ANALYZING THE SOCIOECONOMIC DETERMINANTS OF ADOPTION OF CLIMATE SMART AGRICULTURE IN NAWALPARASI DISTRICT OF NEPAL

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ABSTRACT

Climate change is an emerging global issue and its impact on agriculture of the developing countries has been increasing substantially in the last two-decade. Relevancy of issues how much the climate smart agricultural technologies were reaching at farm level and their economics of adoption were not properly studied in the past. Research examined the various climate smart agricultural technologies, the benefit of it and the socioeconomic factors affecting its adoption in the purposively selected Agyouli village of Nawalparasi district. For obtaining primary data from the respondents, 100 samples were selected by using a simple random sampling technique. The study was done by direct interviews and focus group discussions with the selected respondents through the means of questionnaires and checklist respectively in May 2018. The results of the primary information further complemented by using secondary data collected from the published sources. The community seed bank, green manure, biogas, legume intercropping, improved varieties, integrated pest management and integrated plant nutrient management as climate smart agricultural technologies in the farms of adopters contributed significantly higher farm income, productivity, gross income and benefit-cost ratio of paddy production for the adopters by NRs. 24377.9, 1.5 t ha^{-1}, NRs. 35298.7 and 0.88 respectively than non-adopters. Further analysis of binary logistic regression model assessed the significant effect of age of household head, economically active household members and the training on the likelihood of adoption of climate smart agriculture. The study recommends climate smart agricultural technologies throughout the country in the changing context of climate change.

Keywords: *adopter, benefit-cost ratio, binary logistic regression, climate change, seed bank*

INTRODUCTION

Agriculture is an integral part of the Nepalese economy. Agriculture is not only the source of livelihood but also the means of additional income and nutrition for the farmers and their families. But, in recent years, climate change has posed serious threats to farming communities. Especially the resource-poor small-scale farmers in a developing country like ours are more vulnerable and more likely to suffer from these adversities of climate change due to their lower capacity to adapt to and fight back the adverse impacts of climate change as Nepal is predicted to be one of the most severely affected countries by the impacts of climate change in the years to come (Synnott, 2012).

Climate change is not only a hot issue in Nepal, but even is a global issue as it has been distressing the global economy. Increasing greenhouse gases (GHGs) emissions because of human activities have been the major cause of climate change since greenhouse gasses are major drivers of global warming. Conventional agriculture is responsible for 14% of global GHGs emissions and livestock plays a considerable role in climate variation in terms of their contribution to GHG emissions (Panta, 2011). Acharya (2012) revealed that the higher side temperature rise seems terrible as it is nearly 2.0°C on average in Western Nepal which is almost three times the lower average temperature. Such temperature rises in Nepal, if compared to the global trend, is significantly higher.

Climate change increases the duration, frequency and intensity of meteorological droughts (Burke et al., 2006). Droughts and irregular rainfall reduce agricultural production and ultimately results in food insecurity. Climate change also responsible for the appearance of new diseases and pests in crops and livestock. According to Malla (2008), both insect and disease pests of plain ecosystems are expected to shift even in the hills and mountains. For example, rust and foliar blight of tropical area in the past years have been reported in the mountains and mid-hills, which can adversely affect agricultural production.

The current agricultural practices of mono-cropping, excessive dependence on diesel-based heavyweight farm machinery and increased use of agrochemicals in growing crops are further triggering the emission of GHGs and causing climate change. The impacts of climate change in agriculture are the decrease in productive land in some regions and an increase in other regions. So, it is an interwoven mess to the world (Pathak et al., 2003). Therefore, the strategies to mitigate the impacts of climate change must be based on the community's traditional and local knowledge. So, to address both food security and climate change of nation it is necessary to change the agricultural practices to the climate smart one, which ensures both food security by increasing productivity, agriculture adaptation to climate change and mitigation of climate change by reducing the GHGs emission. FAO (2013) defines climate-smart agriculture (CSA) as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces GHGs (mitigation) where possible, and enhances achievement of national food security and development goals". In this definition, the principal goal of CSA is identified as food security and development while productivity, adaptation, and mitigation are identified as the three interlinked pillars necessary for achieving this goal (Lipper et al., 2014; FAO, 2013). CSA technologies enhance resource use efficiency and higher productivity and yields. It contributes to slow down the adverse effects of climate change and enables us to meet the three pillars of CSA as sustainably increase agricultural productivity, maintaining productivity by adapting to climate changes, and reduce or remove GHGs emissions.

With fewer options to fight back these adversities and adapt to the impacts of climate change, farmers are finding agriculture less profitable day-by-day thereby being forced to shift towards other enterprises reluctantly. As per the objective of the Climate Change Policy of Nepal 2019, to implement climate adaptation-related programs and mitigating the adverse impacts we must analyze climate-smart agriculture over conventional agriculture from the individual farming household point of view.

The broad objective of conducting research was to analyse the status and impact of climate smart agriculture in Nawalparasi district in Nepal. The specific objectives of the study were as follows.

1. To determine the different climate-smart agricultural technologies adopted by the farmers
2. To study the impact of climate-smart agricultural technologies on farm income and rice production
3. To assess the socio-economic factors affecting the adoption of climate smart agriculture

The research questions of the study were as follows;

1. What are the benefits of the adoption of climate smart agriculture?
2. What are the factors responsible for the adoption of climate smart agriculture?

MATERIALS AND METHODS

Sampling techniques and sample size

The study used both primary and secondary sources of information. Most of the primary data were generated through household survey, focus group discussions and direct observations in May 2018. We selected Agyouli village of Kawasoti Municipality in Nawalparasi district purposively as the respondents of that village had been implementing the CSA programme with the help of Local Initiatives for Biodiversity, Research and Development (LI-BIRD). By using a simple random sampling technique, 100 farming households were selected from the different wards of Kawasoti municipality for interview. The sample size was calculated by using Solvin's formula (1960).

$$n = N / \left(\left(1 + N \times e^{\wedge} 2\right)\right) \approx 100$$

Where, n= Sample size, N= Number of households in the village (2538) and e= Critical value (0.1)

Researchers also used secondary sources of published information collected from e-resources of Food and Agriculture Organization, Local Initiatives for Biodiversity, Research and Development (LI-BIRD), and Central Bureau of Statistics (CBS) Nepal.

Data collection

The research team prepared a well-structured interview schedule and organized pre-testing of the interview schedule with ten household heads around the study area. The final questionnaire was prepared by cumulating the missing information.

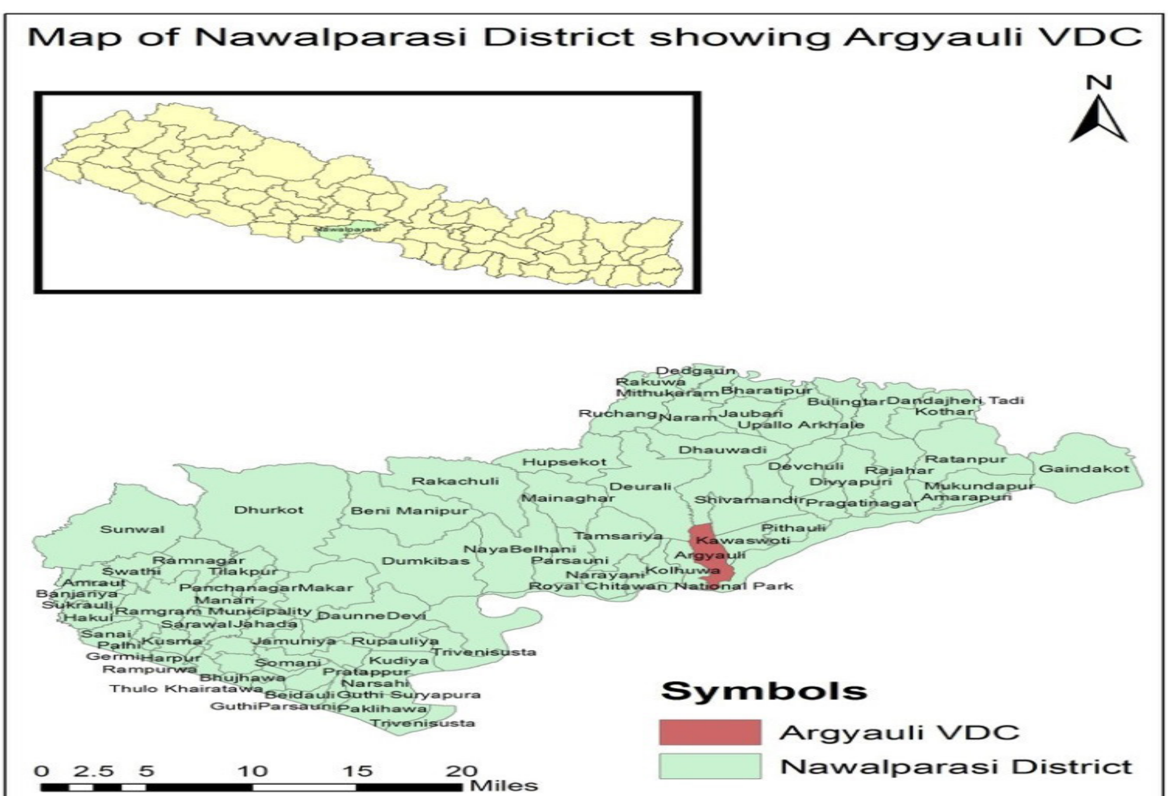

Figure 1. Map of the study area

Data analysis

Researchers coded, cleaned and entered the collected primary information with the help of Microsoft excel. Data were analysed with the help of IBM SPSS Statistics 21 and STATA 12. Bar diagrams were used to show the different climate smart agricultural technologies adopted by the farmers to meet the 1st objective of the study. To meet the 2nd objective of the study, we compared the economics of paddy production and the annual income of the farmers between adopters and non-adopters. The productivity of rice, cost of rice production, income from rice production, margin and B:C ratio were calculated by using the following formulae.

Productivity = Production of rice in current year/Area of cultivation

Cost of production = Total variable cost required for the production of the rice

Gross income = Total production × Price per unit

Gross margin = Gross income - Cost of production

B:C ratio = Gross income/Cost of production

The t-test was done to check the significance of comparative economics among adopters and non-adopters. Similarly, we used logistic regression to assess the socio-economic factors affecting the adoption of climate smart agriculture as 3rd objective. The logit model is the most suitable tool analyzing dichotomous responses which allows examining how a change in any independent variable changes all the outcome probabilities (Regmi, 2010). The logit function of the probability of adopting CSA by our respondents is illustrated from Gujarati, (2003);

$$L_i = \ln [P_i /1- P_i] = Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i$$

Where Y_i = a binary dependent variable (1, in case farmers, adopted CSA & 0, otherwise), X_i includes the vector of explanatory variables used in the model, β_i = parameters to be estimated, β_0 = a constant term, ε_i = error term of the model, exp (e)=base of the natural logarithms, L_i = Logit and $[P_i /1- P_i]$= odd ratios, i= 1, 2, 3, 4,……, n farm households. Thus, the binary logistic regression model is expressed as;

$Y_i = f (\beta_i X_i)$

Where, X_i represents socioeconomic determinants like; the age of the household head, economically active family members (Age in the range of 15-59), cultivated land, livestock holding, total annual income, support from organizations. The farmers adopting any of the technologies under the smartness category of CSA (Table 1) were supposed to be the adopters of the CSA (Paudel et al., 2017).

Table 1. Smartness category of CSA

Smartness category	Technologies
Water smart	Drip irrigation, DSR, SRI, Rainwater harvesting
Nutrient smart	IPNM, Green manuring, Intercropping with legumes
Carbon smart	IPM, Biogas
Energy smart	Zero tillage, Solar pump
Knowledge smart	Seed bank, Improved varieties, Integration of farm with fisheries, Contingent crop planning
Weather smart	Crop and livestock insurance, Weather based crop advisory

RESULTS AND DISCUSSION

Adoption of climate-smart agricultural technologies

The level of adoption of CSA varies among the adopters. Figure 2 shows that the majority of adopters (71.4%) have been adopting community seed banks for getting seeds of different cereals, pulses and vegetables followed by 32% of adopters adopting green manure for rice. Likewise, 25% of the adopters had been adopting biogas as cooking fuel and 19% of the adopters were using improved varieties of rice and vegetables in their farms. About 16.7% of the adopters did intercropping legumes with cereals and oilseed crops whereas 11.9% of the adopters were adopting integrated pest management (IPM) in the vegetables and rice field. Similarly, other important CSA technologies supported by the programme and owned by the respondents were integrated plant nutrient management (IPNM) for vegetables, solar pump for irrigation in rice and maize, zero tillage technology for the cultivation of garlic, contingent cropping for vegetables and cereals and weather-based crop advisory for farming.

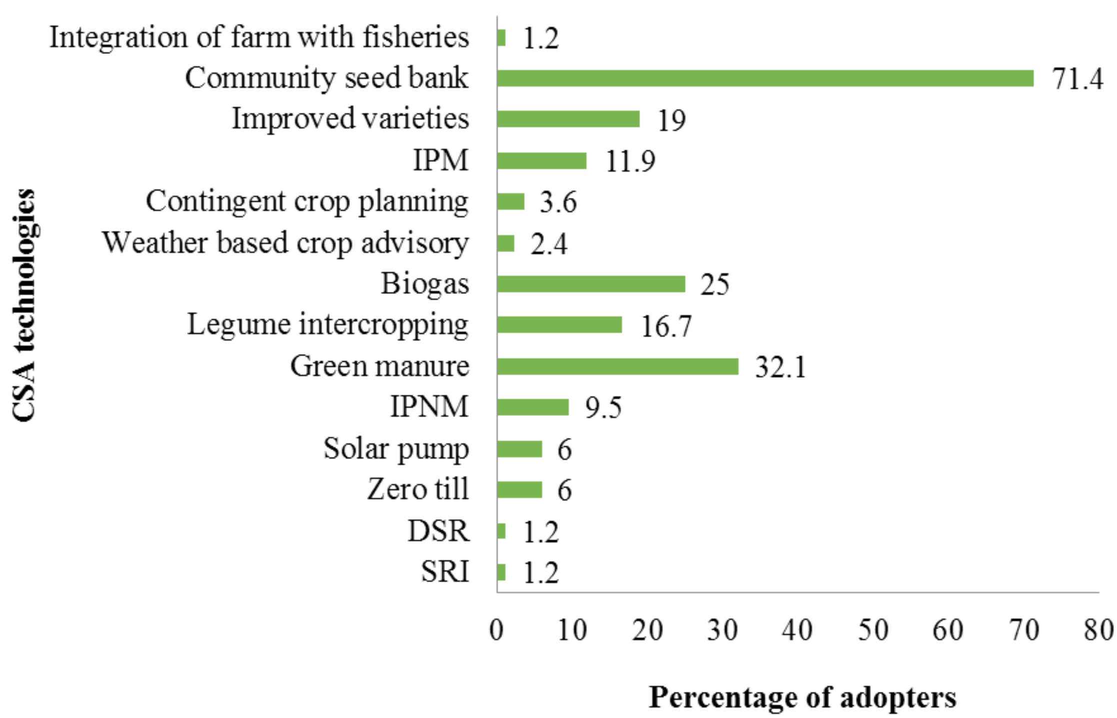

Figure 2. CSA technologies adopted by the adopters in the study area

Source: Field survey, 2018

Impact of climate-smart agriculture

Financial analysis of paddy production among adopters and non-adopters

Paddy was the major agricultural crop of the study area with average productivity of 4.05 tons per hectare. The financial analysis of paddy production among adopters and non-adopters was shown in Table 2.

Table 2. Comparative financial performance of paddy production among adopters and non-adopters in the study area

Particulars	Adopter	Non-Adopter	Mean Difference	t-statistics	P-value
Productivity (Mt/ha)	4.2	2.7	1.5	3.096***	0.003
Cost of cultivation(NRs/ha)	71636.9	63562.5	8074.4	0.648	0.518
Gross income (NRs/ha)	107392.4	72093.7	35298.7	2.922***	0.004
Gross margin (NRs/ha)	35755.5	8531.2	27224.3	1.488	0.140
B:C	2.1	1.2	0.88	2.064**	0.042

*Note: *** Significant at P =0.01; ** Significant at P =0.05 level* *Source: Field survey, 2018*

The paddy productivity was 55% higher, which was significantly greater to adopters than that of non-adopters. Both gross income and B:C ratio per hectare of paddy production were significantly higher to the adopters. Quite similar results were also reported by Dhakal (2015) in maize production with the use of climate-smart sustainable soil management practices in Khotang district. Adoption of CSA technologies like short duration, drought resistant, and improved varieties of rice and use of green manure and IPNM might have increased the paddy production, productivity, income, and B:C ratio of the adopters than that of non-adopters.

Household income

The major sources of income of people in the study site were farm activities, non-farm activities and remittance. The first income source from the farm activities was significantly higher (NRs 47565.4) in adopters than non-adopters (NRs 23187.5). Similarly, the composition of farm income was also found to be significantly greater in adopters than non-adopters as shown in Table 3. Mikémina et al. (2018) using a simulation model also concluded that higher income can be realized from agriculture with the adoption of climate change adaption strategies than from conventional farming. Use of climate-smart technologies like conservation farming, integrated farming, IPNM, IPM, short duration, drought resistant and high yielding varieties of crops would increase the production and productivity of the agriculture sector and hence increase the farm income and its share in total household income.

Table 3. Comparison of income between the adopters and non-adopters in the study area

Annual income source	Adopter	Non-Adopter	Mean Difference	t-statistics	P-value
Farm income (NRs)	47565.4	23187.5	24377.9	2.145*	0.034
Non-farm income (NRs)	162892.8	215281.2	-52388.3	-1.125	0.263
Remittance (NRs)	132607.1	97500.0	35107.1	0.509	0.612
Share of farm income (%)	22.0	7.7	14.2	2.254*	0.026
Total annual income (NRs)	343065.4	335968.7	7096.7	0.109	0.914

*Note: * Significant at P = 0.05 level* *Source: Field survey, 2018*

Factors affecting the adoption of climate smart agriculture

The binary logistic regression model was used for the identification of the major factors affecting the adoption of CSA in the area. Among the tested six variables, age, economically active members and training received from the organization were significant for adoption.

The age of the household head was negative and highly significant (P<0.01) on the adoption of CSA. This indicates that with an increase in the age of household head there was less chance of adoption of CSA technologies. We felt adopters of any new technologies were often energetic youths and it is difficult to convince the old member about new farming technologies and they are interested in conventional methods of farming. Results were similar to the finding of Uddin et al. (2014), whose study showed that the probability of adaptation of CSA technology significantly decreases as the farmers got older. Similarly, the result was similar to the outcome of an article written by Acquah (2011).

An economically active household member was found positively significant (P<0.05) on the adoption of CSA. This result was also supported by the finding of Gbetibouo (2009) who found that household size enhances the farmer's adaptive capacity in the Limpopo Basin of South Africa. Similarly, this result was in line with the finding of Lamichhane et al. (2016) which stated that larger families tended to adapt the climate change more than smaller families. Farming in Nawalparsi district was mostly labor-intensive and farmers tended to use labor-intensive adaptation strategies such as conservation farming.

Training from the organizations was found positive and highly significant (P<0.01) on the adoption of CSA. This might be because farmers received the ideas about climate change and CSA technologies which increase the likelihood of the farmers adopting these technologies. These results could be explained by the fact that the farmers of Nawalparasi district not only exposed but also got implementation opportunities to climate change information and CSA technologies through different NGOs working over there. Results showed that the training and other supports could be intensified to increase the adoption rate of such needy CSA in the district. Our results were consistent with the findings of Deressa et al. (2009), who stated that information on climate change played a significant role in influencing farmers' adaptation choice. Our finding was in line with the results of Lamichhane et al. (2016) who stated that if a farmer was exposed to the training and information related to climate change then the probability of adoption of adaptation strategies increases by about 66.1%. Likewise, our results were also supported by the finding of Hussain et al. (1994) who concluded that training and visit programs encouraged the farmers in the adoption of new agricultural technologies.

Table 4. Logit analysis of factors affecting the adoption of CSA in the study area

Variables	Coefficient	P>|z|	SE	dy/dx
Age of HHH (Years)	-0.113**	0.003	0.038	-0.004
EA household members (No.)	0.844*	0.039	0.408	0.031
Total cultivated land (Ha.)	0.713	0.598	1.351	0.026
Livestock holding (LSU)	0.242	0.190	0.185	0.007
Total annual income (Ln)	-0.709	0.352	0.762	-0.026
Training (#)	2.580**	0.005	0.910	0.172
Constant	10.755	0.237	9.104	
Summary statistics				
Number of observations (n)	100			
Log likelihood	-21.018			
Pseudo R square	0.522			
LR chi^2	45.90**			
Prob> chi^2	0.000			

*Note: # indicates dummy variable, ** Significant at P = 0.01; * Significant at P = 0.05 level*

CONCLUSION

Climate smart agricultural technologies are the key components to address the effect of climate change in the Nepalese agriculture system. It is now necessary to adopt climate smart agriculture to combat climate change and sustainably increase agricultural production. Technologies and practices like community seed banking, green manuring, IPM, IPNM were found as mostly adopted CSA technologies in the study area. Farm production and farm income of CSA adopters were significantly greater in comparison to the non-adopters, and the factors like age of household head, economically active members in the family and training received by the farmers were found to have a significant influence on the adoption of CSA. Hence, the key findings of our study indicate that CSA is delivering financial benefits to the farmers. We, thus, emphasize CSA as an integrated form of recent technologies to bring into policy discussions and promote these in each district of the country with the coordination of relevant organizations working in climate change adaptation.

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