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Understanding Climate Change Adaptation by Farmers in Crop Production in Nepal

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Abstract This study was conducted in Jhapa (Terai), Sindhuli (Hill) and Kalikot (Mountain) districts of Nepal from February 2015 to end of April 2016, to assess the understanding of climate change adaptation by the farmers in crop production using survey questionnaire. In the context of food sufficiency condition, Jhapa was more food secured followed by Sindhuli and Kalikot. The majority of respondents also perceived that climatic factors has affected their cropping pattern. Among various climatic factor, drought was major cause of loss in cereal, legume and vegetable production as perceived by majority of respondents. On trend analysis of three districts from 1989-2013 by Mann-Kendall test showed that maximum temperature and average temperature was significantly increasing by 0.042°C/year and 0.044°C/year respectively. While rainfall was significantly decreasing by 22.779 mm/year. On the impact analysis of rice in Jhapa, rainfall has significantly negative relation at 5% confident level while relative humidity has significantly negative relation to rice yield at 10% confident level. Similarly, in Kalikot rainfall has significantly positive relation to rice yield at 10% confident level. The results also suggest that in wheat at Jhapa, maximum temperature has significantly positive relation to wheat yield at 10% confident level. Among the three districts, varietal richness was found in Jhapa. Majority of respondents in Jhapa and Sindhuli have changed their varieties and adapted new varieties. The adaptation of new crops varieties by the majority respondents was for the greater yield. As adaptive capacity varies from district to district, this study argues that plan and policy should be formulated and focused on the location specific adaptation mechanism under changing climate.

Keywords: *climate change, food security, crop production and adaptation*

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1. Introduction

Nepal has three physiographic zones (mountain, hill, and Terai) and five climatic zones (tropical, subtropical, temperate, sub-temperate, sub-arctic and arctic) across 800 meters length east west and 200 meters width north-south and across elevation range of below 100 to 8848masl, the highest pick in the world. The mountains are experiencing rapid snow melting while the Terai is facing prolonged drought. Agriculture and livestock activities are adversely affected by these changes. Nepal has been constantly experiencing changes in weather and climate throughout the country. Temperature data analysed for the past clearly show the increasing trend of temperature over time, although the progression is not linear [9] nor is the change uniformly distributed across the geographic regions [8]. Nepal is prone to a variety of recurring climate-induced risks such as floods, drought, hailstorms, avalanches, glacial lack outburst floods (GLOFs) and heat and cold waves. Poor, disadvantaged and excluded groups residing in rural areas are usually the hardest hit by these natural disasters. Agriculture, the principal economic sector, is highly exposed and most vulnerable to these extreme climate events. Global climate change constitutes an additional threat to the already deprived rural population heavily engaged in agriculture. The climate change projections indicate that the main impacts are likely to include significant warming and uneven and erratic distribution of precipitation, leading to increased frequency of extreme weather and climate events, including floods and droughts. It is likely that new areas will be affected by a variety of different climate-induced threats, exacerbating the negative impacts of climate events. Agriculture sector is highly exposed and vulnerable to extreme climate events and the impacts of climate change in Nepal. Agricultural production is constrained by frequent natural disasters-floods, droughts, landslides, intense rain, hailstorms and cold and heat waves.

2. Research Objectives

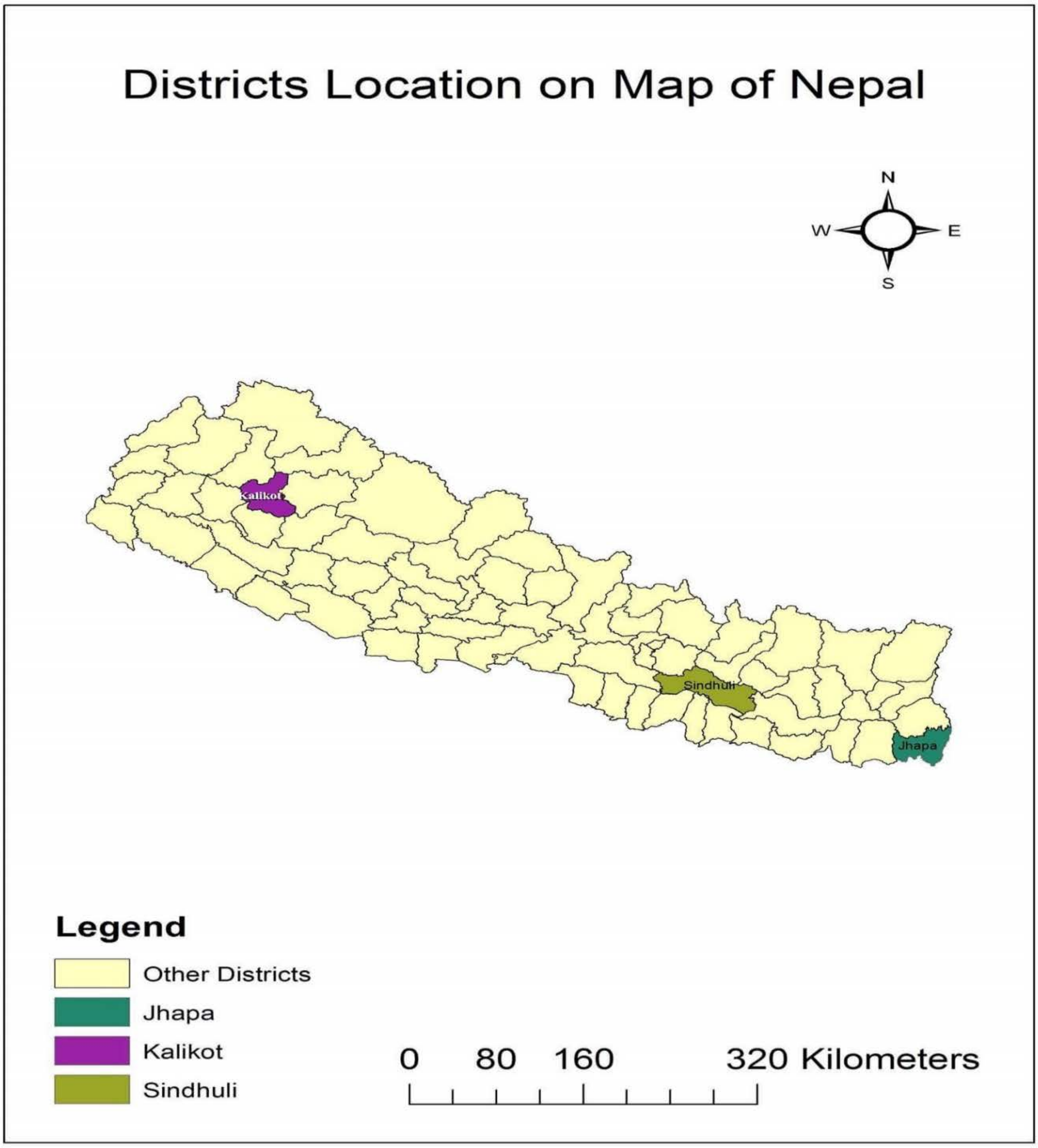
The broad objective of this research study was to understanding climate change adaptation practice in agriculture sector of the country through the study of impacts of climate change and adaptation strategies in the agriculture sector. However, the specific objectives of the study areas outlined below.

- To assess the overall food scarcity situation across three different ecological zones of the country;
- To explore the impacts of climate change and adaptation strategies in crop production.

3. Materials and Methods

3.1. Study Sites

The research study was carried out in three different districts (Jhapa, Sindhuli and Kalikot) covering 6 VDCs two each in sample districts representing the three climatic regions in Nepal.



Map 1. Nepal showing the research sites

3.2. Selection of the Study VDC

This research project was been carried in Shanti Nagar and Prithivinagar VDCs of Jhapa, Bhimsthan and Bhadrakali VDCs of Sindhuli, and Manma and Raku VDCs of Kalikot districts of Nepal. The VDCs were selected with the consultation of district levels stakeholders such as DADO, DDC offices for the study purpose.

Table 1. Selection of HHs for the study purpose

District	VDCs	Total HHs	Sample HHs
Jhapa	Shantinagar	1790	178
	Prithibinagar	1608	140
Sindhuli	Bhimsthan	1160	127
	Bhadrakali	850	94
Kalikot	Manma	1696	158
	Raku	741	71
Total		7845	768

3.3. Household Survey, Focal Group Discussion and Key Informant Survey

For this study, information was captured by the households' questionnaire, focus group discussions, and key informant survey from the key respondent selected.

3.4. Data Analysis

Both descriptive and analytical methods were used to analyse the data collected from various sources both quantitatively and qualitatively.

Assessment of food security

Indexing

Indexing method was used to calculate food sufficiency index, index for coping strategies and problems associated and reasons on food security analysis. The household, which were studied, were categorized into four categories. These categories include food sufficient from own farm production lees than 3 months, more than 3 months but less than 6 months, more than 6 months but less than 9 months, and more than 9 months using scaling techniques and the scale assigned were 0.25, 0.5, 0.75 and 1 respectively. Based on respondents frequencies weighted index were calculated for analysis of food sufficiency index of the study areas. Food sufficiency index was then calculated by weighted average mean.

Ifs= $\sum S_i f_i/N$

Ifs =Index value for intensity value for food sufficiency, coping strategy and problems and reasons

S_i = Scale value of i^{th} intensity

f_i = Frequency of i^{th} response

N = Total number of respondents.

Mann-Kendall Statistical Trend

Mann-Kendall test is a nonparametric statistical trend test widely used for the analysis of trend in climatologic and hydrologic time series [10]. The null hypothesis H_0 for this test is that there is no trend in the series whereas alternative hypothesis that there is trend in the series. The test is based on the calculation of Kendall's tau, which is a measure of association between two samples, which is itself based on the ranks within the samples. The computational procedure for the Mann-Kendall test considers the time series of n data points and Ti and Tj as two subset of the data where i= 1, 2, 3, …, n-1 and j= i+1, i+2, i+3, …, n. The Mann-Kendall statistics was computed based on equations.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sign(Tj - Ti)$$

$$Sign(Tj - Ti) = \begin{cases} 1 \;\; if \;\; Tj - Ti > 0 \\ 0 \;\; if \;\; Tj - Ti = 0 \\ -1 \;\; if \;\; Tj - Ti < 0 \end{cases}$$

Where, Tj and Ti are the annual values in years j and i, j>i, respectively.

The variance (σ^2) for the S-statistic is defined by:

$$\sigma^2 = \frac{n(n-1)(2n+5)\sum t_i(i)(i-1)(2i-5)}{18}$$

in which t_i denotes the number of ties to extent i. The summation term in the numerator was used only if the data series contains tied values. The standard test statistic Z's was calculated as follows:

$$z = \begin{cases} \frac{S-1}{\sigma} & for \; S > 0 \\ 0 & for \; S = 0. \\ \frac{S+1}{\sigma} & for \; S < 0 \end{cases}$$

It was then quantified using sen's slope. It was computed by using the equation

$$Q_i = \frac{x_j - x_k}{j - k} \text{ for } i = 1, 2, 3\ldots, N.$$

It is calculated by using XLSTAT.

Impact of climate change in rice, maize and wheat

Linear regression data model

Time series model is appropriate to access the impact of climate change on rice, wheat and maize production. Analysis was done by using time series data of climatic variables (eg; rainfall and temperature) and crop yield and production of available years that are taken from different secondary sources. Linear specification models was applied to gauge impact of climatic variables on crop yield and production due to lack of longitudinal cross sectional data within a mentioned time.

$$Y_t = \beta_0 + \beta_1 \mathrm{T\,max}_t + \beta_2 \mathrm{T\,min}_t + \beta_3 Rain_t + \gamma \mathrm{DD} + \varepsilon_t$$

Where

Y_t = Annual crop production (mt), $Rain_t$ = Seasonal average rainfall (mm), Tmax = Seasonal average maximum temperature, Tmin = Seasonal average minimum temperature, DD= District fixed effect, ε= Error term and t= Years

Analyse of adaptation strategies related to crop varieties

Listing the crop varieties, those were used previous and present day. Critically analyse the varietal characteristics under climatic change scenario. Here, previous days refer to before ten years.

4. Result and Discussion

4.1. Food Security

4.1.1. Food Sufficiency Condition

Food sufficiency from own production could be single most indicator explaining the majority of variation in social community. Jhapa seem to be more secure followed by Sindhuli and Kalikot in term of food sufficiency condition based on the month basis. In Jhapa, majority of people have food sufficiency condition for 9-12 months. While in Sindhuli, the majority have food sufficiency condition for 3-6 months and 0-3 months for Kalikot.

4.1.2. Food Sufficiency Index

Food sufficiency index were ranked by using four point scales comprising of sufficiency from own production less than 3 months, more than 3 months and up to 6 months, more than 6 months and up to 9 months and more than 9 months were 0.25, 0.50, 0.75 and 1.00 respectively. Food sufficiency index near to one indicates the situation is food secured while near zero means food unsecured situation. Table 2 showed that Jhapa has FSI= 0.763, Sindhuli has FSI= 0.646 and Kalikot has FSI= 0.469. Thus, Jhapa is more food secured district followed by Sindhuli and Kalikot as shown in Table 2.

Table 2. Food sufficiency index of the survey districts

Name of District	Food Sufficiency Index
Jhapa	0.763
Sindhuli	0.646
Kalikot	0.469

(Source: Survey, 2015).

4.2. Climate Change

4.2.1. Climate Change Perception of the Respondents

Perception is sensory a view of the respondents. On the context of knowledge on climate change, majority of the respondents perceived that they were aware about the climate change. Among the districts, majority of respondents of Jhapa and Sindhuli were aware about climate change, while majority of respondents of Kalikot were unaware of climate change.

On the context of temperature, majority of respondents of all the districts perceive that there was increase in the temperature in recent years than compared with previous years. Similarly, majority of the respondents of all the three districts perceived that there was decrease in the intensity and amount in the rainfall. Sticking with the same view majority of respondents perceived the increase in the drought condition in the recent years.

In the context of snowfall, majority of people perceived about the decrease for snowfall in Kalikot and Sindhuli while major portion of respondents of Jhapa were unaware of the snowfall. Mixed perception was found in the context of cloudy days. Some respondents were unaware of the cloudy situation, some perceived that there was increase but still the majority of respondents perceived decrease in the cloudy days in recent days in all three district.

Table 3. Climate change perception of the respondents

Perception on		Jhapa (n= 318)	Sindhuli (n=262)	Kalikot (n=188)	Chi-Sq Value
Climate Change Knowledge	Yes	313(98.43)	221(84.35)	74(39.36)	2.56**
Temperature	Increasing	302(94.97)	251(95.8)	172(91.49)	4.18
Intensity of Rainfall	Increasing	34(10.69)	11(4.2)	5(2.66)	16.17**
Amount of Rainfall	Increasing	12(3.77)	15(5.73)	9(4.79)	70.13**
Drought	Increasing	296(93.08)	254(96.95)	183(97.34)	6.99**
Snowfall	Increasing	38(11.95)	69(26.34)	19(10.11)	2.77**
Cloudy Day	Increasing	48(15.09)	79(30.15)	57(30.32)	69.31**

(Source: Survey, 2015)
Figures in the parentheses indicates percentage
** indicates significance levels at 5%.

4.2.2. Climatic Factors for Crop Losses

On the context of cereals, legumes and vegetables, major climatic factor for loss in production was due to drought experienced by majority of respondents in three districts, which was followed by heavy rainfall as second major factor in Jhapa and Sindhuli. However, frost was second major factor to cause production loss in Kalikot and third factor to cause loss in Sindhuli. Moreover, hailstone was third factor to cause production loss in Jhapa while hailstone was fourth factor in Sindhuli and Kalikot experienced by respondents as shown in Table 4.

Table 4. Climatic factors and crop loss

Destroyed In	Factors	Jhapa (n=318)	Sindhuli (n=262)	Kalikot (n=188)
Cereal	Drought	187(58.81)	116(44.27)	103(54.79)
	Heavy Rainfall	71(22.33)	76(29.01)	25(13.3)
	Hailstone	60(18.87)	33(12.6)	11(5.85)
	Frost	0(0)	37(14.12)	46(24.47)
Legumes	Drought	167(52.52)	109(41.6)	103(54.79)
	Heavy Rainfall	69(21.7)	76(29.01)	25(13.3)
	Hailstone	67(21.07)	35(13.36)	12(6.38)
	Frost	15(4.72)	41(15.65)	45(23.94)
Vegetable	Drought	168(52.83)	116(44.27)	99(52.66)
	Heavy Rainfall	97(30.5)	77(29.39)	27(14.36)
	Hailstone	53(16.67)	33(12.6)	14(7.45)
	Frost	0(0)	36(13.74)	46(24.47)

(Source: Survey, 2015)
Figures in the parentheses indicates percentage .

4.3.3. Change in Crop Performance

On the context of change in crop performance caused by climate change in the last 10 years, majority of the respondents experienced the change in the crop yield and the decreasing trend. Climate change has affected the crop performance in negative way. Majority of respondents experienced the decrease in biomass, size of grain, quality of grain and flavour of the crops in last 10 years at their locality of three districts as shown in the Table 5.

Table 5.Change in crop performance in the last 10 years

Crop performance		Jhapa (n=318)	Sindhuli (n=262)	Kalikot (n=188)	Chi-sq value
Change in yield	Yes	291(91.51)	233(88.93)	186(98.94)	16.4**
	No	27(8.49)	29(11.07)	2(1.06)	
Biomass change	Decreasing	283(88.99)	201(76.72)	143(76.06)	
Size of grain	Decreasing	281(88.36)	169(64.5)	172(91.49)	
Quality of grain	Decreasing	276(86.79)	169(64.5)	174(92.55)	
Flavour	Decreasing	282(88.68)	175(66.79)	172(91.49)	

(Source: Survey, 2015)
Figures in the parentheses indicates percentage
** indicates significance levels at 5%.

4.3.4. Most Affected crop and Affected Stages

On the context of effect of climate change on various growth stages of rice and maize, majority of respondents experienced the effect of climate change was more on the flowering stage of rice and maize in three district while grain filling stage in the second rank which was followed by harvesting, vegetative growth and germination. On the same way, effect of climate change on various growth stages of wheat, majority of respondents experienced the effect of climate change was more on the flowering stage of wheat in three district while grain filling stage in the second rank which followed by vegetative growth, harvest and germination as shown Table 6.

Table 6. Crop affected in different stages

Crop	Growth Stages	Jhapa (n=318)	Sindhuli (n=262)	Kalikot (n=188)	Chi-Sq Value
Rice	Germination	8(2.52)	15(5.73)	7(3.72)	73.1**
	Vegetative Growth	15(4.72)	39(14.89)	11(5.85)	
	Flowering	214(67.3)	99(37.79)	88(46.81)	
	Grain filling	72(22.64)	76(29.01)	59(31.38)	
	Harvesting	9(2.83)	33(12.6)	23(12.23)	
Maize	Germination	7(2.2)	6(2.29)	4(2.13)	27.9*
	Vegetative Growth	56(17.61)	40(15.27)	14(7.45)	
	Flowering	105(33.02)	107(40.84)	73(38.83)	
	Grain filling	78(24.53)	78(29.77)	69(36.7)	
	Harvesting	72(22.64)	31(11.83)	28(14.89)	
Wheat	Germination	9(2.83)	13(4.96)	11(5.85)	14.4*
	Vegetative Growth	35(11.01)	51(19.47)	32(17.02)	
	Flowering	108(33.96)	87(33.21)	64(34.04)	
	Grain filling	126(39.62)	85(32.44)	58(30.85)	
	Harvesting	40(12.58)	26(9.92)	23(12.23)	

(Source: Survey, 2015)
Figures in the parentheses indicates percentage
* and ** indicates significance levels at 10% and 5% respectively.

Table 7. Trend analysis of climatic factors

Climatic Factors	Linear Trend Slope	Mann Kendall's Test	Response	Remark
Jhapa (1989-2013)		**Sen's Slope**		
Maximum temperature	0.034	0.038	Increasing	Significant
Minimum temperature	0.033	0.015	Increasing	Not significant
Average temperature	0.033	0.024	Increasing	Significant
Rainfall	-40.486	-42.411	Decreasing	Significant
Humidity	0.056	0.122	Increasing	Not significant
Sindhuli (1989-2013)				
Maximum temperature	0.058	0.039	Increasing	Not significant
Minimum temperature	-0.0006	-0.038	Decreasing	Not significant
Average temperature	0.048	0.021	Increasing	Not significant
Rainfall	-25.115	-27.766	Decreasing	Not significant
Humidity	-0.022	-0.179	Decreasing	Not significant
Kalikot (1989-2013)				
Maximum temperature	0.068	0.065	Increasing	Significant
Minimum temperature	0.029	0.033	Increasing	Significant
Average temperature	0.049	0.048	Increasing	Significant
Rainfall	2.223	1.703	Increasing	Not significant
Humidity	0.068	0.071	Increasing	Not significant
Overall (1989-2013)				
Maximum temperature	0.053	0.042	Increasing	Significant
Minimum temperature	0.019	0.017	Increasing	Not significant
Average temperature	0.043	0.044	Increasing	Significant
Rainfall	-21.126	-21.779	Decreasing	Significant
Humidity	-0.034	-0.020	Decreasing	Not significant

4.4.5. Trend Analysis of Climatic Variables

Mann Kendall's test was used for the trend analysis. For the trend analysis maximum temperature, minimum temperature, rainfall and humidity were used. The result (Table 7) showed that in Jhapa, maximum temperature has shown significantly positive trend. Average temperature has also shown significantly positive trend. While rainfall has shown negatively significant trend. This indicates that maximum temperature and minimum temperature of Jhapa were significantly increasing at the rate of 0.038°C/year and 0.024°C/year. While rainfall was significantly decreasing at the rate of 44.411 mm/year.

In Sindhuli, maximum temperature, minimum temperature, average temperature, rainfall and humidity did not show significant trend.

In Kalikot, maximum temperature, minimum temperature and average temperature has shown significantly positive trend. It also showed that maximum temperature is increasing by 0.065°C/year, minimum temperature is increasing by 0.033°C/year and average temperature is increasing by 0.048°C/year.

In the context of trend analysis of climatic parameters of three districts, maximum temperature and average temperature has shown significantly positive trend. Similarly, rainfall has shown significantly negative trend. Likewise, minimum temperature and humidity did not show significant trend. This result showed maximum temperature was increasing by 0.042°C/year and average temperature was increasing by 0.044°C/year. Similarly, result also shown that rainfall was decreasing by 22.779 mm/year as shown in Table 7.

4.4.6. Impact of Climate Change on Different Crops

Generally, for the impact analysis of climate change on different crops indirect crop simulation model and regression analysis is used. Here, we used multi linear regression model in which crop yield (rice, wheat, maize and millet) of each district (secondary data) is dependent variable and climatic variable (temperature, rainfall and humidity) of growing season are the independent variable. Multivariate regression analysis to access the impact on crops is used in [4].

Regression analysis on Rice:

The result suggest that in rice, the model explains 40% to 15% variation on rice yield in three districts. In Jhapa, rainfall has negatively significant and relative humidity has significantly positive relation to rice yield at 5% confident level and 10 % confident level respectively. Similar result was found in Karn [6] that rainfall has negative effect on rice yield. In Sindhuli, climatic variables could not significantly influence the rice yield. Similarly, in Kalikot rainfall has significantly positive relation to rice yield at 10% confident level, while other climatic variable could not significantly influence the rice yield as shown in Table 8.

Regression analysis on Wheat:

The result suggest that in wheat, the model explains 40% to 9% variation on wheat yield in three districts. In Jhapa, maximum temperature has significantly positive relation to wheat yield at 10% confident level. In addition, in Sindhuli relative humidity has significantly negative relation to wheat yield at 5% confident level while climatic variable could not significantly influence the wheat yield in Kalikot as shown in Table 8.

Regression analysis on Maize:

The results suggest that in maize, the model explains 47% to 7% variation on wheat yield in three districts. In Jhapa, maximum temperature and minimum temperature has significantly positive relation at 5% confident level and 10% confident level respectively. While in Sindhuli, maximum temperature has significantly positive relation with maize yield at 5% confident level as shown in Table 8.

Table 8. Impact of climate change on different crops

Crop	Factors	Jhapa	Sindhuli	Kalikot
Rice	Tmax (coff)	225.92	25.88	-56.49
	Tmin (coff)	-27.04	26.93	108.2
	Rainfall (coff)	-0.34**	-0.07	1.46*
	RH (coff)	58.59*	30.94	-9.06
	R sq	0.4	0.15	0.18
Wheat	Tmax (coff)	300.81*	69.37	113.53
	Tmin (coff)	-32.46	-69.34	-61.02
	Rainfall (coff)	3.46	2.35	16.06
	RH (coff)	23.64	-49.32**	0.12
	R sq	0.14	0.4	0.09
Maize	Tmax (coff)	422.35**	120.97**	38.75
	Tmin (coff)	168.86*	-95.33	45.32
	Rainfall (coff)	-0.47	0.06	-0.2
	RH (coff)	12.62	-23.35	12.45
	R sq	0.45	0.47	0.07

Coff, R sq, Tmax, Tmin, Rainfall and RH are Coefficient value, R square value, Maximum temperature, Minimum temperature, Rainfall and Relative Humidity of the growing season

* and ** indicates significance levels at 10% and 5% respectively.

Table 9. Adaptation of new variety and reason of adaptation

New variety		**Jhapa (n=318)**	**Sindhuli (n=262)**	**Kalikot (n=188)**	**Chi-sq value**
Changing of new variety	Yes	288(90.57)	219(83.59)	59(31.38)	233.6**
Reason					
New cereals variety	Greater yield	240(75.47)	203(77.48)	127(67.55)	128.7**
	Disease resistant	50(15.72)	15(5.73)	4(2.13)	
	Change in income	2(0.63)	0(0)	32(17.02)	
New vegetable variety	Greater yield	160(50.31)	128(48.85)	97(51.6)	19.6**
	Disease resistant	78(24.53)	74(28.24)	59(31.38)	
	Change in income	36(11.32)	10(3.82)	9(4.79)	
New fruit variety	Greater yield	128(40.25)	108(41.22)	92(48.94)	13.2**
	Disease resistant	78(24.53)	58(22.14)	42(22.34)	
	Change in income	38(11.95)	21(8.02)	24(12.77)	
New legumes variety	Greater yield	139(43.71)	94(35.88)	113(60.11)	35.8**
	Disease resistant	85(26.73)	102(38.93)	40(21.28)	
	Change in income	34(10.69)	22(8.4)	18(9.57)	

(Source: Survey, 2015)

Figures in the parentheses indicates percentage

** indicates significance levels at 5%.

4.4.7. Adaptation of New Variety and Reason of Adaptation

On the context of adaptation of varieties, majority of respondents in Jhapa (90.57%) and Sindhuli (83.59%) has changed their varieties and adapted new varieties. While in Kalikot minority of respondents, (31.38%) has only changed their varieties. In addition, the reason for the adaptation of new varieties experienced by the majority respondents for cereals, vegetables, fruit and legumes was for the greater yield, which was followed by resistance for the disease and pest and change in income as shown in Table 9.

4.4.8. Adapted Varieties of Different Crops

Table 10 shows the name of varieties of different crops grown previously (10 years ago) and varieties grown at present. Here old varieties are the landraces of different crop of three districts. Due to change in climatic factors that caused frequent loss in production and autonomous adaptation of high yielding varieties caused the loss of landraces of different crops. Moreover, farmer has adapted improved varieties to insure the food security. In total, 256 varieties of the different crop were reported across the study sites. In adaptation of new varieties, more number of varieties were adapted in rice (54), followed by maize (27), potato (23), wheat (16), millet (13) and buckwheat (5) varieties. In old varieties, more number of varieties were adapted in rice (31), followed by maize (30), potato (23), wheat (18), millet (13) and buckwheat (3).

This indicates that Jhapa has more varietal richness and more food secured while Kalikot has less varietal richness and less food secured. Siphnon (2015) found similar result that varietal richness has positive relationship to food security.

Table 10. Name of Adapted varieties of different crops

Crop	Jhapa	Sindhuli	Kalikot
Old Varieties (Rice)	Harintole, Atte, Bacchi, Champa, Dangi Mara	Local, Mansuli, Taichung, Krishana, Sabitri	Patle, Kalo Dhan, Local , Marshi
New Varieties (Rice)	Ranjeet, Rp, Swarna, Radha 12, Radha 4	Sabitri, Makawan, Hardinath, Krishi	Chandanath, Himali, Khumal 1
Old Varieties (Wheat)	Rato Begali, Seto, Kalo, Local	Rato, Mude, Chiwanak, Kalo, Kanchan	Dalkhane, Jhuse Rato, Mude,Badadi
New Varieties (Wheat)	NL-297, Gautam, RR21, NL-1473	Gatuam,RR 21, NL-297, NL-1573, Krishi, Annapurna	Wk 1204, Rato Begali, Annapurna, Improved
Old Varieties (Maize)	Murali, Local Rato, Sathiya, Seto, Yellow Local	Dhobika Paheli, Sathiya, Seto, Murali	Deu Dhule, Bhalu Makai, Local Rato, Kande, Sunau
New Varieties (Maize)	Rampur Composite, Rampur Pahele, Arun 2, All Ronder	Rampur Compostie, Rampur-1, Deuti, Arun Pahelo	Makwanpur 3, Makwanpur 4, Deuti
Old Varieties (Millet)	Kali, Mudke, Seto, Rato	Kali, Pahelo, Dalle, Seto	Dalle, Jhaure, Seto, Angule, Somale
New Varieties (Millet)	Kali, Mudke, Seto, Rato	Kali, Pahelo, Dalle, Seto	Dalle, Jhaure, Seto, Angule
Old Varieties (Potato)	Kanpure, Jagga, Thanpure Local, Local	Janak Dev, Lalgulaf, Seto, Rato, Local	Seto, Local
New Varieties (Potato)	Jagannath, Khumal Rato, T.P.S	Cardinal, Janak Dev, Lal Gulaf, Rato	Rato, Improved, Kurfi Sindure
Old Varieties (Buckwheat)	……..	Mithe, Titte	Chucche, Local, Mithe, Titte
New Varieties (Buckwheat)	……..	Mithe, Titte	Mithe, Titte

(Source: Survey, 2015).

4.5. Adaptation Measures in Agriculture

On the context of adaptation measures for agriculture, Jhapa ranked use of short duration varieties by 45.91%, use of hybrids by 31.45% and diversity in cropping by 16.98% of respondents in decreasing order. In Sindhuli use of hybrid by 31.45%, use of more chemicals (fertilizer and pesticides) by 27.1% and short duration varieties by 13.38% of respondents in decreasing order. Nevertheless, in Kalikot, respondents preferred quitting farming by 12.23%, engage in other occupation by 11.7% and use of hybrid by 11.17% respondents in decreasing order as shown in Table 11.

Table 11. Ranking of adaptation measures to cope with different climatic hazard

Agriculture adaptation Strategies	Jhapa (n=318)	Sindhuli (n=262)	Kalikot (n=188)	Chi-sq value
Short duration varieties	146(45.91)	35(13.36)	11(5.85)	201.7**
Diversity in cropping	54(16.98)	10(3.82)	8(4.26)	
More use of chemical fertilizer/pesticides	7(2.2)	71(27.1)	2(1.06)	
Use of hybrids	100(31.45)	116(44.27)	21(11.17)	
Quit farming	2(0.63)	8(3.05)	45(23.93)	

(Source: Survey, 2015)
Figures in the parentheses indicates percentage
** indicates significance levels at 5%.

5. Conclusion

In a country like Nepal, where most of the rural people are below poverty line and agriculture dominates the major share of country's GDP, sensitivity to changes in climate is more pronounced. Thus adaptation play vital role to sustain the livelihood of those resource poor and marginal farmers. This study was carried out to access crop production strategies adapted by them to cope adverse effect of climate change.

On the context of food security, Jhapa seem to be more secured followed by Sindhuli and Kalikot. Majority of respondents of all the districts perceived that there is increase in the temperature, intensity and amount in the rainfall was variable, increase in number and period of drought, decrease in snowfall period in recent years than compared with before ten years. Majority of respondents perceived that there was decrease in number of flood, increase in number of hailstone, decrease in the level of water in the river. Respondents also perceived that loss of crop production in ten years was due to climatic factors like drought, heavy rainfall, hailstone, frost and others. Majority of respondents also experienced that drought was the major climatic factor to cause loss in production of cereals, legumes and vegetables.

Majority of the respondents experienced the decrease in the crop yield. Majority of respondents experienced the decrease in biomass, size of grain, quality of grain and flavour of the crops.

On the trend analysis of three districts (1989-2013), maximum temperature and average temperature have shown significantly positive trend and rainfall have shown significantly negative trend. Likewise, minimum temperature and humidity did not show significant trend.

Impact analysis of rice results suggest that in Jhapa, rainfall and relative humidity has significant relation to rice yield. Rainfall has negative effect while relative humidity has positive effect on rice yield. Similarly, in Kalikot rainfall has significantly positive relation to rice yield. The results also suggest that in wheat, maximum temperature has significantly positive relation to wheat yield at Jhapa. In addition, in Sindhuli relative humidity has significantly negative relation to wheat yield while climatic variable could not influence the wheat yield in Kalikot. In Jhapa maximum temperature and minimum temperature has significantly positive relation at where as in Sindhuli maximum temperature has significantly positive relation with maize yield.

On the context of adaptation of varieties, majority of respondents in Jhapa and Sindhuli has changed their crop varieties and adapted new varieties. While in Kalikot few respondents has changed their crop varieties. Those respondents who have changed their crop varieties have adapted-improved varieties, which has higher productivity to meet the increasing demand of food. Among various reasons for the adaptation of new varieties experienced by the majority respondents for crop production were for the greater yield, followed by resistance for the disease and pest and change in income. Varietal richness was found high in Jhapa followed by Sindhuli and then Kalikot. On adaptation measures to climate change, change in crop was found to be adapted by the majority of the respondents in Jhapa and Sindhuli. In agriculture, use of short duration varieties, use of hybrid and quitting agriculture was preferred in Jhapa, Sindhuli and Kalikot simultaneously.

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[5] NeCSAP. 2014. Nepal Food Security Bulletin Year 2014, Issue 42 Map 1: Food Security Phase Classification Map , mid-March to mid-July 2014 Food Security Phase Classification Map Source: NeKSAP District Food Security Networks (DFSNs). *Nepal Food Security Bulletin*, 42, 1-6.

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Annex

Annex 1: Source of Income

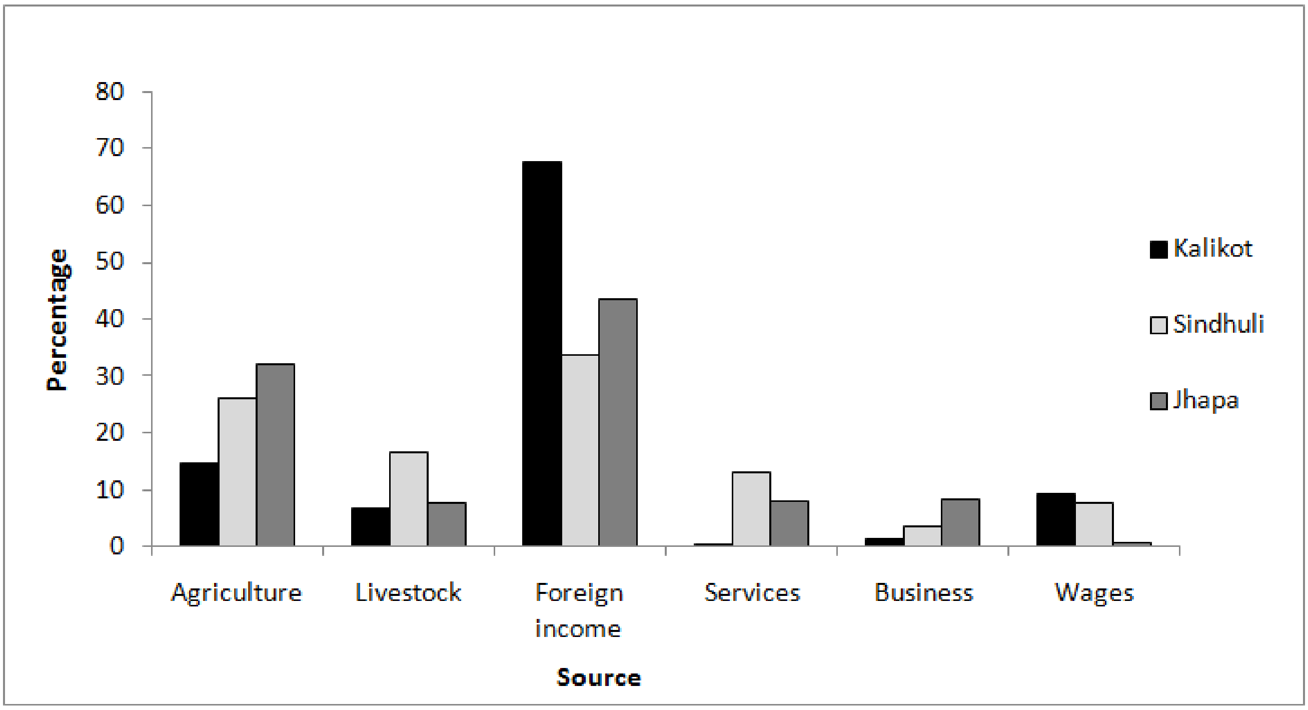
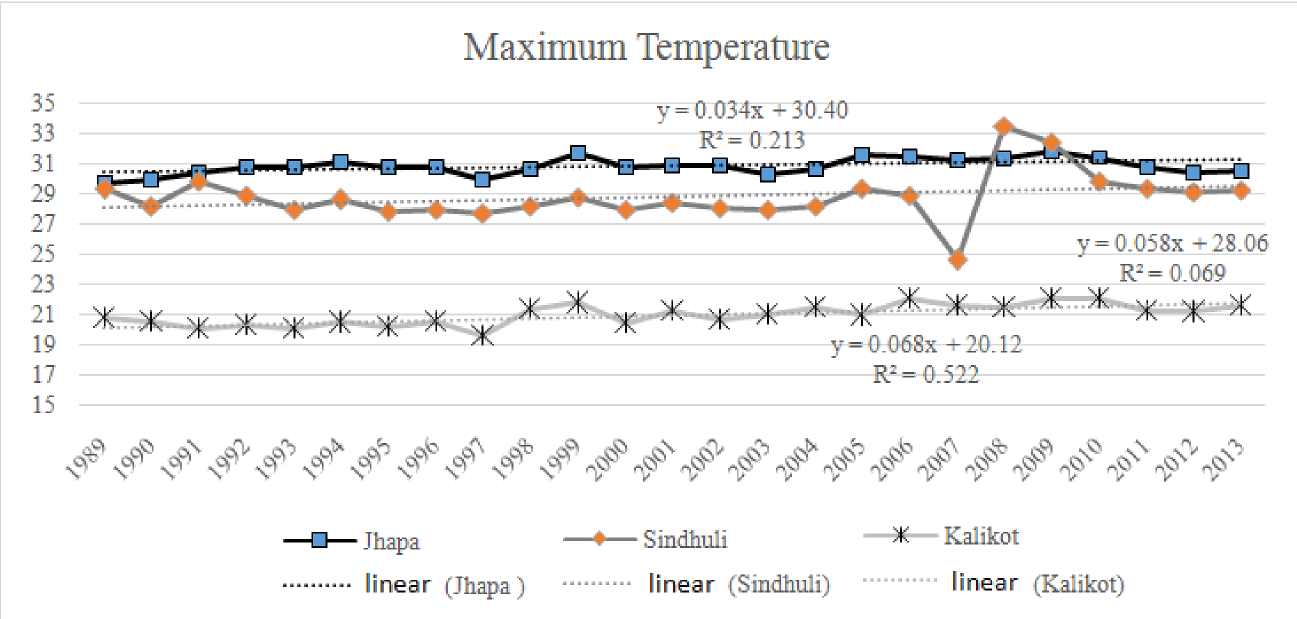
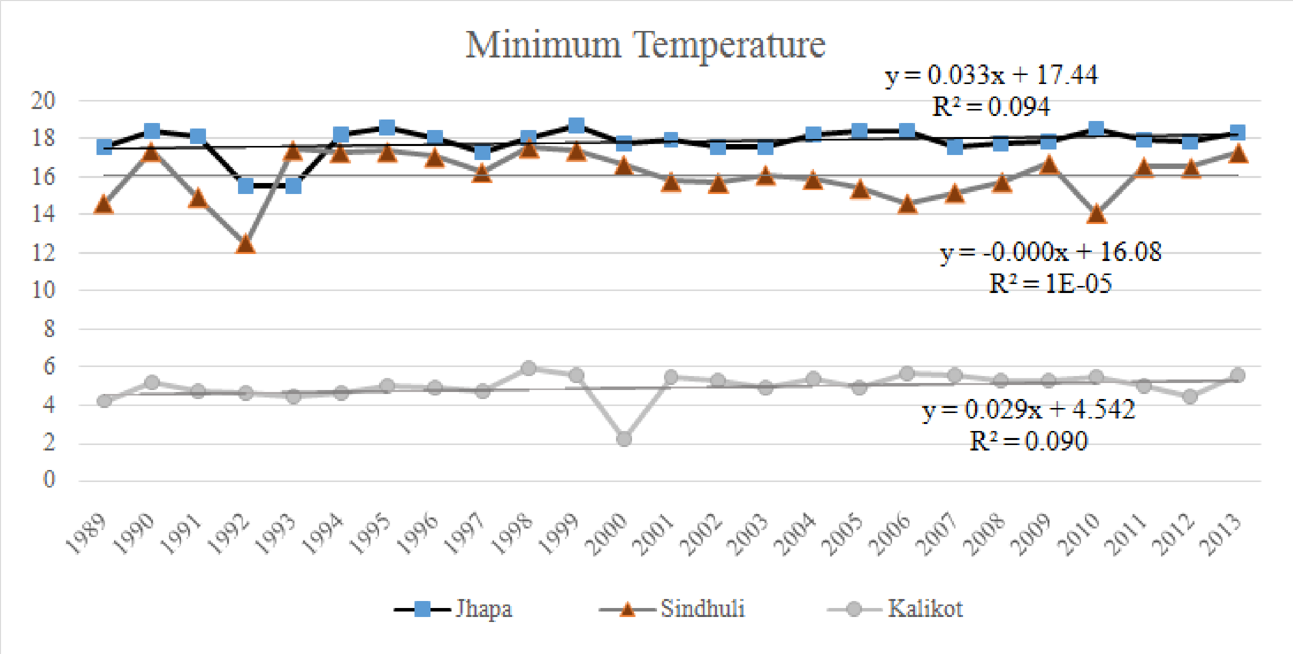


Figure 1. Income Sources of Respondents (Source: Survey, 2015)

Annex 2: Maximum temperature of Jhapa, Sindhuli and Kalikot (1989-2013)



Annex 3: Minimum temperature of Jhapa, Sindhuli and Kalikot (1989-2013)



Annex 4: Annual rainfall of Jhapa, Sindhuli and Kalikot (1989- 2013)