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# IMPACT OF CLIMATE CHANGE ON CROPPING SYSTEM AND ADAPTATION STRATEGIES UNDERTAKEN BY INDIGENOUS COMMUNITY: A CASE STUDY FROM JIRI MUNICIPALITY, DOLAKHA, NEPAL

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## ABSTRACT

Climate change is a proven and burning issue in world. It has visibly impacting different nation. The study was focused to assess the impact of climate change on cropping system and adaptation strategies undertaken by indigenous community in Jiri Municipality of Dolakha district, Nepal in 2022, which was dominated by the indigenous community namely Jirel. In survey, 212 households were selected from five wards of Jiri Municipality using purposive sampling technique. Preliminary study, scheduled questionnaire survey, field observation, focus group discussion and key informant interview were the primary information sources and secondary information were collected and analyzed using SPSS software; Microsoft Excel and Logistic regression model. From this research on Jiri Municipality of Dolakha district of country Nepal, it is again proved that the climate at the local level has been experiencing increasing trends of both precipitation and temperature (1992-2021). Analysis of agricultural data and meteorological data (2008/09 to 2019/20) shows that the annual yield of the crops like maize, wheat, millet and potato are increasing annually. This signifies that there was positive impact to crop production of study area. At the same time series, both trend of temperature and precipitation are annually increasing. Farmers have experienced that agricultural productivity is decreasing than in the recent years because of different diseases, pest, erratic rainfall, etc. However, there was also positive impact of climate change in study area because climatic variables created favorable environment to grow cauliflower, cabbage, chilly, pumpkin, lemon, kiwi fruit and spinach which were unusual crop species of study area before. Local people's experience part shows mixed outcomes i.e. positive as well as negative impact on agricultural production due to climate change. As per the analysis of sales of chemical fertilizers data (2014/15 to 2019/20) in the study area, there was fluctuating trend of chemical fertilizers i.e. significant decrease in the sales of urea with 107.64 Mt per year. Crop yield trend showed highly positive correlation for maize, wheat and millet whereas low positive correlation for potato along with the sales of chemical fertilizers. Majority of the respondents are practicing intercropping and planning to use hybrid seeds, pesticides, chemical fertilizers, tunnel and irrigation channel, similarly, to adapt new crops and to change planting time of crops. Whereas, 100% of the respondents were using bio fertilizers to cope with increasing climatic trend.

**Keywords:** Adaptation, Agriculture, Climate change, Impact, Jiri Municipality

## INTRODUCTION

Climate is commonly defined as the weather averaged over a long period of time (AMO, 2009). The standard averaging period is 30 years (BMO, 2009). Climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period (UNFCCC, 1997). During the past few decades the world has been experiencing significant increase in global temperature resulting into climate change. Scientists are now confident that this rapid rate of increase in temperature is due to human induced factors that is emission and accumulation of GHG in the earth's atmosphere. From 1906 to 2005 the global average surface temperature increased by 0.74 [0.56 to 0.92] °C. The linear warming trend over the 50 years from 1956 to 2005 was 0.13 [0.10 to 0.16] °C per decade is nearly twice that for the 100 years from 1906 to 2005 (IPCC 2007). Intergovernmental Panel on Climate Change (IPCC) has also projected that by 1990 global average surface temperature will increase by 1.8 - 4.0°C.The recent study showed that the temperature of the earth is increasing at 0.41˚c per decade (Kansakar et al., 2004).

Climate Change has been happening across the country with varying degrees of impacts (Shrestha & Aryal, 2011). The impacts of the climate change are visible in various sectors like vegetation, hydrology and rising temperature affecting the normal productivity of the ecosystem (Khatiwada, 2011). The international fund for Agriculture development (IFAD) has also recognized climate change as one of the important factors affecting rural poverty and as one of the challenges that need to be addressed wisely (IFAD, 2009). Changing temperatures and erratic rainfall pattern are affecting crop production in Nepal (Malla 2008). Adaptation is important to climate change issue in two ways- one relating to assessment of impacts and vulnerabilities, the other of the development and evaluation of response options. Nepal is an agriculture-based country where more than 65% of the population engages in agriculture for livelihood and agriculture shares about 33% of its Gross Domestic Product (GDP) at current price and 35% at 2000/01 constant price (MOAC, 2010b). Agriculture is the most susceptible sector to the climate

  

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change due to the fact that the climate change affects the two most important direct agriculture production inputs namely precipitation and temperature (Deschenes & Greenstone, 2007).

## MATERIALS AND METHODS

### Study Area

Dolakha is one of 77 districts of Nepal, and takes up northeastern corner of Bagmati Province, lying in Janakpur zone. Absolute location of Dolakha lies between 270 28’ to 280 00’ north latitude and 850 50’ to 860 32’ eastern longitude. Jiri is the municipality in Dolakha district among eight other municipalities. It lies at an elevation from 1649 m to 5341m from the sea level and it occupies 211.25 km of the land area. There are 9 wards in this municipality.

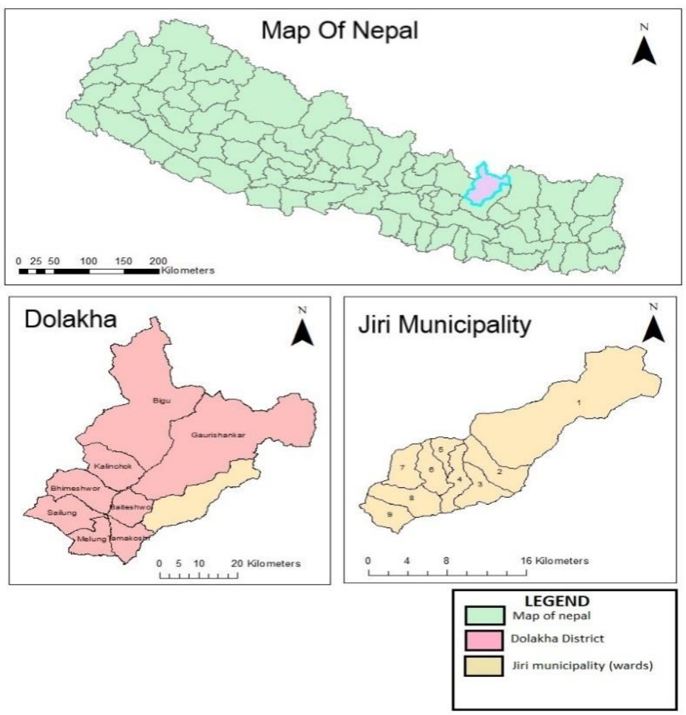


**Figure 1: Map of Study Area**

### Methods of Data Collection

### Primary Data Collection

### Scheduled Survey

For the scheduled survey, structural questionnaire was prepared, and interview was conducted on the various aspects like household profile, different aspect of the climate change, agriculture production and various types of the adaptation measures employed by the indigenous people to adapt the impacts of the climate change. The Jirel population live in the Jiri municipality is 3360 (21.66%) according to the statistics of the National Census 2068.The sample size for the study was calculated by using the formula given by Krejice and Morgan in 1970;

$$s = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where,

s = Sample size

N = total number of households

Population proportion=21.66% (0.2166)

X = Confidence level(1.96)

d = Error limit at 5 % (0.05)

By using the above formula sample size was calculated which was 212.

Thus, the households of Jirel community in Jiri Municipality of Dolakha district were selected through purposive sampling technique.

**Field Observation**

Preliminary study was carried out to take the general information about the impacts of the climate change on the livelihood and crop production of the study area before starting the actual field work. During the preliminary study and actual field work, information was collected, and photographs were taken.

**Focus Group Discussion (FGD)**

FGD was carried out to collect the information about past and the present changes in the climate, change in cropping patterns, pest and adaptation practices in agricultural field to cope with climate change. FGD was conducted with the experienced farmers, local leaders, teachers, social workers and local people.

**Key Informant Interview (KII)**

KII was conducted with the farmers, teachers, local politicians and social workers to get the information about climate change, changing agricultural patterns, pest, extreme climate events and adaptation practices in agricultural field to cope with climate change.

  

**Secondary Data Collection**

**Climatic Data**

The climatic data from Department of Hydrology and Meteorology was collected to analyze the temperature and precipitation trends to observe the change in climatic variability in the study area. For temperature data analysis, data from Jiri station was collected. Whereas, for precipitation data analysis, data from station of Charikot was used.

**Agricultural Data**

For the agricultural data analysis process, production data of different types of crop of Dolakha district were collected from Statistical Information on Nepalese Agriculture, MOAD, 2022. For maize, wheat, millet and potato data from 2008/09 to 2019/20 were collected and analyzed.

**Chemical fertilizer Data**

Sales of chemical fertilizer data of the Dolakha district was collected and analyzed. Data was collected from Statistical Information on Nepalese Agriculture, MOAD (2022) from the year 2014/15 to 2019/20.

**Socio-Economic Data**

Data published from District Agricultural Office, Charikot, book published from Jiri in the name of budget program of year 2078 /2079 were used to analyze the socio-economic condition of the people. Relevant articles, journals, newspaper, Research papers, magazines were also used as supplementary sources during data analysis.

**Data Processing, Analysis and Interpretation**

Results obtained from the primary data collection (household survey, KII, FGD, field observation) from the Jiri Municipality of Dolakha district was analyzed using Statistical Package for Social Sciences (SPSS 21) program. Data obtained through the different sources were processed, analyzed and interpreted by using appropriate tools. All the obtained data were entered and analyzed by using SPSS 21, MS excel and Arc GIS 10.5.

## RESULTS

**Climatic Analysis**

**Precipitation Analysis**

**Annual average precipitation trend**

  

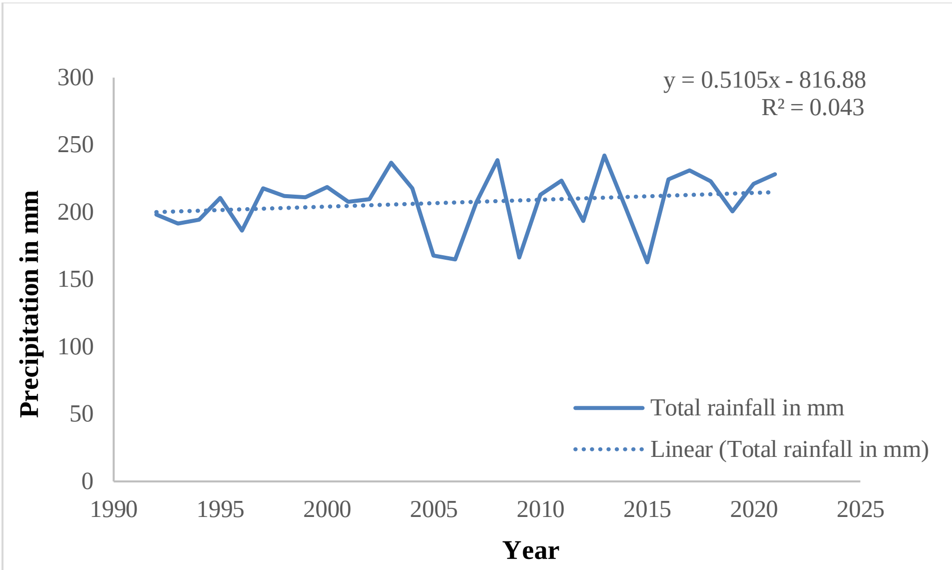


**Figure 2: Annual average precipitation (Source: DHM, Nepal, 2022)**

**Annual average seasonal precipitation trend**

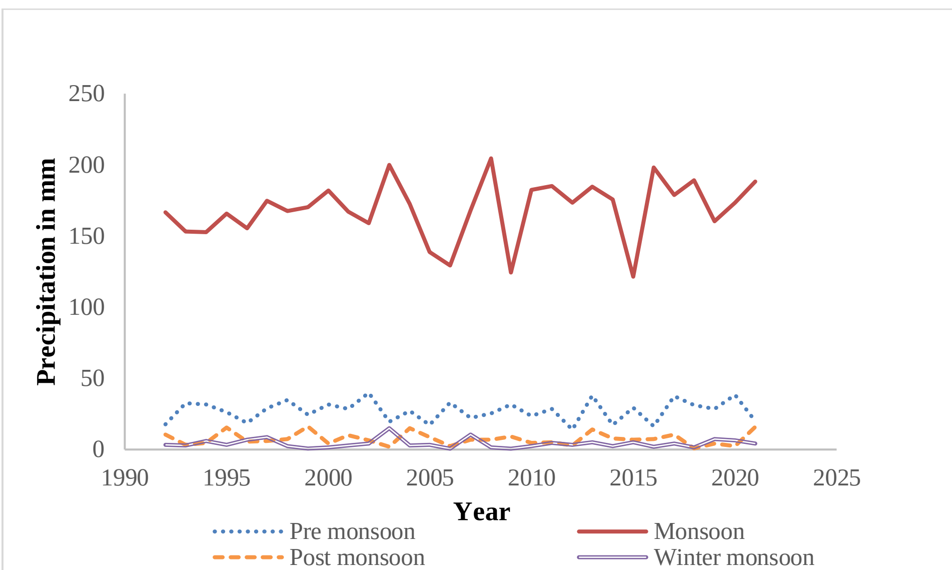


**Figure 3: Annual average seasonal precipitation trend (Source: DHM, Nepal, 2022)**

  

**Average Monthly Rainfall**

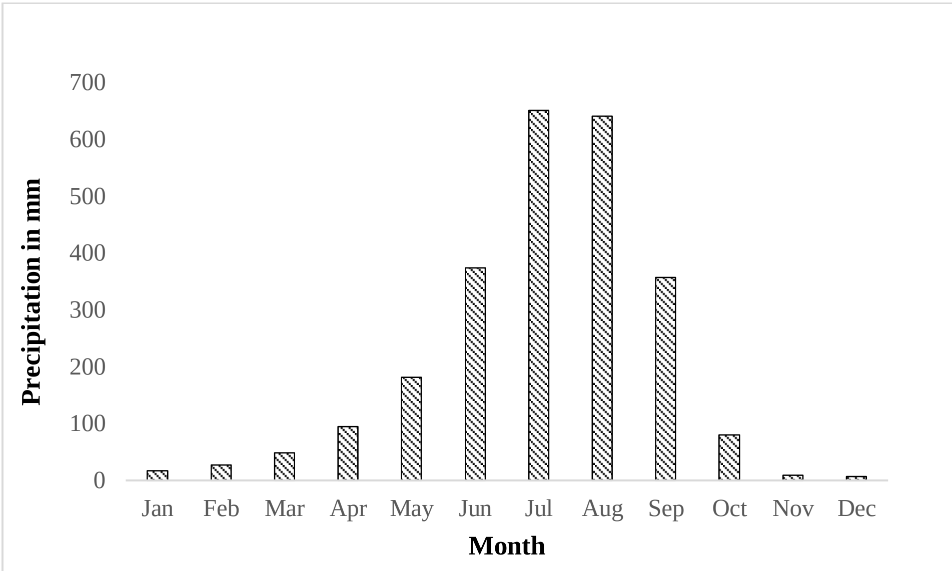


**Figure 4: Mean monthly rainfall from 1992 to 2021 (Source: DHM, Nepal, 2022)**

**Average Monthly Decadal Rainfall**

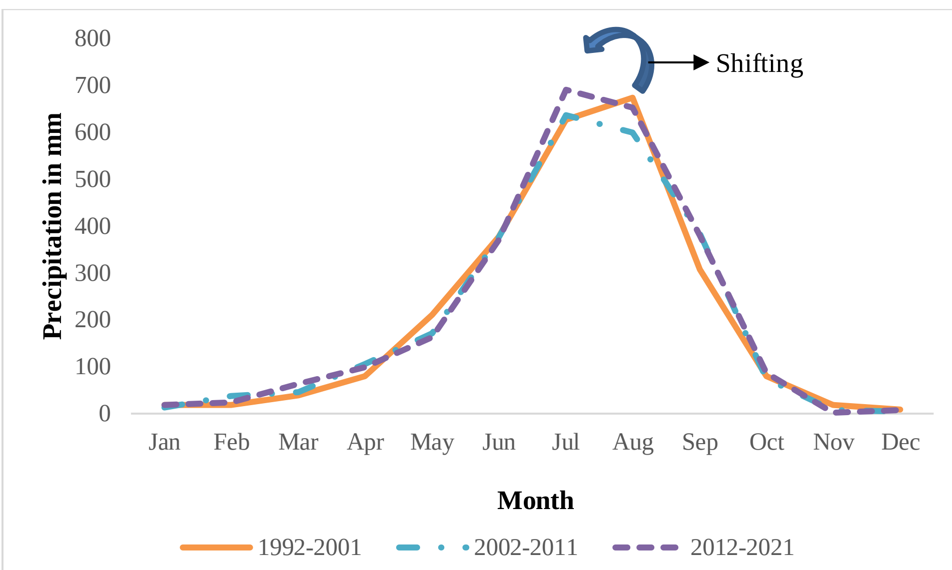


**Figure 5: Average monthly decadal rainfall from 1992 to 2021 (Source: DHM, Nepal, 2022)**

  

### 4.1.1.5 Seasonal Precipitation change

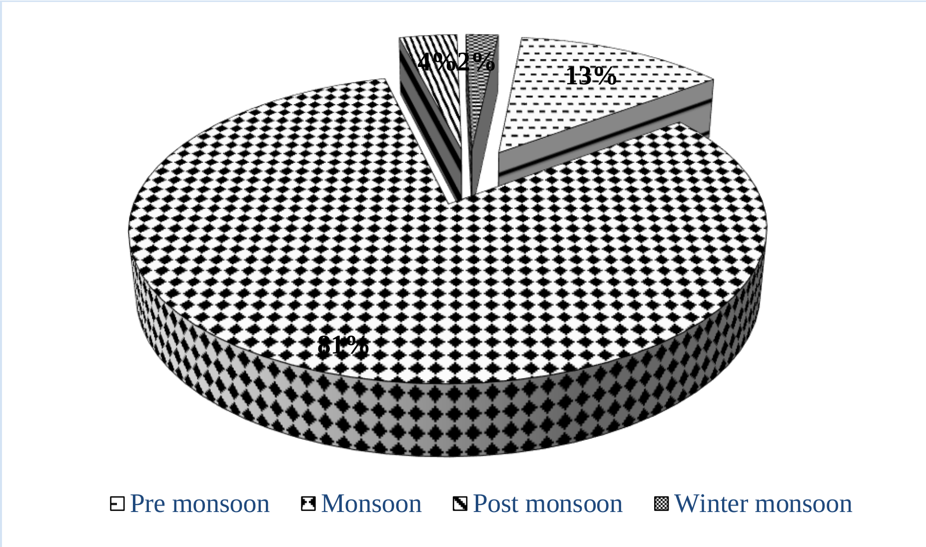


**Figure 6: Seasonal distribution of rainfall in study area (Source: DHM, Nepal, 2022)**

### Temperature Analysis

### Annual Average Temperature

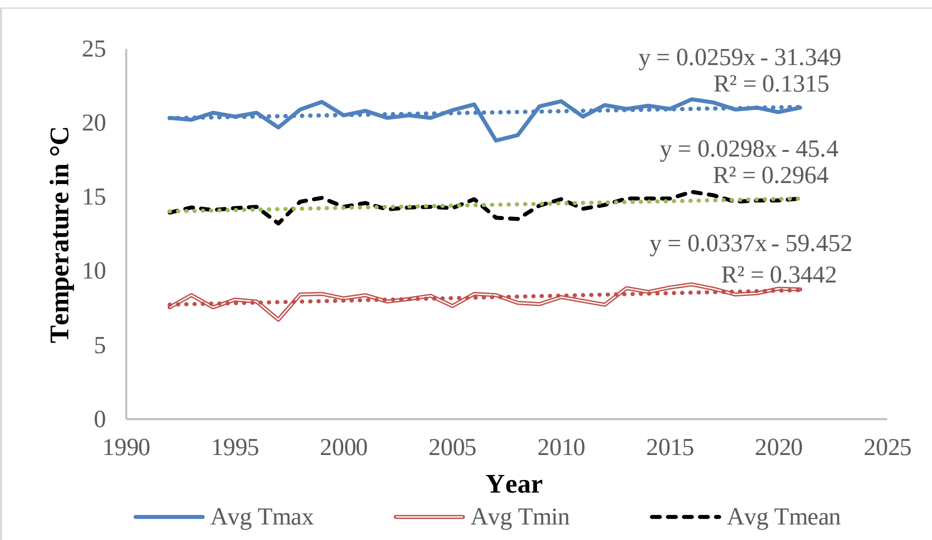


**Figure 7: Annual average temperature trend of study area (Source: DHM, Nepal, 2022)**

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## Seasonal Average Temperature

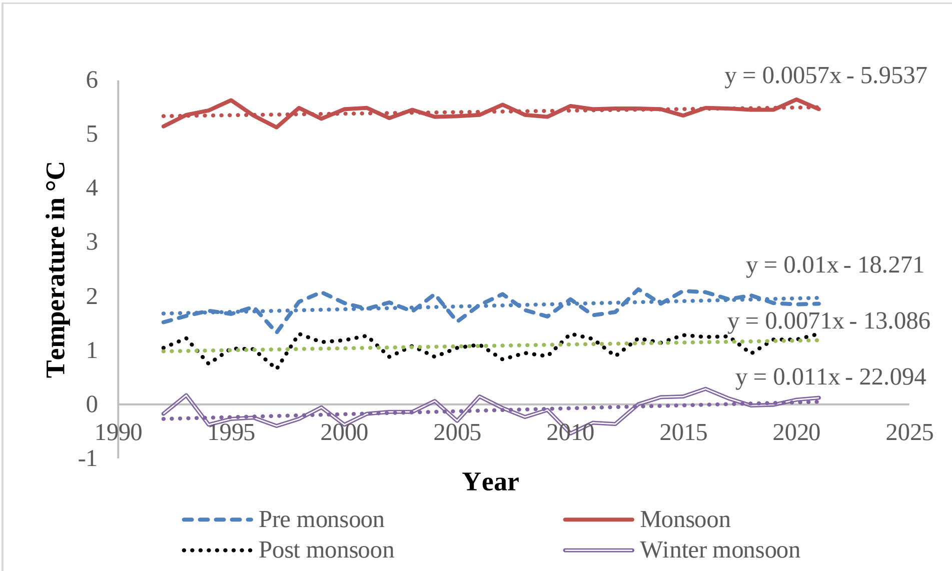


**Figure 8: Annual seasonal average min temperature of study area (Source: DHM, Nepal, 2022)**

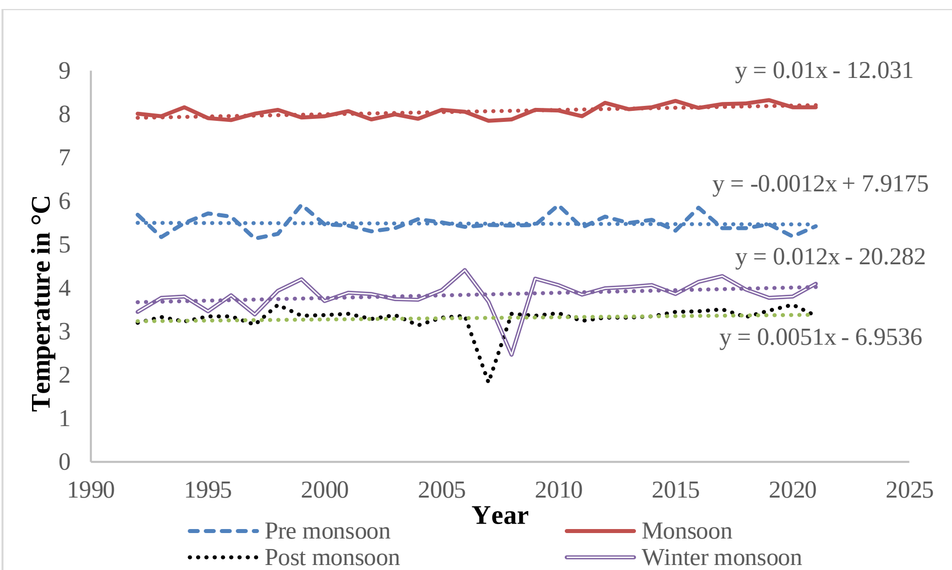


**Figure 9: Annual seasonal average max temperature of study area (Source: DHM, Nepal, 2022)**

  

**Monthly Average Temperature**

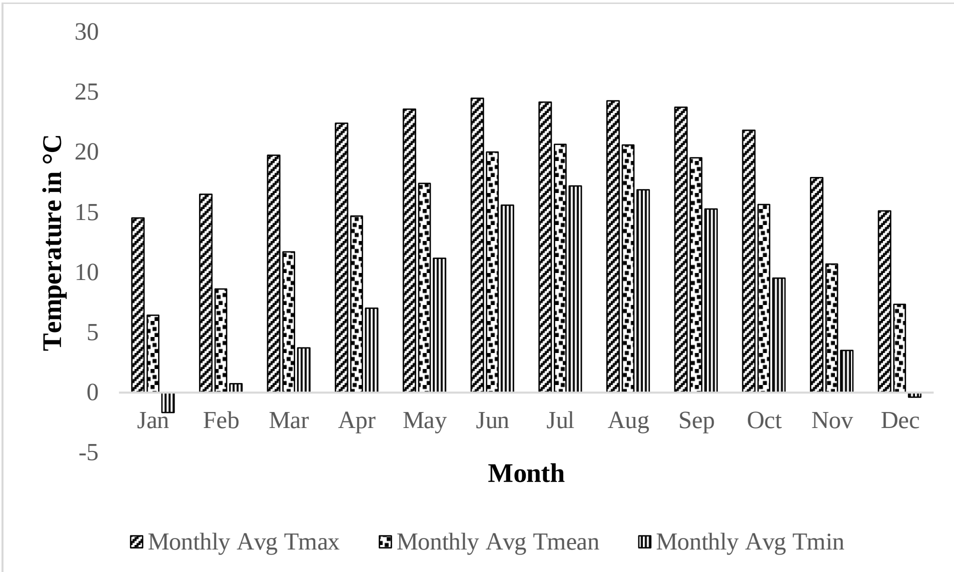


**Figure 10: Monthly average temperature of study area (Source: DHM, Nepal, 2022)**

**Average Monthly Decadal Temperature**

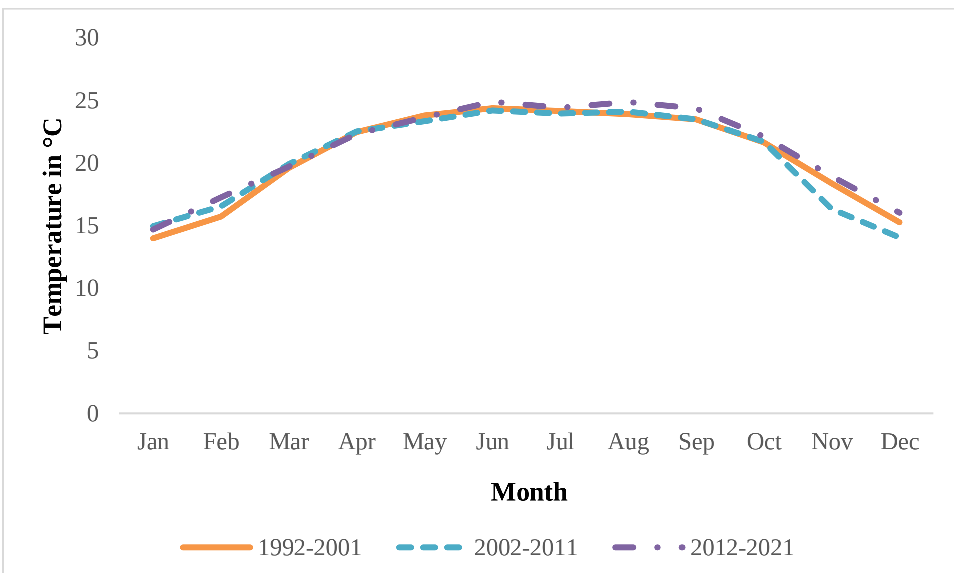


**Figure 11: Average monthly decadal maximum temperature**

  

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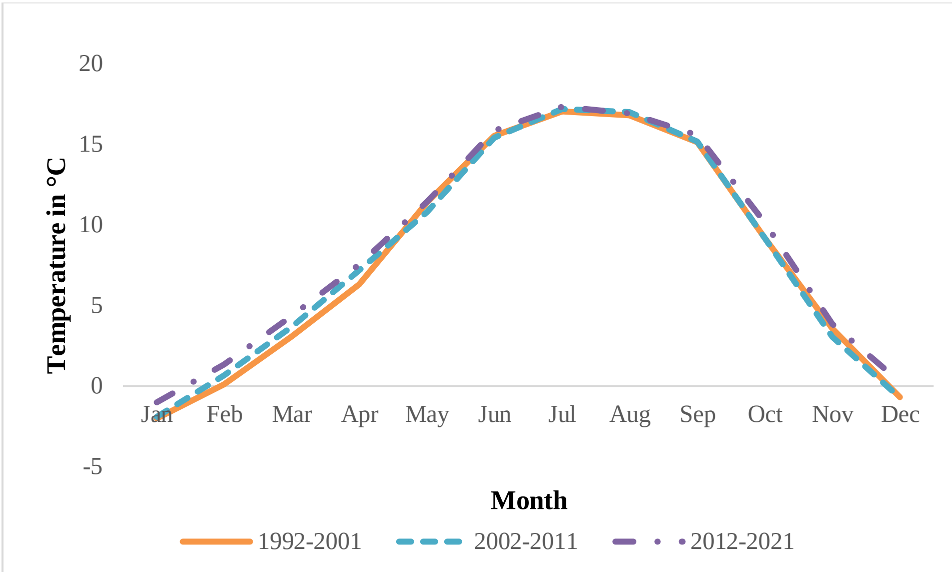


**Figure 12: Average monthly decadal minimum temperature**

## Agriculture Production Analysis

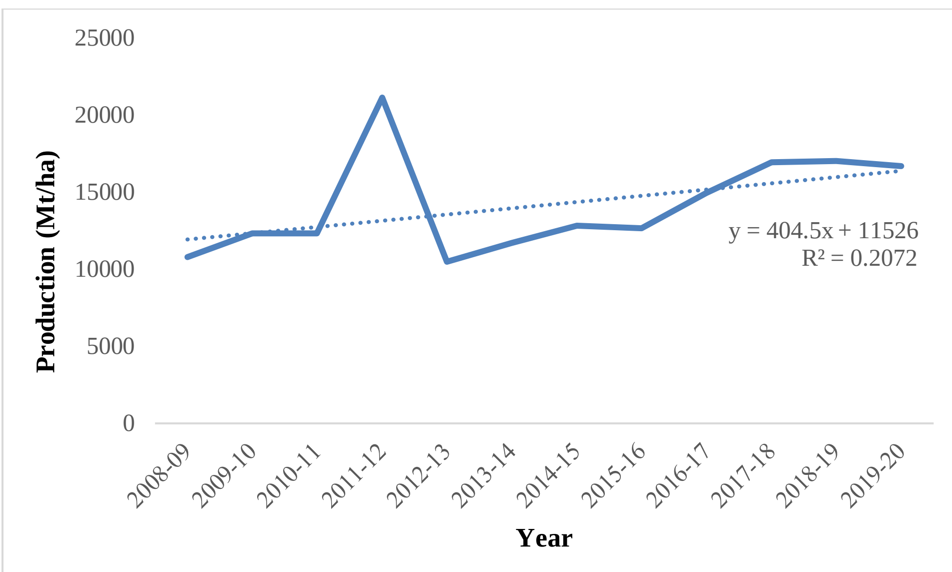


**Figure 13: Annual maize yield**
**(Source: Statistical Information on Nepalese Agriculture, MOAD, 2022)**

  

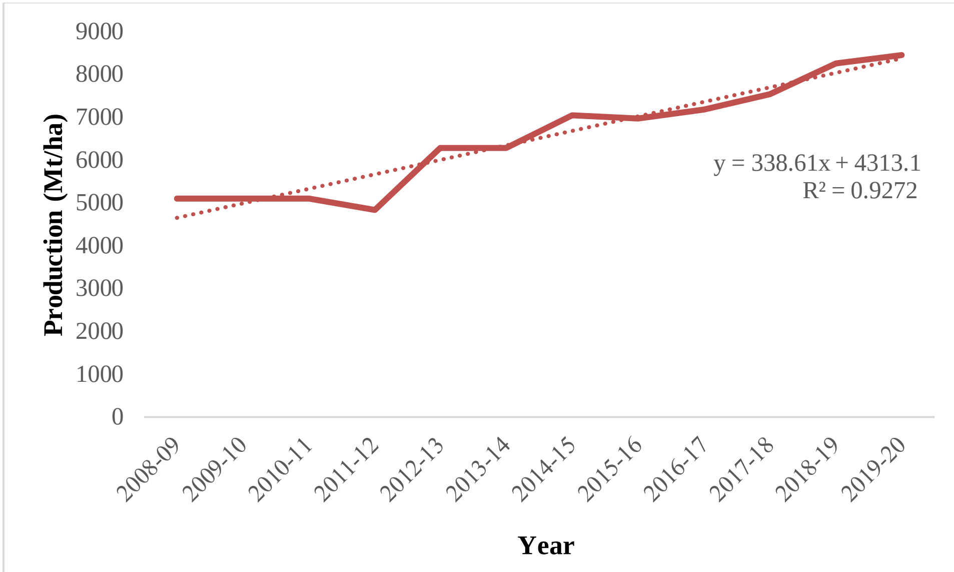


**Figure 14: Annual wheat yield**

**(Source: Statistical Information on Nepalese Agriculture, MOAD, 2022)**

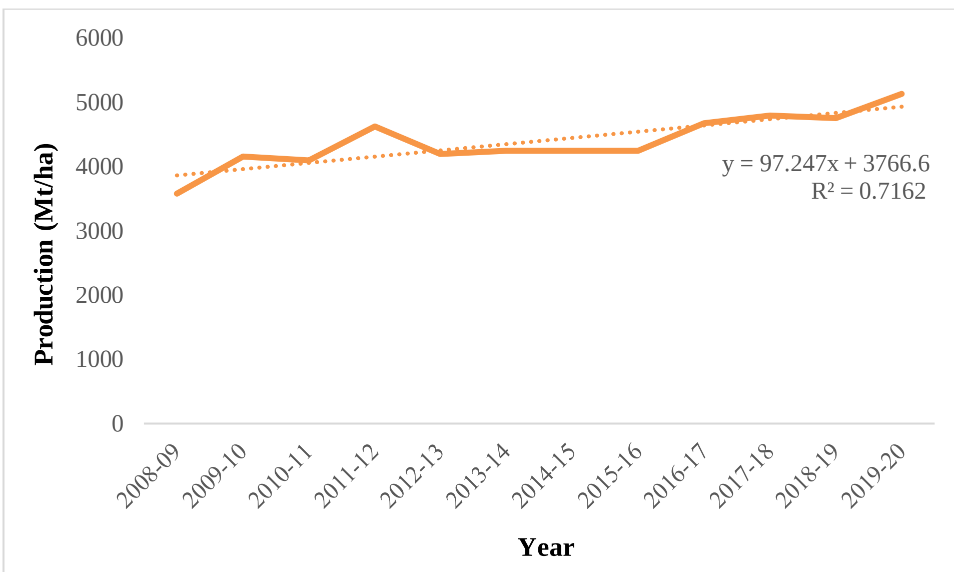


**Figure 15: Annual millet yield**

**(Source: Statistical Information on Nepalese Agriculture, MOAD, 2022)**

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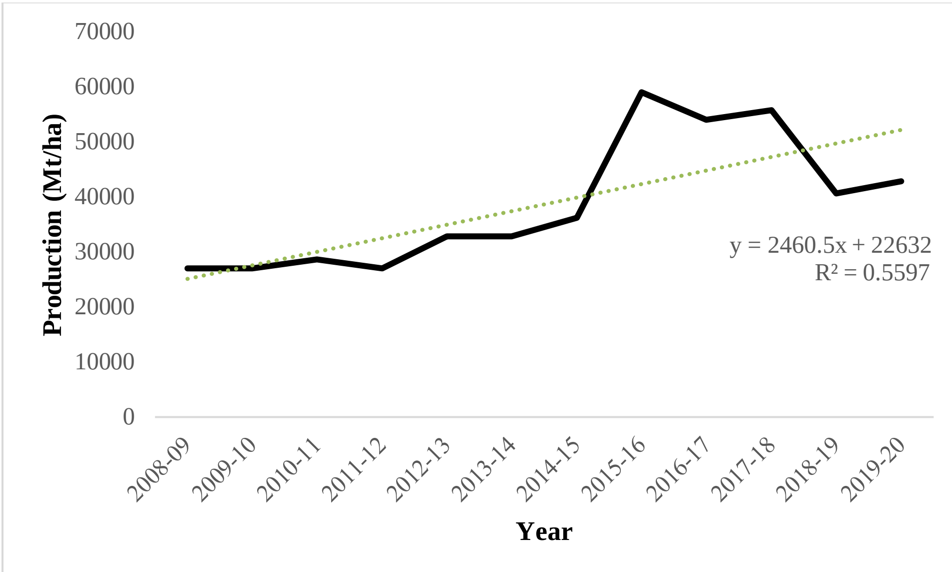


**Figure 16: Annual potato yield**
**(Source: Statistical Information on Nepalese Agriculture, MOAD, 2022)**

**Relation between Crop yields with Rainfall and Temperature**

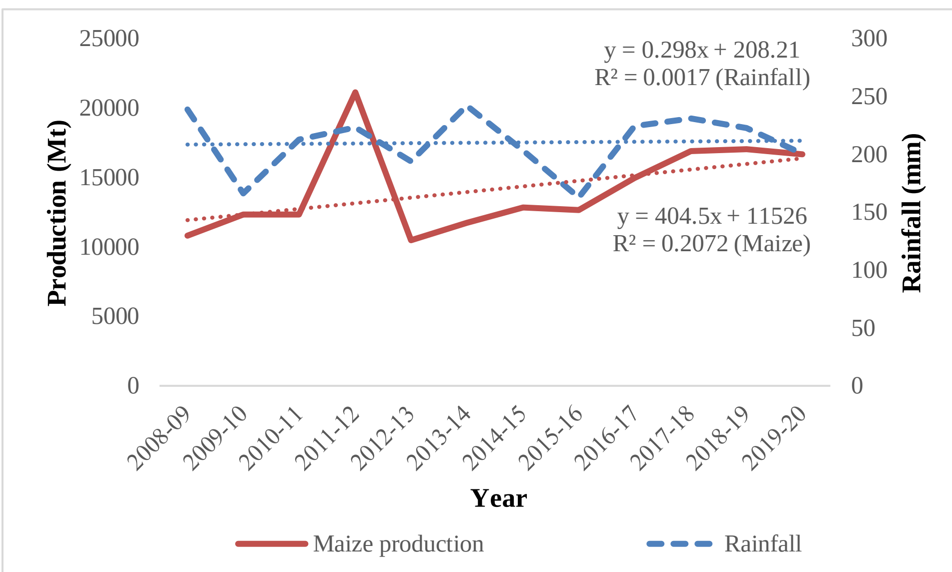


**Figure 17: Relation between Rainfall and Maize yield**

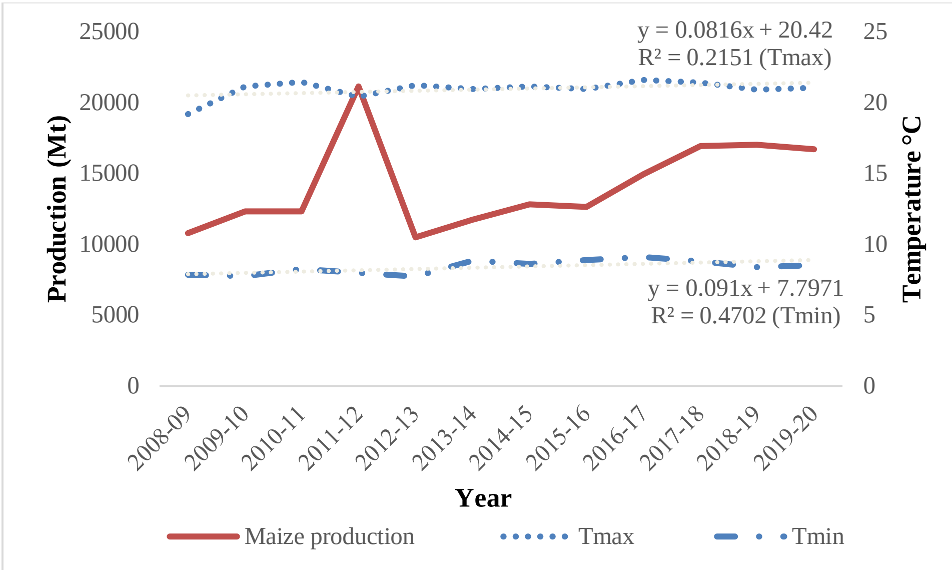


**Figure 18: Relation between Temperature and Maize yield**

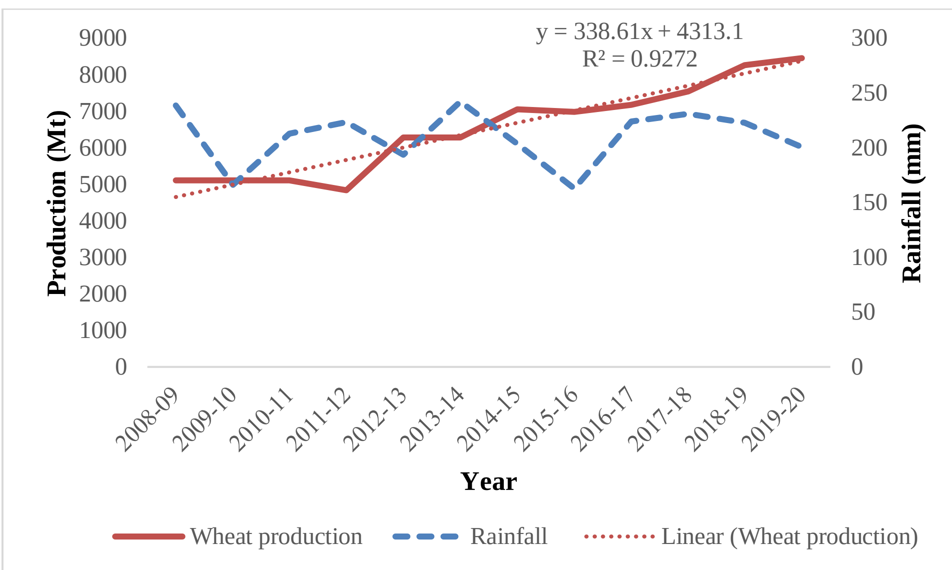


**Figure 19: Relation between Rainfall and Wheat yield**

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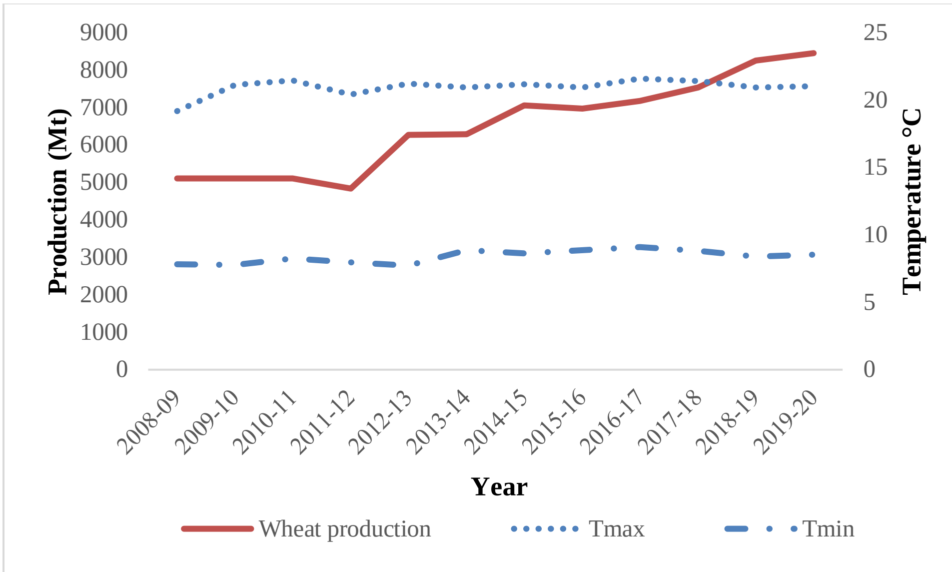


**Figure 20: Relation between Temperature and Wheat yield**

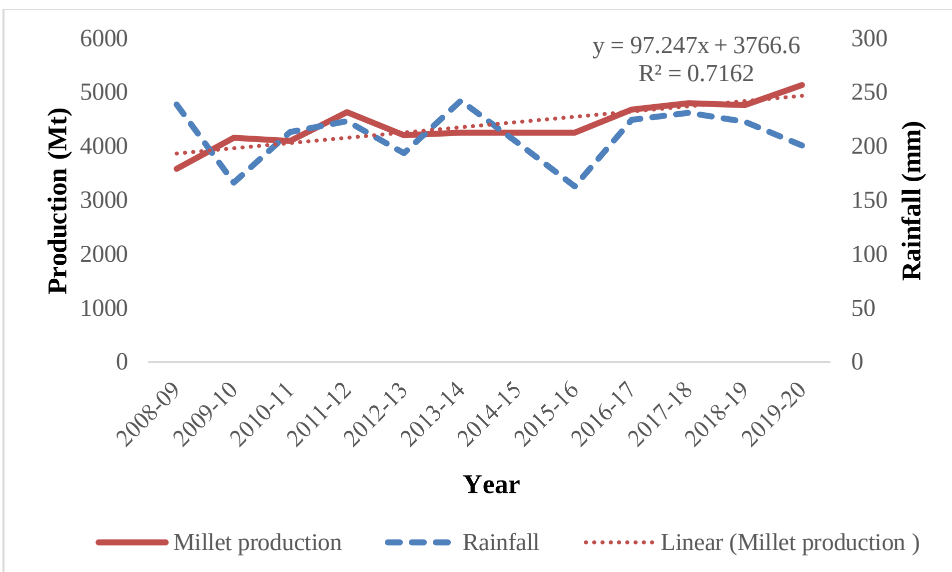


**Figure 21: Relation between Rainfall and Millet yield**

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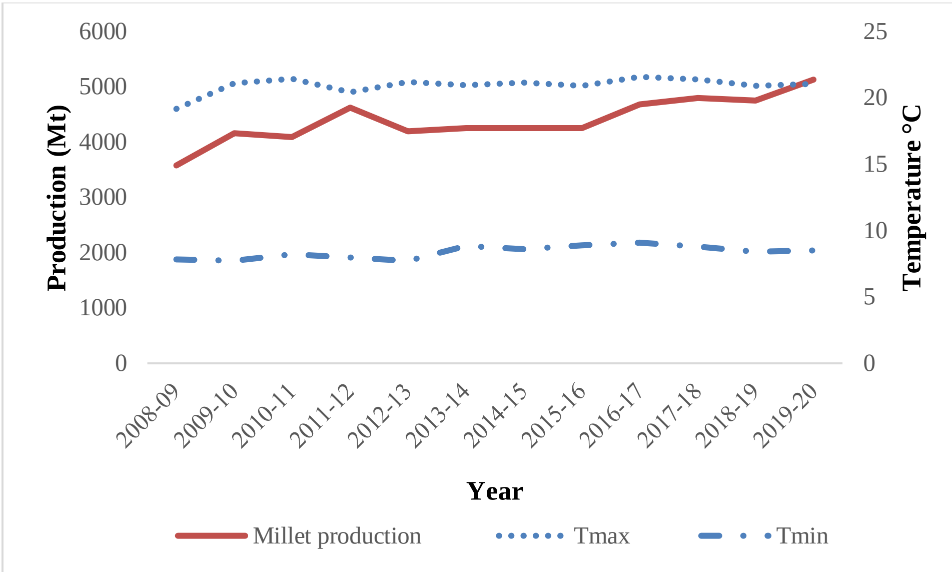


**Figure 22: Relation between Temperature and Millet yield**

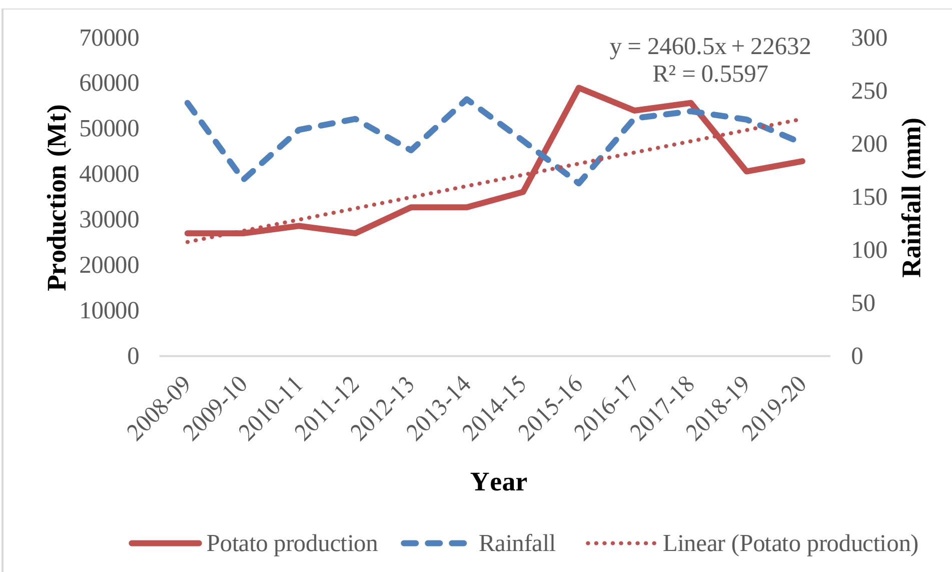


**Figure 23: Relation between Rainfall and Potato yield**

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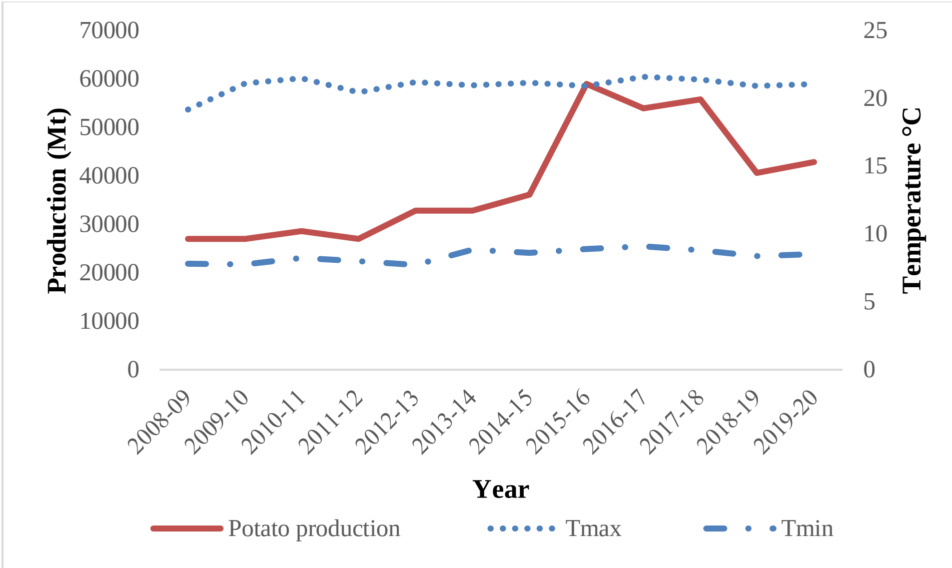


**Figure 24: Relation between Temperature and Potato yield**

**People's perception about climate change**

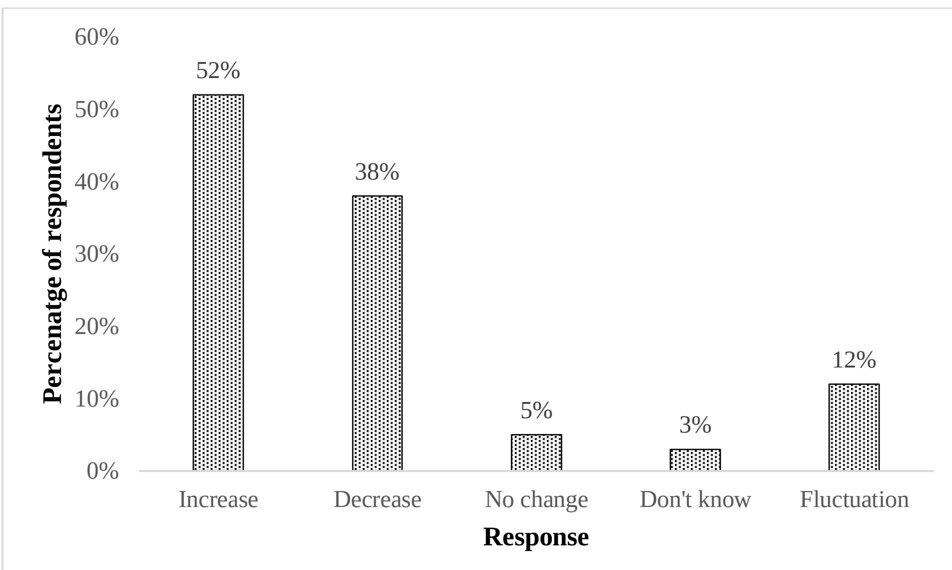


**Figure 25: People's response about change in precipitation**

  

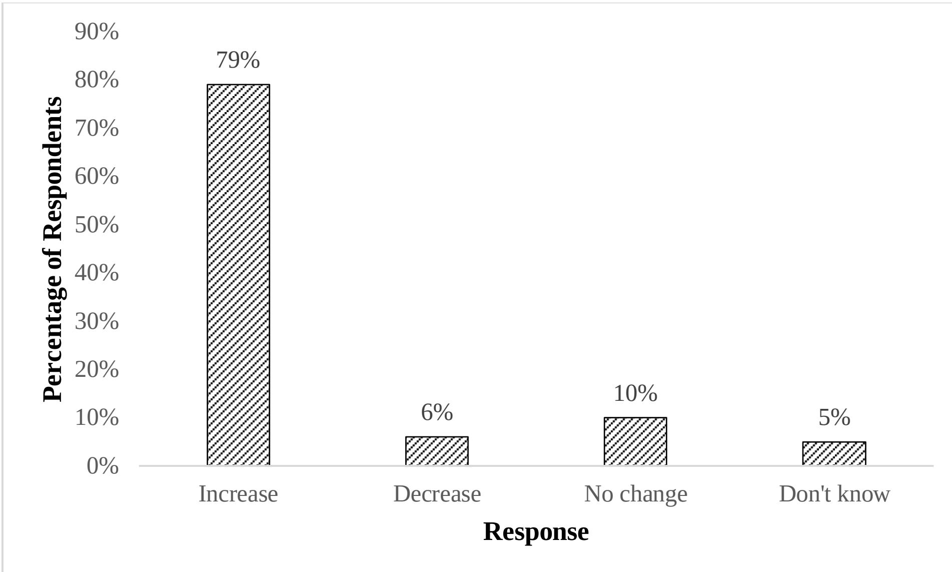


**Figure 26: People's response about change in temperature**

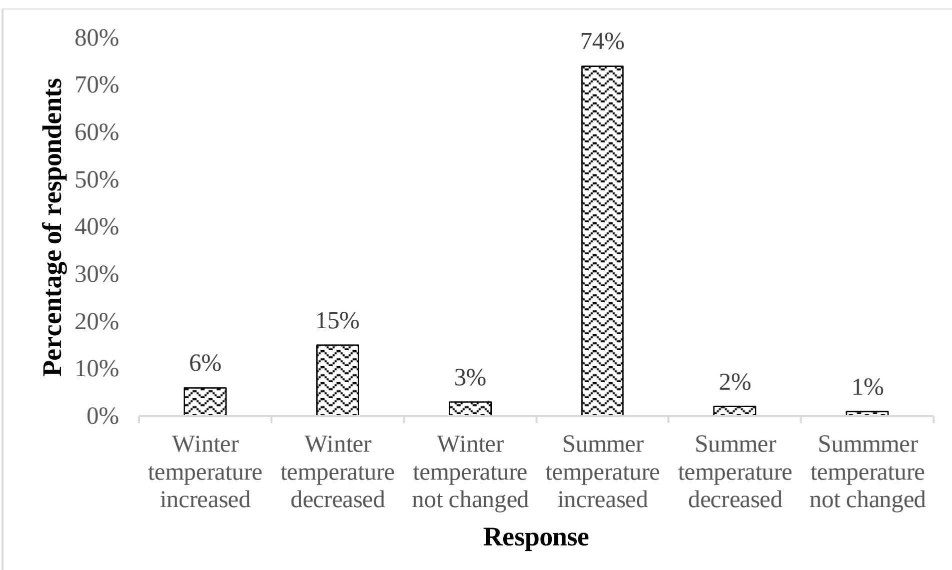


**Figure 27: People's response about seasonal temperature change**

**People's perception on impact of Climate Change on Agricultural production**

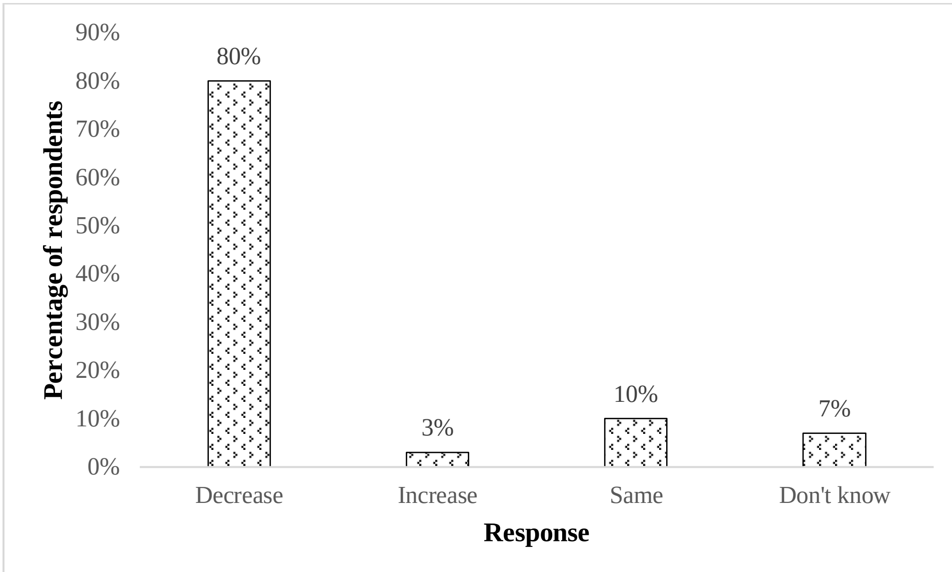


**Figure 28: People's perception about change in soil moisture**

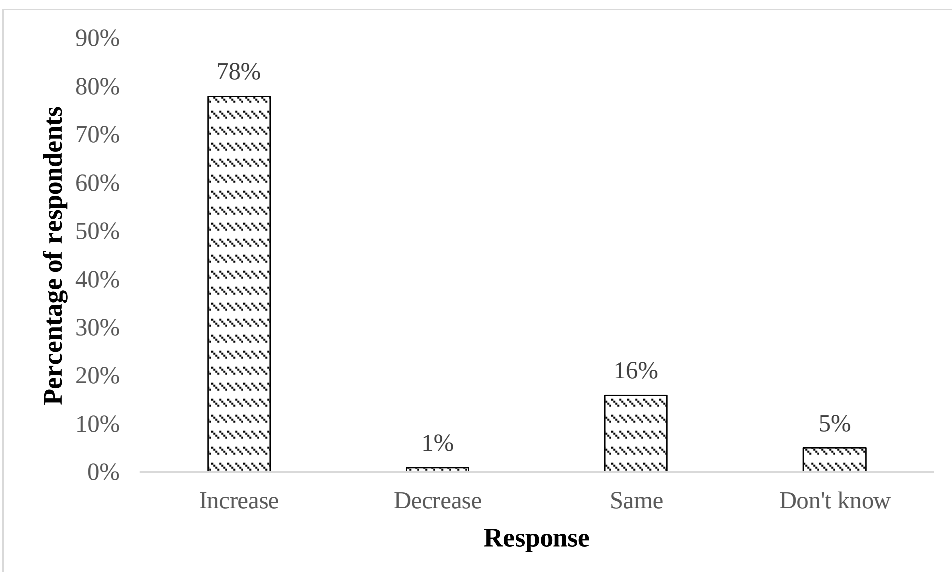


**Figure 29: People's perception about experience of new pest species**

  

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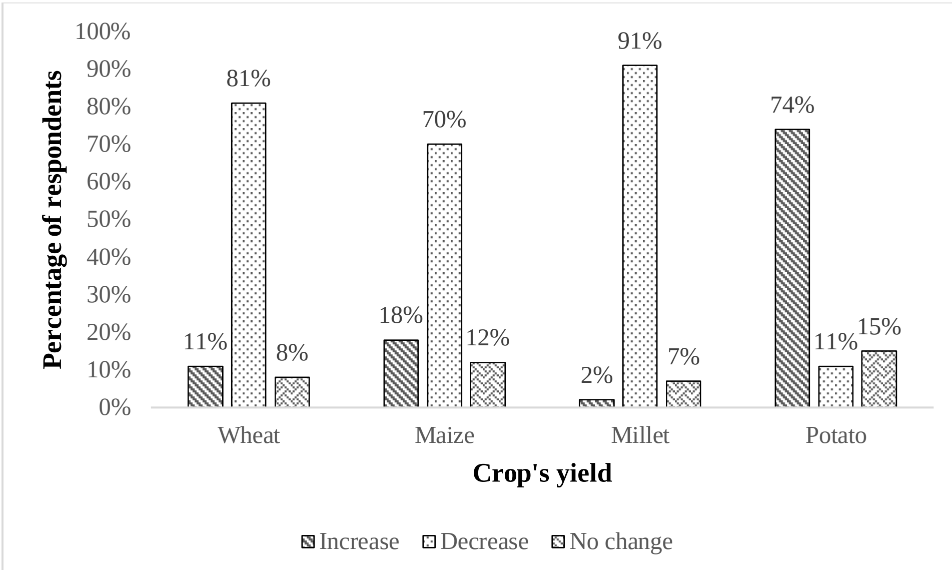


**Figure 30: Crop's yield mostly affected by decrease in soil moisture and experience of new pest species**

## Climatic data and social validation

Unusual changes in climate such as rising temperatures, irregular monsoon and change in intensity and pattern of rainfall have become increasingly noticeable in Nepal (Manandhar et al., 2011). Climatic data analysis i.e. analysis of records of temperature and precipitation for last 30 years in one hand and in another hand, survey was carried out in the sample respondents at sample households of the study area. From climatic data, the annual average maximum temperature, minimum temperature and mean temperature of the study area was found to be increasing yearly with 0.0259°C, 0.0337°C and 0.0298°C per year respectively. The seasonal trend on minimum temperature of Jiri Municipality on all season i.e., Pre-monsoon (March to May), monsoon (June to September), post monsoon (October to November) and winter monsoon (December to February) showed increasing trend. The seasonal trend on maximum temperature of Jiri Municipality on all seasons i.e., Pre-monsoon, monsoon, post monsoon and winter monsoon showed fluctuation trend (increase or decrease). The monthly temperature of the Jiri Municipality shows that all maximum, mean and minimum temperature reaches highest at the peak in June (summer season) and lowest temperature in January (winter season).

From the analysis of the 30 year's rainfall data 81% of the total rainfall was occurred in the monsoon season whereas, 13%, 4% and 2% of the total rainfall were occurred in pre-monsoon, post monsoon and winter monsoon respectively. While plotting the precipitation datum, it was observed that the annual average precipitation was increasing at the rate of 0.5105 per annum.This shows that there was actual increment of temperature and precipitation in the study

  

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area. Same responses were collected from local people, before that assurance was needed for whether they were aware about climate change or not. When they were asked about the matter, 92% of respondents replied that they were aware about the climate change through different formal and informal medium, some of them have also attended climate change related trainings and workshops and rest of them that is 8% were still unknown about climate change. Majority of respondents i.e. 79% responded that temperature is increasing while 50% responded that precipitation is increasing. This validate that there was actual increase in temperature and precipitation in study area.

**Relationship between Agricultural data and local people's experience**

As discussed above, agricultural data analysis has shown increment of production in all the crop species (maize, wheat, millet and potato) of study area. According to respondents, 78% among total respondents were experiencing increment in new pest species whereas, 80% among total respondents were experiencing decrement in soil moisture of study area. They added increase in new pest species and decrease in soil moisture have created problem to agricultural production by inhibiting the crop's growth and by causing different diseases to crop. When respondents were asked about the productivity of crops that are mostly affected by new pest species and soil moisture, then 11%, 81% and 8% respondents replied increase, decrease and no change respectively similarly, 18%, 70% and 12% respondents replied increase, decrease and no change respectively as well as 2%, 91% and 7% respondents replied increase, decrease and no change respectively and 74%, 11% and 15% respondents replied increase, decrease and no change respectively in wheat, maize, millet and potato yields respectively. While asking about the agricultural productivity to the respondents they replied that the agricultural productivity is decreasing than in the recent years because of different diseases, pest, erratic rainfall, etc. However, they have also realized positive impacts of climate change because high temperature and precipitation have created favorable environment to grow for unusual and important crops like cauliflower, cabbage, chilly, pumpkin, lemon, kiwi fruit and spinach etc.

Local people's experience part shows mixed outcomes i.e. positive as well as negative impact on agricultural production due to climate change. The reliability of the data sets used in this research for correlating the productivity and climatic data is low but not least. There might be further opportunity to research in this matter with most reliable data sets generated from other source of records.

**Local adaptation measures in the study area**

**Use of chemical fertilizers**

  

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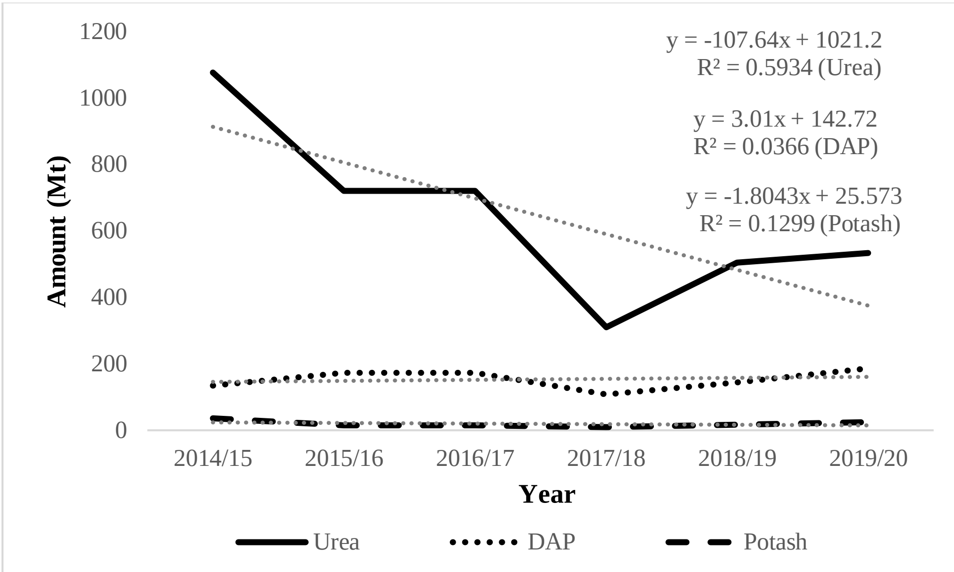


**Figure 31: Sales statistics of chemical fertilizers in Dolakha district (Source: Statistical Information on Nepalese Agriculture, MOAD, 2022)**

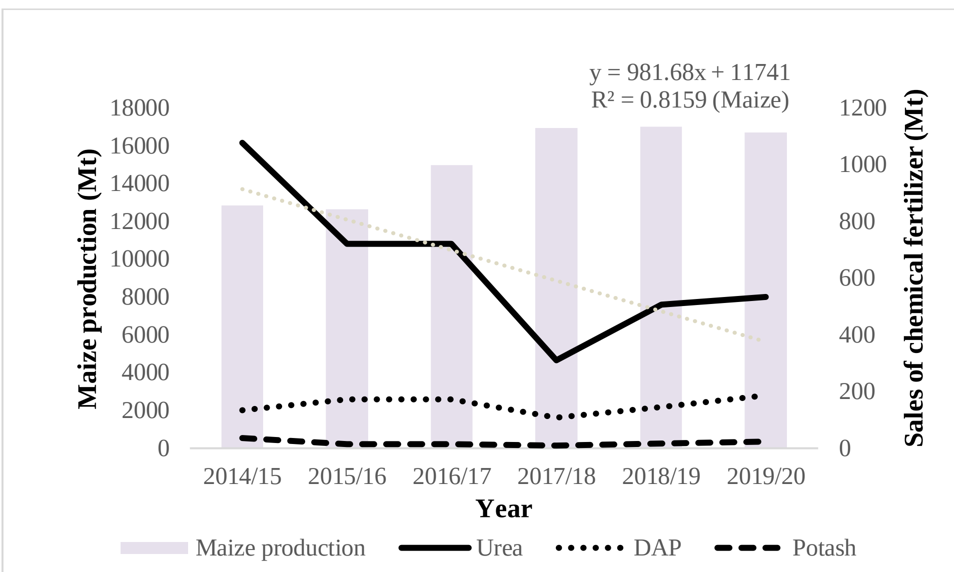


**Figure 32: Relationship between sales of chemical fertilizer and maize yield**

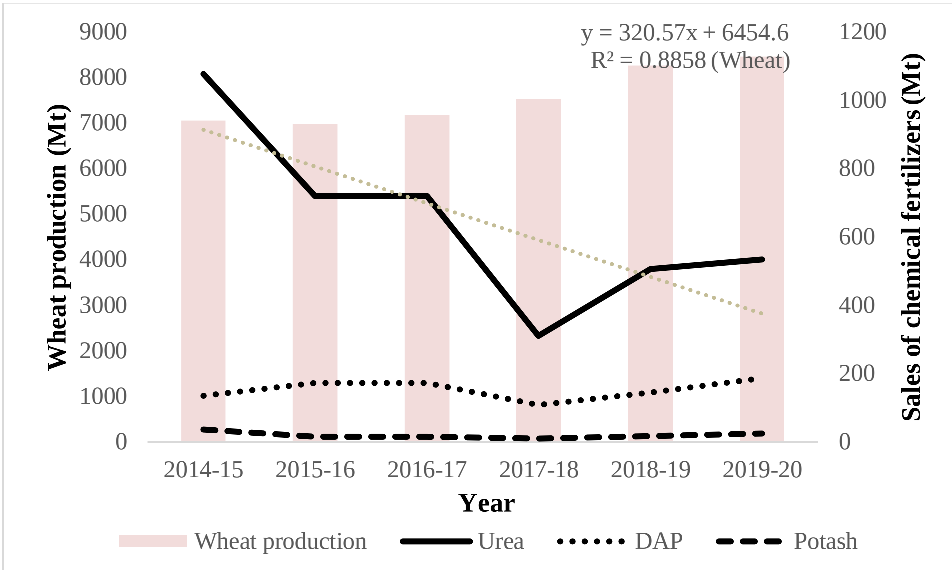


**Figure 33: Relationship between sales of chemical fertilizer and wheat yield**

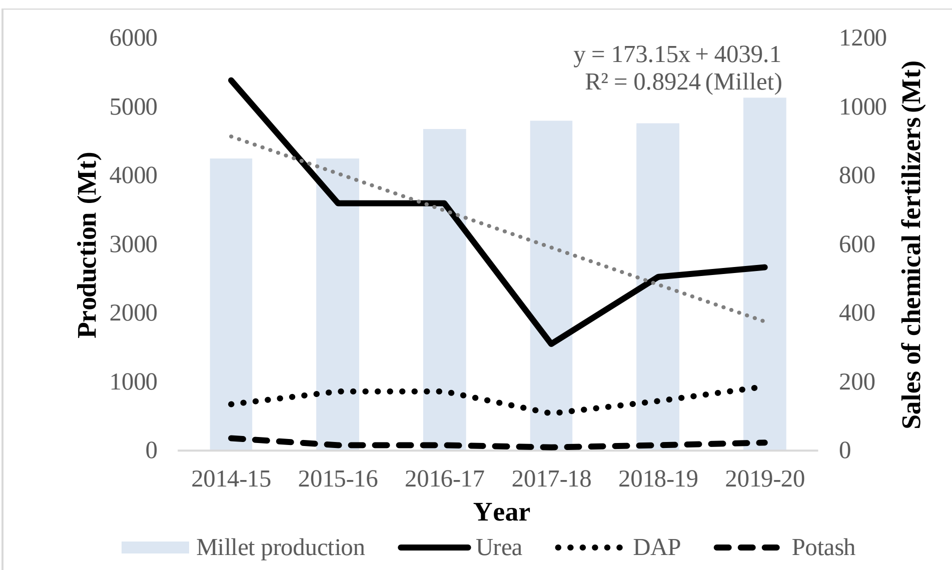


**Figure 34: Relationship between sales of chemical fertilizer and millet yield**

  

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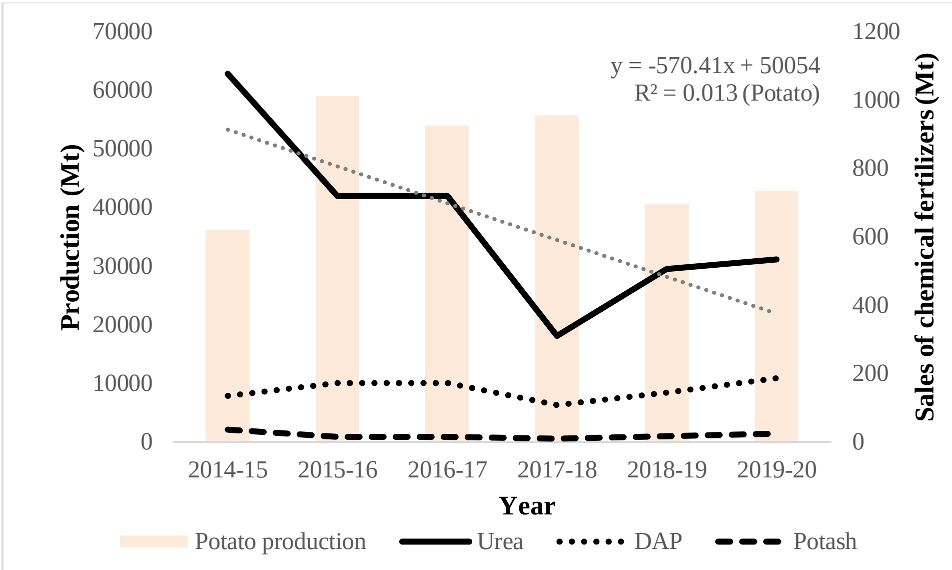


**Figure 35: Relationship between sales of chemical fertilizer and potato yield**

**Conservation of forest and water source management**

The Jirel were adapting to erratic rainfall by conserving forest and planting perennial plants around the water springs to help conserve the water sources. They also used drought-resistant crops provided by the District Agricultural Office at Charikot. Some farmers did not cultivate anything during drought seasons of the year whereas some of them had developed irrigation channels.

**Early harvesting as adaptation**

In the case of erratic rainfall, some of the farmers tried to predict it by observing the changing weather (thundering and lightning). There was nothing that the villagers could do to stop the effects of erratic rainfall than to prevent the crops from getting affected which could be done by early harvesting. This could be done only when the crops were almost ripe. Same was the case for less rain and drought.

**Use of modern technology**

The villagers were found to be experimenting with hybrids and improved seeds from the local market for quantitative agricultural production. Some farmers also used plastic tunnels for farming green vegetables such as cabbage, cauliflower, pumpkin and spinach.

**Adaptation to increasing insect pests by use of home-made pesticides and fertilizers**

  

Jirel used to sprinkle homemade pesticides/ repellant on their plants, which were prepared by adding tobacco in urine (of both human and cattle) and adding water to dilute the mixtures. This practice was helpful in chasing away the pests, especially the red ants. Apart from this, the farmers also made use of Artimisia vulgaris (Titepate) and the leaves of Zanthoxylum armatum (Timmur) in this mixture. These indigenous ways of keeping the pests away were found to be very useful in every step of the plant growth. The use of market pesticides, moreover, affected the plants, humans and animal health so they preferred to avoid chemical pesticides.

**Plantation of new crop species**

The villagers adapted to increasing temperature by planting new varieties of crops and vegetables. They also adapted new cash crops such as kiwi fruit, lemon, and chilly. The local government also conducted trainings and awareness programs in the villages on integrating traditional and modern ways of farming. They were also provided with seed bins and technical support for local seed production.

As an adaptive practice to the changing climate, farmers in Jiri Municipality are now increasingly turning towards production of green vegetables, potato, chilly and lemon in open or inside greenhouse. Majority of the respondents are practicing intercropping and planning to use hybrid seeds, pesticides, chemical fertilizers, tunnel (green house) and irrigation channel, similarly, to adapt new crops and to change planting time of crops.

## DISCUSSION

The core of the results and the analysis came from historical climatic data and its variability over time, field observations, scheduled survey, key informant interview and focus group discussion. This showed that there was variation in local climate, rising temperature, rainfall variability, increasing climatic events and appearance of new pest and diseases in crops. These variations also have both positive and negative impacts on agricultural production and livelihood of the local people. People's perception about climate change and its impact on agricultural production were reported. Furthermore, the adaptation measures adopted in the study area were reported.

**Climatic data analysis**

The graph of total rainfall from the year 1992 to 2021 shows a small increase in rainfall trend with 0.5105 mm per year (Figure 2). Similar outcome was observed by Baidya et al. (2008) according to which, most of the stations of Nepal shows increasing trend of total annual precipitation. The graph of seasonal rainfall pattern in figure 3 shows fluctuation trend i.e., increasing trend for pre monsoon and monsoon seasons with 0.0278 and 0.5244 mm per annum respectively whereas decreasing trend for post monsoon and winter monsoon seasons with 0.0353 and 0.0064 mm per annum respectively in the last 30 years which contradicts to

  

Ichiyanagi et al. (2007) who found that winter rainfall over western Nepal has increased. The reason may be due to the change in the wind patterns. The mean monthly rainfall for the month July was found highest and the month December receives the less rainfall (Figure 4). A similar study done by Joshi et al. (2011) at Doti showed July as wettest month and November as the driest month, which is one month earlier. Erractic weather conditions induced by climate change and intense human activities might be the cause for shifting in the driest month. When the monthly rainfall averaged over decades (Figure 5), then the result showed that precipitation has fluctuated over decades. Similar observation was carried out by Shrestha et al. (2000), according to this report, the precipitation data from Nepal over the past three decades show large decadal variability in the all-Nepal as well as regional (within Nepal) precipitation records. From the analysis of rainfall data, maximum percentage of total rainfall occurred in the monsoon season with 81% (Figure 6). The analysis done by PAN (2009) also shows that the maximum rainfall occurred during monsoon season in Nepal.

The temperature data (1992to 2021) indicates that there was increasing trend of temperature in both annual average wise and seasonal average wise temperature i.e. for maximum temperature, mean temperature and minimum temperature has increasing trend with 0.0259°C, 0.0337°C and 0.0298°C per year respectively (Figure 7) while for seasonal average minimum temperature, it was 0.01°C (pre-monsoon), 0.0057°C (monsoon), 0.0071°C (post monsoon) and 0.011°C (winter monsoon) per year respectively as shown in Figure 8 whereas for maximum temperature, it was 0.0012°C (pre-monsoon), 0.01°C (monsoon), 0.012°C (post monsoon) and 0.0051°C (winter monsoon) per year respectively ( Figure 9). Chaulagain (2006) also found temperature change to be more pronounced at higher altitudes than at lower altitudes. According to the report prepared by CIRDAP in 2016 stated that temperature data from the Jiri meteorological station over the period 1980-2010 show an increasing trend with an increase of approximately 1°C in the annual average max temperature. Monthly average data on study area shows that all maximum, mean and minimum temperature reaches highest in June and lowest in January (Figure 10). The national level data prepared by PAN (2009) also show that, except Midwestern development region almost all regions of the country showed an increasing trend. There was remarkable increment of maximum and minimum temperatures in monsoon and winter seasons respectively when compared with other seasons in recent decade (2012 to 2021) as shown in figure 11 and figure 12. IPCC (2013), also found that temperature of both the winter and summer seasons has been in increasing trend.

**Impact of Climate Change on crop production and Adaptation measures**

Climatic data for the year 2008/09 to 2019/20 shows increasing trend for both rainfall (0.298mm/year) and temperature data (maximum temperature = 0.0816°C/year, minimum temperature = 0.091°C/year). Agricultural data for the same time period shows that maize, wheat, millet and potato are annually increasing their yield with 404.5, 338.61, 97.247 and 2460.5 Mt/ha/year respectively (Figure 13 to 24). Weather is an atmospheric condition at the surface timescale from minutes to weeks and has an important impact on agriculture (ICIMOD/ UNEP, 2007).

Research has provided evidence that upland farmers have to some extent benefitted from the changes, while lowland farmers lose out most of the times. According to Shrestha & Aryal (2011), temperature increase has mixed effect in the case of wheat as the actual yield of wheat has increased in the western region with the rise of temperature whereas; temperature increase has a negative effect on maize yield. Though temperature rise has a more negative effect to maize yield, the trend is similar to wheat. This may be due to the use of temperature resistant improved seeds.

Among 212 households, 92% of respondents were aware about climate change. Majority of the respondents responded that precipitation (52%) and temperature (79%) was increasing which validate the actual data analysis. Similar observation was carried out by Thapa, BJ (2019) according to which, farmers in Bhimeshwor Municipality, Dolakha have also experienced changes in climate. They have perceived changes in intensity and timing of rainfall, and an unusual rise in both summer and winter temperatures. Due to such rise in temperature, numerous extreme weather events were reported to be experienced by the respondents in the area. The direct impacts due to increasing temperatures are reduced crop yield, erratic rainfall, increased pests and diseases, landslides and droughts in the study area. The changing climate, however, has gradually created more favorable conditions for the diversification of agriculture. Crop diversification as a potential farm-level response to climatic variability and change has been explained by Bradshaw et al. (2004).

From questionnaire survey, result shows positive impact of climate change on agricultural production. According to them, positive impact was due to favorable climatic condition to grow unusual and important crops like green vegetables, potato etc. Howden et al. (2007) too, suggested that pest, disease and weed problems due to projected climate changes should be dealt with more sustainably using integrated pest and pathogen management as well as by adopting pest and disease resistant varieties. Thapa, BJ (2019) also has found the cultivation of cash crops such as potato cucumber, cabbage, cauliflower, tomato, pumpkin, chili, kiwi fruit and lemon both in the open and in greenhouses, has recently expanded into Topar and Lisapoto villages of Bhimeshwor Municipality, Dolakha.

In order to cope with changing climatic pattern, Dolakha district has adopted the use of chemical fertilizer in their farmland to raise the production of crops. Sales of urea, DAP and potash shows fluctuation trend i.e., decreasing trend of Urea, increasing trend DAP and also decreasing trend of Potash with 107.64, 3.01 and 1.8043 Metric ton (Mt) per year respectively. Contrast to Shrestha (2010) in his paper, revealed that with the growing popularity of modern agriculture, fertilizer consumption in Nepal has been increasing over the years. The reason may be farmers are aware about the implications of chemical fertilizers on crops and human health. Crop yield trend was 981.68, 320.57, 173.15 and -570.41 for maize, wheat, millet and potato with Mt/ha per year respectively, which showed highly positive correlation with 0.903, 0.941 and 0.945 for maize, wheat and millet respectively whereas low correlation with 0.114 for potato. Majority of the respondents have already practicing intercropping and planning to use hybrid seeds, pesticides, chemical fertilizers, tunnel (green house) and irrigation channel similarly, to adapt new crops and to change planting time of crops. The statement by Manandhar et al. (2010) explained that farmers have made changes in their cropping calendar and cropping sequences to cope with changing climatic pattern. Similarly, Thapa, BJ (2019) stated for seasonal calendar shifts due to climate change, the Thamis had to change crop plantation timings. The villagers were also found to be experimenting with hybrids and improved seeds from the local market for faster and larger quantities of production. They mostly used hybrid seeds for vegetables and for staple crops mostly in the case of insufficient home stored seeds.

## CONCLUSION

Jiri Municipality of Dolakha district, Nepal has been experiencing increasing trends of both precipitation and temperature. Annual precipitation trend was increasing with 0.5105 mm per year. There was the lowest precipitation in 2015 with 162.7583mm and the highest in 2013 with 242.1333mm. In case of annual average seasonal precipitation trend, pre-monsoon trend and monsoon trend were increasing with 0.0278 and 0.5244 mm per annum respectively whereas post monsoon and winter monsoon trends were decreasing with 0.0353 and 0.0064mm per annum respectively. From the year 1992 to 2021 it was finalized that July was the wettest month i.e., the average monthly rainfall of July months was 651.1533 mm whereas December month was the driest month and receives very low amount of rainfall i.e.7.104 mm. When the monthly rainfall averaged over decades were divided in to three equal parts, i.e., from the year 1992-2021 to the years 1992-2001, 2002- 2011 and 2012-2021 respectively, then the result shows that monsoon rainfall has fluctuated over decades in the study area. During the period from 1992 to 2021, maximum rainfall used to occur during august season now the study shows that, high peak point of rainfall has shifted to July season i.e., one month earlier than before. Thirty years data from 1992 to 2021 on rainfall shows that the monsoon season (June-September) contributes 81 percent of the total annual rainfall. Similarly, pre-monsoon (March-May), post monsoon (October-November) and winter monsoon (December-February) seasons account 13 percent, 4 percent and 2 percent respectively. The average temperature, minimum temperature and maximum temperature of the study area was found to be increasing yearly with 0.0259°C, 0.0337°C and 0.0298°C per year respectively. The seasonal trend on minimum temperature of Jiri Municipality on all seasons i.e., Pre-monsoon, monsoon, post monsoon and winter monsoon showed increasing trend with 0.01°C, 0.0057°C, 0.0071°C and 0.011°C per year respectively whereas on minimum temperature showed fluctuating trend i.e., decreasing trend in pre monsoon with 0.0012°C per year and increasing trend in monsoon, post monsoon and winter monsoon with 0.01°C, 0.012°C and 0.0051°C per year respectively. The monthly temperature of the Jiri Municipality shows that all maximum, mean and minimum temperature reaches highest at the peak in June (summer season) and lowest temperature in January (winter season). When the monthly maximum and minimum temperature were averaged over decades i.e. 1992-2001, 2002-2011 and 2012- 2021, then the result shows that monsoon temperature and winter temperature has increased in a remarkable way when compared with other seasons during recent decade i.e. 2012-2021.

Analysis of agricultural data and meteorological data from the year 2008/09 to 2019/20shows that the annual yield of the crops like maize, wheat, millet and potato were increasing by 404.5, 338.61, 97.247 and 2460.5 Mt/ha/year respectively. The trend of average precipitation was annually increasing with 0.298mm similarly, for maximum temperature and minimum temperature it was increasing with 0.0816°C and 0.091°C per year respectively. This signifies that there was positive impact of CC to maize, wheat, millet and potato crops. Local people's experience part shows mixed outcomes i.e. positive as well as negative impact on agricultural production due to climate change.

The response adapted by the local people is indigenous type rather than high technology and cost involving. In order to cope with changing climatic pattern, Dolakha district has adopted the use of chemical fertilizer in the farmland to raise production of crops. Trends between 2014/15 to 2019/20on sales of different fertilizers like urea, DAP and potash are fluctuating with -107.64, 3.01 and -1.8043 Mt per year respectively. Crop yield trend for the same time period was 981.68, 320.57, 173.15 and -570.41 for maize, wheat, millet and potato with Mt/ha per year respectively, and it showed highly positive correlation with 0.903, 0.941 and 0.945 for maize, wheat and millet respectively whereas low correlation with 0.114 for potato. Majority of the respondents are practicing intercropping and planning to use hybrid seeds, pesticides, chemical fertilizers, tunnel (green house) and irrigation channel, similarly, to adapt new crops and to change planting time of crops. This study on extreme events will help the policy makers to look seriously towards the role of this warming and its consequences in agriculture.

  

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