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Determinants of livestock farmers' adaptation strategies to climate change in Gandaki province, Nepal

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ABSTRACT

Climate change is a global issue that has significantly impacted the agriculture and livestock sectors. Adaptation is a crucial approach to reducing the negative impact of climate change. This study identifies the key factors influencing livestock farmers' adaptation to climate change in Gandaki Province, Nepal. A multi-stage random sampling technique was used to collect data from 1158 households in five districts (Mustang, Kaski, Tanahu, Nawalpur, and Gorkha) of Gandaki province, western Nepal. A pretested structured questionnaire for households and a checklist for FGDs were used to collect the data. This study utilized descriptive and inferential statistics. A binary logistic regression model was used to identify the determinants of livestock farmers' adaptation strategies to climate change. Knowledge of climate change and its impact on livestock was common among farmers. Socioeconomic, demographic, climatic, agro-ecological settings and accessibility-related factors are responsible for adaptation strategies among livestock farmers. This study concludes that place of residence, availability of land for livestock, household size, agro-ecological setting, and access to credit are the determining factors in adaptation strategies to climate change impact in Gandaki Province, Nepal. The finding of this study may be beneficial in identifying the relevant adaptation strategies at the local level.

Keywords: Adaptation, Climate change impact, Determinants, Farmers, Livestock

Climate change is a global phenomenon that significantly threatens human civilization. It has impacted the welfare of human beings and the overall balance of the ecosystem. Erratic rainfall, increasing drought and flood incidences, and new diseases directly and indirectly impact human security (Obayelu *et al.* 2014). The temperatures of Nepal increased at a rate of 0.056°C per year compared to the base year (1971-2014) (Department of Hydrology and Meteorology (DHM) 2017). Medium-term (2016-2045) and long-term (2036-2065) projections based on the reference period (1981-2010) also reveal that there will be a significant increase in temperature in Nepal (DHM 2017). Nepal is one of the most vulnerable countries in the world, and it is affected by climatic variabilities due to its geographical structure (Budhathoki and Zander 2020). Farmers in developing countries like Nepal are vulnerable to climatic hazards because they primarily depend on weather-based rain-fed agriculture systems for their subsistence livelihoods (Gentle and Maraseni 2012, Khanal *et al.* 2022).

Agriculture is the mainstay and a vital economic activity of most Nepalese people. Agriculture and forestry sectors contribute 25.8% to the gross domestic product (GDP) and provide employment opportunities to 73.9% of the total employed population in Nepal. Moreover, the livestock sector alone contributes 27% of agriculture's gross domestic product (AGDP) and about 13% of the national GDP (Ministry of Finance (MOF) 2021, Central Bureau of Statistics (CBS) 2019, Ministry of Agriculture and Livestock Development (MALD) 2021).

The livestock sector is seriously affected by climatic hazards. Climatic hazards (droughts, floods, and erratic rainfall) directly and indirectly impact livestock production and growth, leading to heavy losses (Shrestha and Baral 2018). In this context, Nepalese livestock farmers lack the capacity and resources to cope with such outcomes (Shrestha and Baral 2018). So, it is necessary to lessen the impacts of climate change on livestock to fulfill the growing demand for livestock products. Limiting the negative impacts of climate change is a significant challenge for the international communities. In this context, mitigation and adaptation are vital for managing these impacts. Nepal has already recognized climate change impacts as a key challenge to the country's overall well-being and development and has formulated several policy measures related to adaptation strategies. Adaptation is the best option for protecting vulnerable communities and ecosystems and reducing the risks (MoPE 2017, Devkota *et al.* 2011).

Adaptation effectively reduces climate change impact,

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particularly for smallholder subsistence farmers, and depends on the system's adaptive capacity, regions, and communities. However, adaptive capacity is primarily influenced by socioeconomic and demographic characteristics, farm size, livestock ownership, institutional knowledge of climate change, and cultural and other climatic factors (Smit *et al.* 2000, Nguyen *et al.* 2021, Dang *et al.* 2019, Masud *et al.* 2017, Karki *et al.* 2020, Adger *et al*. 2003, Khanal *et al.* 2022). The different means of adaptation at the household level may be the use of new species of livestock, nutritional strategies, risk management practices, and institutional changes such as accessibility of veterinary services, provision of subsidy, reduction of tax, insurance of livestock, and others (Deressa *et al.* 2009). Most existing literature focuses on agriculture, but less attention has been paid to the livestock sector in developing countries like Nepal. So, the main aim of this paper is to identify the determinants of livestock farmers' adaptation strategies to climate change impacts in western Nepal.

MATERIALS AND METHODS

Study area: This study used a multistage sampling. In the first stage, Gandaki province which consists of eleven districts was purposively chosen. In the second stage, five districts: Tanahu, Kaski, Gorkha, Mustang, and Nawalpur were also selected purposively based on the holding of significant livestock population and ecological diversity. Tanahu was chosen based on the maximum number of cattle, goats, and pigs, followed by Kaski for buffalo and Gorkha for sheep. Mustang and Nawalpur were included to represent alpine Himalaya and sub-tropical Terai region respectively, ensuring the coverage of the province full topographical spectrum- Himalaya, Hill and Mountain of the province. In the third stage, the municipalities, rural municipalities, and wards (lowest level of political division) were chosen randomly. Finally, households and eligible respondents were chosen purposively at the fourth stage. This strategy balanced deliberate geographic and livestock diversity representation with randomized local level sampling (Kumar *et al*. 2024).

Respondents: The survey interviewed 1158 respondents proportionately distributed across five districts in Gandaki province. A household head (member) who was 45 years and above, had resided in the area for at least 15 years, and kept at least one major livestock at the time of the survey was selected as the respondent. This approach aimed to prioritize senior farmers, as their extended residency and experience were deemed for reliably assessing long term climate change impacts compared to younger residents. If the household head was unavailable, another qualified household member meeting the age and residency requirements was interviewed.

Questionnaire: A structured questionnaire was used for the household survey, where focus group discussions (FGDs) were conducted to understand the hidden realities (Parker and Tritter 2006). To ensure the content validity, an extensive review of relevant literature was conducted, and the reliability of the structured questionnaire was evaluated using Cronbach's alpha (α), which yielded an overall value of 0.90.

The survey questionnaire was developed through a comprehensive review of existing literature. Initially, it contained 44 items to assess farmers' views on climate change and its livestock-related impacts. For this analysis, six questions for perception and seven questions for climate change impacts were selected based on their relevance and clarity in addressing climate change perceptions and livestock impacts. Climate change was defined as the perceived change in climatic parameters (average minimum and maximum temperature and rainfall) over 15 years (Kumar *et al*. 2024). All items utilized 5-point Likert scale (1: strongly disagree to 5: strongly agree). Moreover, fifty-six adaptation-related questions were included in the questionnaire. Perception-related five-point Likert questions were re-categorized into three categories: disagree, neither agree nor disagree, and agree, and adaptation-related questions were recoded into Yes or No for analytical purposes.

Statistical analysis: Both descriptive (frequency analysis, mean, standard deviation) and inferential (Chi-Square test for goodness of fit and binary logistic regression) analyses were used. A chi-square test for goodness of fit was used to assess the significant difference in the proportions of responses (it is also used to test the representativeness of the population by using sample data). Adaptation was used as a dependent variable, while socioeconomic and demographic factors were used as independent variables. Although the survey initially included a broad set of livestock adaptation strategies, this analysis focused on the six most important strategies: participation in livestock insurance, access to veterinary services, implementation of modified roofing systems, adoption of heat and cold-tolerant local breeds, use of climate-resilient breeds, and diversification of livestock species. These core strategies were identified through focus group discussions (FGDs) conducted across the province.

Each dependent variable (adaptation strategies) was re-categorized into two groups (No: 0 and Yes: 1), while the set of independent variables; age, education, occupation, caste, place of residence, family types is categorical, while the mean availability of land for livestock, availability of food, and household size are continuous. This study used a binary logistic regression model to identify the determinants of livestock farmers' adaptation strategies to climate change impacts, as the dependent variables are binary (No and Yes). Statistical Packages for Social Sciences (SPSS) version 26.0 was used to analyze the data.

RESULTS AND DISCUSSION

Selected background characteristics of livestock farmers: Table 1 shows the key demographic characteristics of livestock farmers. The findings indicate that over 56% of

Table 1. Selected background characteristics of farmers

Characteristic	Number (N)	Percent (%)
Age (years)		
45-54	657	56.7
55-64	316	27.3
65 and above	185	16.0
Mean (SD) in year	54.6 (9.2)	
Sex		
Male	736	63.6
Female	422	36.4
Place of residence		
Rural	665	57.4
Urban	493	42.6
Education		
Illiterate=1	141	12.2
Literate (informal=2)	383	33.1
Basic=3	336	29.0
Secondary=4	241	20.8
Higher education=5	57	4.9
Jobs in other than agriculture and livestock		
No other job (0)	555	47.9
Jobs in other areas (1)	603	52.1
Caste group		
Upper caste (coded as 1)	632	54.6
Janajati (coded as 2)	405	35.0
Others (coded as 3)	121	10.4
Agro-ecological setting		
Tropical	548	47.3
Sub-tropical and temperate	500	43.2
Sub-alpine and alpine	110	9.5
Family type		
Nuclear (1)	630	54.4
Extended (2)	528	45.6
Access to credit scheme		
Yes	456	39.4
No	702	60.6
Involvement in income diversification		
Yes	689	59.5
No	469	40.5
Mean household size	5.19 (2.23)	
Mean availability of food (in months)	8.38 (4.69)	
Mean availability of land for agriculture (hectare)	0.33 (0.11)	
Mean availability of land for livestock (hectare)	0.13 (0.08)	
Total Sample (n)	1158	

the farmers were aged between 45 and 54, whereas only 16% were above 65 years, with an average age of 54.6. Males accounted for more than 63% of the respondents, and 57.4% were from the rural areas. In terms of education, 12.2% had no formal schooling, while just 4.9% had attained higher education. Approximately half of the participants belonged to the upper caste and were engaged in occupations beyond agriculture and livestock farming.

Over 47% of the farmers resided in tropical agro ecological zones, while 43.2% were from subtropical and temperate regions, and 9.5% from subalpine and alpine areas. Approximately 54% belonged to nuclear families, and only 39.4% had access to credit programs, whereas 59.5% engaged in income diversification. The average household size was 5.19 members, with food sufficiency lasting 8.39 months on average, and the mean land area available for livestock was 0.13 hectares.

Livestock farmers' perception of climate change: Table 2 shows farmers' perceptions of climate change and the mean with standard deviations. Although the survey questionnaire included several statements regarding livestock farmers' perception of climate change, this study included the seven most common statements to measure perception. The results revealed that the mean perception was 2.28 with a standard deviation of 0.57, indicating agreement with various dimensions of climate change. Livestock farmers perceived the increase in the maximum temperature, changed the timing of the rainfall, increased the frequency of droughts and floods, and decreased grass availability. The Chi-Square test of goodness of fit revealed a significant difference in farmers' perceptions.

Livestock farmers' perceptions about climate change impact on livestock: Table 3 reveals farmers' perceptions on how climate change affects livestock. To assess their perceptions, seven commonly observed impacts were examined. The findings showed that around 60% of farmers believed climate change led to reduced livestock weight, shorter lifespan, and lower quality of milk and meat. Additionally, over 60% agreed that it caused more diseases, higher illness rates, and increased production costs. The mean values supported these percentage-based results. A chi-square goodness of fit test also confirmed that the variation in farmers' perceptions was statistically significant.

Determinants of livestock farmers' adaptation strategies

Table 2. Perception of farmers about climate change

Perception	Disagree 1	Neutral 2	Agree 3	Mean	SD	Chi-Square
Increase the maximum temperature	12.2	21.0	66.8	2.27	0.65	9.71**
The timing of rainfall changed	6.1	22.4	71.5	2.33	0.53	6.81**
The amount of rainfall changed	4.6	327.8	67.6	2.27	0.49	3.63**
Annual average rainfall decrease	7.3	24.5	68.2	2.27	0.53	4.65**
Increase the drought incidents	6.5	23.1	70.4	2.32	0.55	3.23**
Increase the number of flood incidence	11.6	21.8	66.6	2.25	0.63	9.81**
Overall				2.28	0.57	

**: significant at 0.01

Table 3. Perception of farmers about climate change's impact on livestock farming

Perception	Disagree 1	Neutral 2	Agree 3	Mean	SD	Chi-Square
Decrease the weight of livestock	15.0	29.0	56.0	2.09	0.64	12.8**
Decrease the quality of milk	14.3	26.6	59.1	2.13	0.63	10.7**
Decrease the quality of meat	12.5	31.7	55.8	2.11	0.59	11.5**
Increase the diseases of livestock	7.5	29.1	63.4	2.27	0.58	11.4**
Increase the risk of morbidity	10.4	29.1	60.5	2.22	0.61	9.5**
Decrease the longevity of livestock	9.0	26.6	64.4	2.26	0.58	13.6**
Increase the cost of livestock production	9.5	29.7	60.8	2.23	0.59	10.9**
Overall				2.16	0.60	

**: significant at 0.01

Table 4. Adjusted odds ratios (aOR) from logistic regression models of adaptation strategies of livestock farmers to the impact of climate change on livestock

Variables	Involved in livestock Insurance	Utilized veterinary services	Modified the roof of the shed	Used diseases tolerant breeds	Diversified livestock varieties	Adopted heat and cold-tolerant local breeds
Place of residence						
Rural (r)						
Urban	0.72**	1.79**	1.59**	1.84**	1.38*	2.09**
Age group						
45-54 (r)						
55-64	1.04	0.95	0.92	0.78	0.83	1.02
65 and above	1.20	1.15	0.77	0.89	0.84	1.07
Sex						
Male (r)						
Female	0.63**	0.67**	0.83	1.01	1.24	1.21
Education						
No (r)						
Yes	0.94	0.91	1.89	0.91	0.64	1.31
Availability of land for livestock	1.02	1.03	0.83	1.23**	1.07*	1.22**
Availability of food	0.99	1.01	0.96**	1.03*	1.03	1.02
Household Size	0.98	0.99	1.04	0.93*	1.88**	0.86**
Family type						
Nuclear (r)						1
Joint	0.75	0.76	0.83	1.58**	0.77	1.87**
Jobs other than agriculture and livestock						
No (r)						1
Yes	1.17	1.04	1.15	1.72**	0.87	1.79**
Agro-ecological setting						
Tropical						1
Sub-tropical and temperate	2.95**	1.13	0.76	0.28**	0.53**	1.25**
Sub-alpine and alpine	0.81	0.66	0.53	0.15**	0.72	0.28
Access to credit schemes						
No (r)	1	1	1	1	1	1
Yes	5.41**	3.98**	1.11	0.51	1.91**	0.91
-2LL	1021.58	1321.28	876.79	1106.81	1271.61	1075.15
Hosmer and Lemeshow *Chi-Square value*	7.07, p = 0.53	15.40, p = 0.08	5.34, p = 0.75	11.85, p = 0.15	3.89, p = 0.87	9.61, p = 0.15
Cox Snell R-Square	0.32	0.10	0.02	0.21	0.06	0.25
Nagelkerke R-square	0.41	0.14	0.04	0.28	0.08	0.34

**: Statistically significant at $p<0.01$, *:Statistically significant at $p<0.05$, r: Reference category

to climate change impacts: Table 4 shows the determinants of livestock farmers' adaptation strategies to climate change impacts. Six adaptation strategies were included as dependent variables for binary logistic regression analysis. Place of residence, sex, education, availability of land for livestock and food, family types, and jobs other than agriculture and livestock were significantly related to the farmers' adaptation strategies. Livestock farmers in urban areas were likelier to adopt different strategies than rural farmers. However, urban farmers were less likely to be involved in livestock insurance programs than rural farmers. This may be because the accessibility of the facilities and resources in urban areas is higher than in rural areas.

Age and education of the farmers did not appear as significant determinants of adaptation strategies in this study. Findings from the focus group discussions (FGDs) also revealed that illiterate farmers showed greater knowledge than their literate counterparts, possibly due to the lower level of engagement of literate individuals in the livestock sector. However, other studies revealed that there was a positive impact of education on different adoption strategies (Igodan *et al*. 1988, Asfaw and Admassie 2004, Asfaw *et al*. 2017, Mohammed *et al.* 2020).

Compared to males, females were less likely to be involved in livestock insurance (aOR=0.63, $p<0.01$) and receiving veterinary services (aOR=0.67, $p<0.01$). This disparity may be attributed to the socio-cultural and traditional gender roles that grant males greater access to resources, thereby placing them in a more advantageous position than females. This finding is also consistent with other global studies (Deressa *et al.* 2009, Obayelu *et al.* 2014) in which female-headed households had a lower capacity to be involved in soil and water conservation. Farmers having land for livestock were more likely to be involved in different adaptation activities (used diseases tolerant diseases (aOR:1.23, $p<0.01$), diversified the livestock varieties (aOR:1.07, $p<0.01$), and adapted heat and cold tolerant local breed (aOR:1.22, $p<0.01$). Farmers from joint families were more likely to be involved in heat tolerant (aOR:1.87 $p<0.01$) and disease tolerant strategies (aOR:1.58, $p<0.01$) than nuclear families.

Jobs other than agriculture and livestock sectors emerged as significant predictors for the adoption of disease-tolerant livestock (aOR:1.72, $p<0.01$) and heat- and cold-tolerant breeds (aOR:.79, $p<0.01$). Household size was also positively related to the diversification of livestock varieties. As the number of household member increases, the likelihood of diversification of livestock varieties also increases. This finding is consistent with a study of African agricultural farmers (Hussan and Nhemachena 2008). Accessibility of credit scheme had a positive impact on the adoption of livestock insurance (aOR:5.41, $p<0.01$), utilization of veterinary services (aOR:3.98, $p<0.01$), and adoption of livestock varieties (aOR:1.91, $p<0.01$). Other studies have also shown the positive impact of accessibility of credit schemes on adaptation (Deressa *et al.* 2009, Khanal *et al.* 2022).

Climate change impact and adaptation are context-dependent phenomena, so the agro ecological setting is also significantly related to the adaptation practices. This study found that farmers from sub-tropical and temperate regions were more likely to participate in livestock insurance (aOR:2.95, $p<0.01$) and adoption of heat and cold-tolerant local breeds (aOR:1.25, $p<0.01$) as compared to farmers of tropical regions. However, farmers of sub-tropical and temperate were less likely to adopt disease-tolerant breeds (aOR:0.28, $p<0.01$) and diversification of livestock varieties (aOR:0.53, $p<0.01$) as compared to the farmers of tropical regions. Qualitative findings of FGDs also confirmed the findings of quantitative analysis. The farmers of different agro ecological settings have different adaptation measures (Deressa *et al.* 2009).

In conclusion, livestock farmers demonstrated an awareness of climate change and observed its adverse effects on livestock. To address these challenges, farmers implemented various adaptive strategies. The choice and effectiveness of these strategies were significantly shaped by regional setting, gender, land availability for livestock, household structure, off-farm employment, and access to credit facilities. Rural female farmers faced limited access to critical resources, information, and technological support, underscoring the need for targeted interventions to ensure equitable resource distribution. Enhancing employment opportunities beyond the agricultural and livestock sectors, along with improved access to financial services, may strengthen farmers' adaptive capacity and facilitate the effective use of technologies to mitigate the adverse impacts of climate change on livestock.

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