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 (0.06°C/year) and minimum temperature (0.03°C/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 CO2, N2O and CH4 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 (CO2) 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, droughts, 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 CO₂ 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 (Panithi 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](image-url)
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).

\[ Y_t = \beta_0 + \beta_1 T_{\text{max}} + \beta_2 T_{\text{min}} + \beta_3 \text{Rain}_t + \gamma DD + \varepsilon, \quad \ldots \ldots \quad \text{Eq 1} \]

Where,

- \( Y_t \) = Annual rice production (Mt)
- \( \text{Rain}_t \) = Average rice grown seasonal rainfall (mm)
- \( T_{\text{max}} \) = Average rice grown seasonal maximum temperature (°C)
- \( T_{\text{min}} \) = Average rice grown seasonal minimum temperature (°C)
- \( DD \) = District fixed effect
- \( \varepsilon \) = 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 | 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) |

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 (28.33%), Dalit (11.67%), Brahmin (8.33%) and others (4.1%). 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)|
| Aadibasi/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 (100.0)        | 320 (100.0)| 659 (100.0)|

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.

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.

Fig. 2. Source of information on climate change for farmers 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, Surkhet also 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)    |
| Drought hazard            | Decreased 9 (7.5)      |
| Landslide hazard          | Increased 16 (13.3)    |
|                           | Decreased 5 (4.2)      |
|                           | Same 70 (58.3)         |

**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)     |
|                                                          | Earlier                | 36(60)                | 34(56.7)          | 70(58.33)     |
| Rice yield                                               | Later                  | 10(16.7)              | 22(36.7)          | 32(26.67)     |
|                                                          | Same                   | 14(23.3)              | 4(6.7)            | 18(15)        |
|                                                          | Higher                 | 48(80)                | 53(88.3)          | 101(84.17)    |
| Weed infestation                                         | Lower                  | 11(18.3)              | 7(11.7)           | 18(15)        |
|                                                          | Same                   | 1(1.7)                | 0(0)              | 1(0.83)       |
|                                                          | Higher                 | 49(81.7)              | 52(86.7)          | 101(84.17)    |
| Pest infestation                                         | 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).

![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)](source: DHM, 2016)
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).
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                  | 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(33.3)      |
|                                          | US-312                 | 29(48.3)              | 23(38.3)          | 52(43.3)      |
|                                          | 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 (Cauliflower, 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 sukkha-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 farmers 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 farmers 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/ha/c) 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 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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