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Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability in Rice Production at the Kaski and Chitwan Districts, Nepal

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Authors' contributions

This work was carried out in collaboration between both authors. Author SK designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author RRK guided the statistical analysis and manuscript writing. Both authors read and approved the final manuscript.

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ABSTRACT

This study was conducted to access perception of farmers about climate change particularly to access the effect of climatic variables on yield of rice crops based on regression model for 1999-2013 climatic data and yield data. The other objective include to learn adaptation strategies to climate change and assess factor influencing adaptation strategies adopted by farmers in hill (Kaski) and terai (Chitwan) of Nepal. Primary data were obtained through Focus Group Discussions (FGDs) and field survey. Descriptive statistics, time series regression model, logit model and seemingly unrelated regression (SUR) model were used. About 87.5 percent of the respondent perceived the change in weather parameter such as temperature and rainfall. A majority of respondents (96%) perceived the increase in temperature and 83% respondents from Kaski perceived decreasing rainfall trend whereas about 86% respondents from Chitwan perceived increasing rainfall trend. The major climate change adaptation strategies used by the respondents include; rice variety change (61%), better irrigation management (59%), changing cropping pattern

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(43%), terrace improvement (37%) and direct seeded rice (DSR) adoption (23%) in the study area. The SUR model revealed that age, education, household income were positively and statistically significant on different climate change adaptation strategies for rice cultivation. Time series regression model reveled that total seasonal rainfall for rice cultivation had positively and significantly determined to rice production area, production and yield, but total annual rainfall had negative determination on area, production and yield of rice. Empirical results analysis showed that improved crop varieties and irrigation as the most important adaptation measures. It also revealed that farmers lacked the capacity to implement the highly ranked adaptation practices. Results revealed that farmers facing negative impact of climate change due to low household income and lack of information on adaptation methods. This analysis of adaptation practices and constraints at farmer level will help facilitate government policy formulation and implementation.

Keywords: Rainfall; temperature, rice-farmers; logit; policy; Nepal.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is most important cereal crop of the world providing staple food for more than 50% of the world population and ranks first in Nepal. It occupies 58% of the total cultivated land and 55% of the total food grain production and provides more than 50% of total calorie requirement of the Nepalese people [1]. The average optimum temperature for rice is 22-30℃ [2] and there might be a substantial reduction in production when the temperature exceeds the range [3,4].

Climate change is considered the most critical global challenge of the century. It is predicted that global temperatures will increase further by between 1.4℃ and 5.8℃ by 2100. Climate change may affect agriculture and food security by altering the spatial and temporal distribution of rainfall, and the availability of water, land, capital, biodiversity and terrestrial resources.

A number of negative effects of major concern to farmers have also been reported. Delaying onset of monsoon shift the crop calendar which reduces the yield in the absence of adaptation measures [5]. A drought in the eastern region of Nepal decreased the rice production by 30% in 2006 and heavy flooding in the mid-western and far-western regions in 2006 and 2008 destroyed crops in many places [6]. Rain fed farming of rice seems to greatly affected by the climate change especially rainfall in Nepal. [7] studied showed that the rice yield in Nepal was badly affected from 1971 to 2000, when the monsoon rainfall was lower than normal. The study reported by [8] show that a 1℃ rise in day time maximum temperature during the ripening phase contribute to an increase in rice yield by 27 kg per ha up to a critical threshold of 29.9℃ beyond that productivity declines. Since the current average maximum temperature for 1999 to 2008 is already 30.8℃ thus, it is expected that rice yields are negatively affected by increases in the daily maximum temperature [8].

Numerous empirical studies suggest that climate change will have a bigger impact on agriculture in developing countries relative to developed countries [9]. Nepal being the developing country and its economy greatly dependent on agriculture, it is very sensitive to climatic variability. Developing countries such as Nepal, while not contributing significantly to global warming, are more sensitive to the effects of climate change because of their weak coping capacity [10]. Although Nepal's contribution to global emissions is negligible i.e. 0.025% of total annual greenhouse gas emissions of the world [11] it is experiencing the increasing trends and the associated effects of climate warming and the adverse effects of climate change on Nepal are significant due to its fragile economic and environmental base.

Adaptations are adjustments or interventions that take place to manage the losses or take advantage of the opportunities presented by a changing climate. Adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region, or community. Globally, many studies have been used to understand farmers' perceptions about climate change and its associated effects on agriculture. Although perceptions are not necessarily consistent with reality, they must be considered to address socioeconomic challenges [12]. [13] indicated that adaptive capacity is context specific and varies among countries, among communities, among social groups and individuals, and over time.

Discussions of adaptation practices and barriers to adoption need to be informed by empirical data from farmers. To ensure farmers' readiness for extreme weather events and collaboratively learn about the evolution of weather patterns, efforts to focus on farmers and their current activities, knowledge, and perceptions are essential [14]. Farmers' willingness to accept and use prescribed measures could be enhanced if their perceptions and understanding are considered in designing such measures. By contrast, current models used in predictions of climate change and adaptation practices are at a global scale and need to be downscaled to accommodate realities at the community level [15]. But the bulk of the available studies on potential long-term threats to the agricultural sector from climate change are based on developed countries. There are far fewer attempts to study impacts in developing countries. [16] agreed that climate change adaptation advancement in Nepal at both national and local level is constrained due to lack of strategic clarity and policy visioning. The present study seeks to fill this gap by analyzing the impact of climate change on rice production and the farmers' adaptation strategies.

The main objective in this study is to assess the impact of climate change and adaptation strategies adopted by farmers to mitigate the changing climate in hill and terai regions. This study will help government policy decisions about suitable adaptation practices that are applicable and most preferred by farmers. It will also ensure that critical barriers to adoption are effectively addressed.

2. METHODOLOGY

2.1 Survey Design and Study Area

In order to study the climate change patterns and effects in two fundamentally different ecological regions, two districts in the western development region of Nepal were selected: Chitwan district in the Terai region (lowland) and Kaski district in the Mountain region (upland) (Fig. 1). Chitwan district borders on India and ranges in altitude from 144 to 179.89 meter above sea level (msal). Both tropical and sub-tropical climate is present in Chitwan district. The temperature ranges from minimum of 7℃ to maximum 42.5℃ and average annual precipitation of 2000-2500 mm (mean 1967.9 mm). Kaski district ranges in altitude from 450 to 8091 m above sea level. The climate of Kaski district is diverse, ranging from sub-tropical, temperate, tundra and alpine, rainfall receiving 3979 mm of monsoon precipitation annually.

A total of 120, 60 from each village development committee (VDC) of rainy season rice farming households surveyed and sample has been selected based on purposive-random sampling. Semi-structured questionnaires were used to investigate farmers' perceived changes in temperature and rainfall, causes and effects of climate change, and adaptation practices being used by farmers. Two focus group discussions (FGDs) and key informants interview were conducted to double check the survey data. The household survey and FGDs were conducted between May and June 2015. The selection of communities was based on the accessibility and knowledge of agricultural officers.

In both study sites, climate data of rainfall and temperature from 25 years (1989-2013) back is used for trend analysis. Climatic data at national maize research programme (NMRP), Rampur in Chitwan district, and at regional airport Pokhara in Kaski district were collected from the department of hydrology and meteorology (DHM), Kathmandu, as well as data on area and production of rice were obtained from department of agriculture (DOA). For the analysis of impact of climatic variables on the area, production and yield of rice, we used 15 years' time series data of maximum temperature, minimum temperature, and average temperature; total seasonal rainfall of rainy season rice growing period and total annual rainfall of surveyed districts.

2.2 Statistical Analysis

2.2.1 Household and climate data analysis

Data were analyzed using SPSS (Version-20.0) and STATA (Version-12.0). Frequencies, percentages, and means are the basic descriptive statistical tools used to represent farmers' perceptions about long-term changes in climatic variables and the associated causes (Table 1). Chi square tests were performed to investigate the correlation between farmers' perception of climate change and climatic factors. Trend analysis of long-term climate data was done to ascertain the changes in climate pattern and to analyze the match between farmers' perceptions and climatic facts.

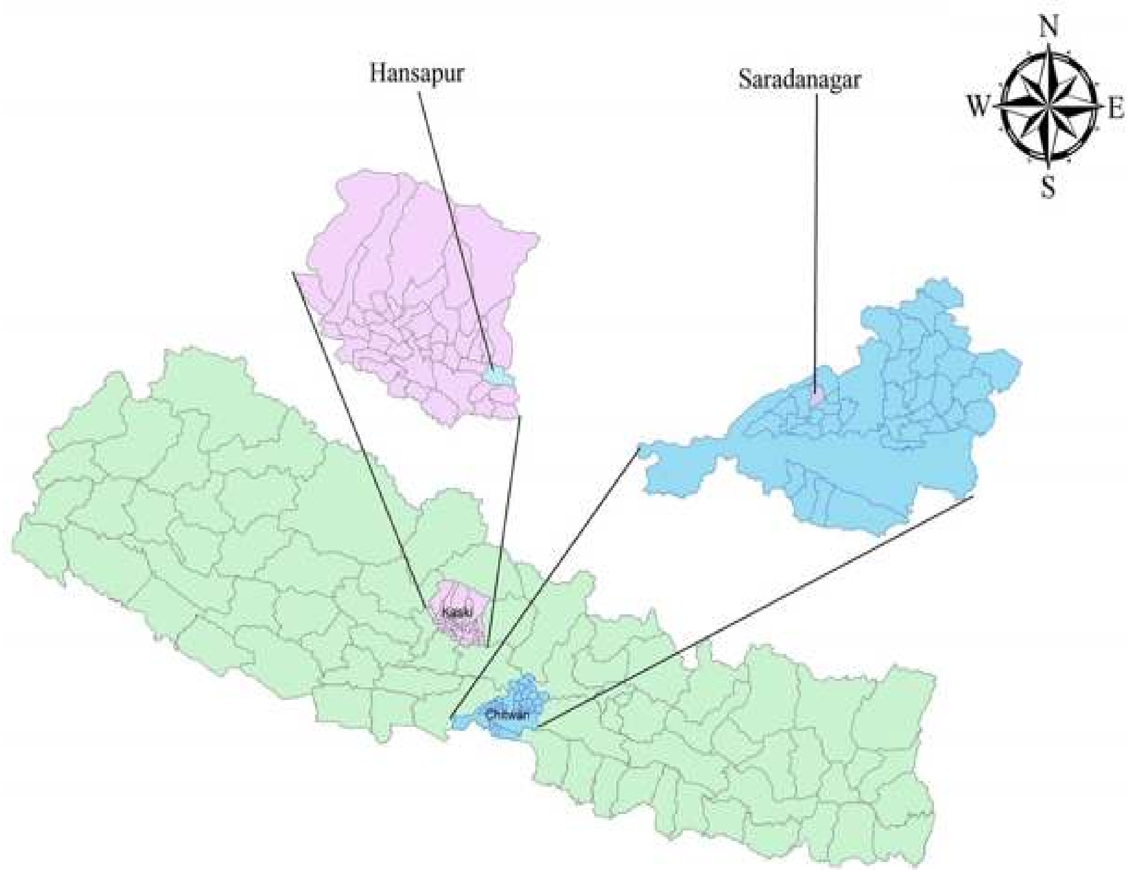

Fig. 1. Map of Nepal showing study sites

Table 1. Description of data variables

Variables	Description of variable	Mean	Standard deviation
Age	Age of the respondent in year	44.93	14.58
Gender	Sex of the respondent (1-Male, 0-otherwise)	0.59	0.49
Family	Type of family (1- Nuclear, 0- otherwise)	0.68	0.46
Education	Education status of respondent (Year of schooling)	6.67	4.41
Migrate	Number of migrated people in household	0.55	0.49
Land	Area under rainy season rice (in Kattha, 1 kattha = 333.33 m^2)	14.78	11.30
Organization	Any family member involve in organization (if 1-Yes, 0-otherwise)	0.63	0.48
Credit_Ass	Household access to credit (1- Yes, 0- otherwise)	0.70	0.46
LogIncome	Annual income of household (NRs. in natural log)	12.66	0.63

Table 2. Correlation matrix among the variables

Variables	Age	Gender	Family	Education	Migrate	Land	Credit_Ass	Organization	Income
Age	1								
Gender	.282	1							
Family	-.219	-.019	1						
Education	-.432	.050	.109	1					
Migrate	.016	.040	-.239	.070	1				
Land	.464	.144	-.122	.061	-0.076	1			
Credit_Ass	-.088	-.063	-.211	.274	.106	.037	1		
organization	-.051	-.069	-.109	.007	-.069	-.019	.068	1	
Income	-.021	-.135	-.207	.192	.277	.062	.288	-.175	1

2.2.2 Time series regression model

Time series data model is used to access the impact of climate change on rice production. Analysis was done by using time series data of climatic variables (e.g. Rainfall and temperature) and rice yield and production of 15 years that are taken from publication of agribusiness promotion and statistics section [17].

$$Y_t = \beta_0 + \beta_1 T\max_t + \beta_2 T\min_t + \beta_3 Rain_t + \gamma DD + \varepsilon_t$$

Where,

- Y_t = Annual rice Production (Mt.)
- Rain = Annual average rainfall (mm)
- T_{max} = Annual average maximum temperature (℃)
- T_{min} = Annual average minimum temperature (℃)
- DD = District fixed effect
- ε = Error term
- t = Years

2.2.3 Adaptation strategy

Logit model was used to identify the socio-economic factors affecting the farmers' adoption of adaptive strategies, using the functional form of logit model expressed by [18] as:

$$Zij = \beta 0 + \beta 1Xij + \beta 2Yij + \beta 3Wij + \mu ij$$

Thus, the binary regression model was expressed as:

Y_i = f (ß$_i$ X$_i$) = f (age of respondent, gender of the respondent, family type of household, years of schooling of respondent, number of peoples migrated, area under rainy season rice, family member involvement in organizations, access to credit, and annual household income).

Here, same explanatory variables (variables affecting adoption strategy) determined the different dependent variables (adaptation strategy), so we use seemingly unrelated regression (SUR) model to gauge the factor affecting adaptation strategy.

To check for the collinearity problem, a sample estimate of the correlation between explanatory variables in the model was carried out (Table 2), showing no correlation between among the variables that have been used in logit regressions. The degree of multicollinearity was not exist in the correlation matrix. If the correlation coefficient between any pair of explanatory variables is greater than 0.9 in absolute value, it is argued that it could serve as an indication of a strong linear relationship and cause potential bias to the analysis [19]. None of the correlation coefficients is greater than 0.5. Thus, there are not needed any formal criteria for determining the magnitude of correlation that cause poorly estimated coefficients in our regression models.

3. RESULTS AND DISCUSSION

3.1 Farmers' Perception of Climate Change

Change in weather parameters is important factor that determine the farmers' perception about climate change. Respondent were asked whether they had experienced any deviation in the weather parameters like rainfall and temperature. Majority of the respondent (87.5%) had observed the seasonal change in rainfall and temperature (Table 3).

Similarly, nearly 96.2% and 39% of respondent perceived the increase in summer and winter temperature respectively. Majority of respondent (77.3%) in Kaski and 61.5% in Chitwan perceived decreased and increased in winter temperature respectively.

Farmers perceived that there was wide variation in the rainfall pattern as compared to past 25 years. Majority of the respondent (85.7%) perceived the decrease in rainy days, out of this 90.6% and 80.8% of respondent perceived decrease in rainy days in Kaski and Chitwan respectively. Respondent perception for intensity of rainfall was different across the district. Majority of the respondent (83.0%) in Kaski perceived decrease in intensity of rainfall but majority of respondent (86.5%) in Chitwan perceived increase in intensity of rainfall.

3.2 Climate Data Analysis

3.2.1 Trend of temperature and rainfall at Chitwan

The trend analysis showed that maximum temperature, minimum temperature, and average temperature increased by 0.012℃, 0.052℃ and 0.032℃ per year (Fig. 2). Average maximum temperature was increased in less than average of Nepal (0.042℃ per year) [20]. The trend analysis strongly supports the farmer perception that temperature was increasing.

Table 3. Farmer's perception about climatic parameters

Perception about		**Total (N = 120)**	**Kaski (n = 60)**	**Chitwan (n = 60)**	**Chi-square**
Change in rainfall and temperature	Yes	105 (87.5)	53 (88.3)	52 (86.7)	0.07
	No	15 (12.5)	7 (11.7)	8 (13.3)	
If yes					
Summer temperature	Increasing	101 (96.2)	51 (96.2)	50 (96.2)	4.00
	Decreasing	2 (1.9)	2 (3.8)	0 (0.0)	
	not noticed	2 (1.9)	0 (0.0)	2 (3.8)	
Winter temperature	Increasing	41 (39.0)	9 (17.0)	32 (61.5)	31.03***
	Decreasing	53 (50.5)	41 (77.3)	12 (23.1)	
	not noticed	11 (10.5)	3 (5.7)	8 (15.4)	
Frequency of rainfall	increasing	6 (5.7)	4 (7.5)	2 (3.8)	
	decreasing	90 (85.7)	48 (90.6)	42 (80.8)	6.50**
	not noticed	9 (8.6)	1 (1.9)	8 (15.4)	
Intensity of rainfall	increasing	37 (35.2)	5 (9.4)	32 (86.5)	
	Decreasing	59 (56.2)	44 (83.0)	15 (28.8)	34.06***
	not noticed	9 (8.6)	4 (7.5)	5 (9.6)	

*Notes: Figures in parentheses indicate standard deviation. *** and ** indicate significance at 1 % and 5 %, respectively*

The trend analysis showed the 4.95 mm per year increment in total rainfall in Rampur station, but the seasonal cumulative rainfall from June to November was decreased by 0.43 mm per year (Fig. 3).

3.2.2 Trend of temperature and rainfall at Kaski

The trend analysis of temperature of Hansapur showed that maximum temperature increased by 0.046℃ per year and minimum temperature was increased by 0.036℃ per year (Fig. 4). These increases are consistent with many of the regional temperature trend analysis [21,22]. A study for 1997-2008 conducted by [23] in Lumle (Kaski) also found similar increasing trend of both maximum and minimum temperature with average value 0.033℃ per year.

The trend analysis shows that total rainfall was decreased with 21.93 mm per year (Fig. 5). The seasonal rainfall also decreased by 17.21 mm. The precipitation trend studied by [23] for year 1999-2008 at Lumle (Kaski) showed that monsoon precipitation is decreased by 18.13 mm per year.

3.3 Adaptation Strategies of Farmers to Cope Climate Change in Rice Cultivation

It could be inferred from the Table 4, that changing crop variety under changing climatic condition was found as the most commonly used method (61%). Less than 1/10th of the respondents changes varieties with improved varieties in Kaski. Most of the farmers in Kaski replaced their previously used local variety (*Mansara, Gurdi, Anadi)* with more yielding fertilizer response short duration local variety (*Ekle)* and improved variety *(Sabitri, Radha-7, Radha-9),* but all respondent in Chitwan replace previous crop varieties (*Mansuli)* with either hybrid (*Sindur, Gorakthnath, US-312)* or improved *(Sabitri,Ramdhan (OR), Sawamansuli, Sonamansuli)* varieties. About 68.9% and 51.7% of respondent from Kaski and Chitwan apply irrigation management, respectively. Changing cropping pattern was adaptation strategy of 42.9% of the respondent. Out of which 64.4% and 26.7% of respondents from Kaski and Chitwan adapt changing cropping pattern, respectively. Terrace improving was adaptation strategy of 37.1% of the respondent. Terrace improving was adopted by 62.2% and 18.3% respondent in Kaski and Chitwan, respectively. DSR was adaptation strategy of 22.9% respondent. Majority of farmers (35.6%) adopt DSR in Kaski. Chemical pest management was also an adaptation strategy of 35% respondent of Chitwan. Most of the farmers in both the regions are attracted towards the adaptation of low rainfall monsoon pattern by replacing their local variety with new commercial improved variety recommended by research organization.

3.4 Impact of Climatic Variables on Area, Production and Yield of Rice

The result showed that mean maximum temperature has negative effect on area, production and yield but minimum temperature has positive impact on yield (Table 5). The trend analysis result also showed mean maximum temperature in Chitwan is 30.97℃ (Fig. 2) which is higher than the critical threshold of 29.9℃ [8] for rice cultivation. But the seasonal rainfall (June to November) has significant positive impact on production of rice because the rice cultivation mainly depend on rainfall in studied area (Table 5).

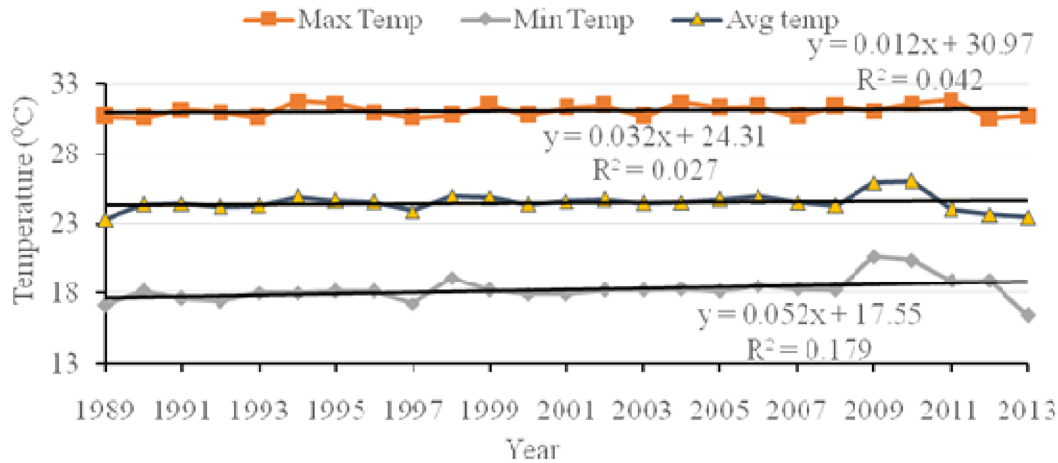

Fig. 2. Trend of temperature (℃) at Chitwan (1989 - 2013)

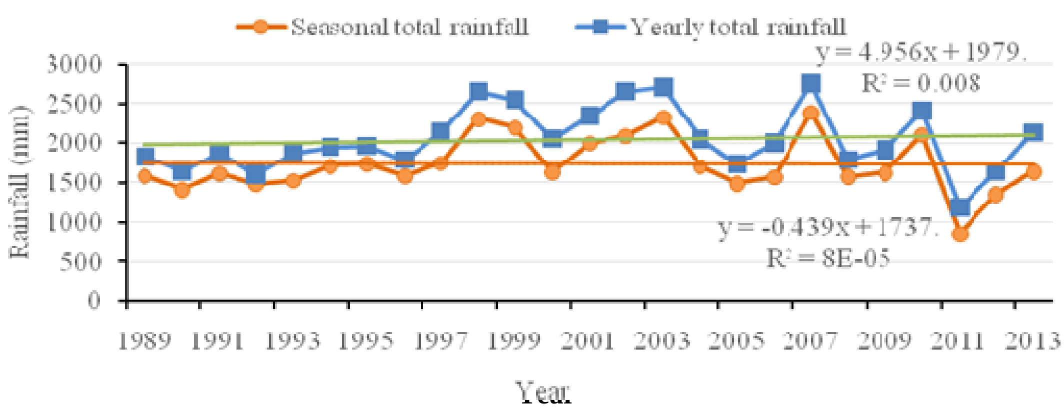

Fig. 3. Trend analysis of seasonal and total rainfall at Chitwan (1989-2013)

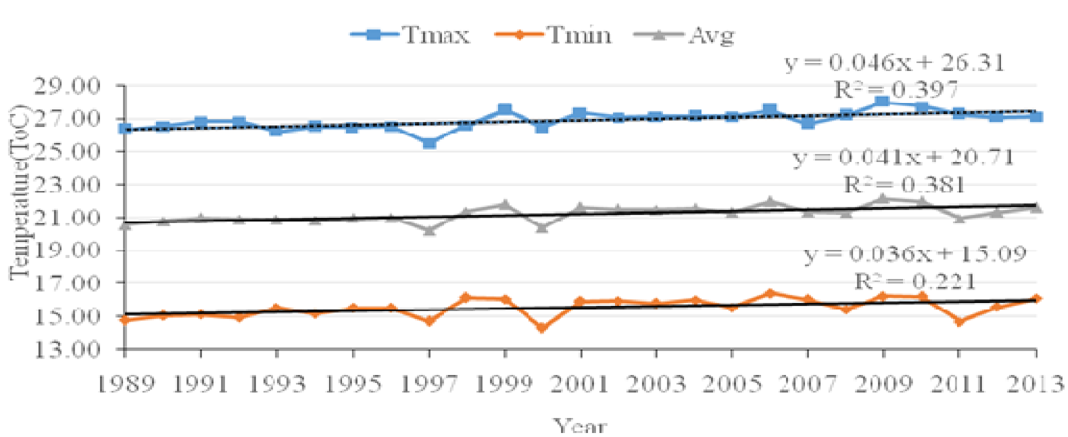

Fig. 4. Trend of temperature at Kaski (1989-2013)

Table 4. Adaptation strategies on climate change in rice cultivation

Strategies		Total (N=120)	Kaski (n=60)	Chitwan (n=60)	Chi-square
Adopt any climate change mitigation measures	Yes	105(87.5)	45(75.0)	60(100.0)	17.143***
	No	15(12.5)	15(25.0)	0(0.0)	
If yes		Total (N= 105)	Kaski (n=45)	Chitwan (n= 60)	
1) Change crop varieties	Yes	64(61.0)	4(8.9)	60(100.0)	89.68***
	N0	41(41)	41(91.9)	0(0.00)	
2) Changing cropping pattern	Yes	45(42.9)	29(64.4)	16(26.7)	14.98***
	No	60(57.1)	16(35.6)	44(73.3)	
If yes, what you do	late sowing	42(93.3)	29(100.0)	13(81.2)	5.82***
	early sowing	3(6.7)	0(0.0)	3(18.8)	
3) Direct Seeded Rice (DSR)	Yes	24(22.9)	16(35.6)	8(13.3)	7.20*
	No	81(77.1)	29(64.4)	52(86.7)	
4) Green manuring	Yes	12(11.4)	0(0.0)	12(20.0)	10.16***
	No	93(86.6)	45(100.0)	48(80.0)	
5) Terrace improving	Yes	39(37.1)	28(62.2)	11(18.3)	21.216***
	No	66(62.9)	17(37.8)	49(81.7)	

*Notes: Figures in parentheses indicate standard deviation. *** and ** indicate significant at 1% and 5%, respectively.*

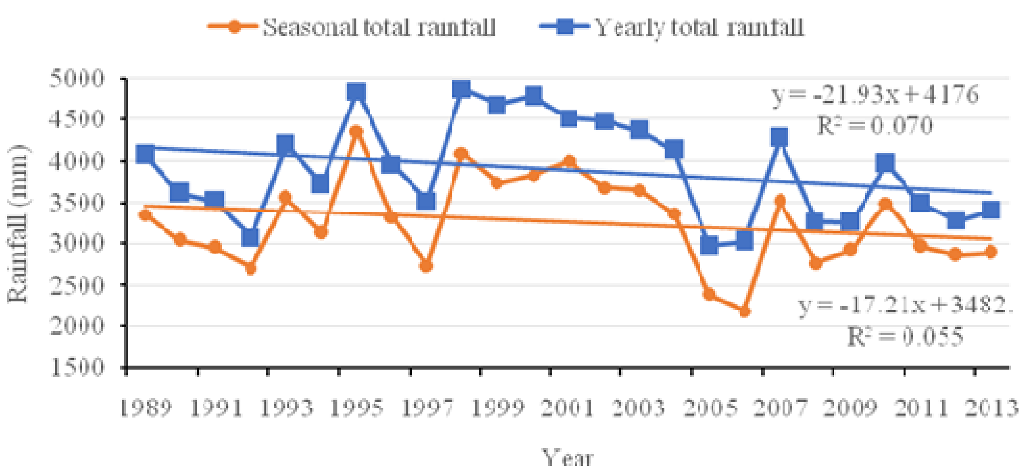

Fig. 5. Trend of Seasonal (June -Nov) and total rainfall at Kaski (1989 - 2013)

Table 5. Climatic variables affecting area, production and yield of rice

Variable	Yield		Production		Area	
	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
T_max	-23.397	155.36	-977.54	6273.297	-458.632	1210.936
T_min	116.98	104.26	-1669.65	4209.868	-1629.944*	812.6318
T_aver	-322.33*	171.84	-2872.803	6938.843	2149.961	1339.406
Season Rainfall	0.976**	0.390	45.201***	15.75	8.21**	3.041
Total_rain	-0.934**	0.342	-43.898***	13.83	-8.05***	2.67
Districts	836.29	497.63	45522.91**	20093.85	8759.296**	3878.72

*Note: ***, ** and * indicate significant at 1 %, 5 % and 10 %, respectively. Area in hectare, Yield in metric ton per hectare and production in metric ton*

3.5 Knowledge on Climate Change and Adaptation Strategies

Among the various explanatory variables affecting climate change knowledge of respondent, education and area under rainy season rice cultivation were found positively significant. By 1 year increase in the years of schooling of respondent there was chance of 6% and 9% probability of increasing climate change knowledge and adaptation of adoption strategies by the respondent (Table 6). Similarly [24] reported that increase in years of schooling would result in increase in the probability of the adaptation measures.

Annual household income was positively significant while migration and land holding were negatively significant on adopting climate change adaptation strategies. If the annual household income is increase by 1%, the probability of adopting climate change adaptation strategy will be increased by 12% (Table 6). Household with higher annual cash earning has higher ability to bear risk and they are in better position to adapt new techniques in their farm and farming practices. If a member migrated from house, the climate change adaptation will be decreased by 16%. [24] also reported that increases in annual household cash earnings increases the probability of adaptation.

3.6 Factors Affecting Adaptation Strategies adopted by the Farmers to Cope Climate Change Impact

Eight different dependent variables as models were used to access same explanatory variables that determined on different adaptation strategies adopted (Table 7). SUR analysis result showed that age, education, household income were major explanatory variables found positively significant in farmers' decision to adaptation of different climate change coping strategies (Table 8).

Age of respondent was positively significant on adaptation decision to change crop varieties, pest management and cropping pattern change. Keeping other factors constant, increasing the age of the respondent by one year, the probability of adaptation to climate change by changing the crop varieties, applying pest management and changing cropping pattern will increase by 14%, 0.3% and 0.8% respectively. [25] found that age was positively related to the adoption of climate change measures. If the years of schooling of respondent increased by a year, there was 5.5%, 2.7% and 1.5% more chances of adopting model 1, 2 and 3 strategies respectively. [26] stated that educated and experienced farmers are expected to have more knowledge and information about climate change and agronomic practices that they can use in response.

Family member's involvement in the organization was found important factor affecting the adaptation decision of DSR. If any member involved in organization, the probability of adopting DSR increased by 17.1%. Household member's access to credit positively and significantly impact on adoption of variety change decision. Several studies have shown that access to credit is an important determinant enhancing the adoption of various technologies [27,28,29,30,31]. Annual household income was positive significant for both decision on adopting varietal change and applying chemical fertilizer.

Table 6. Factors affecting respondent knowledge on climate change and climate change adaptation strategy

Variables	Climate change knowledge (Yes=1)			Climate change adaptation on rice cultivation (Yes=1)		
	dy/dx	Coefficient	Std. error	dy/dx	Coefficient	Std. error
Age	0.000	0.001	0.004	0.0007	0.012	0.001
Family	-0.221*	-1.194	0.127	0.007	0.115	0.058
Education	0.0671***	0.325	0.015	0.091**	0.153	0.006
Migrate	-0.351	-1.819	0.129	-0.1624**	-2.58	0.064
Land	0.0118*	0.057	0.006	-0.004**	-0.071	0.002
LogIncome	0.223	1.084	0.140	0.122**	2.047	0.049

*Note: ***, ** and * indicate significant at 1 %, 5 % and 10 %, respectively*

Table 7. Dependent variables used in seemingly unrelated regression

Model	Dependent variable
Model 1 as strategy of rice variety change	Change rice verities (Yes=1)
Model 2 as strategy of pest management	Applying pest management (Yes=1)
Model 3 as strategy of chemical fertilizer management	Use chemical fertilizer (Yes=1)
Model 4 as strategy of irrigation management	Applying irrigation (Yes=1)
Model 5 as strategy of changing cropping pattern	Planting time change (Yes=1)
Model 6 as strategy of using direct seeded rice	Grow direct seeded rice (Yes=1)
Model 7 as strategy of using green manure crop	Applying green manure crop (Yes=1)
Model 8 as strategy of terrace improving	Terrace improving (Yes=1)

Table 8. Determinants of farmers' decision to adopt different strategies of adaptation

Variables	Model 1 (dy/dx)	Model 2 (dy/dx)	Model 3 (dy/dx)	Model 4 (dy/dx)	Model 5 (dy/dx)	Model 6 (dy/dx)	Model 7 (dy/dx)	Model 8 (dy/dx)
Age	0.14*	0.003*	0.001	0.005	0.008*	-0.000	0.002	0.002
	(0.007)	(0.002)	(0.002)	(0.004)	(0.004)	(0.002)	(0.001)	(0.003)
Education	0.055**	0.027***	0.015*	0.018	0.018	0.012	8.009	-0.002
	(0.026)	(0.009)	(0.009)	(0.015)	(0.015)	(0.010)	(.0075)	(0.014)
Organization	-0.393*	-0.07	0.062	-0.193*	0.144	0.171***	0.003	0.119
	(0.143)	(0.059)	(0.072)	(0.102)	(0.094)	(0.062)	(0.011)	(0.089)
Credit_Ass	0.44***	0.046	0.1408	0.160	-0.209***	-0.050	0.026	-0.054
	(0.158)	(0.055)	(0.098)	(0.127)	(0.122)	(0.088)	(0.036)	(0.113)
Log income	0.857***	-0.010	0.153**	-0.135	-0.017	-0.029	-0.022	-0.086
	(0.224)	(0.046)	(0.077)	(0.111)	(0.107)	(0.075)	(0.021)	(0.107)
Summary statistics								
N	120	120	120	120	120	120	120	120
LR $chi^2(12)$	92.8***	34.25***	20.14*	13.30	14.27	17.16	26.75***	16.71
Log likelihood	-36.77	-40.04	-48.56	-76.46	-72.25	-51.46	-24.29	-67.31
Pseudo R^2	0.556	0.299	0.171	0.080	0.089	0.142	0.355	0.110
Area under ROC curve	0.941	0.849	0.767	0.669	0.685	0.775	0.901	0.73
Correct classified	91.67 %	85 %	85 %	60.83 %	65.83 %	77.5 %	90.74 %	67.5 %

*Notes: *, ** and *** indicate significant at 1%, 5% and 10 % respectively. dy/dx indicate marginal effect after logit. Figures in parentheses indicate standard error*

4. CONCLUSION

This study examined farmers' perceptions of long-term climate change, adaptation measures undertaken, and the determinants of adaptation decisions based on household surveys conducted in terai and hilly regions of Nepal. Climatic parameters were significantly changed in the study area. So farmers were adapting the different adaptation strategies. This analysis aimed to strengthen understanding about farmers' decision-making process to enable policymakers and other stakeholders to support adaptation to climate change at the farm-level. While agricultural adaptation to climate change involves more than farm-level changes in farming practices, farm-level adaptations are an essential component of adaptation of agricultural systems. Therefore, it is crucial to understand how the social, economic, institutional, and ecological context mediates the climate impacts and influences the adaptation response. Given the importance influence of having access to extension services and formal sources of credit on farmers' decision to adapt, policy-makers should extend and improve upon such services, ensuring that they reach small-scale subsistence farmers. Providing support to the poorest farmers is critically important, given that this group is the most vulnerable to long-term climate change, and least-equipped to make the changes needed to sustain their livelihoods in the face of such a threat. Addressing these market imperfections, of lack of access to information and credit, and ensuring effective targeting requires strong leadership and involvement of the government in planning for adaptation and implementing measures to facilitate adaptation at the farm level. There are no one-size-fits-all strategies for promoting adaptation of the agriculture sector. In studied area, the results show that raising awareness about climate change and the available adaptation options is important to encourage farmers to adapt. Government aid, extension services, and information on climate change appear to facilitate adaptation among the poorest farmers while wealthier farmers are more likely to adapt given access to land, credit and information about climate change. More research is needed on the types of adaptation options that are selected by various farmers, and the long-term implications of these choices.

While this study focuses on farm-level adaptations, actions on multiple scales are needed to promote adaptation. Additional actors, such as the private sector, non-government organizations, local institutions, such as farmers associations, and the media, should become more involved in promoting adaptation. Government investments in enhanced and expanded water control, development of better crop varieties, and improved crop management practices, such as agro-forestry also require government support to be taken up by a larger number of farmers. Ultimately, given the constraints to adaptation highlighted in this study, many farmers may turn to adaptation options outside the agriculture sector, including migration, or finding wage employment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. MOAD. Statistical information on Nepalese agriculture. Government of Nepal, Ministry of agriculture development, Agribusiness promotion and statistics division, Agri Statistics section Singha Durbar, Kathmandu, Nepal; 2013a.
2. MOPE. Initial national communication to the conference of the United Nations framework convention on climate change. Ministry of Population and Environment of Nepal, Kathmandu; 2004.
3. Challinor A, Wheeler T, Slingo J. Assessing the vulnerability of crop productivity to climate change thresh hold using integrated crop climate model. In H. Schellnhuber, W. Cramer, N. Nakicenivic, T. Wigley, & G. Yohe (Eds.), Avoiding Dangerous Climate Change. Cambridge University Press, Cambridge, U.K.; 2006.
4. Reilley J, Zinyowera M, Watson R, Moss R, Dokken D. Agriculture in a changing climate. Impacts and Adaptations; 1996.
5. Prasai BK. National issue paper on the agriculture sector (Adaptation); 2010. (Retrieved August 5, 2015)
6. Malla G. Climate change and its impact on Nepalese agriculture. The Journal of Agricultural and Environment. 2008;9:62-71.
7. Nayava JL. Variation of rice yield with rainfall in Nepal during 1971-2000. Journal of Hydrology and Meteorology. 2008;5(1): 93-102.
8. Karn PK. The impact of climate change on rice production in Nepal. South Asian Network for Development and Environmental Economics (SANDEE), Working Paper No. 85-14; 2014.
9. Stern N. The economics of climate change: The stern review. Cambridge, UK Cambridge University Press; 2006.
10. Huq S, Rahman A, Konate M, Sokona Y, Reid H. Mainstreaming adaptation to climate change in least developed countries (LDCs); 2003. Available:http:/www.un.org/special-rep/ohrlls/ldc/LDCsreport.pdf (Retrieved August 11, 2015)
11. Karki MB. Nepal's experience in climate issues. Fourteenth Asia Pacific Seminar on Climate Change. Sydney, Australia; 2007.
12. Kusakari Y, Asubonteng KO, Jasaw GS, Dayour F, Dzivenu T, Lolig V, Donkoh SA, Obeng FK, Gandaa B, Kranjac-Berisavljevic G. Farmer-perceivedeffects of climate change on livelihoods in Wa West District, Upper West Region of Ghana. J. Disaster Res. 2014;9:516–528.
13. Smit B, Wandel J. Adaptation, adaptive capacity and vulnerability. Global Environmental Change. 2006;16(3):282-292.
14. Jackson LE, Pascual U, Hodgkin T. Utilizing and conserving agro biodiversity in agricultural landscapes. Agriculture. Ecosystem and Environment. 2007;121: 196–210.
15. Nhamo N, Daniel M, Fritz OT. Adaptation strategies to climate extremes among smallholder farmers: A case of cropping practices in the Volta Region of Ghana. British Journal of Applied Science and Technolgy. 2014;4:198–213.
16. Regmi BR, Bhandari D. Climate change adaptation in Nepal: Exploring ways to overcome the barriers. Journal of Forest and Livelihood. 2013;11(1).
17. MOAD. Statistical information on Nepalese agriculture - time series information 1999/2000-2011/2012. Government of Nepal, Ministry of agriculture development, Agribusiness promotion and statistics division, Agri Statistics section Singha Durbar, Kathmandu, Nepal; 2013b.
18. Gujrati DN, Porter DC. Basic econometrics. New York: McGraw-Hill; 2004.
19. Hill CR, Griffths WI, Judge GG. Undergraduate econometrics. Second edition, John Wiley and Sons, Inc., USA; 2001.
20. Baidya SK, Karmacharya J. Observed and future climate change in Nepal. Proceeding of climate workshop held at Kathmandu. Kathmandu, December 19-21. 2007;22-23.
21. Baidya SK, Shrestha ML, Sheikh MM. Trends in daily climatic extremes of temperature and precipitation in Nepal. Journal of Hydrology and Meteorology. 2008;5(1):38-51.
22. Shrestha AB, Wake CP, Mayewski PA, Dibb JE. Maximumtemperature trends in

the Himalaya and its vicinity: An analysis based on temperature records from Nepal for the period of 1971-94. Journal of Climate. 1999;16(3):282-292.
23. Timilsina YP. Chronological trend of climate in the lumle village. International Journal of Interdisciplinary Studies. 2015; 3(1).
24. Deressa TT, Hassan RM, Ringler C, Alemu T, Yusuf M. Determinant's of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change; 2009. DOI: 10.1016/j.gloenvcha.2009.01.002
25. Bayard B, Jolly CM, Shannon DA. The economics of adoption and management of alley cropping in Haiti. Journal of Environmental Management. 2007;84:62-70.
26. Maddison D. The perception and adaptation to climate change in Africa. CEEPA Discussion Paper No. 10. Centre for Environmental Economics and Policy in Africa, University of Pretoria; 2006.
27. Anderson JR, Thampallai J. Soil conservation in developing countries. Agriculture and Rural Development Department, World Bank Washington, DC; 1990.
28. Hassan RM, Kiarie N, Mugo N, Robin O, Laboso A. Adoption and performance of maize in Kenya. In R. M. Hassan (Ed.), Maize technology development and transfer: A GIS approach to research planning in Kenya. CAB International, London; 1998.
29. Kandlinkar, M, Risbey J. Agricultural impacts of climate change: If adaptation is the answer, what is question? Climate Change. 2000;45:529-539.
30. Tizale CY. The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia. (PhD thesis, Department of Agricultural Economics, External and Rural Development, Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa); 2007.
31. Yirga C, Shapiro BI, Demeke M. Factors influencing adoption of new wheat technologies in Wolemera and Addis Alem areas of Ethiopia. Ethiopian Journal of Agricultural Economics. 1996;1(1):63-84.

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