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Research Article

Impact of Climate Change on Rice Production and Local Adaptation Practices Adopted by Farmers in Surkhet, Nepal

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Abstract

A total of 120 sample households were randomly selected from two municipalities of Surkhet for this study. The primary data were collected by survey questionnaire, direct observation, FGD whereas secondary data of rainfall temperature and rice productivity were collected from different sources. Majority of farmers perceived increase in temperature, decrease in rainfall frequency, decrease in rainfall duration and increase in flooding hazard during rainy season. Trends analysis of temperature and rainfall data over 35 years (1980-2015) showed, increasing trends of maximum temperature (0.06ºC/year) and minimum temperature (0.03ºC/year) which were in the line with the farmer's perception. Trend analysis revealed that total annual precipitation was decreasing by 3.77 mm/year while monsoon rainfall was increasing by 0.051 mm/year. About 20% respondents had clear knowledge on climate change. The major source of information was media (43.43%) and self-experiences (36.3%). The major climate change adaptation practices adopted by farmers were use of drought resistant varieties, flood resistant varieties, use of electric water pump, and use of local irrigation channel. The study showed that only 39.17% of the respondents know about crop insurance policy and only 6.66% of the total respondents done crop insurance on different crop. The regression analysis showed that rainfall and average maximum temperature has positive effect on yield and production. The study showed that farmers were positive to adapt climate change adaptation strategies. So, government and policy makers should focus on climate resilient adaptation strategies formulation for rice cultivation through intensive research and extension package.

Keywords: Climate Change; Rice production; Adaptation

Introduction

Climate change and global warming are the great concern of today as they affect the natural ecosystem. Climate change refers to variation in the global climate or regional climate over long time period. Increase in concentration of greenhouse gases (GHGs) mainly CO_2, N_2O and CH_4 in atmosphere due to natural as well as anthropogenic factors is causing climate change (IPCC, 2007) affecting the agriculture, human health, forestry, biodiversity, aquatic, terrestrial and mountain ecosystem which has been burning issue of discussion and debate in recent decades. Exponential increasing in Carbon dioxide (CO_2) concentration, which contributes more than 80% of total GHGs emission causes greenhouse effects (Malla, 2008). Nepal's contribution to the global greenhouse gases emission is 0.025% (Oli & Shrestha, 2009). Climate change is an emerging environmental challenge, which has been considered through several basic indicators such as increased temperature, variability and uncertainty of precipitation. Extreme weather condition such as heat waves, drought, floods, erratic and inconsistent rainfall, change in crop production pattern, rise in sea level, polar ice and glacier melting, increase in infestation of disease and pest are some of incidences likely to happen due to climate change (IPCC, 2007).

Climate is one of the major determinants for agricultural production and productivity. Temperature, solar radiation, rainfall, soil moisture and CO_2 concentration are all important climatic variables that determine agricultural productivity. It is major concern about the impact of climate change on agricultural system as agriculture is highly vulnerable to climate change, which is more complex and not linear relationship. The impact of climate change as witnessed in recent times has adversely affected agriculture in various ways. Higher temperature beyond optimum range eventually reduce crop yield due to higher respiration and increased development rates while encouraging the proliferation of disease, pest and weed. The average temperature increased by 0.06°C per annum (Maraseni, 2012) in Nepal. Variation and uncertainty of rainfall increase leads to crop failure. Moreover, the overall climate change impact on agriculture sector is expected to be negative even though there may be positive effect on some crops in some region of the world, threatening the global food security (Malla, 2008).

Nepal is a small mountainous landlocked agrarian country in South Asia with area of 147, 181 sq. km and located between latitude of 26°22' to 30°27' north and longitude 80°04' to 88°12' east. Nepal is the fourth most vulnerable country for climate change (Panthi *et al*., 2016) and very sensitive to small changes in climatic variables. About 1.9 million people are vulnerable & 10 million exposed to increasing risk due to climate change in Nepal (MoE, 2010). The agriculture sector accounts for 33% of total Gross Domestic Product (GDP) and 65.6% of Nepal's population is engaged in agriculture (MoAD, 2012). Nepal's agriculture is largely rain fed and over 50% of Nepalese farmers are small holders cultivating less than 0.5 ha (CBS, 2011). Rice is the major and most prestigious food crop in Nepal. It is grown in diverse environment from tropical plain region to foot of mountain up to highest elevation (3050 masl). It contributes nearly 20 % to the agricultural gross domestic product (AGDP) and provides more than 50 % of the total calorie requirement of the Nepalese people (MoAD, 2014).

Objectives

The broad objective of this study is to assess impact of climate change, farmers perception and adaptation measures adopted by farmers to cope with adverse impact of climate change in Surkhet of Nepal.

Specific Objectives

- To assess the farmer's perception on climate change in the study area.
- To analyze the trends of climate change and its impacts on rice production and productivity.
- To document the local adaptation practices adopted by farmer to cope with climate change.

Materials and Methods

Purposively two municipality was selected upon the discussion with District Agriculture Development Office (DADO), Surkhet. Two wards per municipality were randomly selected. During the selection of the respondent at least 10 years of settlements within this locality were included in the sample, because they provide valuable and useful information regarding the past trends on climatic variables. Altogether 120 rainy season rice cultivating respondents, 60 households from each municipality were selected through stratified random sampling method for this study as shown in Fig. 1.

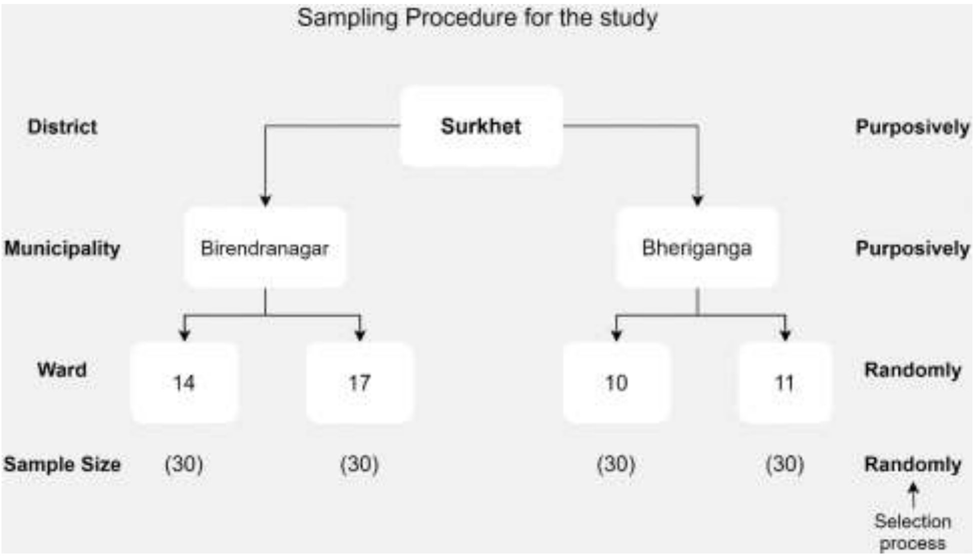


Fig. 1: Sampling procedure for the study

Primary data and secondary data were collected for this study. Household visit and interview method was used for data collection for primary data collection. Those households were selected randomly and triangulated the data conducting one FGD on each village also verified by KII with DADO, Agriculture Service Center (ASC) and personnel. Secondary data were collected from DADO, ASC and Department of Hydrology and Meteorology (DHM). The collected data were coded, tabulated and analyzed by using Statistical Package for Social Science (SPSS), MS Excel and STATA.

Regression Analysis

Time series model is most used and appropriate to access the impact of climate change on rice production and productivity. The analysis was done in SPSS (16 version) by using time series data of climatic variables (Rainfall and temperature) and rice yield and production of 15 years that are taken from different secondary data sources. Rice growing period for Surkhet is June to November. Climate data of rice growing period was considered during regression analysis. Linear specification models are applied to gauge impact of climatic variables on rice yield and production due to lack of longitudinal cross-sectional data within a mentioned period (equation 1).

$$Y_t = \beta_0 + \beta_1 T\max_t + \beta_2 T\min_t + \beta_3 Rain_t + \gamma DD + \varepsilon_t \quad \text{……….. Eq 1}$$

Where,

Yt = Annual rice production (Mt)

Raint = Average rice grown seasonal rainfall (mm)

Tmax =Average rice grown seasonal maximum temperature (°C)

Tmin = Average rice grown seasonal minimum temperature (°C)

DD = District fixed effect

ε = Error term

t = Years

Results and Discussions

Socio-Economic and Demographic Information of The Respondents

Population Characteristics of Respondents by Age Group

Identification of the respondents according to age group is very important because old age person have good knowledge about climate change trends and they are the better source of required information. In this study, out of the 120 respondents, majority of them (50%) were in the range of 35-60 years followed by the age group below 35 (34.2%) and above 60 years (19%) as shown in Table 1.

Sex of the Respondents

The study revealed that most of the respondents were Male (50.83%) across the study site with 49.17% being female as shown in Table 2.

Table 1: Distribution of respondent by age group on July 2016

Age group	Age of respondents	
	Frequency	Percentage
<35	41	34.2
35-60	60	50
>60	19	15.8
Total	120	100

Table 2: Distribution of respondents by sex on July 2016

Sex of respondent	Municipality		Total
	Birendra Nagar	Bheriganga	
Female	24(40)	35(58.3)	59(49.17)
Male	36(60)	25(41.7)	61(50.83)
Total	60(100.0)	60(100.0)	120(100.0)

Figure in the parenthesis indicate percentage

Educational Level of Respondents

Education plays a vital role in socio- cultural and economic change in a society. To assess the educational status of respondents, six categories, namely illiterate (who cannot read and write), Literate (who gain informal education and can only read and write), primary (formal education up to five), secondary (up to ten), higher secondary (up to twelve) and graduate/university, of education group was formed. Most of the respondents were found to be literate (49.3%) followed by secondary (49%), primary (27.3%), Illiterate (26.7%), higher secondary (6%) and university (1.7%) as shown in Table 3.

Table 3: Distribution of respondents by education level on July 2016

Educational level	Municipality		Total
	Birendra Nagar	Bheriganga	
illiterate	13(21.7)	5(8.3)	18(26.7)
Literate	17(28.3)	21(35)	38(49.3)
Primary	8(13.3)	14(23.3)	22(27.3)
Secondary	18(30)	19(31.7)	37(49)
Higher secondary	3(5)	1(1.7)	4(6)
University	1(1.7)	0(0)	1(1.7)
Total	60(100.0)	60(100.0)	120(100.0)

Figure in the parenthesis indicate percentage

Household and Farm Characteristics in The Study Area

Ethnicity of The Respondent's Household

In the study area, majority of the respondents were Aadibasi/Janajati and Chhetri followed by Dalit, Brahmin and Others. Out of 120 the respondents, 47.5% were Aadibasi/Janajati followed by Chhetri (28.333%), Dalit (11.67%), Brahmin (8.33%) and others (4.16%). In the Birendra Nagar Municipality, majority of the respondents were Janajati (60%) whereas, in Bheriganga, majority of the respondents were Chhetri (36.7%). Distribution of respondents in the study area is presented in Table 4.

Table 4: Distribution of survey household by ethnicity on July 2016

Ethnicity	Municipality		Total
	Birendra Nagar	Bheriganga	
Brahmin	8(13.3)	2(3.3)	10(8.33)
Chhetri	12(20)	22(36.7)	34(28.33)
Dalit	1(1.7)	13(21.7)	14(11.67)
Adibasi/Janajati	36(60)	21(35)	57(47.5)
Others	3(5)	2(3.3)	5(4.167)
Total	60(100.0)	60(100.0)	120(100.0)

Figure in the parenthesis indicate percentage

Primary Occupation of The Respondent

Occupation of local community people reflect the nature of micro-economy of any locality and various commercial, business as well as employment opportunity in the area and also determines the well -being of living standard. The study revealed that majority of the households primary occupation was Agriculture (86.67%) contributed by 85% from Birendra Nagar and 88.3% from Bheriganga. Percentage of households involved in service was 8.33% followed by business 5% as shown in Table 5.

Table 5: Primary occupation of the household on July 2016

Ethnicity	Municipality		Total
	Birendra Nagar	Bheriganga	
Agriculture	51(85)	53(88.3)	104(86.67)
Service	4(6.7)	6(10)	10(8.33)
Business	5(8.3)	1(1.7)	6(5)
Total	60(100.0)	60(100.0)	120(100.0)

Figure in the parenthesis indicate percentage

Gender of The Population in Study Site

Total population of the 120 sampled households was 659. Among them, 49.77 percent were male and 50.23 percent were female. In Birendra Nagar, percentage of Male (50.74%) was higher than female (49.26), whereas, In Bheriganga, female (51.25%) were more than Male (48.75%) as shown in Table 6.

Table 6: Gender distribution of population in the study households on July 2016

Gender	Municipality		Total
	Birendra Nagar	Bheriganga	
Male	172(50.74)	156(48.75)	328(49.77)
Female	167(49.26)	164(51.25)	331(50.23)
Total	339(100.00)	320(100.00)	659(100.00)

Figure in the parenthesis indicate percentage

Size of Land Holding

Land is the important component of any farming system. 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 households have small category of land holding (64.17%), followed by medium (18.33) and large (17.5%) as shown in Table 7.

Table 7: Size of land holding in the study area on July 2016

Land size	Land category	Municipality		Total
		Birendra Nagar	Bheriganga	
<0.5	Small	27 (45)	50 (83.3)	77 (64.17)
0.5-1	Medium	13 (21.7)	9 (15)	22 (18.33)
>1	Large	20 (33.3)	1 (1.7)	21 (17.5)
Total		60 (100.0)	60 (100.0)	120 (100.0)

Figure in the parenthesis indicate percentage

Average Size of Land Holding

Average size of landholding was 1.02 Ha in the study area (Table 8) with minimum of 0.1 ha and maximum of 3.03 ha in total.

Table 8: Average size of land holding of respondents on July 2016

Municipality	Land holding (ha)		
	Average	Minimum	Maximum
Birendra Nagar	0.72	0.03	1.7
Bheriganga	0.3	0.07	1.33
Total	1.02	0.1	3.03

Average Size of Rice Land Holding

Average size of rice cultivating land was 0.87 ha with minimum of 0.04 ha and maximum of 2.9 ha in total (Table 9).

Table 9: Average size of rice land holding of respondents on July 2016

Municipality	Land holding (ha)		
	Average	Minimum	Maximum
Birendra Nagar	0.66	0.01	1.7
Bheriganga	0.21	0.03	1.2
Total	0.87	0.04	2.9

Farmer's Perception on Climate Change

Awareness of Respondent on Climate Change in Study Area

The frequency of extreme weather events such as drought, flooding, heat stress, landslide, hailstone and snowfall has been increasing (MoPE, 2004). The study revealed that 1.7 percentages of the respondents more clearly know about climate change, 20 % respondents clearly know, 61.7 % had little knowledge on climate change and 16.7 % respondents had no idea about climate change as shown in Table 10.

Table 10. Awareness of respondents of the study area on climate change on July 2016

Awareness	Frequency	Percentage
More clearly	2	1.7
Clearly	24	20.0
A little bit	74	61.7
Do not know	20	16.7

Source of Information

During the study, Farmers expressed their response about climate change directly and indirectly, they relate it to their past experience, feeling and knowledge on rainfall, pattern, temperature and drought as compared to past. Respondents obtained information and experience on climate change by media (43.43%) followed by self-experience (36.36%), from local leaders and neighbor (13.13%) and organization (7.07%) as shown in Fig. 2.

Fig 2. Source of information on climate change for farmers on July 2016

Perception on Changing Temperature and Precipitation

There is gradual increase in atmospheric temperature in different ecological zones of western development region of Nepal (Manandhar, 2009). Most of the respondents (82.5%) felt the increase in temperature as compared to the past 10 years. 68.3% of the respondents felt the increase in hotter days, which was also proved by the increasing trend of maximum, average and minimum temperature from Surkhet meteorological station as shown in Fig. 4.

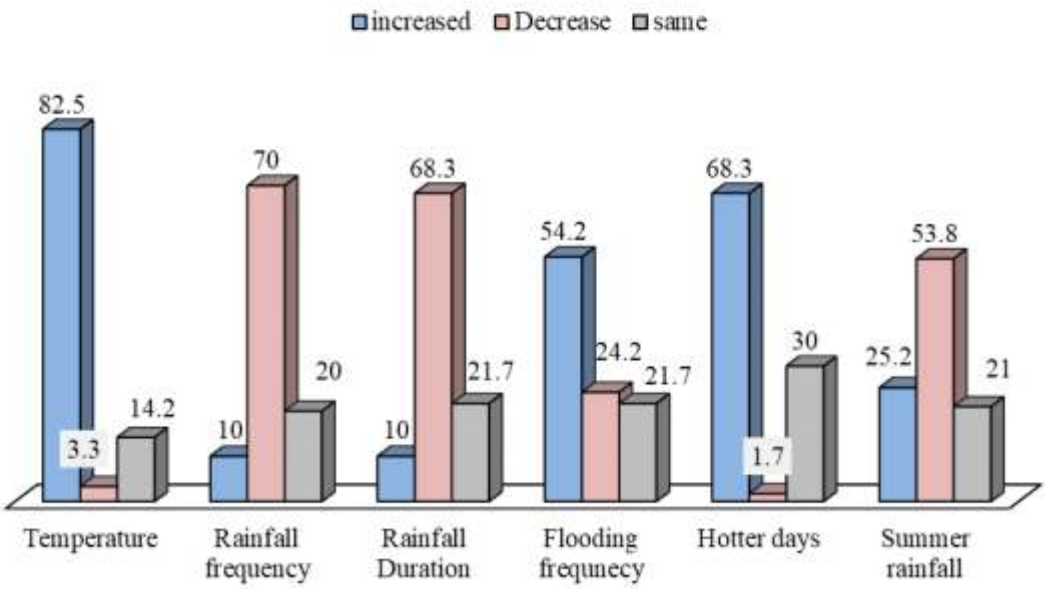


Fig. 3: Respondent perception on microclimate in the study area on July 2016.

Farmer of the study perceived that there was decreased in precipitation as compared to the past. The majority of respondents reported decline in rainfall frequency (70%), rainfall duration (68.3%) and summer rainfall (53.8%). The trend analysis of 35-year data obtained from metrological station, Surkh*et al*so showed that the total rainfall was decreased by 3.77 mm per year as shown in Fig. 5. However, 54.2% respondents experience increased flooding frequency as compared to past in the study area. The study showed that Rainfall pattern was also experienced as inconsistent with the higher intensities of rain and less number of rainy days (Sapkota *et al*., 2010).

Perception on Occurrence of Climatic Hazards

The study revealed that the flood hazard is more experienced (61.7%) in the study area followed by drought (36.7%) as shown in Table 11.

Respondent's Experience on Rice Cultivation Practices as Compared to Past Ten Year and Present Time

Cultivation practices of rice experienced by farmers can be used to evaluate both climatic and non-climate factors affecting production and productivity of rice. Comparing the experience of farmers on rice transplanting and harvesting time, drought duration, insect pest infestation and yield variation ten years before and now is found in changing scenario. Majority of the respondents had transplanted (57.5%) and harvested (60.83%) rice earlier in the present time as compared to past. Although, there was decreasing trend as in time series analysis of pre-monsoon rainfall 0.6487 mm per year, due to use of electric motor, irrigation pump and dry nursery bed with early rice variety during nursery establishment and transplantation rice was earlier than before. The study revealed that 58.3% of the respondents had more yield than past ten years before; this may due to use of quality seed, hybrid varieties and better cultural practices as shown in Table 12.

Table 11: Respondent's perception on climatic hazards on July 2016

Climatic hazard	Respondents perception	
Flood hazard	Increased	74 (61.7)
	Decreased	9 (7.5)
	Same	36 (30)
Drought hazard	Increased	44 (36.7)
	Decreased	6 (5)
	Same	70 (58.3)
Landslide hazard	Increased	16 (13.3)
	Decreased	5 (4.2)
	Same	99 (82.5)

Figure in the parenthesis indicate percentage

Table 12: Respondents experience on rice cultivation practices comparing before ten year and now on July 2016

Rice cultivation practices as compared to before 10 years	Respondents experience	Birendra Nagar (n=60)	Bheriganga (n=60)	Total (N=120)
Transplanting time	Earlier	36(60)	33(55)	69(57.5)
	Later	2(3.3)	5(8.3)	7(5.83)
	Same	22(36.7)	22(36.7)	44(36.67)
Harvesting time	Earlier	37(61.7)	36(60)	73(60.83)
	Later	2(3.3)	5(8.3)	7(5.83)
	Same	21(35)	19(31.7)	40(33.33)
Rice yield	Earlier	36(60)	34(56.7)	70(58.33)
	Later	10(16.7)	22(36.7)	32(26.67)
	Same	14(23.3)	4(6.7)	18(15)
Weed infestation	Higher	48(80)	53(88.3)	101(84.17)
	Lower	11(18.3)	7(11.7)	18(15)
	Same	1(1.7)	0(0)	1(0.83)
Pest infestation	Higher	49(81.7)	52(86.7)	101(84.17)
	Lower	10(16.7)	7(11.7)	17(14.17)
	Same	1(1.7)	1(1.7)	2(1.67)

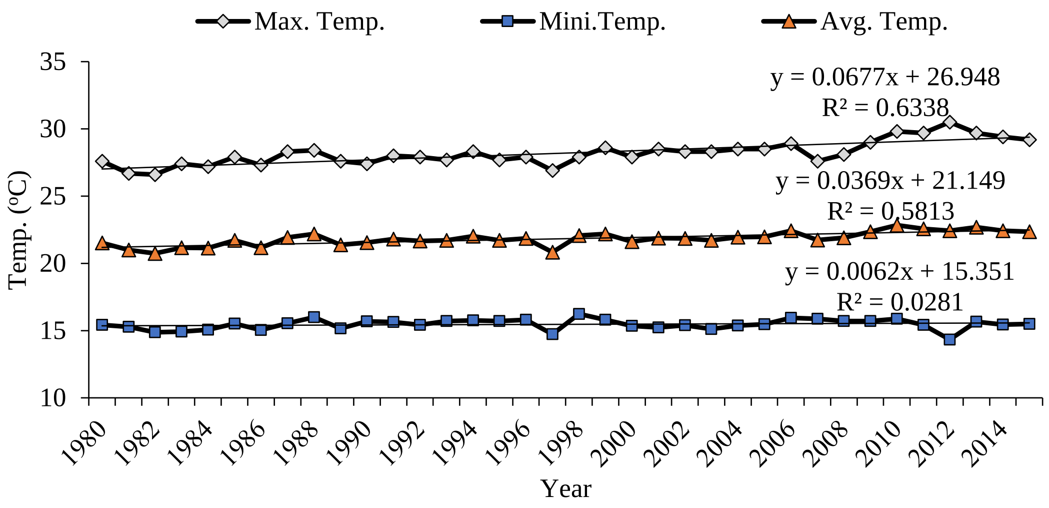
Figure in the parenthesis indicate percentage

Trends Analysis of Annual Maximum, Minimum and Average Temperature

Strong indicators of climate change scenario were detected in the climate variable data (temperature and rainfall) recorded by weather station nearby survey site over recent history (1996-2015) obtained from the metrological office Surkhet. Increase in annual maximum, minimum and average temperature were observed as shown in Fig. 4. The annual maximum temperature of this region has increased by 0.06°C per year. The annual minimum temperature of this region has increased by 0.03°C and annual average temperature increased by 0.006°C per year. The trends analysis strongly supports the farmer's perception that temperature was increasing. Increase in annual maximum temperature of this region is in line with national annual maximum temperature (DHM, 2017). The trend analysis of maximum temperature in Nepal found that the average annual warming between 1971 and 1994 was 0.06°C/year (Shrestha *et al*., 1999).

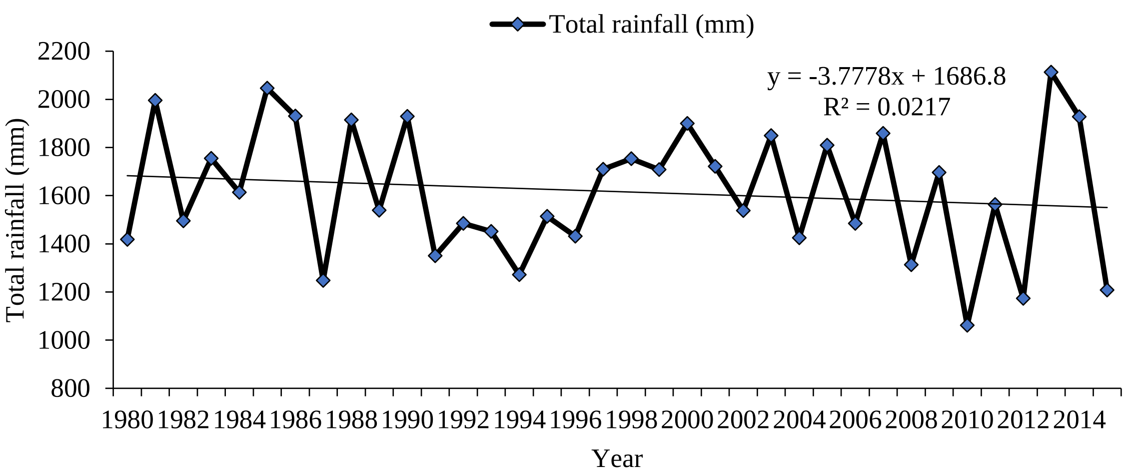
Trend Analysis of Total Rainfall in Study Area

Total precipitation of the study area was found to decreasing. The trend analysis of 35 year data showed that the total rainfall was decreased by 3.77 mm per year as shown in Fig. 5. The study on Rainfall trends analysis of thirty years (1971-2000) metrological data showed that the annual rainfall and number of rainy days were decreasing in month of July in Surkhet (Nayava, 2004).



(Source: DHM. 2016)

Fig. 4: Average maximum, average minimum and mean annual temperature as recorded in Birendra Nagar metrological station, Surkhet (1980- 2015)



(Source: DHM, 2016)

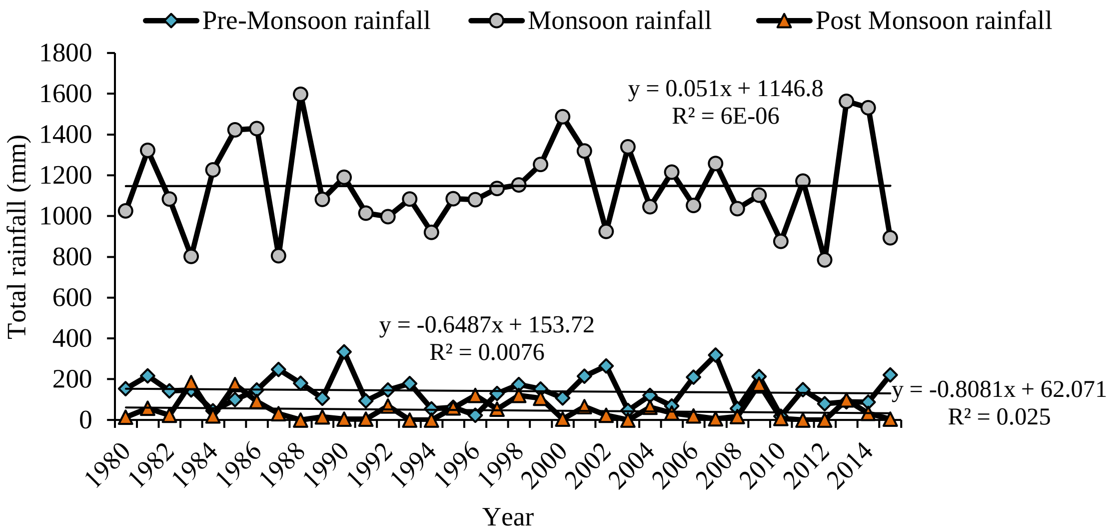
Fig. 5: Total precipitation in Surkhet (1989-2015)

Pre-Monsoon, Monsoon and Post-Monsoon Rainfall Trend

The total pre-monsoon (March- May), monsoon (June to September) and post monsoon (October-November) rainfall trend were found to be varying across time horizon. The pre-monsoon rainfall showed decreasing trend by 0.64 mm per year, Monsoon rainfall increased by 0.051 mm per year and post monsoon rainfall decreased by 0.8 mm per year as shown in Fig. 6. The study on relationship between rainfall and rice yield from 1971 to 2015 showed that there is positive relationship between amount of monsoon rainfall and rice yield (Nayava, 2017). Thus, the increase in monsoon rainfall is better for rice yield. However, the nature of rainfall, its amount, Seasonal distribution and intensity, Frequency of occurrence, variability and areal variation are the major factors affecting agricultural potential (Nayava, 1980).

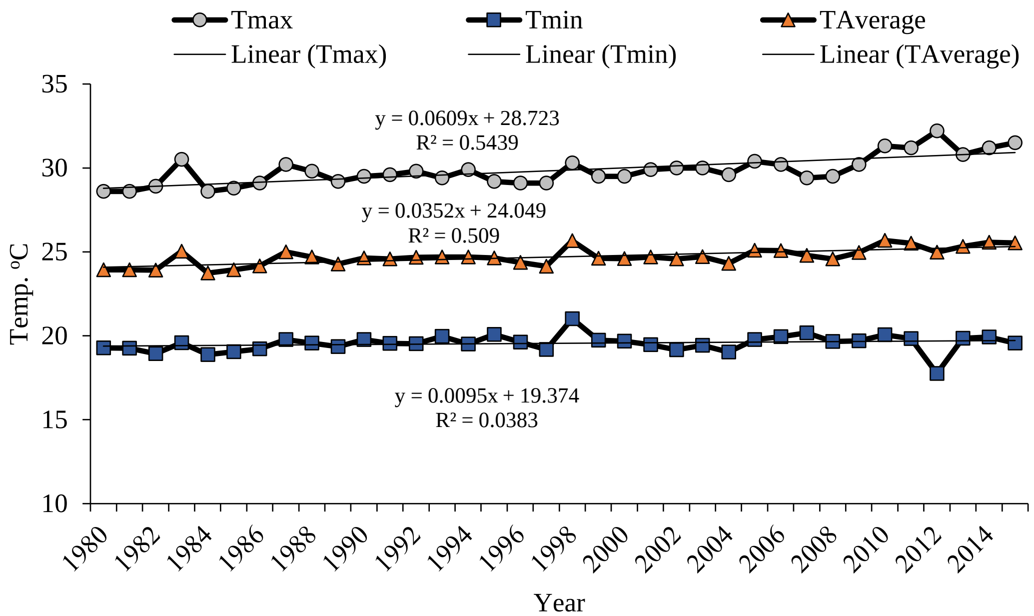
Rice Growing Season Maximum, Minimum and Average Temperature Trend

The trend analysis showed that the temperature of rice growing season is increasing trend. The maximum temperature was increased by 0.06°C per year while minimum and average temperature was increased by 0.009°C and 0.035°C per year respectively as shown in Fig. 7. The Study on trend analysis of annual mean temperature from 1973-2003 also showed a rising trend in Surkhet (Bhandari, 2013).



(Source: DHM, 2016)

Fig. 6: Pre monsoon, monsoon and post-monsoon rainfall in Surkhet (1980-1999)



(Source: DHM, 2016)

Fig. 7: Rice growing season maximum, minimum and mean temperature in Surkhet (1980-2015)

Trend of Total Rainfall and Productivity of Rice

The trends analysis of total seasonal rainfall (June to November) and productivity of rice showed that the productivity of rice had increased by 0.12 ton/ha, while the total seasonal rainfall was decreased by 13.01 mm per year over time period as shown Fig. 8. The study on trend analysis of rice yield with rainfall and temperature from 1975-2003 showed that yield of rice is increasing trends in Surkhet (Bhandari, 2013).

Econometric Models

Impact of Climate Variables on Area, Production and Yield of Rice

For the analysis of impact of climatic variables on the production and productivity of rice, 15 years, time series data of minimum temperature, maximum temperature, average temperature and seasonal rainfall of rainy season rice growing period of surveyed district were used. The mean area of rice cultivation was 13028 ha with productivity of 3 ton/ha. The rice growing period mean maximum temperature and minimum temperature found 30°C and 20°C, respectively in Table 13.

Climatic variables affecting the production and productivity of rainy season rice is presented in Table 14. The result showed that maximum temperature had significant positive effect on the production and productivity of rice. This indicates that, one unit increase in the maximum temperature will increase production of rice by 3278 Metric Ton. The temperature trends analysis from 1975-2003 showed that the average seasonal mean temperature from March-June and from July-November was 24.69°C and 23.7°C, respectively in surkhet (Bhandari,2013). Increase in maximum temperature up to 29.9°C favors increase in paddy yield (Karn, 2014). The study on rice in NARC Tarahara, Nepal also showed that increase in maximum temperature up to 2°C and minimum temperature up to 1°C have positive impact on rice yield but beyond that temperature it has negative impact in rice production (Rai *et al*., 2014). Similar case was found by a research conducted at Hilly area of Nepal (Lalitpur) that increase in temperature favors rice production till 2°C (Ghimire *et al*., 2016).

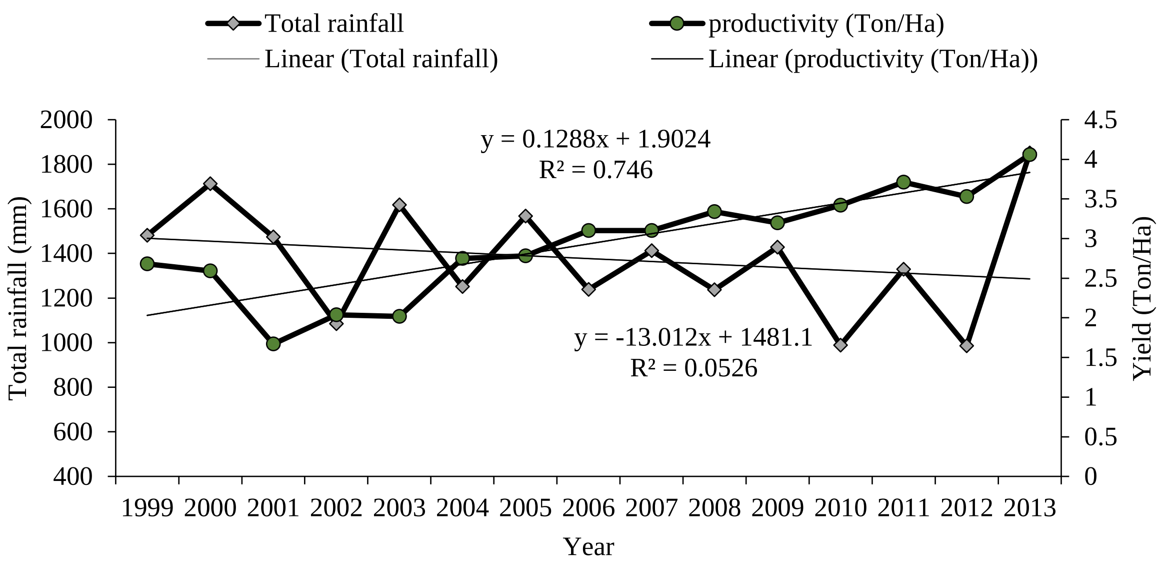


Fig. 8: Total rainfall and yield of rice (1999-2013)

Table 13: Statistical description of variables used to gauge impact of climatic variables on rice production (1999-2013)

Variables	Description of variables	Mean	Maximum	Minimum	SD
Area	Rice cultivating area in ha	13028	14600	12327	871
Yield	Yield in metric ton/ha	3	4	2	1
Production	Production in metric ton	38825	59322	20673	11161
Rainfall	Total seasonal rainfall (June to November) in mm	1377	1850	985	254
T_Max	Maximum temperature (June to November) in °C	30	32	29	1
T_Min	Minimum temperature (June to November) in °C	20	20	18	1
T_Avg	Average temperature (June to November) in °C	24.91	25.7	24.3	0.39

Table 14: Climatic variables affecting on production and yield of rice

Variables	Productivity		Production	
	Coeff.	**Std. Err**	**Coeff.**	**Std. Err**
Total seasonal rainfall	0.0000717	0.0006864	4.210388	10.34878
T_max	0.5779776**	0.2174659	11227.41***	3278.486
T_min	0.4471465	0.3029905	6189.412	4567.842

Note: *** and ** indicates significance at 1 percent and 5 percent level respectively

Table 15: Farmer's adaptation practices on rice production on July 2016

Adaptation practice	Respondents experience	Birendra Nagar (n=60)	Bheriganga (n=60)	Total (N=120)
Use of hybrid variety	No use	29(48.3)	11(18.3)	40(33.33)
	US-312	29(48.3)	23(38.3)	52(43.33)
	Shankar -360	1(1.7)	17(28.3)	18(15)
	Gorkhnath -504	0(0)	8 (13.4)	8 (6.66)
	No use	34(56.7)	44(73.3)	78(65)
Use of drought resistant Variety	Sukkha-1	18(30)	9(15)	27(22.5)
	Sukkha-2	7(11.7)	6(10)	13(10.83)
	Sukkha-3	1(1.7)	1(1.7)	2(1.67)
	No use	42(70)	54(90)	96(80)
Use of flood tolerant	Swarnasub-1	15(25)	3(5)	18(15)
	Swarnasub-2	3(5)	3(5)	6(5)
	No use	37(61.7)	44(73.3)	81(67.5)
Local variety	Dadamansuli	23(38.3)	10(16.7)	33(27.5)
	Thapajini	0(0)	2(3.3)	2(1.67)
	Gude	0(0)	4(6.7)	4(3.33)
	Use of electric motor	37(63.8)	5(8.6)	42(35)
Nursery preparation, irrigation	Dry seed bed	10(17.2)	8(13.8)	18(15)
	irrigation channel	10(17.2)	45(77.6)	55(45.83)
	Manually	59(98.3)	60(100)	119(99.17)
Weed management	Chemical	1(1.7)	0(0)	1(0.83)
	Chemical	53(88.3)	33(55)	86(71.67)
Pest management	IPM	2(3.3)	0(0)	2(1.67)
	Organic	5(8.3)	27(45)	32(26.67)
Know about Crop insurance	No	34(56.7)	39(65)	73(60.83)
	Yes	26(43.3)	21(35)	47(39.17)
	No	54(90)	58(96.7)	112(93.33)
Crop insurance	Cereal (Rice)	0(0)	1(1.7)	1(0.83)
	Vegetables (Cauli flower, tomato, cucumber)	4(6.7)	1(1.7)	5(4.17)
	Livestock (Cow)	1(1.7)	0(0)	1(0.83)
	Bee	1(1.7)	0(0)	1(0.83)

Figure in the parenthesis indicate percentage

Farmer's Adaptation Practices to Changing Climate on Rice Production

The farmers having low income and low adaptive capacity are hit hard by climate change (Regmi *et al*., 2009). Local knowledge and innovations are important insights to solve the big problems so they should be promoted instead of being ignored or subsided (Krone *et al*., 2006). Majority of the respondents used rice hybrid variety US-312 (43.33%) followed by Shankar-360 (15%) and Gorakhnath (6.66%). The study showed increase in disease, pest and weed infestation in present year as compared to past ten years before. Farmers of study area just started to adopt different drought resistant, flood resistant rice varieties to cope with the climate change adversities. Out of the 120 households, 22.5 percent farmers used drought resistant rice variety Sukkha dhan-1, followed by Sukkha dhan-2 (10.83%) and sukkah-3 (1.67%). About 20 percent farmers use flood resistant variety; 15% of farmers used Swarna sub-1 and 5 % of farmers used Swarna sub-2. In the study area, 45.83 % of farmers used irrigation channel during nursery preparation, 35 % of farmers used electric motor pump for irrigation. Similar practices were adopted by farmeres such as; changing sowing/planting date of crop, use of improved varieties, using more chemical fertilizer and using pest management practices coping with adverse climatic conditions in Bardiya district (Sharma *et al*.,2020). Crop insurance is one of the adaptation practices to climate change (Table 15).

Conclusion

Most of the farmers in the study area perceived climate change at present time in terms of change in rainfall pattern, rainfall duration, rainfall intensity, rainfall frequency, onset of monsoon, increase in climatic hazard and changes in summer temperatures in terms of hotness. Commonly, drought led to low crop yield especially in the rain-fed rice farming system. The flooding cause damaged and loss of standing crop in field by buried, sedimentation and increase in pest infestation. Moreover, flooding also cause loss of human live, shelter and affect the livelihood. The study was carried out to assess the climate change impact on rice production, perception of famers to climate change and local adaptation strategies in response of changing climate. Surkhet district of Mid-western inner terai region was taken in consideration for the proposed study. Two municipalities from the district were purposively selected. Altogether, 120 household, 60 from each municipality, were selected by simple random sampling method. Primary data were collected by administering the questionnaire survey, focus group discussion, key informant interview and direct observation. Secondary data related to climate were obtained from DHM, Mid and far-western regional climate office, Surkhet and data related to rice production obtained from DoA and DADO-Surkhet.

The study population was dominated by Janajati (47.5%) mainly Tharu community with an average family size of 5.67, which is little more than national status. Agriculture including livestock was major occupation (86.6%) of the respondents with average landholding size of 1.02 ha. Total monsoon rainfall, minimum temperature and maximum temperature were increasing by 0.051 mm, 0.03°C and 0.06°C per year respectively in Surkhet, over the times as perceived by the farmers. But the mean annual rainfall and total rainfall were decreasing by 0.351 mm and 3.77 mm per year respectively. There was increasing trends of disease pest infestation as perceived by farmers.

The optimum temperature range for rice growing period is 22- 30°C. The regression analysis for independent (climatic variable) and dependent variables i.e. {productivity (MT/hac) and production (MT)} showed that the average maximum temperature has positive effect on yield and production. However, since the current average temperature for 1999 to 2008 is already 30.8°C. It is expected that rice yields are negatively affected by increase in daily maximum temperature.

The increase in monsoon rainfall is favorable for the increase in rice yield but the variation in precipitation cause flooding and drought occurred during rice production leads to reduction in production. Rice productivity and production with climatic variables shows that productivity and production are increasing due to increase in maximum temperature but it will be desirable that farmers are sensitized about climate change, its impact, and its adaptation to be prepared for future climate extreme events.

The increase in disease, pest infestation is major problems for farmers. Farmers were practicing different coping and adaptation strategies in their farm based upon their experience to tackle with changing climate. But there should be promotion of local and indigenous adaptation practices followed by farmers which are economically feasible ecologically sound and environmentally acceptable. Changing climate under rainfed condition was affecting the normal cropping calendar and crop rotation as compared to the past by the farmers. Changes in cropping calendar hinder the crop growth leading poor yields. Farmers used a range of adaptation strategies to cope and adapt to climate effects. The strategies used for adaptation included afforestation, change in planting dates, switching to irrigation farming, construction of irrigation channel, plastic pond, water harvesting tank, practicing mulching, shifting to cropping system, crop diversification and engagement in non-farming activities. Despite being willing to use the coping and adaptation strategies, most of the smallholder farmers faced challenges such as lack of capital, adaptation knowledge and water for irrigation.

Authors' Contribution

This work was carried out in collaboration with all authors. BB Khadka, H Sharma and AP Subedi conceptualized and designed the research plan. BB Khadka acquired of the Data, performed the statistical analysis and interpretation, wrote the first draft of manuscript and Critically revised the manuscript. SC Dhakal guided the statistical analysis and manuscript writing. All the authors read, finalized and approved the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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