Impact of Climate Change on Production of Maize and Adaptation Measures in Deurali and Hupsekot VDCs, Nawalparasi, Nepal

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ABSTRACT

The study was conducted to analyze the impact of climate change on production of maize and adaptation measures in Nawalparasi district of Nepal during the year 2012. Altogether 120 households, 60 from each VDC in Deurali and Hupsekot were selected randomly for the study. Majority of the farmers (61.67%) had faced climate related crisis, very few farmers (5.67%) had received assistance through community group, followed by NGOs/INGOs and government. Majority of the farmers perceived decrease in number of colder days, decrease in number of rainy days, duration and amount of rainfall in rainy season (June to September). Similarly increase in number of hotter days as compared to past years. Maximum numbers of the farmers were suffered from drought (60.5%) and floods/river bank cutting (55.83%) hazards, so they prioritized the drought and floods/river bank cutting for obtaining urgent and immediate solution. The trend analysis showed that the area and productivity allocation for maize was decreasing at 0.0058 ha per year and 0.31 q/ha in respectively over the last 10 years. Prolonged dry spells, unavailability of labor and lack of assured irrigation facilities combined with increasing disease, insects and weeds infestation were the major reason for declining area and productivity of the crops in the study area. Analysis of the climatic data (Rainfall and Temperature) of the Dumkauli station (last 36 years) showed that annual rainfall was increased at the rate of 12.64 mm per year. Similarly, maximum temperature was decreasing significantly at the rate of 0.0009^{0}c per year, while minimum temperature was increasing significantly at the rate of 0.0142^{0}c per year over the last 36 years. Farmers practiced different adaptation strategies to respond to climate change impacts in agriculture. Farmers utilized weeds and residues as mulching material to conserve moisture, use of high yielding crop varieties, rain water harvesting and increased use of chemicals in the field. The study revealed that age, number of total family members in household, education, information gain about climate change, number of economically active family members and experience of farmers were the significant variables to practice different stronger adaptation strategies by the farmers. The study concluded that farmers perceived the climate change, their farming practices and livelihood options were negatively affected and immediately they require effective adaptation mechanism.

Keywords*: production of maize, adaptation measures, Nawalparasi district of Nepal*

1 INTRODUCTION

Scientists are clear that climate change is happening, and that it is due to emissions of greenhouse gases produced largely by industrialized countries (IPCC, 2007a). Climate change is the global issue at present. It is one of the most complex challenges that humankind has to face in the coming decades. Climate change poses an increasing threat to the sustainability of agricultural production and livelihood strategies of poor rural people worldwide. Scientific studies show that world climate is changing and it affects the overall systems in the earth. The concentration of green house gases in the atmosphere has increased significantly since the industrial revolution in 1750s. The amount of Carbon dioxide has increased by 31%, Methane by 151% and Nitrous oxide by 17 % (Regmi, 2007a).

Agriculture has been an important sector for Nepalese economy with about 32.35% contribution to its GDP, and engaging 65.7% of total population (MOAC, 2009). Agricultural system of Nepal is highly dependent upon the climatic factor. Only 34.53% of cultivable land is with irrigation facilities, and remaining land is entirely dependent on the natural rainfall for irrigation (MOAC, 2009).

Maize (*Zea Mays* L.) is the most important cereal crop of the world providing staple food for 35% of the world population and ranks second in Nepal after rice. It is a major staple in the Eastern Gangetic Plains (EGP) of South Asia, a region comprising the India, Nepal and Bangladesh. It's area and production in Nepal is 9, 06,253 hectare and 20, 67,722 mt/ha respectively (MOAC, 2011).

Climate change has serious impact on agriculture and livelihood of farming community. Unequal land distribution, traditional farming system and micro-climatic adversities perpetuated by the climate change brings additional challenge to food security and overall livelihood options in Nepal. About thirty-one percent of people in Nepal are living below the poverty line and are struggling to secure year round food supply to sustain their lives and livelihood (Practical Action, 2008). Poor, marginalized and disadvantaged people in rural areas of Nepal, who solely depend on natural resources and climate sensitive sectors such as agriculture, forestry and fisheries for their livelihood, are more vulnerable to climate change impacts (Dahal, 2006 and Regmi and Adhikari, 2007).

Majority of the farmers in Nepal depend on the monsoon rain for crop cultivation. So, the changes in the rainfall pattern may be fatal for them. The extreme rainfall and downpour causes landslides, soil erosion and loss of lives as well. The scenarios of rising temperatures, more variation in summer and winter temperature, more erratic and higher intensity of rainfall for few period indicates the possibility of droughts and floods, more often; physical plant damage by flooding and water-logging, loss of irrigation canals as well as related problems such as increased pest and pathogen outbreaks, early blooming, appearance of noxious weed species, enhanced soil erosion and ultimately affecting the livelihood options of farmers. Agricultural sector, with the low productivity increases and high rate of population growth, climate change is likely to have serious consequences for sustainability of Nepalese agriculture (Alam and Regmi, 2004).

This study explores the perception of farmers on climate change and its impacts in agriculture, which is very helpful for developing effective adaptation strategies and reducing the vulnerability of the climate change. The outcomes of this research would be highly useful for understanding the site specific issues and formulating appropriate policy in the similar socioeconomic settlements to build the resilience of the community.

2 METHODOLOGY

The study was conducted in Nawalparasi district. Deurali and Hupsekot VDCs of the district were purposively selected for the study. The reason behind the selection was that these two VDCs fall in the Giruwari Watershed region.

Altogether 120 households were taken, as the sample comprising 60 farmers from each VDCs were selected randomly which include farmers and marginalized people. Various sources and technique were used for collection of necessary information. In this study both the primary and secondary data were collected and analyzed.

Participatory methods were used to collect data, to share experience and knowledge of vulnerable communities towards climate change. Both qualitative and quantitative research techniques including observation, focus group discussion and questionnaire survey were applied in this study. Focus group discussion was conducted with farmers and marginalized communities together with other environmentalists and key informants to collect information about impacts of climate change in the area. Interview schedule was prepared to collect primary information from farmers and marginalized people.

Data analysis

Both the primary and secondary information collected from the field survey and other means was coded, tabulated and analyzed by using Statistical Package for Social Sciences (SPSS), STATA 10 and Micro-Soft Excel. Variables like family size, occupational pattern, educational status, and size of holding were analyzed by using simple descriptive statistics such as frequencies, percentage, mean and standard deviation.

Climate change impact analysis

The yield function Model was used to study the effect of precipitation and temperature on crop yield.

$$\text{Ln } YH_t = a + b_1T + b_2 \ln PRC_t + b_3 \ln TMP_t$$

Where,

YH= yield for't' years

T= Time trend/years

PRC_t= Rainfall measured in millimeters for't' years

TMP_t= Temperature measured in degree Celsius for't' years.

a, b2, b3=intercept and slope of the estimated regression line, which were obtained from the sample data with the least squares criterion

Logit regression model

In the logit model, suppose Y_i be the binary response of the farmers and take only two possible values; Y = 1, if farmer practiced different stronger adaptation strategies and Y = 0, if practicing few (poor) adaptation strategies. Suppose x was the vector of several explanatory variables affecting to practice different adaptation strategies and β, a vector of slope parameters, which measures the changes in x on the probability of the farmers to practice stronger adaptation strategies. The probability of binary response was defines as follows:

If Yi = 1; $P(Y_i = 1) = P_i$

$Y_i = 0$; $P(Y_i = 0) = 1 - P_i$

Where, $P_i = E(Y = 1/x)$ represents the conditional mean of Y given certain values of X.

The logit transformation of the probability of the practicing stronger adaptation strategies by farmers were represented as follows.

$$L_i = \ln \left[\frac{P_i}{1-P_i} \right] = z_i = \alpha + \sum_{i=1}^{n} \beta_i x_i + \epsilon_i$$

Where Y_i = a binary dependent variable (1, if farmers practicing stronger adaptation practices, 0 otherwise), x_i includes the vector of explanatory variables used in the model, β_i = parameters to be estimated, $€_I$ = error term of the model, exp (e) = base of the natural logarithms, L_i = Logit and $\left[\frac{P_i}{1-P_i} \right]$ = Odd ratios.

Thus, the binary logit regression model was expressed as:

$Y_i = f(\beta_i x_i)$ = f (Age, Gender, Area, Total family members, Economically active family members, Education, Farming experience, Credit, Training, Irrigation, number of livestock, Information and assistance received during climate change impacts).

Indexing

Various problems and reasons were ranked with the use of index. Scaling techniques, which provides the direction and extremity attitude of the respondent towards any proposition (Miah, 1993) was used to construct index. The intensity of problems and reasons faced by the farmers' were identified by using five point scaling technique comparing most important, somewhat important, important, and less important and least important using scores of 1.00, 0.80, 0.60, 0.40, and 0.20, respectively. The formula given below was used to find the index for intensity various problem/reasons.

$I_{prob} = \sum S_i F_i / N$ Where,

I_{prob} = Index value for intensity of problem

$\sum$ = Summation

S_i = Scale value of i^{th} intensity

f_i = Frequency of i^{th} intensity

N = Total number of respondents

3 RESULTS AND DISCUSSION

Population and household characteristics in the study area

Total population of the sampled households were 941, In terms of gender, 47.92 % were male and 52.08 % were female in Deurali VDC, Likewise 50.54% were male and 49.46 % were female in Hupsekot VDC. Among the total population, 49.20 % were male and 50.80 % were female in the study area. The study revealed that, most of the respondent were male (66.67 %) across the study sites (Table 1). On comparison 60 % in Deurali VDC and 73.33 % in Hupsekot VDC were male.

Table 1. Distribution of population by gender and sex of the respondents in the study area (2012)

Gender	Gender	Name of the VDCs		
		Deurali	Hupsekot	Total
Gender of Population	Male	230(47.92)	233(50.54)	463(49.20)
	Female	250(52.08)	228(49.46)	478(50.80)
	Total	480(100)	461(100)	941(100.00)
Sex of the respondents	Male	36(60)	44(73.33)	80(66.67)
	Female	24(40)	16(26.67)	40(33.33)
	Total	60(100)	60(100)	120(100)

Figures in parentheses indicate percentage

Educational status of the study population

The survey revealed that large proportion of the members of the sampled households (32.09%) attained primary level education and lower proportion of the population attained University level education (0.96%).The illiterate population was higher (24.51%) in the Hupsekot VDC as compared to the Deurali VDC (22.29). Lower illiterate population in the Hupsekot VDC may be due to the geographical remoteness. The educational attainment of the members of sampled households was represented in Table 2.

Table 2. Educational status of the study population in the study area (2012)

Educational Level	Name of the VDCs		
	Deurali	Hupsekot	Total
Illiterate	107(22.29)	113(24.51)	220(23.38)
Informal Literate	61(12.71)	87(18.87)	148(15.73)
Primary	159(33.12)	143(31.02)	302(32.09)

Secondary	107(22.29)	93(20.17)	200(21.25)
Higher Secondary	38(7.92)	24(5.21)	62(6.59)
University	8(1.67)	1(0.22)	9(0.96)
Total	480(100)	461(100)	952(100)

Figures in parentheses indicate percentage.

Distribution of the economically active population in the study area

Age of the family members was categorized in to three classes, less than 15years, economically active age (15-59 year) and more than 59 year. Majority of the population (54.62%) was of economically active age. The percentage of economically active population was higher (56.04%) in Deurali VDC than Hupsekot VDC (53.15%). The distribution of the economically active population in the study area was presented in table 3.

Table 3. Population composition in the study area (2012)

	VDCs		
Age group(Years)	Deurali	Hupsekot	Total
<15	158(32.92)	168(36.44)	326(34.65)
15-59	269(56.04)	245(53.15)	514(54.62)
>59	53(11.04)	48(10.41)	101(10.73)
Total	480(100)	461(100)	941(100)

Figure in parenthesis indicate the percentage of total.

Size of the holding

The different category of the land holding by the household in the study area was illustrated in table 4. Land is the important component of any farming system, which needs investment of labor and seeds to yield a product. Land ownership within the agrarian economy of the study area provides a major source of income, which is an important natural asset that farmers have. Majority of the household have Small category of land holding (52.5%) followed by medium (30.00%) and large (17.5%).

Table 4. Size of the holding in the study area (2012)

Farm Size(ha)	Land category*	Deurali	Hupsekot	Total
<0.5	Small	31(51.67)	32(53.33)	63(52.5)
0.5-1	Medium	18(30.00)	18(30.00)	36(30.00)
>1	Large	11(18.33)	10(16.67)	21(17.5)
	Total	60(100.0)	60(100.0)	120(100)

* Land category according to NRB report. Figure in parenthesis indicate the percentage.

Average size of holding

Land is one of the important assets for agricultural production. Before and after comparison was made to study the average size of land holding on recall basis by farmers. Average size of own holding was 0.54 ha before and 0.40 ha at present in Deurali VDC and 0.52 ha before and 0.49 ha at present in the Hupsekot VDC (Table 5). The study revealed that as the time passes farmer lose their ownership over the land. There was also decline in the average cultivated land in the study area. Farmers also practiced share cropping in the study area which was higher in the Deurali VDC than Hupsekot VDC. Farmers reported that they were losing the ownership of the land over the times due to the riverbank cutting, floods and every year the fragmentation of land was increasing, this may create the lower production and productivity which was unable to meet the higher food demand for growing rate of population in adverse climatic condition. Decline in the size of own land and cultivated land necessitates to increase the per unit production from the land, so, under the adverse climatic condition farmer couldn't increase their production and threatening their food security and livelihoods.

The average size of irrigated holding was declined in the Deurali VDC and that was increased in the Hupsekot VDC. Average irrigated holding was decreased from 0.53 ha to 0.48 ha in Deurali VDC because farmers reported that they were losing their irrigated land due to floods, riverbank cutting and loss of irrigation canal. Similarly it was increased from 0.32 ha to 0.33 ha in Hupsekot VDC because there was increase in average irrigated holding due to the establishment of the Shallow tube wells for irrigation purpose.

Before and present analysis of owned land, Irrigated land, un-irrigated land, Cultivated land, Uncultivated land, Shared land and Upland were done using paired sample t-test. Owned land, irrigated land, uncultivated land, shared land and upland were found highly significant under paired sample t-test. Similarly, un-irrigated land and cultivated land were non-significant

Table 5. Average size of holding in the study area (2012)

	VDCs					
	Deurali			Hupsekot		
Particulars	Before(Mean±SD)	Present(Mean±SD)	Mean	Before(Mean±SD)	Present(Mean±SD)	Mean
Owned land	0.54±0.46	0.40±0.33	0.12*	0.52±0.38	0.49±0.06	0.3*
Cultivated land	0.60±0.46	0.53±0.39	0.7	0.54±0.36	0.55±0.36	-0.1
Shared in land	0.06±0.21	0.13±0.27	-0.07*	0.03±0.16	0.06±0.20	-0.03*
Irrigated land	0.53±0.44	0.48±0.39	0.5*	0.32±0.29	0.33±0.29	-0.01*
Unirrigated land	0.07±0.17	0.05±0.14	0.02	0.22±0.25	0.22±0.26	0.00
Upland	0.30±0.49	0.27±0.41	0.3*	0.53±0.37	0.51±0.38	0.2*
Uncultivated land	0.01±0.06	0.01±0.04	0.00*	0.03±0.09	0.03±0.08	0.00*

S.D. = Standard Deviation, * Significant at P = 0.01.

Perception of farmers about the occurrences of floods and number of floods

The study revealed that 57.5% of the respondents respond the same type of floods as compared to past followed by 25.83% small flooding, 15% pronounced flooding and 1.67% flash flooding. Similarly, 45% of the respondents respond decrease in number of floods as compared to past as shown in table 6.

Table 6. Perception of farmers about the occurrences of floods and number of floods (2012)

Occurrences of flood as compared to past		Number of floods as compared to past	
Pronounced flooding	18(15.00)	Increase	46(38.33)
Same	69(57.5)	Same	20(16.67)
Small flooding	31(25.83)	Decrease	54(45.00)
Flash flooding	2(1.67)		
Total	120(100.0)	Total	120(100)

Figure in parenthesis indicate the percentage.

Perception of farmers about the occurrences of landslides, number of landslides and occurrences of hailstorms

The study revealed that 55% of the respondents reported that occurrences of landslides was small while 41.67% of the respondents felt more occurrences of landslides as compared to past. In the same way 50.83% of the respondents viewed that number of landslides has increased as compared to past. Similarly 47.5% of the respondent realized increase in occurrences of hailstorms as compared to past (Table 7).

Table 7. Perception of farmers about the occurrences of landslides, number of landslides and occurrences of hailstorms (2012)

Occurrences of landslides		Number of landslides		Occurrences of hailstorms	
Bigger	50(41.67)	Increase	61(50.83)	Increase	57(47.5)
Same	4(3.33)	Same	6(5.00)	Same	9(7.5)
Small	66(55.00)	Decrease	53(44.17)	Decrease	54(45)
Total	120(100.0)	Total	120(100.0)	Total	120(100.0)

Figure in parenthesis indicate the percentage

Reasons for declining area and productivity of maize over the time

The area and production allocation for maize was increasing in the districts but decreasing in the study area. The major reasons for declining area allocated for maize over the time were, lower production and productivity followed by land fragmentation, land remain fallow due to unavailability of irrigation/drought, lower profit than other crops and vegetables and loss of land due to floods/landslides (Table 8). Both area and productivity of maize declined over the time. In the same way unavailability of labour, lack of quality seeds and variety, more infestation of diseases and pests and Wildlife damage were other reason for declining the maize productivity as perceived by the respondents as shown in table 9.

Table 8. Reason for declining area allocation for maize in the study area (2012)

Reasons	Maize	
	Index value	Rank

Lower production and productivity	0.91	I
Due to land fragmentation	0.83	II
Land remain fallow due to unavailability of irrigation/drought	0.75	III
Lower profit than other crops and vegetables	0.63	IV
Loss of land due to floods/landslides	0.54	II

Note: Scale value ranges from1 to 0.2, where 1= most important, 0.8= somewhat important, 0.6= moderate important 0.4= less important, 0.2= least important.

Table 9. Reason for declining maize productivity over the time in the study area (2012)

Problems/Reasons	Deurali		Hupsekot	
	Index value	Rank	Index value	Rank
Lack of quality seeds and variety	0.54	IV	0.87	I
Due to unavailability of labour	0.83	I	0.79	II
More infestation of disease	0.73	II	0.49	IV
More damage by insects	0.66	III	0.63	III
Increased wildlife damage	0.47	V	0.43	V

Note: Scale value ranges from 1 to 0.2, where 1= most important, 0.8= somewhat important, 0.6= moderate important, 0.4= less important, 0.2= least important.

Production of maize in relation to climatic variables

The regression analysis computed for the maize revealed that 76% of the variance in maize production can be explained by the climatic parameters under study. Tunde *et al.*, (2011) also reported 50% of the variance in maize can be explained by the climatic parameters. Climatic variables therefore, have impact on maize yield over the years under study. The study has actually revealed that other factors, such as solar radiation, type of soil, soil fertility and farm methods may also be responsible for crop yield. Though, the regression results show very few significant relationships between yield and climate variables, such coefficient can be used to assess real effect of climate variables in change of yield of food-crops considered for this study. Climate variables show significant relations with maize yield as shown in table 10. The coefficient indicates that maize yield increase significantly with increase in seasonal rainfall. Maize yield shows negative relation with seasonal average temperature, i.e., if seasonal average temperature increases yield of maize will decline sharply. Joshi *et al.*, (2011) also reported that maize yield shows negative relation with seasonal summer maximum temperature.

Table 10. Productivity of maize in relation with climatic variables

Crop	Variables	S.E.	Regression coefficient	F value	P value
Maize	Tmp	7.361	-1.1481	-1.521	0.086*
	Rnfl	0.410	1.232	1.683	0.008***
	Time	0.06	0.0030	4.941	0.000***

R= 0.875 and R^2= 0.766, *** Significant at the 1% level (P<0.01) and * significant at the 10% level (P<0.1), tmp – average seasonal temperature of maize, rnfl – seasonal rainfall of maize and S.E. indicates standard error.

Factors affecting to practiced different adaptation strategies in agriculture

Logit regression analysis

Farmers in the study area were found to practicing many adaptation strategies to adopt climate change impacts in their farm and farming practices. Followings were the adaptation strategies they were practicing;

Practicing stronger adaptation measures

1) Use of mulching material in the crop field to conserve moisture and to respond drought, composting of weeds and crop residues.
2) Use of tube-well, generator (for pumping water) for irrigation purpose in order to respond to prolonged drought and loss of previous irrigation canals and wetlands.
3) Use of high yielding hybrid crop varieties to boost up the production.
4) Use of plastic tunnelling and hot bed to protect crops and seedlings.
5) Initiate integrated pest and disease management to respond the increasing attack of pest and disease in crop field.
6) Water harvesting through dam construction
7) Crop introduction/substitution

Practicing poor adaptation measures

1) Changing the crop rotation.
2) Increased use of chemical fertilizers.
3) Changing planting time of crops only.
4) Rainwater harvesting for irrigation facility at the drought time
5) Soil improvement activities

There were number of adaptation strategies practiced by farmers so that it was difficult to study the determinants of practicing different adaptation strategies separately. So, adaptation strategies practiced by farmers in the study area were categorized into binary response by practicing stronger and more adaptation measures = 1, (> 6 of stronger adaptation measures) and 0 otherwise (by practicing poor or few adaptation measures).

Table 11. Logit regression results to identify the factor influencing to practicing more adaptation strategies to the climate change impacts in agriculture in the study area (2012)

Variable	Coefficients	P>|z|	Standard error	dy/dx^b	$S.E^b$	Expected sign
Age	0.050^{***}	0.009	0.019	0.0053	0.002	+
Gender (#)	0.474	0.419	0.587	0.0506	0.06	+/-
Total family members	0.363^{*}	0.066	0.197	0.0387	0.021	+
Education (#)	0.489^{**}	0.039	0.236	0.522	0.024	+
Area	-0.829	0.385	0.954	-0.0885	0.101	-
Training (#)	0.617	0.284	0.576	0. 0642	0.057	+
Information (#)	1.471^{**}	0.021	0.638	0.203	0.104	+
Received assistance (#)	0.941	0.261	0.837	0.130	0.145	+
Economically active members	0.408^{*}	0.058	0.215	0.436	0.023	+
Irrigation (#)	0.235	0.664	0.543	0.025	0.057	+
Experience (#)	2.695^{**}	0.033	1.265	0.179	0.0509	+
CONSTANT	-5.850	0.001	1.722	-	-	
Summary statistics						
Number of observation(N)	120					
Log likelihood	-46.7999					
LR chi2(9)	34.36^{***}(Prob>chi2 = 0.0006)					
Pseudo R^2	0.2685					

Goodness of fit test	Pearson chi2 (107) = 93.72 Prob> chi2 = 0.8165
Overall correct prediction	76.67%

(#) represents Dummy variable

*** Significant at P = 0.01; ** significant at P = 0.05; * significant at P ≥ 0.1

[b] Marginal change in probability (marginal effects after logit) evaluated at the sample means.

Logit regression analysis focused on the 120 farmers engaged in agricultural activities and their adaptation strategies to combat the climate change impacts on agriculture. The wald test (LR chi 2) for the model indicates that, the model has good explanatory power at the 1 % level. The Pseudo R^2 was 0.2683. The overall predictive power of the model (76.67%) was quite high. The link test shows that _ hatsq was not significant meaning the model did not have omitted variables. For the interpretation of the model, marginal effects were driven from the regression coefficients, calculated from partial derivatives as a marginal probability. The interpretation was shown in table 11.

Logit regression analysis shown that, six variables were statistically significant for practicing stronger adaptation strategies, they were; age, total family members in the household, education, information on climate change, number of economically active members, experience (Table 11). Five others variables namely gender, area, training, receive assistance during climate change and irrigation were statistically non significant.

Age of household head is positively significant (P<0.01) to practicing more adaptation strategies to climate change. According to the findings, keeping other factor constant, a unit increase in number of age in the household head would result in 0.53 % increase in the probability of practicing more adaptation strategies.

Higher the number of total family members in household, higher will be the probability of practicing more adaptation measures to the climate change. The study reveals that, number of total family members was positively significant (P<0.1). According to findings, keeping other factor constant, a unit increase in the number of total family members would result in 3.87% increase in the probability of practicing more adaptation strategies.

Education (dummy) level of the household was positively significant (P<0.05) to practicing more adaptation strategies to climate change. According to the findings, keeping other factor constant, a unit increase in number of educated people in household would result in 52.2 % increase in the probability of practicing more adaptation strategies. Higher level of education may increase the ability of the farmers to receive, decode and understand the information relevant to making innovative decision. Deressa *et al.*, (2009) also reported a unit increase in years of schooling would result in to the 1% increase in the probability of soil conservation and 0.6% increase in change in planting dates to adapt climate change.

Higher the number of respondents hearing information about climate change (dummy), higher will be the probability of practicing more adaptation measures to the climate change. The study shows that, number of respondents hearing information about climate was positively significant (p<0.05) and , keeping other factor constant, a unit increase in the number of respondents hearing information about climate change would result in 20.3% increase in the probability of practicing more adaptation strategies.

Higher the number of economically active family members in the household, higher will be the probability of practicing more adaptation measures to the climate change. The study revealed that, number of economically active family members was positively significant ($P<0.1$) and keeping other factors constant, a unit increase in the number of economically active family members, probability of practicing more adaptation strategies would increases by 43.6%. This might be due to the availability of the more labor force in the agricultural activities. Gbetibouo (2009) reported the increasing household size positively influence the adaptation strategies. Teklewold *et al.*, (2006) also reported the higher size of the household reduces the labor constraints and influence the adoption of new technology positively.

Experience (dummy) is important variable affecting to adapt climate change. Experience of household head was positively significant ($P<0.05$) and unit increase in the year of farming experience would increases the probability of practicing more adaptation strategies by 17.9%. This might be due to the facts that, experienced farmers have high skills in farming activities, farm management, and they can minimize the impacts by adopting new innovation and adjusting their farming practices. Similar finding were reported by Nhemachena and Hassan (2007) and Gbetibouo (2009) in southern Africa.

4 SUMMARY AND CONCLUSION

The research was carried out to study the farmers' perception and adaptation to climate change and its implication in maize production in Deurali and Hupsekot VDC. It has been found that population were dominated by janajati/indigenous (58.33), dalit (21.67%) and brahmin/chhetri (20.00%) with 32.09% people primarily educated in the study area. The average land holdings were 0.40±0.33 ha and 0.49±0.06 ha in Deurali and Hupsekot VDCs respectively. It has been found that most of the population were engaged in agriculture (68.83%) followed by remittance (13.00%) and then wage labor (12.46%), Service (3.2%) and finally business (2.51%).

Very few farmers 6.67% had clearly heard about the information of climate change and its impacts, 52.5% of the farmers do not know about the climate change and its impacts. 65% of the respondents got the information through media. Majority of the farmers (65.83%) perceived decrease in number of colder days and 78.83% farmers' perceived increase in number of hotter days as compared to past years. Similarly, 97.5% farmers perceived that summer become hotter as compared to past years and 65% farmers perceived that winter has become colder.

Majority of the farmers, 72.5%, 80% and 55% perceive decrease in number of rainy days, duration and amount of rainfall in rainy season (June to September) respectively as compared to the past. 81.67% of the farmers perceived the delay onset of monsoon and 86.67 % farmers perceived the prevalence of longer period drought as compared to the past, so their crop rotation and crop calendar were severely affected. Majority of the farmers in the study were suffered from drought (60.5%) and floods/river bank cutting (55.83%) hazards so they prioritized the drought and floods/river bank cutting hazards for obtaining urgent and immediate solution.

Farmers in the study area changed their crop rotation and cropping calendar. Due to the late onset of monsoon, the cropping calendar for maize was affected seriously. Farmers waited for onset of rain for sowing spring and rainy maize but occurrences of late rainfall did not allow them to follow past cropping calendar. The trend analysis of area and productivity of maize showed the decreasing trends over the time. The area and productivity allocation for maize was decreasing at 0.0058 ha per year and 0.31 q/ha respectively over the last 10 years. Prolonged dry spells, unavailability of labor, lower profit than other crops and lack of assured irrigation facilities combined with increasing disease, insects and weeds infestation were the major reason for declining area and productivity of the crops in the study area. The local landraces of the crops were almost near to extinction.

It has been found that rainfall variation in Nawalparasi district is becoming more erratic and variability in recent years. Analysis of the rainfall data of the Dumkauli station (last 36 years) showed the increasing trend for rainfall. All the rainfall (total rainfall, monsoon rainfall, pre-monsoon rainfall and post monsoon rainfall) were increasing over the years and only winter monsoon rainfall showed the decreasing trend. Annual rainfall was increased at the rate of 12.64 mm per year. Trend analysis showed that maximum temperature was decreasing significantly at the rate of 0.0009^0c per year, while minimum temperature was increasing significantly at the rate of 0.0142^0c per year over the last 36 years.

The regression analysis computed for the maize revealed that 76% of the variance in maize can be explained by the climatic parameters under study. Climate variables (temperature and rainfall) show significant relations with maize yield. The coefficient indicates that maize yield increase significantly with increase in seasonal rainfall and maize yield decline sharply with the increase in seasonal average temperature.

Majority of the household 72.5% need food from additional sources rather than their own production, [60.00% in Deurali and 85.00% in Hupsekot]. Majority of the household adopted buying on credit basis (31.91%) and followed by daily wage earning (28.72%) to cope with the food deficit situation. Very few farmers 27.6% had got surplus production from their own production which is sufficient to feed their family members for all the year round.

Farmers in the study area practiced different adaptation strategies to respond to climate change impacts in agriculture. Farmers utilized weeds and residues as mulching material to conserve moisture, plastic tunneling for vegetables, use of high yielding crop varieties, altering planting time in accordance with the onset of rainfall, rain water harvesting, water harvesting through dam construction, crop substitution and increased use of chemicals in the field.

Logit regression analysis showed that a unit increase in educated people in household, economically active family members, information gain about climate change and experience of farmers would increases the probability of practicing different adaptation strategies by 52.2%, 43.6%, 20.3% and 17.9% respectively. Similarly a unit increase in age and total family members in household would increases the probability of practicing different adaptation strategies by 0.53% and 3.87% respectively.

Most of the farmers perceived the change in climate at present in terms of change in rainfall pattern, duration, timing, intensity, onset of monsoon, and change in summer and winter temperature in terms of hotness and coldness. Changes in climatic condition affecting the crop rotation and normal cropping calendar followed in the past by the farmers. Changes in cropping calendar hinder the crop growth and poor yield. Area and productivity of the maize was decreasing over the year due to the declining soil fertility and lack of year round assured irrigation facilities threatening the food security for growing population. Total annual rainfall, minimum temperature and maximum temperature were increasing over the time as perceived by the farmers. Farmers practicing different coping and adaptation strategies in their farm based upon their experience to tackle changing climate but it seems important to plan sustainable adaptation strategies and make farmers prepared to tackle the emerging impacts of climate change in forthcoming days.

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