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Research Article

Assessment of Status of Climate Change and Determinants of People's Awareness to Climate-Smart Agriculture: A Case of Sarlahi District, Nepal

Sandhya Adhikari,[1] **Sara Rawal**,[2] **and Sandesh Thapa**[2]

[1]*Institute of Agriculture and Animal Science, Paklihawa, Nepal*
[2]*Gokuleshwor Agriculture and Animal Science College, Tribhuwan University, Baitadi, Nepal*

Correspondence should be addressed to Sandesh Thapa; sand.thapa.2056@gmail.com

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This study aims to analyze the status of climate change and determinants of people's awareness of climate change in Sarlahi district, Nepal. A total of 102 respondents were selected randomly from the study area and interviewed using a semi-structured questionnaire from May 12, 2021, to May 23, 2021. Along with the determinants, this survey emphasized finding climate-smart alternatives favoring not only the population or sectors like agriculture but also the climate itself. The chi-square test was conducted to measure the relationship between the operational variables, which revealed that there was no significant relationship between gender and knowledge of climate change, occupation and knowledge of climate change, land ownership and knowledge of climate change, guardian and knowledge of climate change, and decision role and knowledge on climate change. However, education, family size, and age had a significant effect on the knowledge of climate change. The binary logit model reported that age, years of schooling, training related to climate change, and involvement with cooperatives were found to have a significant effect on people's awareness of climate change. Thus, improving people's adoption of climate-smart agriculture in the education system of the study area and training the people in the study area should be a prime concern.

1. Background

1.1. Climate Change Scenario. The discussion of climate change has been ongoing for a very long time. Many of us are still unaware of the consequences of long-term climate change, and many have neglected it too. The perception of climate change not only affects its mitigation but also gets impacted by the response from people. Different studies have been employed to understand the factors that can fuel people's perceptions, knowledge, and awareness about climate change [1, 2]. The farmers' perceptions of climate change should focus on ongoing adaptation measures and decision-making at the policy level [1]. In the past few years, studies have revealed the relationships among adaptation, production, and revenue gained under climate change scenarios [3, 4]. The evidence for climate change is certain, and its impact is observed globally. The countries with low-income status or better known as developing nations are affected more and are learning to adapt to such conditions, which is becoming a priority for human development [5, 6]. Farmers with small landholdings were found to be more aware and could respond to this stress, but due to several limiting factors, such as financial status and lack of proper technology adoption, the response was null [7]. The knowledge of the climate is of strategic importance, which ensures the viability of production systems and defines strategies to deal with environmental challenges [8, 9]. Farmers' traditional knowledge also provides a significant action to cope with fluctuating climatic conditions [7, 9–15].

1.2. Climate Change and Its Status in Nepal. "Climate-smart agriculture (CSA) is defined as a strategy to address the challenges of climate change and food security by sustainably increasing productivity, bolstering resilience, reducing GHG emissions, and enhancing the achievement of national food security and development goals" [16].

Climate change has had a huge impact on the livelihoods and farming systems of people in low-income developing nations [11, 17–19]. The major impact of climate change has been reported in the high hills and snow-capped mountains [11, 20, 21].

There is a clear consensus on two key issues among researchers in the field of climate change. First, global climate change is occurring at an alarming rate of approximately 0.8°C since the early 20th century [18]. South Asian nations are prone to climate change, which affects food production, thereby threatening food security [21, 22]. The changing climate-induced damage may vary from region to region, but farmers dependent on rain-fed farming areas have been found to be severely affected [23]. Case studies have demonstrated that CSA is crucial for African countries to increase crop productivity and net revenue, build resilience, and ensure food and nutritional security and diversity with a decline in greenhouse gas emissions at a local level [24].

CSA aims to support efforts from grassroots to top levels for the sustainable use of agricultural systems to ensure nutrition and food security [25]. The use of the ecological advantage to support productivity, tolerance, and mitigation in agricultural systems is mitigated by CSA.

ICIMOD has developed a resilient mountain village with the elements of CSA to address the issues of climate change at the local level and to protect and promote the production of vulnerable communities in hilly areas of Nepal [26]. For developing countries like Nepal, this is a big conundrum. On the one hand, initiatives, such as CSA, backed by renowned international organizations promise a better future through food security, adaptation, and resilience to climate change and mitigation of its effects in the long run [27].

The present study aims to report farmers' knowledge and support for climate change and farmers' awareness of climate change. Furthermore, we aimed to report the socioeconomic factors affecting farmers' knowledge of climate change and their willingness to adopt CSA.

2. Methodology

2.1. Site Selection. The study was conducted in Ishworpur municipality in the Sarlahi district, which lies in the Janakpur Zone of the southeastern Nepal of Province no. 2. The district is situated between latitude 26°45' N to 27°10' N and 84°41' E to 85°50' E longitude (Figure 1). The altitude ranges from approximately 60 m (lower tropical) to 659 m (upper tropical) from the mean sea level. The study area has a hot and humid climate all year round with a precipitation of 1732.94 mm and an annual average temperature of 23.59. The total population of Ishworpur municipality was 68,626 (50.3% females and 49.7% males) with a mean population density of 418.9/km^2 as of census 2021 [28, 29]

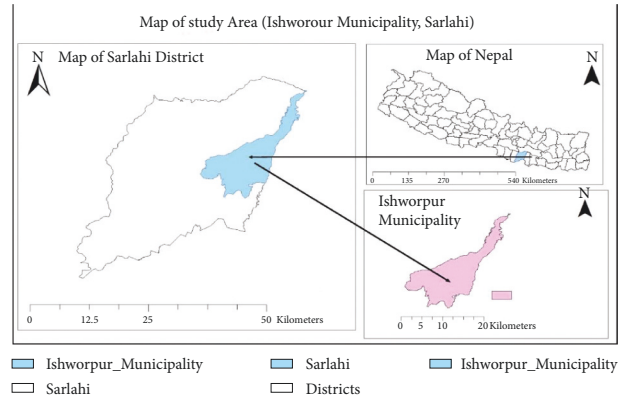

Figure 1: Map of the study area.

whichreported that around 37% have introduced more than three new varieties of the crop in the last 10 years as of 2011 and still very few are aware of climate change in the study area. We selected ward no. 4 of the Ishworpur municipality for our study because this area has faced many climate change issues and constraints at the farmer's level.

2.2. Research Design and Sample Size. A semistructured questionnaire was prepared [15, 30, 31], and pretesting was conducted in the study area with ten respondents each to check the accuracy of the questionnaire and collect more precise information. The data collected during the pretesting were not considered for analysis as the questionnaire was finalized after pretesting by including some relevant issues of cropping diversity and issues from the study area. The survey was conducted from March 12, 2021, to May 23, 2021. Primary information presented in the manuscript is from key informant interviews in the study area and recommendations from the focused group discussion (FGD), which has critical importance in such case studies as it helps to better share and adopt new information, techniques, and methods by group contact.

In FGD, there were 102 respondents, which included approximately 14% of the population involved in agriculture in the study area [32]. Key informant interviews were conducted using semistructured questionnaires, and FGD was conducted to share the information collected from the study area and circulate the farmers' opinions.

2.3. Data Analysis. The collected data were analyzed using IBM SPSS V.21.0 [33] and Stata 16 [34]. The coding used in the data sheet is given in Table 1. Descriptive statistics, including count, average, standard deviation, and Pearson chi-square association, were analyzed using IBM SPSS V 21.0. However, for the binary logit regression analysis, Stata (Stata Corp, LLC) was used [35].

2.3.1. Binary Logit Regression. A binary logit model [36] was introduced in this study to determine the factors affecting people's awareness of CSA. It is popular among prediction analyses for estimating probability [37] and always ranges

Table 1: Details of parameters used in the binary logit regression model.

Variables	Type	Details	Code used	Average
		Dependent variable		
Aware about climate-smart agriculture (CSA)	Dummy	Farmers are aware about CSA	1 = aware 0 = unaware	0.41
		Explanatory variable		
Gender	Dummy	Sex of respondent	1 = male, 0 = female	0.62
Age	Continuous	Age of respondent	Years	48.03
Number of members in family	Continuous	Size of family	Number of people living in a family	5.7
Land holding (Kattha)	Continuous	Land under cultivation	Area of land	20.17
Schooling years	Continuous	Education level	Schooling year	4.2
Economically active population	Continuous	Employed members in a family	Number of members in a family employed	2.29
Involvement with cooperatives	Dummy	Member of cooperatives in study area	1 = yes, 0 = no	0.48
Contact with extension worker	Dummy	Farmers contact with extension worker	1 = yes, 0 = no	0.52
Trainings related to climate change	Dummy	Participated in training or not	1 = participated, 0 = not participated	0.11

between 0 and 1. The values in the range of 0 and 1 are true in the logit model only and not for other regression models [37]. For the logit regression model, awareness about CSA was the dependent variable, whereas the explanatory variables were gender, age, schooling years, family size, economically active population, landholding (in Kattha unit), training taken, contact with extension workers, and involvement with cooperatives (Table 1) [31]. The logit regression model was also used [15, 31, 38] to determine peoples' awareness of climate change. Joshi et al. [36] also adopted this model to determine the socioeconomic factors influencing the adoption of good agricultural practices in bananas.

The odds ratio was used to determine the likelihood of farmers' awareness of CSA. In addition, the natural log of odds is used to determine the logit value, as shown in (2) and (3). Furthermore, the logit regression model with respect to intercept, coefficients, and dependent and independent variables [37] are shown in (3).

$$\text{Odds}(Y) = \frac{P(Y=1)}{1-P(Y\neq 1)}. \quad (1)$$

Applying natural log on both sides,

$$\ln \text{odds}(Y) = \ln\left[\frac{P}{1-P}\right] = \log \text{it}(Y). \quad (2)$$

Furthermore,

$$\log \text{it}(Y) = \alpha + \beta 1X1 + \beta 1X2 + \beta nXn + \varepsilon 0, \quad (3)$$

Y represents the dependent variable (aware about CSA or not); X1, X2...Xn represent the explanatory variable (gender, age, years of schooling, number of members in the family, economically active population, landholding (in Kattha), training taken, contact with extension workers, and involvement with cooperatives); β represents the coefficient of the explanatory variable; $\varepsilon 0$ represents the error index.

2.3.2. Area under ROC Curve (AUROC). ROC analysis is currently widely used in nearly all fields of science, including artificial intelligence [37], and in agriculture [39, 40]. The ROC provides a measure of how well the fitted model distinguishes true cases from true noncases. The AUROC can also be interpreted as the average probability of correctly visualizing a positive case across all possible cutoff points of the predictor [40]. The value of the area under the ROC curve ranges between 0 and 1, which can be expressed as a percentage.

In this study, after the logit regression model, the ROC under AUC (Figure 2) was determined and found to be 0.9631, that is, 96.31% of the cases are true cases, and as per [37], there is excellent discrimination or the curve is said to have positive discrimination, which was further supported by Kleinbaum and Klein and Debats et al. [37, 39].

3. Results and Discussion

3.1. Socioeconomic Characteristics. The socioeconomic and demographic characteristics of the respondents are given in Table 2. These characteristics include age, gender, ethnicity, level of education, primary occupation, secondary occupation, total landholding, land ownership, guardian, and decisive role. The literacy rate was found to be lower than that of the national average in the study area, and it has been reported that 50% of respondents are literate. The majority of respondents were male (61.76%). The predominant ethnic groups in the study area were found to be Brahmin and Chhetri, which occupy approximately 60% of the population size, and the rest were Madhesis. The chi-square test of the association between caste and people's knowledge of climate change has a significant effect ($\chi^2 = 13.28$, $p \leq 0.0001$). The study revealed that agriculture was the primary occupation in the study area, representing a higher number of people involved in the occupation than those involved in the occupation at the national average (65.6%).

The secondary occupations of the respondents such as business (3.92%), labor (10.78%), driving (7.84%), service (2.95%), teaching (2.95%), and farming as a profession (both primary and secondary) were recorded from 71.56% of the respondents. Our findings indicated that the majority of females have ownership in fixed assets, such as land

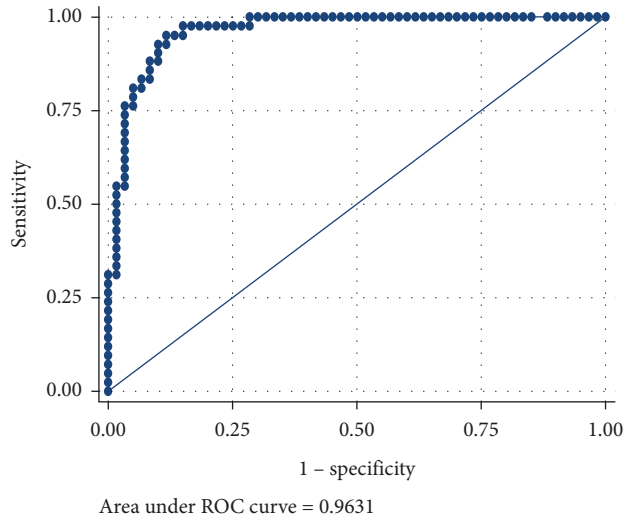

Figure 2: Area under ROC curve.

Table 2: Socioeconomic characteristics and association with knowledge of climate change.

Socioeconomic characteristics	Knowledge on climate change		Chi-square	*P* value
	Yes	No		
Sex				
Male	41	22	2.6622	0.103; ns
Female	19	20		
Age group				
25–35	11	7	15.479	≤0.001**
36–49	17	12		
50–60	14	31		
Above 60	0	10		
Family size				
Less than 4	19	11	9.02	≤0.01**
4–6	15	27		
>6 (joint)	8	22		
Education of respondent				
Illiterate	4	47	46.79	≤0.000001**
Literate	38	13		
Primary occupation				
Agriculture	60	42	—	—
Secondary occupation				
Business	3	1	10.2474	0.248; ns
Daily wages	5	6		
Driving	2	6		
Service	2	1		
Teaching	3	0		
Agriculture (primary and secondary)	27	46		
Total land holding (average)	20.97	19.406	27.07	0.132; ns
Land ownership				
Male	9	9	0.7026	0.402; ns
Female	51	33		
Guardian				
Male	56	40	0.1619	0.687; ns
Female	4	2		
Decision role				
Male	58	40	0.1338	0.715; ns
Female	2	2		

*Significant at less than 10% LOS. **Significant at less than 1% LOS.

(82.35%), but still male is the guardian (94.12%), and there is a strong dominance of males in the decision-making sector (96.08%).

The chi-square test of association revealed that there was no significant relationship between sex and knowledge of climate change ($\chi^2 = 2.6622$ and p value ≤ 0.103), occupation and knowledge of climate change ($\chi^2 = 10.2474$, $p \leq 0.248$), land ownership and knowledge of climate change ($\chi^2 = 0.7026$ and p value ≤ 0.402), guardian and knowledge of climate change ($\chi^2 = 0.1619$ and p value ≤ 0.687), and decision role and knowledge on climate change ($\chi^2 = 0.1338$ and p value ≤ 0.715) but has a significant effect on education, family size, and age group, as given in Table 2.

3.2. Knowledge about Climate Change. Among 102 respondents, nearly everyone was unaware of the term "climate change" initially, but with further discussion, some of them were found to be familiar with it. Approximately 58.8% of the total population was found to have a better understanding of climate change (Figure 3). The term "climate change" was completely novice for the remaining 41.2% of the total population. Radio was found to be the main medium for the dissemination of the information and revealed that 84.35% of the total population heard about climate change from radio, 13.46% knew about climate change from television, and 2.19% knew from both radio and television (Figure 4).

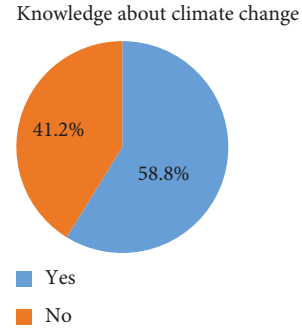

Figure 3: Knowledge about climate change.

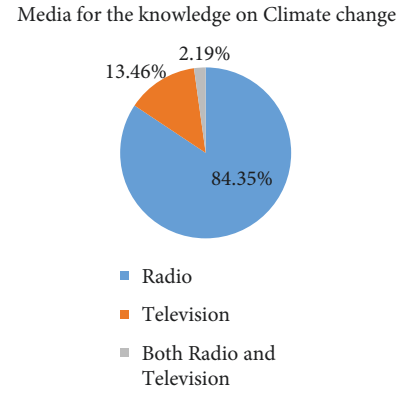

Figure 4: Sources of knowledge about climate change.

3.3. Perception regarding the Rainfall Status and Effect on Crop Production

3.3.1. Rainy Season Crops. The respondents were surveyed based on the status of yearly rainfall. The majority of the respondents (65.68%) revealed that there was untimely rainfall in the rainy season with more intensity, and 34.31% said that there was an intense early onset of the rainfall. Both early onset and untimely rainfall have a huge impact on crop production. Major seasonal crops, such as rice, vegetables, and sugarcane, are highly affected by untimely rainfall in the rainy season. Approximately 79.41% of the total respondents figured out that rice crops have been adversely affected by changes in rainfall patterns. Rice and vegetables were affected by 18.62%, and 0.98% concluded that rice, vegetables, and sugarcane were affected, followed by rice and sugarcane crops (0.98%) (Figure 5).

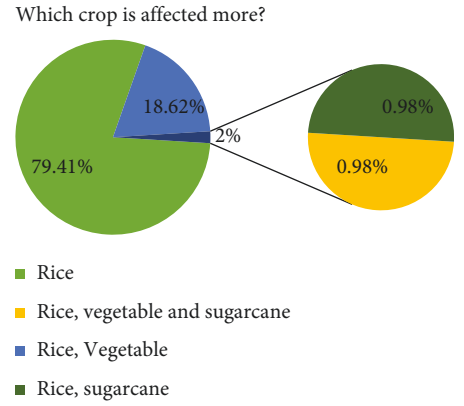

Figure 5: Status of crops affected in the study area.

The perceptions of farmers regarding the impact of climate change on crop production were recorded. The findings of our study illustrate that the productivity and yield of the crop have been drastically reduced, followed by the extreme infestation of pests and diseases in field crops. Untimely rainfall has abruptly increased the maturity period of the crop due to which there is a delay in the cultivation of crops, such as wheat, potatoes, and maize. The dying of plant saplings has also been identified by farmers in the study area. Weed infestation has also created havoc situations in cropping regions. In recent years, insect pest populations have increased enormously, which has become impossible to control without the use of chemical pesticides. Approximately 83.33% of the farmers reported rice ear head cutworms as the major detrimental pest to reduce the yield, 14.71% reported cutworms and bugs, and 1.96% reported cutworms and rice borers damaging the crop from tillering to the mature crop. According to the reports published by LI-BIRD [41], crop yield is affected more, and production loss would be a major cause due to the scarcity of water resources in the coming days.

3.3.2. Winter Season Crops. Winter season crops, such as maize, wheat, potatoes, mustards, vegetables, lentils, and sugarcane, are reported to be affected by winter season

rainfall. Nearly every respondent reported that there was no winter rainfall for the last five years. Maize is the major winter crop cultivated in the study area; 73.53% of the total population revealed maize as the most affected crop among all others due to lack of rainfall. The reduction in the yield and a high infestation of pests, such as fall armyworms, grubs, and disease outbreaks, have been reported in the study area. The yield reduction of maize and the increase in yield of rice at 4°C temperature elevation has also led to a change in the cropping pattern of the farm family [42].

3.4. Insect Pest Reported in Recent Days and Cropping Diversity per Annum. Changes in pest population dynamics were reported in the study area. There are reports on the increasing abundance of fall armyworms and armyworms in the past few years. However, their management is nearly impossible without the use of high-risk chemical pesticides, such as spinosad and cypermethrin, among others, which are expensive and quite unaffordable for small farmers. Of the total farmers, 61.9% reported fall armyworms, 32.2% reported fall armyworms and grubs, and 5.9% reported armyworms causing damage in rice fields. Roughly, the loss in yield due to insect pests was higher in the case of armyworm in rice and fall armyworm in maize and rice. Last year, the farmers experienced a yield loss in the range of 5–40% and 10–35% in rice and maize, respectively.

The cropping history refers to crops grown in the past, which are now discontinued, along with the crops presently grown in the study area. Vegetables, cereal crops (rice, wheat, and maize), and cash crops are chiefly grown nowadays. Cereal crops are the major crops grown by all of the respondents in the study area. Similarly, very few respondents have grown vegetables and cash crops. The details of the cropping diversity of the respondents are shown in Figure 6.

Local rice and tobacco were the chief crops in the past years, but due to changes in rainfall patterns, changes in the cropping system have been reported, which are discontinued due to low productivity, high insect pest incidence, and erratic rainfall patterns.

3.5. Determinants of People's Awareness of CSA. The use of a binary logit model while testing socioeconomic variables and its effect on adoption and awareness has been suggested by Hasan and Akhtar and Badmos et al. [15, 38]. Table 3 provides the outcome of nine explanatory variables on people's awareness of CSA. Among the tested independent variables, schooling year was found to have a significant effect at less than 1% level of significance. The result explained that, with a one-unit increase in the schooling year, the probability of being aware of CSA will increase by 4.9%. Similarly, the effect of schooling years on adoption and awareness has been reported by Joshi et al. [35]. In addition, it has been reported that the education level of respondents has a significant effect on knowledge of climate change, which may influence awareness of CSA [43].

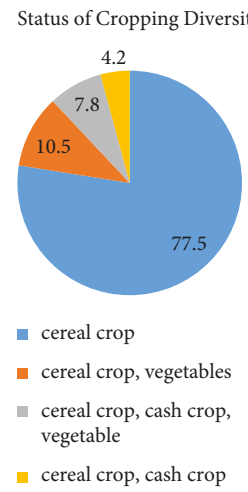

Figure 6: Cropping diversity in the study area.

Farmer's age was also found to have a significant effect on awareness of CSA at less than 5% LOS. It has been reported that with a one-unit decrease in the age of respondents, the probability of being aware of CSA increased by 0.82%. In line with our findings, Shreshtha and Baral [31] also reported that the awareness of climate change has been increased by a decrease in the age of respondents. Typically, farmers in the productive age group under 35–45 years were found to have awareness about CSA, and it has been reported [38] that farmers in productive age groups are more aware than older farmers.

The tested dummy variables, training taken, and involvement with cooperatives were found to have a significant effect on being aware of CSA at 5% LOS. In contrast to our finding, [30] involvement/membership in cooperatives does not have a significant effect on awareness of climate change. If farmers are in contact with extension workers, then the probability of being aware increases by 3%, which is in line with the finding [30] that extension services do not have a significant effect on climate change. However, it has been [31] reported that extension services have a significant effect on awareness of CSA, which might be due to the availability of extension services related to CSA in the study area, which was not found in our study area.

Furthermore, if the farmer is male, the probability of being aware slowed down by 6.88%; if farmers are in contact with extension workers, then the probability of being aware increased by 3%.

In addition, in the continuous variables, the larger the farm size, the lower the probability of being aware by 0.29%. Similarly, the smaller the household size, the greater the probability of being aware that for a one-unit decrease in household size awareness rises by 2.6%, and for a one-unit increase in the economically active population, the probability of being aware increased by 2.7%.

The LR chi-square was found to be 86.25 and was significantly different at less than 1% LOS, which reveals that independent variables (socioeconomic characteristics) have good explanatory power on people's awareness of CSA and

Table 3: Determinants of people's awareness of climate-smart agriculture (CSA).

Parameters	Coefficient	Standard error	Z value	$P^{***} > \mathrm{I\ z\ I}$	dy/dx
Age	−1.046	0.047	−2.22	≤0.026**	−0.082
Sex	−0.876	0.841	−1.04	0.298	−0.0642
Total land holding	−0.372	0.364	−1.02	0.306	−0.002
Schooling years	0.631	0.160	3.94	≤0.0001*	0.049
Training on climate change	2.696	1.563	1.72	0.085*	0.211
Number of members in a family	0.338	0.422	0.80	0.423	−0.265
Contact with extension worker	0.383	0.939	0.41	0.683	0.03
Involvement with cooperatives	1.940	1.147	1.69	0.091*	0.152
Economically active population	0.353	0.531	0.67	0.506	0.277
_Cons	3.162	2.165	1.46	0.144	

Log likelihood = −25.629, LR chi-square = 86.95, prob > chi-square ≤ 0.00001, pseudo $R^2 = 0.6291$, area under the ROC curve = 0.9631. *Significant at less than 10% LOS. **Significant at less than 5% LOS. ***Significant at less than 1% LOS.

its adoption. The pseudo R^2 was found to be 0.6291, which shows that the model has a strong explanatory power on people's awareness about CSA, that is, socioeconomic factors jointly affected the model which signifies that the model fits 62.91%.

3.6. Training, Suggestions, and Recommendations to Combat Climate Change Issues. Of the surveyed 102 respondents, only 11 were found to have benefited from training related to climate change; the rest of the respondents had not received any training related to climate change. All the respondents who had taken training were provided by the local government. Previous studies have reported that training and seminars at the grassroots level were found to be more effective in raising awareness and promoting the adoption of new technology [31, 35].

Suggestions and recommendations to fight climate change per farmer were recorded and presented here. Out of 102 respondents, all of them were positive about taking training related to CSA and subsidies on seed and fertilizers. Excluding this, response from the farmers was recorded as 23 of them suggested to receive subsidies on the new package of practices, 35 of them responded to receive compensation on crop loss due to insects and pests, and 45 responded to receiving subsidies on water pump installation and continuation, as water scarcity is a limiting constraint in agriculture production.

4. Conclusions

Nepal is a country, which is most vulnerable to climate change, and the majority of people are still unaware of climate change and its impact. Based on the findings of this study, there is a strong need for the government, local organizations, stakeholders, funding bodies, and policymakers to introduce economically sound adaptation techniques to cope up with climate change. Acting bodies in the field of climate change in the Sarlahi district, including other parts of Nepal that share plain terrain, should focus on education and training at the grassroots level to improve the adoption of CSA. Moreover, educational programs, training, and extension involvement of workers that enhance the livelihood of the people should be implemented effectively. The local government must prioritize the awareness programs, adaptation practices, and implementation of the CSA projects. Subsidized farming inputs, such as stress-tolerant seeds, manures, farm implements, the application of new technologies, and diversified agricultural systems, can also be sustainable approaches for the mitigation of climate change in agriculture.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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