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Original Article

Relationship Between REDD and Livestock Production Systems: Multinomial Choice Analysis

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Abstract

This paper assess the relationship between reducing emission from deforestation and forest degradation (REDD) regulation and farmers' choice for livestock production systems using a multinomial choice model fitted to data from household survey of 324 farmers from Nepal. The results indicate that intensive livestock system is more likely to have chosen by farmers involving in REDD program. The association between REDD and livestock systems remain when controlling for all factors included in the study. Better access to market and extension, distance to the river, total livestock units, and keeping improved breed are significant and critical for choosing intensive system. The results suggest that REDD regulation may have reduced grazing and forest use and farmers alternative livestock system becomes more intensive. Government policies should consider livestock management system as an important factor while formulating national REDD strategy. Further study is needed to evaluate the net effect of REDD and intensive system.

Keywords: REDD regulation, intensive livestock production, multinomial model, Nepal.

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Introduction

Reducing Emissions from Deforestation and Forest Degradation (REDD)[1] programme has been developed as a new effort in developing countries to enhance carbon stocks in forests and sustainable forest management, gaining international momentum as a climate change mitigation mechanism. Forests contribute significantly to animal husbandry practices and are a critical resource for maintenance of the livelihoods (Pokharel and Byrne 2009). It is therefore important to examine the effect of REDD on choices of livestock production systems at watershed level. In this paper, we look at REDD and livestock production system and what the REDD policy can best focus on. REDD countries have started to develop national level REDD strategies and polices, moving the REDD from pilot projects to national scale design and implementation. At the stage of implementation, REDD countries are required to effectively address the drivers of deforestation and forest degradation, many of which are outside the forest sector, using multidisciplinary approaches (Graham and Vignola 2011). As in other countries, in Nepal,[2] the Ministry of Forest and Soil Conservation (MFSC) has worked on national REDD strategy to address the drivers of deforestation and forest degradation in line with REDD framework provided by the United Nations Framework Convention on Climate Change (UNFCCC). Based on the FAO Country Report (2005) data, Nepal has an annual deforestation rate of 1.63% from 1990 to 2005 which is higher than for most other countries. Between the same periods, shrubland also increased by 4.05% annually indicating a conversion of forested land into degraded forests. On the other hand, a study shows that Nepal has 10.4 metric tons of CO_2 annual mitigation potential through sequestrating carbon in land-based ecosystems (ICIMOD 2009). If this potential is to be harnessed to finance forest management, then the drivers of deforestation and forest degradation need to be addressed first. A study illustrates that agriculture production[3] for domestic urban growth are the primary drivers of tropical deforestation (DeFries *et al.*, 2010). Agricultural and livestock related activities have been considered as one of the major drivers of deforestation in Nepal (MFSC 2006). Some studies (see, for example, Kyalo 2009) have indicated that the choice of livestock production system has associated with the reduction of forest degradation at watershed level.

Livestock has played an integral role in Nepalese farming systems, accounting for 32% of agricultural gross domestic product (AGDP) (CBS 2007) and are closely interrelated with agricultural lands and forests (Tulachan 2001). Nepalese farmers rely on livestock for food, animal products, and household income. Geographically, there are three major types of livestock farming system in Nepal. In high mountain region, the transhumance grazing system or extensive livestock system is practiced by agro-pastoralist societies where families and livestock herds are seasonally moved to pasture areas (Karky 2001; Brower 1990). In the mid-hills, the sedentary grazing system or semi-intensive system predominates, where livestock are usually kept in villages at night and are grazed during the day in the surrounding communal forest or pastureland (Tulachan 2001). Livestock spend half of their time grazing and are fed crop by-products, tree fodder, or grasses during evening and morning hours. However, in the low-to mid-hills and in the intensive cultivated or protected areas, the intensive system (stall-fed) is most common, where livestock are kept in a shed or stockade and crop by-products are often sufficient to maintain animals throughout the winter, supplemented by commercial feed and or forests fodder, grasses, and weeds collected from the farm land constitute sources of forage. It is found that due to the changes in forest management policies including grazing restrictions, households are changing from transhumance grazing and sedentary grazing

[1] The REDD is now expanded to REDD+ that includes conservation, sustainable management and enhancement of biomass in addition to reducing deforestation and degradation.

[2] Nepal's interest in REDD+ lies not only in mitigation but in the potential ability of REDD+ to contribute to wider development goals including poverty alleviation, development of rural livelihoods and adaptation to a changing climate (GoN 2010)

[3] Agricultural production includes both agriculture and livestock.

systems to stall feeding (Gurung *et al.*, 2009). Livestock grazing restrictions in protected areas and community forests have had a positive impact on reducing forest degradation. In a study of lowland *Terai*, livestock grazing restriction in the Madi valley community forests, which is situated within the buffer zone of Chitwan National Park, resulted in households changing their livestock composition and husbandry practices to fewer livestock and increased stall feeding (Gurung *et al.,* 2009). Similarly, in the middle hills of Nepal, low productive cattle numbers per household are declining when compared to before community forests were established (Adhikari *et al.,* 2007). The grazing restriction not only increased stall feeding, but also shifted livestock husbandry practices to favour water buffalo and goat over cows because buffalo are more profitable for milk and meat production and goats have high value as meat (FAO 2006). This choice of different livestock management practices has increased shift to stall feeding, reducing free grazing in the forest based pasture. On the other hand, farmers adopt their animal husbandry practices differently based on their livelihood need and other socioeconomic and geographical characteristics. The farmers adapt livestock management decisions to prevailing climatic conditions based on the availability of resources such as fodder, water, grazing lands and change their livestock type accordingly (Kabubo-Mariara 2008), and this change is further determined by the socioeconomic characteristics of farmers and other local provision (Mustapha *et al.*, 2012). Sherpa and Kayastha (2009) analysed data from livestock farmers in Sagarmatha National Park of Khumbu region of Nepal to identify the socio-economic factors and found that education, tourism, social status and prestige, political change and globalization have modified the animal husbandry practices. Integration of crops, forest, and livestock has been a major basis for subsistence economy in rural areas in many developing countries including Nepal. Since livestock production is an integral part of the local farming system, appropriate interventions and measures for sustainable production cannot be developed without a clear understanding of existing livestock production systems. Since livestock grazing is one major driver for forest degradation, it does determine by REDD incentive, based on the carbon pool, a particular community is entitled to receive under its payment mechanism. Although livestock is one of the main drivers of forest degradation, limited studies (see, for example, Gurung *et al.*, 2009) have addressed the link of forest related policy to livestock husbandry practice. However, these studies are mainly done in protected areas like national park and mostly related to success stories associated with the shift to stall feeding. So far no studies have done on REDD and choice of animal husbandry practices at watershed level. This study is designed to find the association between REDD and choices for livestock production system at watershed level. For this study, three watersheds of Nepal, namely; Kayarkhola of Chitwan district, Charnawati of Dolakha district and Ludhikhola of Gorkha district have chosen. The results of this study is expected to enlighten REDD policy makers and planners by characterizing livestock production systems and identifying opportunities and challenges that are specific to different categories of livestock producers. This can help to formulate policy interventions by considering livestock as one of the important factors in the REDD regulation. It will further support the efforts to realize REDD payments from international REDD financing mechanisms by meeting national REDD targets.

Materials and methods

Study Location and People

This study was conducted in three watersheds (Kayarkhola of Chitwan district, Charnawati of Dolakha district and Ludhikhola of Gorkha district; Fig. 1) of Nepal which are representative of different livestock production system, covering different ecological region ranging from tropical to temperate. And also the comparison of households whether they participated in REDD program or not was possible. The field carbon inventory data shows an overall increase of 2.67 ton carbon per hectare annually in the forests where REDD program was being implemented (ICIMOD, ANSAB and FECOFUN 2011).

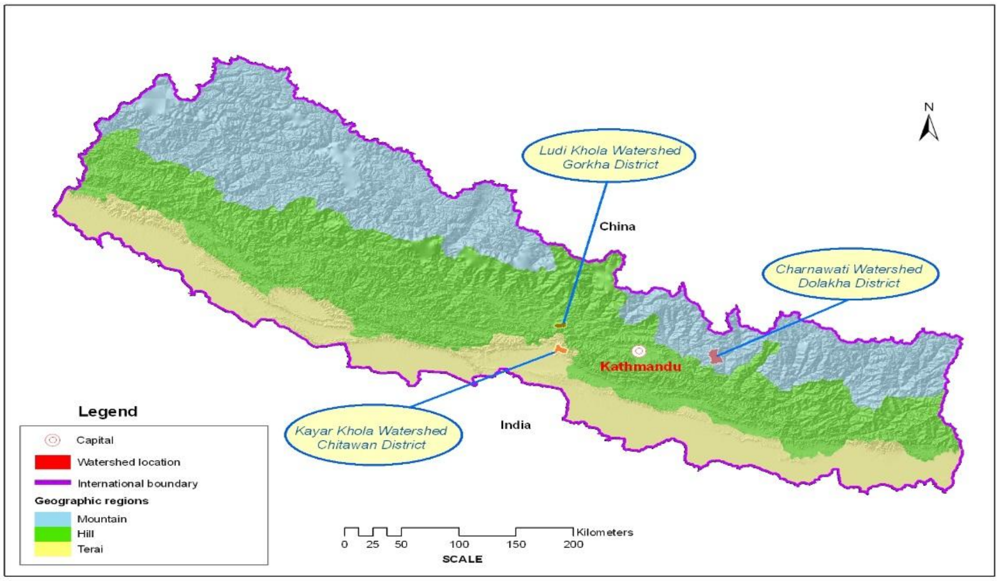

Fig. 1: Location of study sites.

The first site, Kayarkhola watershed of Chitwan district covers 8,002 hectare area and is located at 245 to 1, 944 meter altitude from the sea level. The second site, Ludikhola watershed lies in the Gorkha district of western development region of Nepal, characterized by hill topography and altitude ranging from 318 to 1, 714 meter. This watershed covers an area of 5, 750 hectare with 1, 888 hectare of community forest area. The third site, Charnawati watershed is located in Dolakha district of the central development region of Nepal, covering hill and mountain geography with altitude ranges from 835 to 3, 549 meter. This watershed is spread over 14,037 hectare with total forest area of 5, 996.17 hectare. In all the three watersheds, there are mosaic of different uses of land, consisting of agriculture lands, forests, and settlements throughout the watersheds.

Sampling of Respondents for Household Survey

As the population was scattered over a large geographic area, multi-stage cluster sampling approach was used for this study. This approach was preferred due to its relative convenience, economy, and efficiency compared to other sampling methods. Furthermore, the use of random sampling to derive the final sampling units improves the precision of the estimates (Allen *et al.*, 2002). Within the three watersheds, smaller geographical areas (division) were randomly selected from the list of all divisions in these watersheds, taking into account the general distribution of livestock and program and non-program participants in the study area. Subsequent stages involved a random selection of a sample location, from which a number of smaller units (community forest users groups, CFUGs) were selected. Therefore, the primary sampling units for the survey were 105 CFUGs in the study area. And then, systematic random sampling was used to select individual respondents. The data was collected through household surveys via trained enumerators4 using a structured questionnaire that was administered through face-to-face interviews from December 2012 to January 2013. A total of 324 farmers were interviewed.

Variable Description

Table 1 presents the variable descriptions. This study has categorized three different livestock

[4]The enumerators with the help of research assistant and field staff also conducted focus group discussion (FGD) to verify some information collected in household survey and to ensure the perspectives, role and association of disadvantaged group with local people to contribute on participatory forest management and animal husbandry practices. The enumerators assisted and invited up to 25 people from the randomly selected six CFUGs for discussion.

production system as dependent variable, representing a choice for a particular livestock production system which is coded 0 for extensive system, 1 for intensive, and 2 for semi-intensive system.

Table 1: Description of variables used in the empirical model.

Variables	Description
Livestock system	Livestock production system. Coded as a categorical variable: 0 for extensive system, 1 for intensive system, and 2 for semi-intensive system
Age	Age of household head in year as a continuous variable
Education	Education level of head of household. Categorized into three variables namely no education, primary education, and secondary or higher education.
Sex	Sex of head of household. Coded as a dummy variable: 0 for female and 1 for male
TLU	Tropical livestock unit (TLU) owned by household. Weighted for TLU calculation-Cattle and Buffalo 0.8, Chicken and Duck 0.01, Goat and Sheep 0.1, and Pig 0.2-were used
Land size	Size of land owned in hectares as a continuous variable
Credit	Access to credit facilities. Coded as a dummy variable: 0 for else and 1 for accessed
Extension	Access to extension service either by government or non-government organization or cooperatives or private agencies. Coded as a dummy variable: 0 for else and 1 for accessed
Distance	Distance from house to the nearest river in kilometers (continuous variable)
Market	Travel time from house to the nearest market in minutes (continuous variable)
Farm income	Income received from sale of cereal crops, vegetables, cash crops, milk, and meat products. Dummy takes the value of 1 if farm annual income is less than 45,000 and 0 otherwise
Household size	The number of people living in a household at the time of interview. (continuous variable)
Program	The participation of household in the REDD program and actively involved in its payment system. Dummy takes the value of 1 if yes and 0 otherwise
Carbon stock	Measure the difference in total carbon stock between 2011 and 2012. Coded 1 if more than 220 and 0 otherwise
Livestock experience	Livestock farming experiences in year.(continuous variable)
Improved livestock	Improved breed of livestock owned by farmers. Dummy takes the value of 1 if yes and 0 if no.

As an indicator of REDD regulation, community-level variable carbon stock per hectare of forest was created, indicating 1 if the difference in total carbon stock in CFUG5 between 2011 and 2012 was more than 220 and 0 otherwise, Furthermore, variable that indicated whether households had participated in REDD program or not was also included as a measure of REDD regulation. The control variables are described as follows: age and number of years the farmer has been keeping livestock reflect his/her experiences and might influence the type of systems they adopted. They are expected to be more conservative and be involved in the more extensive livestock

[5]REDD program has been implemented since 2009, with REDD payments of USD 200,000 has been made for the carbon pool locked in 10,000 hectare of community managed forest.

production systems. As educational-level of the household head is likely to be correlated with choice of livestock producing system, education level was also included as a categorical variable, indicating whether the head of household had primary or secondary education with no education as reference group. Land size is conceptualized to be an important determinant of the livelihood outcomes of rural households whose production is natural resource based. The number of livestock might have affected the choice for animal husbandry. Therefore, this possibility is included using tropical livestock unit (TLU) which was computed for each species kept by the household. The household income level could also be related to farmers' choice for animal husbandry. This is also included as a dummy variable indicating whether they have less than 45,000 per annum or more than that level. The access to extension service and credit facilities, distance to river and nearest market, household size, type of livestock, and gender of household head were also included in the estimation model.

Statistical Analysis

The multinomial logistic (MNL) regression model,6 a choice model gaining popularity in choice based studies (see, for example, Kuo and Chen 2004), was used to assess the association of REDD for choosing a particular livestock production system. The MNL permits the determination of choice probabilities for different categories (Madalla 1983; Wooldridge 2002). The model is appropriate when data are individual specific (Greene 2003), the values of the independent variables are assumed to be constant among all alternatives in the choice set. The general multinomial logistic regression model is specified in equation 1.

$$\Pr ob(Y_i = 1) = \frac{e^{\beta_j x_i}}{\sum_{k=0}^{j} e^{\beta_k x_i}}, \; j = 0,1........J \qquad (1)$$

Since there are three categories in the dependent variables, two equations were estimated providing probabilities for the $J+1$ choice for a decision maker with characteristics Xi. The $\beta_i s$ are the coefficients to be estimated through the maximum likelihood method. The empirical specification is simplified as follow.

$$\prod_{ij} = X_i \beta_k + Z_i \alpha_k + W_i \gamma_k + \varepsilon_{ik} \qquad (2)$$

where, $\prod_{ij}$ is the probability that household i chooses to produce livestock through system j, X_i is the household socioeconomic characteristics, Z_i is the household location and W_i is the biophysical characteristics, β_k, α_k and γ_k are the parameters to be estimated and ε_{ik} is the error term. In this context, the parameter estimated represents the relative risk ratios. The problem of indeterminacy can be normalized through setting $\beta_0 = 0$. This is because the probabilities sum up to 1, therefore only J parameter vectors are needed to determine the $J+1$ probability. Thus the probabilities are

$$\Pr ob(Y_i = j / x_i) = \frac{e^{\beta_j x_i}}{1 + \sum_{k=1}^{j} e^{\beta_k x_i}} \quad \text{For } j = 0,1.......J, \beta_0 = 0. \qquad (3)$$

As the coefficients themselves cannot be interpreted easily, relative risk ratios (RRR) of the characteristics on the probabilities were computed to give a more accurate interpretation of the coefficients. The RRR is a transformation of the MNL coefficients through exponentiation. The MNL model estimates $k-1$ equations, where k^{th} equation is relative to the referent group. The RRR of a coefficient indicates the probability of choosing outcome falling in the comparison group relative to outcome falling in referent group changes with the variable in question. A RRR>1 indicates that the probability of the outcome falling in the comparison group relative to the risk of the outcome falling in the referent group increases as the variable increases. While RRR<1 indicates that the probability of outcome falling in the comparison group relative to the risk of the outcome falling in

[6] The data was managed and analyzed using STATA (Version 10).

the referent group decreases as the variable increases that is the outcome is more likely to be in the referent group.

Results

Farmers' Socioeconomic Profiles

Out of the 324 farmers surveyed, the socio-economic characteristics showed that the average household size was 5.7 where 49% did not have any formal education, while 30% and 20% had attained primary and post-primary education, respectively (Table 2). In the sample population, more than half (52%) of the respondents were female.

Table 2: Summary of statistics for respondents and livestock production system specific attributes**.**

	Livestock Production System			
	Intensive (n=211)	**Semi-intensive (n=69)**	**Extensive (n=44)**	**All (n=324)**
Frequencies[a]				
Sex				
Male	100(47.39)	36(52.17)	21(47.73)	157(48.46)
Female	111(52.61)	33(47.83)	23(52.27)	167(51.54)
Household income				
Less than 45,000	70(33.18)	18(26.09)	11(25.00)	99(30.56)
More than or equal to 45,000	141(66.82)	51(73.91)	33(75.00)	225(69.44)
Credit				
Accessed	109(52.66)	35(51.47)	27(61.36)	171(53.61)
No access	98(47.34)	33(48.53)	17(38.64)	148(46.39)
Extension				
Accessed	152(72.04)	48(69.57)	31(70.45)	231(71.30)
No access	59(27.96)	21(30.43)	13(29.55)	93(28.70)
Carbon stock				
More than 220	113(53.55)	26(37.68)	16(36.36)	155(47.84)
Less than or equal to 220	98(46.45)	43(62.32)	28(63.64)	169(52.16)
Program				
Involved	116(54.98)	24(34.78)	18(40.91)	158(48.77)
Not involved	67(45.02)	45(65.22)	26(59.09)	166(51.23)
Education				
No education	104(49.29)	33(47.83)	23(52.27)	160(49.38)
Primary education	70(33.18)	21(30.43)	9(20.45)	100(30.86)
Secondary or higher education	37(17.54)	15(21.74)	12 (27.27)	64(19.75)
Improved livestock				
Yes	47(22.27)	10(14.49)	6(13.64)	63(19.44)
No	164(77.73)	59(85.51)	38(86.36)	261(80.56)
Mean[b]				
Age	44.22(15.34)	44.39(17.18)	41(14.96)	43.82(15.69
Education	3.24(3.17)	2.72(3.32)	3.02(3.50)	3.10(3.25)
TLU	2.49(1.28)	2.11(1.44)	4.62(4.59)	2.70(2.22)
Land size	0.43(0.39)	0.43(0.44)	0.69(0.76)	0.46(0.48)
Household size	5.55(2.37)	4.99(2.60)	7.43(5.90)	5.73(3.23)
Time to market	53.76(39.30)	56.98(47.09)	39.56(31.84)	52.52(40.42
Distance to river	2.92(2.64)	3.44(3.46)	2.57(1.95)	2.98(2.76)
Household income	54366.99 (67727.54)	41492.75 (40871.26)	34813.95 (24968.8)	48980.37 (58960.74)
Livestock experience	23.89(14.14)	23.96(14.04)	24.79(15.66)	24.03(14.29)

[a]Figures in brackets represent percentages; [b]Figures in brackets represent standard deviation.

Only one fifth (19%) of the household had improved breed of livestock. A large proportion (65%) of the respondents had intensive type of livestock production system. This was followed by one fifth (21%) of respondents having semi-intensive type, and 14% having extensive type of livestock production system. On the access to credit facilities either by bank, cooperatives or group saving or by any other financial institution or by individual, the result shows that more than half of the respondents (54%) had access to such institutions, while on agriculture and livestock extension services, a large proportion (71%) of the respondents reported that they had access to extension services that was done either by government or non-government organizations.

Total household income was not well distributed. Due to this skewness, a categorization was done. A slightly higher than one fourth (31%) of the survey households had the income level less than US $ 1.25 per day (less than 45,000 per annum). This figure is slightly higher than the national average data from World Bank. According to the World Bank (2012), 24.82% of the population of Nepal lives under less than US $ 1.25 per day, and 25.2% of the population lives below the national poverty line. Household income in three watersheds was drawn from three main sources namely: on farm activities that include income received from sale of cereal crops, vegetables, cash crops, live animal, milk and meat products; forest based off farm income which include income received from sale of timber and non-timber products based on forest resources; and off-farm (other than forest based) income such as income received from wage labor, job or services, pension, grocery business and remittances.

Livestock plays an important role in sustaining livelihood as it provides 41% of total annual household cash inflows and remaining 59% is covered by off-farm income in three watersheds. The result also indicated that average farmers had 24 years of livestock farming experiences, while an average of 2.7 TLU were keeping by farmers.

Estimation of MNL Model-I and Model-II

The estimation of MNL model was undertaken by normalizing one category, which is usually referred to as the reference category. In this analysis, the extensive livestock production system was considered as the reference group.

Two full models were estimated. Model-I shows the result of considering REDD regulation as measured by program involvement, while Model-II considered the carbon stock level. The result of MNL regression showed that the log likelihood of the fitted model (-234.161 for model-I; -234.429 for model-II) and rejects the null hypothesis that all regression coefficients are simultaneously equal to zero. The likelihood ratios on the other hand were 86.94 for model-I and 86.41 for model-II (degree of freedoms are 30) and the p values are 0.000. These two statistics indicates the rejection of null hypothesis that all regression coefficients across both models are simultaneously equal to zero. Moreover, the model was run and tested for the validity of the independence of the irrelevant alternatives (IIA) assumptions by using the Hausman test for IIA.

The test failed to reject the null hypothesis of independence of the livestock production systems, suggesting that the MNL specification is appropriate to model the choices of livestock systems (chi squared value ranged from 1.337 to 3.702 with probability 0.999 for model-I and from 3.409 to 19.745 with probability values ranging from 0.999 to 0.231 for model-II). In order to explore potential multicollinearity among explanatory variables, partial correlation coefficients were computed for the selected variables.

The correlation analysis found that all partial correlation coefficients are less than 0.5 (Table 3). Therefore, there was no multicollinearity. Further, the analysis was fitted to an ordinary least square model and tested for multicollinearity using variance inflation factors (VIF), Table 4. The VIF of all included variables were less than 5, indicating multicollinearity is not a serious problem in the model. According to Maddala (2000), variables that have VIF<5 are considered to have no multicollinearity. Tables 5 and 6 show the results obtained from the analysis of the MNL regression model, presenting RRR.

Table 3: Partial correlation coefficients for explanatory variables used in the analysis.

	Program	**Sex**	**No edu**	**Primary**	**Secondary**	**Distance**	**Market**	**TLU**	**Land size**	**Experience**	**Household size**	**Household income**	**Improved livestock**	**Age**	**Credit**	**Extension**
Program	1.000															
Sex	-0.068	1.000														
	0.217															
No edu	-0.025	-0.068	1.000													
	0.653	0.220														
Primary	-0.050	0.154[3]	-0.660[4]	1.000												
	0.376	0.005	0.000													
Secondary	0.089[1]	-0.093[1]	-0.490[4]	-0.331[4]	1.000											
	0.010	0.093	0.000	0.000												
Distance	-0.013	0.087	0.053	-0.013	-0.051	1.000										
	0.811	0.117	0.338	0.805	0.359											
Market	-0.041	0.096[1]	0.058	-0.036	-0.031	0.257[4]	1.000									
	0.455	0.081	0.294	0.512	0.578	0.000										
TLU	0.064	-0.078	0.004	-0.001	-0.003	-0.097[1]	-0.011	1.000								
	0.245	0.156	0.935	0.977	0.944	0.078	0.838									
Land size	-0.036	0.181[4]	-0.076	0.082	0.001	0.071	0.174[4]	0.224[4]	1.000							
	0.511	0.001	0.167	0.140	0.981	0.200	0.001	0.000								
Experience	0.0493	0.154[3]	0.078	0.004	-0.102	0.096[1]	-0.015	0.088	0.154[3]	1.000						
	0.381	0.005	0.165	0.931	0.067[1]	0.085	0.782	0.116	0.006							
Household size	-0.002	0.001	0.060	-0.057	-0.008	-0.095[1]	0.164[3]	0.191[4]	0.146[3]	-0.049	1.000					
	0.970	0.982	0.279	0.300	0.876	0.085	0.003	0.000	0.008	0.384						
Household income	0.009	0.027	-0.092[1]	0.093[1]	0.007	0.050	0.038	0.025	-0.047	0.004	0.047	1.000				
	0.862	0.625	0.097	0.093	0.893	0.365	0.495	0.651	0.391	0.930	0.393					
Improved livestock	-0.026	-0.023	0.045	-0.091[1]	0.050	-0.048	0.026	0.028	0.040	-0.064	-0.002	-0.004	1.000			
	0.629	0.629	0.418	0.098	0.369	0.380	0.633	0.613	0.463	0.250	0.969	0.939				
Age	-0.053	0.165[3]	0.410[4]	-0.137	-0.355[4]	0.116[2]	0.108	0.075	0.135[2]	0.237[4]	0.181[4]	-0.035	-0.059	1.000		
	0.340	0.002	0.000	0.013[2]	0.000	0.035	0.051	0.175	0.014	0.000	0.001	0.526	0.283			
Credit	0.030	-0.139	-0.052	0.060	-0.004	-0.131[2]	-0.066	0.139	-0.025	-0.088	-0.006	0.007	0.107[1]	-0.119[2]	1.000	
	0.583	0.012	0.351	0.278	0.931	0.018	0.234	0.012[2]	0.656	0.120	0.909	0.895	0.055	0.032		
Extension	-0.030	0.024	0.043	-0.044	-0.003	-0.131	-0.131	-0.092[1]	-0.045	0.032	-0.011	0.042	0.004	0.068	-0.023	1.000
	0.581	0.655	0.437	0.427	0.956	0.018	0.018	0.097	0.410	0.569	0.844	0.442	0.931	0.221	0.680	

[1, 2, 3] and [4] significant at 0.1, 0.5, 0.01 and 0.001 levels, respectively. Edu. Means education.

Table 4: Variance inflation factor (VIF) test for multicollinearity among variables used in the analysis.

Variable	VIF (Model-I)	VIF (Model-II)
Age	1.47	1.47
Secondary education	1.43	1.43
Primary education	1.34	1.34
Land size	1.20	1.21
Market	1.17	1.17
TLU	1.16	1.18
Distance	1.16	1.19
Household size	1.15	1.15
Sex	1.14	1.14
Experience	1.13	1.13
Credit	1.08	1.09
Extension	1.05	1.06
Improved livestock	1.04	1.04
Household income	1.04	1.04
Program	1.03	
Carbon stock		1.09
Mean VIF	**1.17**	**1.18**

Table 5: RRR estimates for program involvement using multinomial logistic regression (Model-I).

Variable	Livestock Production System					
	Intensive			Semi-intensive		
	RRR	SE	*P* value	RRR	SE	*P* value
Program	2.257**	0.916	0.045	0.949	0.437	0.911
Sex	0.911	0.384	0.826	1.020	0.481	0.966
Primary education	1.766	0.962	0.296	1.177	0.711	0.787
Secondary education	0.450	0.258	0.164	0.443	0.287	0.210
Distance	1.144	0.118	0.194	1.170	0.127	0.149
Market	0.984***	0.006	0.010	0.990	0.007	0.180
TLU	0.684****	0.075	0.001	0.590****	0.083	0.000
Land size	0.741	0.275	0.419	0.756	0.348	0.542
Experience	0.998	0.014	0.892	1.004	0.016	0.773
Household size	0.930	0.049	0.177	0.844**	0.067	0.034
Household income	1.623	0.720	0.275	1.227	0.623	0.687
Improved livestock	3.305**	1.940	0.042	1.543	1.031	0.516
Age	0.994	0.016	0.719	0.978	0.018	0.234
Credit	0.717	0.296	0.421	0.763	0.352	0.557
Extension	2.299**	0.941	0.042	1.366	0.634	0.502

Number of observation=313, LR Chi (30)=86.94, Prob>chi=0.000, Log likelihood=-234.162, Pseudo R^2=0.247

Extensive is the reference livestock production system. *,**,*** and**** significant at 0.1, 0.5, 0.01 and 0.001 levels respectively. RR=Relative Risk Ratio and SE=Standard Error

REDD and Choice of Animal Husbandry

After adjusting for sex, age, and education of household head, distance to river, time to nearest market, TLU, land size, experiences in livestock keeping, household size, household income, keeping improved breed of livestock, and access to market and extension, farmers who involved in REDD program were more likely to have experienced intensive livestock system as farmers who did not involve in REDD (RRR=2.257, p=0.045; Table-5). The results also showed that choice of intensive system was significantly associated with forest carbon stock-level (RRR=3.516, p=0.004; Table-6).

Table 6: RRR estimates for carbon stock using multinomial logistic regression (Model-II).

Variable	**Livestock Production System**					
	Intensive			**Semi-intensive**		
	RRR	**SE**	***P* value**	**RRR**	**SE**	***P* value**
Carbon stock	3.517***	1.537	0.004	2.101	1.028	0.129
Sex	0.834	0.355	0.669	0.992	0.469	0.987
Primary education	1.966	1.113	0.233	1.347	0.838	0.633
Secondary education	0.569	0.324	0.323	0.527	0.337	0.317
Distance	1.223*	0.136	0.069	1.231*	0.143	0.073
Market	0.985**	0.006	0.015	0.992	0.007	0.250
TLU	0.653****	0.073	0.000	0.578****	0.083	0.000
Land size	0.765	0.291	0.481	0.741	0.275	0.419
Experience	1.000	0.014	0.980	1.004	0.016	0.781
Household size	0.918***	0.049	0.010	0.835**	0.066	0.024
Household income	1.828	0.834	0.186	1.349	0.695	0.562
Improved livestock	4.217**	2.639	0.021	1.988	1.390	0.326
Age	0.997	0.017	0.885	0.981	0.018	0.323
Credit	0.814	0.335	0.616	0.832	0.383	0.690
Extension	2.110*	0.870	0.070	1.331	0.621	0.540
Number of observation=313, LR Chi (30)=86.41, Prob>chi=0.000, Log likelihood=-234.430, Pseudo R^2=0.247						

Note: Extensive is the reference livestock production system. *,**,*** and**** significant at 0.1, 0.5, 0.01 and 0.001 levels respectively. RR=Relative Risk Ratio and SE=Standard Error.

Control Variables for Choice of Animal Husbandry

The results of the controls variable which significantly affected the choices of livestock system are explained below. Other control variables such as gender of household head, land size, household income, age of household head, access to credit facility, livestock keeping experiences, and education were associated positively with choices of livestock system but were not significant at convenient levels.

Access to extension service. The RRR for farmers who accessed to extension services to those who did not were 2.299 in intensive system relative to extensive system, holding other variables in the model-I constant. This implies that farmers who had access to extension services were more likely to adopt intensive to those who did not access to such service. Distance to the river. The RRR for a unit increase in the distance from the household to the river, the probability for intensive relative to extensive livestock production system was 1.223 and 1.230 for semi-intensive system (model-II). Increasing the distance by one kilometer holding other variables constant would significantly result a farmer to prefer the intensive livestock production system over the extensive ones.

Market. Travel time to the nearest market had a significant association with the choices of livestock production systems.

TLU. A unit increase in TLU, the probability of choosing intensive livestock system relative to extensive system was 0.683 and 0.590 for semi-intensive (model-I). The TLU was significantly associated and farmers were more likely to have extensive livestock system when the number of livestock increased.

Household size. Increasing household size significantly increased the probability of choosing extensive livestock system (model-II). Keeping improved livestock. The breed of livestock had a significant association with the choices of intensive livestock system. Farmers who kept improved breed were preferred to intensive system than farmers who did not have improved breed: it increases the likelihood of intensive system by 3.3 times relative to extensive system (model-I).

Discussion and Conclusions

In general, the capacity of people to pay for services like veterinary services for livestock intensification is greatly affected by the poverty; therefore, it ultimately constraints the demand for such services. However, Ahuja and Redmond (2004) reported a significant willingness to pay for veterinary services in some poor villages in India. In this study, the farmers that have intensive livestock system have higher incomes; however, this association was not significant in the MNL model. The higher household incomes in intensive farming communities might be due to combination of livestock and crops and may have an inherent incentive for mutual intensification. Liyama *et al.*, (2007) also reported that households with intensive livestock farming system were found to earn higher incomes due to mutual intensification of livestock and fruits in Kenya.

Results show that 65% of farmers in the watersheds have adopted intensive livestock system. With the controls including household income, the results suggest that REDD is significantly associated with probability of choosing intensive system (RRR=2.257-3.516). The influence of REDD is stronger than that of other variables on the probability of choosing intensive system. It would seem that in the presence of REDD regulation, farmers are more likely to have motivated for intensive system. This system relies less on grassland use, need more input and more financial power from farmers. With the REDD, farmers maybe better off due to financial value for the carbon stored in forests, offering incentives to reduce emission from forested lands. Farmers may emphasize increasing carbon sequestration by enhancing existing forests. Therefore, REDD payment may involve in forest and grassland protection. Alternatively, REDD regulation may reduce grazing and forest use and then the farmers have to choose alternative livestock systems. This might lead to more intensive system.

With regard to the confounding factors, the results for distance to river are quite surprising. Increasing the distance by one kilometer holding other variables in the model constant would cause a farmer to prefer the intensive livestock production system over the extensive ones. The extensive livestock production systems are likely to be found in households who are closer to the river. Although this finding is contrary to expectations, it has important implications on the potential impact this system has on the environment.

The extensive system is associated with overgrazing on the riparian zone and other public grazing lands. Likewise, travel time to the nearest market is another important control variable affecting adoption of intensive system. The result shows that peri-urban location is significant in influencing farmers to adopt intensive system. This can be explained by proximity to input sellers (agrovet and feed shops), allowing farmers to acquire the inputs and facilities they needed for livestock production. According to Stifel and Minten (2008), farmers in peri-urban areas have relatively better access to technology and infrastructure, and they might be expected to use new production methods more efficiently. Further, access to markets has significantly affected farmers' use of conservation technologies (Laper and Pandely 1999).

Similarly, as expected, household with small herd size has chosen intensive system. The relationships of these confounding factors are similar to the results obtained in most of the previous studies (Otieno 2013; Deressa *et al.*, 2008).

This study reveals that choices of intensive system is associated with REDD regulation, which may have reduced grazing and forest use indirectly. It seems that these are two parallel effects of REDD regulation but not one is the consequence of the other. Farmers may have supported intensive system with REDD and this would lead to more carbon sequestration, as grass or forests may still be utilized. This choice may have significant effects in the environment and may reduce free grazing and degradation of forest resources which is a vital for sustaining REDD program in the long run.

In this study, choices of intensive system have taken place amidst increasing forest biomass in the watershed. Livestock farmers in three watersheds are in three distinct production systems. Therefore, the national REDD strategy must take cognizance of the importance of livestock production systems and make provision in the REDD implementation to promote intensive and semi-intensive production systems that have had positive impact on the forest resources.

Across the three systems, policy needs to encourage intervention that can enhance sustainability and productivity of livestock production system by putting livestock management at the heart of the REDD activities. Intensive livestock production system (stall-feeding) is associated with high productivity (Nweze and Ekwe 2012).

Farmers may use the payment obtained from REDD and finance the additional inputs and infrastructure needed and that productivity may be higher afterwards. However, more comprehensive study is needed to encompassingly assess environmental impacts of intensive livestock production- for example, runoff of nutrients into the water shed, also regarding greenhouse gas mitigation: REDD may increase carbon storage, but more intensive system may increase CH4 and N20. Nonetheless, this study has focused on the effects of REDD on choices of livestock systems and what a REDD policy may best focus on.

This study suggests a number of different policy options. These options include prioritizing livestock in the mainstream of national REDD strategy, encouraging extension personnel to work more effectively in the watershed areas, facilitating farmers to keep improved breed of livestock, and raising awareness of carbon stock and livestock system. Future research could provide more insights by investigating the environmental impact of intensive system and net effects of REDD and the system.

Competing Interests

The authors declare that they have no competing interests.

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References

Adhikari B, Wiliams F, Lovett JC (2007). Local benefits from community forests in the middle hills of Nepal. Forest Policy Econ., 9: 464-478.

Ahuja V, Redmond E (2004). Livestock services and the poor. Trop. Anim. Health Pro., 36: 247-268.

Allen M, Kilpatrick D, Armstrong M, Briggs R, Course G, Perez N (2002). Multistage cluster sampling design and optimal sample sizes for estimation of fish discards from commercial trawlers. Fish Res., 55: 11-24.

Brower B (1990). Range conservation and Sherpa livestock management in Khumbhu, Nepal. Mt. Res. Dev., 10: 34-42.

CBS (Central Bureau of Statistics) (2007). National accounts of Nepal. National Planning Commission Secretariat, Kathmandu, pp. 1-73.

De Fries R, Rudel TK, Uriarte M, Hansen M (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. Nat Geosci., 3: 178-181.

Deressa T, Hassan RM, Alemu T, Yesuf M, Ringler C (2008). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin of Ethiopia. International Food Policy Research Institute, IFPRI discussion paper 00798, pp. 1-25.

Ekwe OO, Nweze BO (2012). Effect of stall-fed management on growth performance of pure and crossbred Muturu Cattle. World J. Eng. Pure Appl. Sci., 2: 9.

FAO (Food and Agriculture Organization) (2006). Livestock's long shadow: environmental issues and options. Food Agr. Organ., Rome, Italy.

FAO (Food and Agriculture Organization) (2005). Global forest resources assessment 2005: Nepal country report forestry department 192. Food Agr. Organ., Rome, Italy.

GoN (Government of Nepal) (2010). Nepal's readiness preparation proposal REDD 2010-2013, Ministry of Forests and Soil Conservation, Kathmandu, Nepal. Available at http://mofsc-redd.gov.np/new/wp-content/uploads/R-PP_Nepal1.pdf. Accessed December 25, (2013).

Graham K, Vignola R (2011). REDD+ and agriculture: A cross-sectoral approach to REDD+ and implications for the poor. REDD net, networking for equity in forest climate policy. Available at http://redd-net.org/files/REDD%20and%20agriculture%20laid%20up.pdf. Accessed November 29, (2013).

Green WH (2003). Econometric analysis. 5th Ed. Pearson education, Upper Saddle River, New Jersey.

Gurung B, Kristen CN, James LDS (2009). Impact of grazing restrictions on livestock composition and husbandry practices in Madi Valley, Chitwan National Park, Nepal. Environ. Conserv., 36: 338-347.

Hassan R, Nhemachena C (2008). Determinants of African farmers' strategies for adapting to climate change: Multinomial choice analysis. AfJARE., 2: 83-104.

Lapar MLA, Pandely S (1999) Adoption of soil conservation: The case of Philippines uplands. Agr. Econ., 21: 241-256.

ICIMOD, ANSAB, FECOFUN (International Center for Integrated Mountain Development, Asia Networks for Sustainable Agriculture and Bioresources and Federation of Community Forest Users' Nepal) (2011). A monitoring report on forest carbon stocks changes in REDD project sites. International Center for Integrated Mountain Development, Kathmandu, pp. 1-32.

ICIMOD (International Center for Integrated Mountain Development) (2009). Potential for carbon finance in the land use sector of the Hindu Kush-Himalayan region. International Center for Integrated Mountain Development, Kathmandu, Nepal.

Kabubo-Mariara J (2008). Climate change adaptation and livestock activity choices in Kenya: An economic analysis. Nat. Resour. Forum., 32: 131-141.

Karky BS (2001). Approaches to and implications for livestock planning in resources-scarce environments. In: Tulachan P and Maki-Hokkonen, J (eds) Community Empowerment in Livestock resource Planning, International Center for Integrated Mountain Dev. Food Agr. Organ.

Kuo L, Chen Z (2004). A state duration model for brand choice and inter-purchase time. JDS., 2: 125-147.

Kyalo WD (2009). Impact of policy and socioeconomic factors on spatial distribution of livestock production systems in River Njoro watershed, Kenya. MSc Dissertation, Egerton University, Nakuru, Kenya.

Liyama M, Maitima J, Kariuki P (2007). Crop-livestock diversification patterns in relation to income and manure use: A case study from Rift valley community, Kenya. AJAR., 2: 58-66.

Madalla G (1983). Limited dependent and qualitative variables in econometrics. Cambridge: Cambridge University press.

Maddala GS (2000). Introduction to econometrics. 3rd Ed. New Jersey: Prentice-Hall Inc.

MFSC (Ministry of Forests and Soil Conservation) (2006). Third national report to the conservation on biological diversity. Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Mustapha SB, Bzugu PM, Ali IM, Abdullahi A (2012). Determinants of adaptation to deforestation among farmers in Madagali local government area of Adamawa state, Nigeria. RJOAS., 8: 15-20.

Otieno DJ (2013). Market and non-market factors influencing farmers' adoption of improved beef cattle in Arid and semi-arid areas of Kenya. J. Agr. Sc., 5: 32-43.

Pokharel BK, Byrne S (2009). Climate change mitigation and adaptation strategies in Nepal's forest sector: How can rural communities benefit? Nepal Swiss Community Forestry Project, Kathmandu, Nepal, pp. 43.

Sherpa YD, Kayastha RB (2009). A study of livestock management patterns in Sagarmatha National Park, Khumbu region: Trends as affected by socioeconomic factors and climate change. Kathmandu University J. Sci. Eng. Tech., 5: 110-120.

Stifel D, Minten B (2008). Isolation and agricultural productivity. Agr. Econ., 39: 1-15.

Tulachan PM (2001). Mountain Agriculture in the Hindu Kush-Himalaya: A Regional Comparative Analysis. Mt. Res. Dev., 21: 260-267.

Wooldridge JM (2002). Econometric analysis of cross section and panel data. Cambridge, Mass.: MIT press.

World Bank (2012). World Development Indicators. World Bank database.