a marginal probability, were calculated after running binary logistic model to get actual probability on adoption Table 2 (Appendix 1 for details of the STATA commands).

The result from logistic regression analysis indicates that most of the explanatory variables affect the probability of adaptation as it was expected, expect family size. Among the seventeen variables, eleven variables were found significant on adoption decision. Farming experience (P<0.01), education (P<0.01), training (P<0.01), saving(P<0.01), access to credit (P<0.01), access to road and market (P<0.1), cool temperate (P<0.1) climate information (P<0.01), exposed to extremities (P<0.01), member organization (P<0.1) had significantly and positively determined the adaptive capacity of livestock holders, where as family size (P<0.01) was negative and significant factor (Table 2).

The study revealed that a unit increase in education year and farming experience of the household there would be 6.8 % and 1.5 % increase in the likelihood of adoption of adaptation measure. Similarly, being upper caste, member of organization, cool temperate livestock keepers, the probability of adaptation increases by 2.4 %, 13 %, 46.7 % Ceterus Peribus. Similarly having access to credit, climate information, road, exposure to climatic hazards, having saving, the likelihood of adaptation increases by 24.9 %, 92.3 %, 10.7 %, 13.8 %, 38.3 % respectively. On the other hand, with the one unit increase in the family member the likelihood of adaptation decreases by 2.9 %.

Table-2. Determinants of livestock holders' adaptive capacity to climate change

Variables	Coefficients	Robust S E	dy/dx [b]
Sex	0.141	0.956	0.010
Age	-0.038	0.028	-0.002
Family size	-0.383**	0.181	-0.029**
Land holding size	0.063	0.841	0.005
Member_Org	1.624*	0.859	0.130*
Training	2.728***	0.993	0.404***
Caste	0.310	1.099	0.024
Education	0.905**	0.439	0.068**
Credit	5.536***	1.865	0.249***
Saving	4.273***	0.975	0.383***
Exposure_extremities	1.607**	0.804	0.138**
Climatic Information	6.437***	2.504	0.923***
Farming experience	0.192***	0.041	0.015***
Road	2.600*	1.521	0.107*
Cool temperate	3.249*	1.799	0.467*
Warm temperate	1.403	1.636	0.144
Subtropical	1.901	1.324	0.218
Constant	-17.289***	4.58	

Summary statistics of logistic model

Number of observation	=	240
LR Chi^2 (18)	=	250.60*** (Prob> Chi^2 =0.000)
Pseudo R^2	=	0.782
Goodness of fit test	=	Pearson chi^2 (222) =93.22 Prob> chi^2=1.00
Overall area under ROC curve	=	0.986

***, ** and * Indicate significant at 1 %, 5 % and 10 level respectively.

3.4. Barriers to adaptation

Around 55.0 % 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 3).

Table-3. 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 %age The sum of %age figures is not hundred

4. Conclusion

Livestock system was the main source of income in the GRB of Nepal. 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. 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, knowledge, technology, money, market access, and institutional arrangement, were the major barriers to adaptation. The study indicated that member of organization, training, education, credit, saving, exposure to extreme events, climatic information, farming experience, access to road, and cool temperate were determinants of adaptive capacity. Government policies should enable farmers have access to extension services adequately as a lack of climate information has been indicated as a barrier to adaptation to climate change. The public extension service needs to train and employ qualified citizens to fill the extension need gap. 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. Policies strengthening the existing adaptation practiced by livestock holders at the household level such as integrated farming, establishment of cooperative and microfinance, establishment of livestock services centre and veterinary and improved varieties of forage and fodder is recommended to counteract adverse impacts to climate variability and change in the livestock sector of Nepal.

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APPENDIX

Appendix-1. Result from the logistic regression analysis to determine the factors affecting adoption of adaptation strategies given by STATA12

```
Iteration 0:   log likelihood =   -160.228
Iteration 1:   log likelihood = -51.029336
Iteration 2:   log likelihood =  -39.12986
Iteration 3:   log likelihood = -35.718786
Iteration 4:   log likelihood = -34.945944
Iteration 5:   log likelihood = -34.929574
Iteration 6:   log likelihood = -34.929539
Iteration 7:   log likelihood = -34.929539

Logistic regression                               Number of obs   =        240
                                                  LR chi2(17)     =     250.60
                                                  Prob > chi2     =     0.0000
Log likelihood = -34.929539                       Pseudo R2       =     0.7820
```

adaptation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.1406237	.956095	0.15	0.883	-1.733288	2.014535
agehh	-.0382948	.0280716	-1.36	0.173	-.0933141	.0167246
familysize	-.3825627	.1809792	-2.11	0.035	-.7372754	-.02785
landarea	.0630311	.8413615	0.07	0.940	-1.586007	1.712069
member_organization	1.624023	.8592879	1.89	0.059	-.06015	3.308197
training	2.727632	.9933716	2.75	0.006	.7806598	4.674605
caste	.3101337	1.098865	0.28	0.778	-1.843602	2.46387
eduhh_dummy	.9050317	.4394242	2.06	0.039	.0437762	1.766287
acccredit	5.536456	1.865219	2.97	0.003	1.880694	9.192218
saving	4.273106	.9749186	4.38	0.000	2.362301	6.183911
extreme	1.607225	.8040881	2.00	0.046	.0312413	3.183209
dumminfcat	6.436507	2.504423	2.57	0.010	1.527928	11.34509
farmingexperience	.1922785	.0405709	4.74	0.000	.1127611	.271796
road	2.600254	1.521103	1.71	0.087	-.3810527	5.58156
cool	3.249311	1.799096	1.81	0.071	-.2768522	6.775474
warm	1.402509	1.636233	0.86	0.391	-1.80445	4.609467
subtropical	1.900518	1.323512	1.44	0.151	-.6935179	4.494555
_cons	-17.28942	4.575575	-3.78	0.000	-26.25738	-8.321457

```
Marginal effects after logit
      y  = Pr(adaptation) (predict)
         =  .08213404
```

variable	dy/dx	Std. Err.	z	P>|z|	[	95% C.I.]	X
sexhh*	.0101871	.0665	0.15	0.878	-.120152	.140526	.841667
agehh	-.002887	.00257	-1.12	0.262	-.007934	.00216	52.5042
family~e	-.0288407	.01817	-1.59	0.113	-.064462	.00678	5.7
landarea	.0047518	.06329	0.08	0.940	-.119291	.128794	.753784
member~n*	.1309338	.0917	1.43	0.153	-.048787	.310655	.491667
training*	.404384	.21857	1.85	0.064	-.024002	.83277	.179167
caste*	.0238385	.08681	0.27	0.784	-.146311	.193988	.433333
eduhh_~y	.0682286	.03732	1.83	0.067	-.00491	.141367	.770833
acccre~t*	.248655	.09002	2.76	0.006	.07222	.42509	.7625
saving*	.3834436	.13217	2.90	0.004	.124392	.642496	.5375
extreme*	.1385758	.09578	1.45	0.148	-.04914	.326292	.4375
dummin~t*	.9230063	.09083	10.16	0.000	.744992	1.10102	.120833
farmi~ce	.0144955	.00692	2.10	0.036	.00094	.028051	25.6625
road*	.1070221	.06141	1.74	0.081	-.013347	.227391	.85
cool*	.4676228	.34953	1.34	0.181	-.217442	1.15269	.25
warm*	.1446624	.21975	0.66	0.510	-.286038	.575363	.25
subtro~l*	.2185374	.21422	1.02	0.308	-.201325	.6384	.25

(*) dy/dx is for discrete change of dummy variable from 0 to 1