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Climate Change and Agricultural Households: What Determines Their Awareness in Dang District, Nepal?

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Abstract

Climate change has impacted Nepal's agricultural sector more than other economic sectors. Fluctuating rainfall pattern, rising temperatures, and occurrence of climatic extremes are substantially affecting agricultural productivity and food security. Agricultural households' considerations for reasons behind climate change are divergent from its occurrence. This study aims to analyze the trends in climatic parameters and identify the factors that determine the awareness of households to climate change using data from climate change impact survey of Nepal. The study is focused in Dang district with a sample size of 320. The univariate probit model was used to examine determinants of agricultural household's awareness to climate change. The study showed about 52% of respondent households are aware of climate change. Mass communication/media such as television and radio are primary sources to sensitize households on climate change. Trend of climatic parameters showed an increasing trend in temperatures for all seasons and decreasing trend for rainfall during autumn and winter seasons. Gender of respondent, household members involved in community-based organizations, experiencing droughts in last 25 years, education of household head, and non-agricultural income sources were positive and significant variables while distance to motorable roads was negative and significant variable determining awareness households. Results imply a need to strengthen and promote community-based organizations for information and knowledge sharing, and increase the on-farm post-production activities, and non-farm opportunities to household members. In addition, considerations should be given to trend in climatic parameters while promoting any adaptation practices to climate change.

Keywords
Climate Change, Agricultural Sector, Awareness, Nepal.

1. Introduction

Climate change is a global issue that has impacted Nepal's agricultural sector. The fluctuating rainfall patterns, rising temperatures, and the occurrence and harshness of climatic extremes are negatively affecting agricultural productivity and food security. The crop productivity is strongly affected by anticipated temperatures, which involve both the timing and amount of rainfall, especially at the most important phases of plant growth. While steady temperature growth may lead to better growing conditions for some crops in certain areas, this latent productivity growth is expected to be constrained by severe weather events, such as intense heat, drought, and irregular rainfalls during the flowering period (Malhi et al., 2021).

Climate risk is directly linked to vulnerability as climate change impacts may result from the interaction of climate-related hazards with vulnerabilities of societies and systems exposed (Selvaraju, 2012). One of the exclusive features of climate change is that it is often seen as an unfriendly psychological menace (Sterman and Sweeney, 2007), whose effects and risks are spatially and temporally distinguished (Woods et al. 2017). Agricultural households' considerations for the reasons behind climate change are divergent from its occurrence. Awareness or knowledge about climate change is considered the first step for making decisions to adopt, implement, and confirm in an innovation-diffusion process developed by Rogers (2003). In other words, awareness-knowledge represents the knowledge of innovation's existence. This type of knowledge can stimulate the individual to learn more about

innovation and, ultimately, to adopt it. Also, it may inspire an individual to learn about the other two types of knowledge. Awareness raising is often regarded as the first step in the adaptation process to manage the likely impacts of climate change and lessen vulnerability, because the degree of awareness tends to reveal the level of exposure to climate risks of a community (Ado et al., 2019). Therefore, being aware requires recognizing that climate change is a problem and understanding the risks and impacts associated with it that need to be addressed (Lieske et al. 2014). In addition, individuals' awareness and perception are considered inputs for climate change adaptation, while the behavior is the output as mentioned by Schlüter et al., (2017) in various behavioral models.

Nepal is ranked as the 10th most vulnerable country to climate change, considering the occurrence of extreme weather events between 2000-2019, with 0.39% losses per unit GDP (Germanwatch, 2021), despite Nepal's very low share (less than 0.10%) of global greenhouse gas (GHG) emissions. ND GAIN (2022) estimated an index by combining political, geographic, and social factors and considered Nepal as the 139th susceptible country out of 182 countries to climate change impacts. The estimate of the direct cost of current climate variability and extreme events was 1.5–2% of the current GDP per year in Nepal which was USD 270–360 million per year in 2013 prices (MoSTE, 2014). Different studies have also shown that the annual mean temperature of Nepal has been rising by 0.06 °Celsius per year, while the climate in Nepal's Himalayan region is changing faster than the global average (Upadhayaya and Baral, 2020). The temperature, rainfall changes, winds, and floods have all hindered the agricultural sector, which is one of the most susceptible sectors to climate change (Aryal et al., 2019). Given Nepal's exposure and its topography, experienced droughts in different years, which have affected crop production in all the ecological zones. The country's dependence on rainfed agriculture makes it mainly susceptible to changes in rainfall patterns. In the recent past, droughts have resulted in substantial decreases in cereal crop yields, particularly affecting maize and wheat production in Nepal (UNCCD, 2024).

The main objective of this paper is to analyze the trends in climatic parameters and identify the factors that determine the awareness and knowledge of the households about climate change in Dang district of Nepal using the data from the climate change impact survey.

2. Materials and Methods

2.1 Sampling and sample size

The National Climate Change Impact (CCI) Survey undertaken by the Central Bureau of Statistics (CBS, 2017) is the source of data for this paper. The Dang district of Lumbini Province was considered for this study. A three-stage sample selection procedure was adopted in CCI survey. In the first stage, the districts were chosen, the Primary Sampling Unit (PSU) in the second stage, and the households were chosen in the final or third stage. The process was applied separately for each of the 16 domains, which were considered as a stratum. Independent samples in each stratum were selected using the Probability Proportional to Size (PPS) sampling procedure, where the number of expected households in a particular district was adopted to be the size measure. After selecting districts with 16 domains, a sample of PSUs was chosen to represent each district. The number of PSUs chosen from each district was determined by dividing the number of households in each domain by 20, divided by the number of districts chosen in that domain. For the listing of the households, two criteria were adopted. They were mentioned as 45 years or older in age of the probable respondent and dwelling in the area for at least 25 years. Primary Sampling Unit (PSU) from 295-310, which represents Dang district (figure 1) with a sample size of 320, is considered for this paper.

Figure 1: Map of the study district

The data for analyzing climatic parameters such as temperatures (maximum and minimum), and rainfall for 1990-2021 was collected from the Department of Hydrology and Meteorology of the Government of Nepal.

2.2 Analytical technique

The outcome is binary nature in this study. The use of a linear regression model leads to biased and inefficient estimates in the case of binary outcomes or qualitative response variables (Greene, 2000). The discrete nature of awareness/knowledge response requires the use of a limited dependent variable model. Hence, the univariate probit model is used to examine the determinants of the agricultural household's awareness of climate change. The model uses the probit function, which is the inverse of the cumulative standard normal distribution, to map the probability of the event onto a linear combination of the predictor variables. The awareness-knowledge of the household is largely measured by a categorical variable, that is, whether a household is aware about climate change or not.

The model is specified in equations (1) and (2) as follows (Gujarati, 2003).

$Pi = Pr\ (Adoption = 1|X) = Pr\ (Ii \geq I*) = F(\beta X)$ … (1)

Or, $Pr\ (Adoption = 1|X) = \varphi\ (\beta o + \beta 1X1 + \beta 2X2 + \ldots + \beta nXn)$ … (2)

Where, Pr (Adoption = 1|X) represents the likeliness of awareness level given the predictor variables; φ(.) represents the cumulative distribution function of the standard normal distribution; β0 represents the intercept term; β1, β2, …, βn are the coefficients estimated for each independent variable; and X1, X2, …, Xn represent the independent variables.

The coefficients (β1, β2, …, βn) were estimated using the Maximum Likelihood Estimation. The assessment of model fit using goodness-of-fit measures like the likelihood ratio (LR) test or pseudo R2, was conducted to ensure the validity and reliability of the results. After the Probit regression, the marginal effects were calculated to obtain the estimates of the average change in the predicted probability of awareness to climate change for a unit change in the predictor variable, provided other variables are held constant. This allows for assessing which factors have a larger or smaller impact on the probability of the outcome.

2.3 Model specification

The dependent variable is the awareness/knowledge of the respondent (taking a value of zero or one). The explanatory variables include household characteristics, socio-economic variables, and institutional variables. They are defined as follows:

$AWARE = \beta 0 + \beta 1GENDUM + \beta 2INCBO + \beta 3DISTMOTOR + \beta 4DROUGHT25 + \beta 5LANDSIZE + \beta 6SERVASC + \beta 7EDN + \beta 8NONAGINCOME + \beta 9TOTMEMB + \beta 10YRSEXPERI + \varepsilon i$

where,

AWARE is awareness of the respondent on climate change (taking a value of 1 for those households that have awareness, while 0 otherwise)

GENDUM is the Gender dummy for the respondent with a value of 1 for male and 0 otherwise

INCBO is the involvement of the household members in community-based organizations (CBOs), taking a value of 1 for those that are involved in CBOs, 0 otherwise.

DISTMOTOR is the distance to the motorable road from the location of the house in km

DROUGHT25 is the perception of the household about the occurrence of droughts in the last 25 years, with a value of 1 for those households that experience droughts, 0 otherwise

LANDSIZE is the size of the landholding of the household in hectares

SERVASC is the service received from Agri Service Center, taking a value of 1 for those that have received services, 0 otherwise

EDN is the no. of years of schooling of the household head

NONAGINCOME is the amount of the annual non-agricultural income earned by the household in thousand NPR

TOTMEMB is the household size in number

YRSEXPERI is the number of years of experience of the respondent in farming.

β0 …..β10 are the parameters to be estimated. εi is the error term.

3. Results and Discussion

3.1 Socio-demographic information

It was revealed that 51.6% of the respondent households are aware and have knowledge of climate change. The average age of the household head was 57.6 years, while only 34.7% were female respondents. The head of the household had on average 4 years of schooling, a household size of 5.65 persons, and a land holding of 0,70 ha. The main occupation of the household head was agriculture and the average years they have practiced agriculture as a main occupation in the study area was 26 years. Only about 24% of the households received services from the public agriculture service centers, 51.6% of the households and their members are involved in community-based

organizations (CBOs), and the distance to a motorable road is about 1.4 km. Moreover, the contribution of non-agricultural sources of income was higher than agricultural sources in total household income (Table 1).

Table 1. Socio-demographic information of the sample households

S.N	Variables	Mean
1	Respondents having awareness to climate change (%)	51.6
2	Age of household head (yrs.)	57.6
3	Female respondents (%)	34.7
4	Household head's Av. years of schooling	4.0
5	Household size (No.)	5.65
6	Land holding size (ha)	0.70
7	Annual income of the Household (USD)	1951
8	Contribution of agricultural income (%)	37.5
9	Contribution of non-agricultural income (%)	62.5
10	Experience in farming (years)	26.0
11	HHs receiving services from Agri Service Center	24.1
12	HHs experiencing drought in the last 25 years	37.2
13	Distance to motor road head (km)	1.4
14	Households and their members involved in CBOs (%)	51.6

3.2 Main sources of information on climate change

In order to be aware on climate change, the farm households received information from varied sources. The mass communication media, such as television and radio, were the main sources. About 46 percent of the respondents considered television as the most important source, followed by radio (23.6%), and neighbors and friends (17.6%). They also received information on climate change by participating in the awareness campaigns, and reading newspapers and publications (Table 2).

Table 2. Sources of Information

S.No.	Sources	No. of respondents	%
1	Radio	39	23.6
2	Television	76	46.1
3	Newspapers	9	5.5
4	Awareness campaign	10	6.1
5	Neighbor and friends	29	17.6
6	Others	2	1.2
e	Total	165	100

3.3 Perception of temperature and rainfall change

The perceptions of the households on seasonal temperature and rainfall change compared to 25 years ago is presented in Table 3. It showed that majority of the households expressed that the summer temperature has increased while winter temperature has decreased compared to 25 years ago. In case of rainfall, over 90 percent of households perceived the decreased both season's rainfall compared to 25 years ago.

Table 3. The perception of the households on temperature and rainfall change (%)

	Increased	Decreased	No change
Temp-Summer	88.4	2.8	8.8
Temp-Winter	33.1	50.3	16.6
Rainfall-Monsoon	4.1	94	1.9
Rainfall-Winter	0.6	97.8	1.6

3.4 Changes in Climatic Variables

The trend of temperature and precipitation by seasons is presented in Table 4. There is an increasing trend in maximum and minimum temperatures for all the seasons while there is a decreasing trend for rainfall during the autumn and winter seasons. The growth of the maximum temperature was the highest during the winter season while it was the lowest during the summer season. The growth of the minimum temperature was the highest during the spring season, while it was the lowest during the winter season. The annual average growth of maximum and minimum temperatures remained at 0.058 and 0.029 degrees Celsius between 1990 and 2021 (Table 4).

Table 3. Changes in seasonal and annual climatic parameters (1990-2021)

Season	Max. Temp. (^{0}C)	Min. Temp. (^{0}C)	Rainfall (mm)
Spring (March-May)	0.076***	0.073***	1.49^{ns}
	(0.16)	(0.29)	(0.02)
Summer (June-Aug)	0.023^{ns}	0.00^{ns}	2.66^{ns}
	(0.01)	(0.01)	(0.01)
Autumn (Sept-Nov)	0.049***	0.04**	-1.98^{ns}
	(0.23)	(0.12)	(0.01)
Winter (Dec-Feb)	0.083***	0.001^{ns}	-0.63^{ns}
	(0.27)	(0.01)	(0.01)
Annual	0.058***	0.029**	1.54^{ns}
	(0.39)	(0.13)	(0.02)

Figures in the parentheses indicate R^2
***,**, and ns indicate significant at 1%, 5% level, and non-significant, respectively.

The future projection of climatic variables is based on the two Representative Concentration Pathways (RCPs) - RCP4.5 and RCP8.5 (MOFE, 2019) in Dang district. Compared to the reference period (1981-2010), the precipitation is likely to increase in all the scenarios and periods. In the medium term, the precipitation would increase by 1.1 to 6.7% while it is projected to increase by 7.62 to 12.36% in the long term. The temperature increase ranged between 1.03 to 1.16% in the medium term and 1.37 to 1.97% in the long term compared with the reference period. It also shows that compared to the reference period, the number of rainy days and consecutive dry days is likely to decrease. There will be an increase in warm days, which can be inferred about the overall temperature rise in the future. The changes in climatic parameters of Dang district are given in Table 5.

Table 5. Changes in Climatic Parameters in Different Periods in Dang district

Parameters	Reference Period (days)	RCP4.5		RCP8.5	
	1981-2010	2016-2045	2036-2065	2016-2045	2036-2065
Change in Precipitation (%)	1619 mm	1.1	7.62	6.7	12.36
Change in Temperature (^{0}C)	22.8	1.03	1.37	1.16	1.97
Change in no. of Rainy days(%)	145	-2.07	-1.23	-0.33	-0.29
Change in Consecutive Dry Days (%)	51.6	11.3	6.1	-0.43	-0.49
Change in Consecutive Wet Days (%)	67.4	-2.36	-0.51	11.92	10.77
Change in Warm Days (%)	36.5	5.85	7.99	6.19	9.96

Determinants of Climate Change Awareness

The result of the probit model on the awareness of the households on climate change in Dang district is presented in Table 6. The variables like the gender of the respondent (GENDUM), household members involved in CBOs (INCBO), distance to motorable roads (DISTMOTOR), experiencing droughts in the last 25 years (DROUGHT25), education of the household head (EDN), and the non-agricultural income sources (NONAGINCOME) were significant variables. All variables were positive except for the distance of the household to the motorable roads. The variables like GENDUM, INCBO, EDN, and NONAGINCOME were significant at a 1% level, while DISTMOTOR and DROUGHT25 were significant at 10% level. On the other hand, the LANDSIZE, SERVASC, TOTMEMB, and YRSEXPERI were not significant. The Log-likelihood Ratio was also highly significant indicating a very good fit of the regression model. The Pseudo R^2 was 0.228.

The results showed that other things being equal, the marginal effects (m.e.) coefficient of 0.16 of GENDUM indicates a 16% increase in awareness of the male respondents. Similarly, 0.21 m.e. coefficient of INCBO shows that

the household members who are involved in various activities of CBOs would be more aware (by 21%) than those not involved in CBOs. DROUGHT25 has a m.e. coefficient of 0.12, which means the households that have experienced droughts in the last 25 years are 12% more aware of climate change than the drought non-experiencing households. The m.e. coefficient of -0.035 for DISTMOTOR can be interpreted as, with an additional kilometer increase in the distance of road from the household, the awareness of the household is more likely to decrease by 3.5%. In the case of education of the household head (EDN) with a coefficient of 0.042, the additional years of schooling would likely enhance the awareness by 4.2%, whereas with additional ten-thousand-rupee increase in the income from non-agricultural sources, there is a likelihood of increasing awareness by 0.4%. The farm household's family members engaged in off-farm jobs other than farming, the more the probability of the farm household is aware of climate change. Education is a prime factor in shaping environmental education among farming communities. In other words, education is the global determinant of climate change (Mustafa et al. 2023). The membership and the involvement of household members in community-based organizations' activities improve social networking through cooperation with fellow farmers in exchanging/sharing information on pertinent issues like climate change, hence raises the awareness level.

Table 6. Results of the probit regression model on climate change awareness.

Variable	Coefficient	Marginal Effects*	P>|z|
GENDUM	0.41	0.16	0.01
INCBO	0.53	0.21	0.001
DISTMOTOR	-0.09	-0.035	0.02
DROUGHT25	0.31	0.122	0.06
LANDSIZE	-0.004	-0.002	0.34
SERVASC	0.09	0.034	0.64
EDN	0.11	0.042	0
NONAGINCOME	0.009	0.004	0
TOTMEMB	-0.013	-0.005	0.67
YRSEXPERI	-0.003	-0.001	0.46
Log Likelihood Ratio Chi square		101.08	0.00
Pseudo R^2		0.228	

*Marginal effects refer to the partial derivatives of the expected value with respect to the vector of characteristics.

4. Conclusion and Recommendations

The study revealed that about 52% of the households are aware and have knowledge of climate change. The household respondents received the information and were sensitized about climate change mainly from mass communication media such as television and radio, friends, and neighbors. Further, it is accelerated by the participation of the people in awareness campaigns organized by different I/NGOs and local agencies.

Similarly, the perceptions of the households on seasonal temperature and rainfall change showed that majority of households expressed that the summer temperature has increased while winter temperature has decreased compared to 25 years ago. While concerned with the rainfall, most of the respondent households perceived a decrease in both season's rainfall.

It is supported by the data of temperature and precipitation of the study area where there is an increasing trend in maximum and minimum temperatures for all the seasons while there is a decreasing trend for rainfall during the autumn and winter seasons. The growth of the maximum temperature was the highest during the winter season, the lowest during the summer season. The future projection of climatic variables revealed that there will be an increase in warm days, which can be concluded about the overall temperature rise in the future.

The results of the probit regression showed that most important variables determining the awareness of the farm households to climate change were the gender of the respondent, membership and involvement in CBOs, distance of the household location from the motorable roads, households' exposure and experience to droughts in the last 25 years, education level of the household head, and the income received from the non-agricultural sources. All variables contributed positively except the distance of the household to the motorable roads to the awareness of the household to climate change. Some important policy implications can be drawn from these results. Given low level of awareness and knowledge, the local and provincial governments and NGOs need to make additional efforts for improving the

awareness and knowledge through organizing various training programs and awareness campaigns on climate change and likely impacts to agricultural sector. The membership and the involvement of household members in community-based organizations' activities improve social networking. In this regard. It is imperative to strengthen the CBOs at the grassroots level that may facilitate in exchanging information among the fellow farmers. The farm household's family members engaged in off-farm jobs other than farming have more awareness of climate change. In this respect, the creation of off-farm jobs and post-production activities at the farm is recommended to be pursued by the local and provincial governments and district-level authorities so that households can increase their income. Moreover, the present trend of temperatures and rainfall need to be considered for implementing any climate change adaptation practices for agricultural sector.

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