STUDY OF CLIMATE CHANGE IN BARDIYA DISTRICT, NEPAL: IMPACT AND ADAPTATION IN AGRICULTURE (A CASE STUDY FROM KALIKA VDC)

A Project Report

submitted in partial fulfillment of the requirements for

the B.Sc. (Honors) Degree in Environmental Science

By

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DECLARATION

I, Reena Bajracharya, hereby declare that the work presented herein is genuine work done originally by me and has not been published or submitted elsewhere for the requirement of a degree. Any literature, data, or works done by others and cited within this report has been given due acknowledgement and listed in the reference section.

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ABSTRACT

This study was conducted with primary aim to identify impacts of climate change in agriculture in Bardiya district of Nepal. Information was collected from both primary and secondary data sources. Primary information was collected through semi-structured and open-ended questionnaire of household survey, key informant survey and focus group discussion. Climatic data alongside agriculture data for a period of 26 years was collected from Department of Hydrology and Meteorology (DHM) and Central Bureau of Statistics (CBS) respectively.

The statistical analysis of climatic data shows that temperature has increased over the years. Trend of precipitation shows large inter-annual variability with substantial decrease in volume of rainfall. Most of the respondent reported change in climate and farming system in their locality. Respondent experienced erratic rainfall pattern, increased temperature, increased frequency and length of drought associated with decrease in water sources in recent years. Local cultivars have disappeared and new invasive weeds have appeared. Farmers were forced to adopt new cultivars, change the planting time to adapt with changing condition. The correlation analysis reveals that temperature is positively correlated with the productivity of rice, wheat and maize and it is statistically significant whereas, rainfall did not show any significant relationship however, showed positive correlation with rice and negative correlation with wheat and maize.

The study revealed that people have started adaptation measures spontaneously, however these adaptation are short-term. Well off farmers have well adjusted their farming practices to account for climate change impacts while the poor farmers are still vulnerable. Adoptions of new varieties, construction of irrigation canals, use of treadle pump, electric machine irrigation, seasonal vegetables production, cultivation by IPM method are the major adaptation measures. Thus the study suggest to address issues of climate change by conducting study at micro level, formulate plan and make program to cope with climate change impacts and to improve livelihood.

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ABBREVIATION

CBS	Central Bureau of Statistics
DADO	District Agriculture Development Office
DDC	District Development Committee
DHM	Department of Hydrology and Meteorology
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GON	Government of Nepal
IPCC	Intergovernmental Panel on Climate change
IPM	Integrated pest management
MOE	Ministry of Environment
M. ton	Metric ton
NAPA	National Adaptation Programme of Action
NARC	Nepal Agriculture Research Council
NCVST	Nepal Climate Vulnerability Study Team
NGO	National Governmental Organization
OECD	Organization for Economic Cooperation and Development
RCM	Regional Circulation Model
SAFBIN	Strengthening Adaptive Farming in Bangladesh, India and Nepal
SPSS	Statistical Package for Social Science
UNFCCC	United Nation Framework Convention on Climate Change
VDC	Village Development Committee
WMO	World Meteorological organization

CHAPTER 1

1.1.INTRODUCTION

Climate change has become one of the major environmental problems and the global challenges for today's growing world. It is predicted that global temperature will increase further by between 1.4 and 5.8 by 2100(IPCC, 2007). By the definition, climate change is a change in mean values of meteorological elements such as temperature and precipitation in the course of certain period over their long term trends (WMO, 1992). United Nations Framework Convention on Climate Change (UNFCCC) uses the term climate change for a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (IPCC, 2007).

The negative consequences of industrialization and environmental degradation have increased the amount of green house gases into the atmosphere contributing to global warming and associated problems. Global warming has led to the unexpected variability and changes in the weather and climatic cycles, leading to accelerated changes and impacts. Least developing countries like Nepal are vulnerable to the impact of climate change. Despite their low contribution to global warming, are more sensitive to climate change because of their weak coping capacity (Huq *et* al. 2003).

Nepal is a small landlocked country with diverse ecology and climatic variation. Ecologically, Nepal is divided into three region: Mountain (upland), Hill (mid hill) and Terai (low land), arranged in latitudinal belts running from north to south. The climate of Nepal varies from Artic to Tropical from north to south. The three regions differ from each other not only with respect to ecological and climatic conditions but and also with respect to climate change scenarios. Such diversity in ecology and climatic condition is reflected in the diversity of local agro-ecosystem and livelihood options. Agriculture is the mainstay of Nepalese economy that accounts for more than one third contributions to total GDP (National Agriculture Census 2011/2012). Since, only limited land in Nepal has irrigation facilities, almost 76% of agriculture land is rain fed. So, Nepalese agriculture production is highly dependable on favorable weather conditions, mainly on the monsoon's timing and availability of rain water. However, increased in temperature have impacted on the changes in the timing, intensity and volume of rainfall and rising carbon dioxide

levels. Delayed and erratic monsoon pattern, increased in heavy rainfall events combined with increased frequency of flood, drought, heat waves and other extremes have caused losses of crop yield and have resulted into food insecurity. Such situation has made agricultural sector one of the most vulnerable to the climate change. Because Nepalese agriculture is highly dependent on weather and climatic conditions, it is highly sensitive to climate variability (Alam and Regmi, 2004).

Such effects of climate change are felt hardest especially by small scale poor farmers because they directly depend on the environment and natural resources for their livelihood and they lack an alternative to provide adequate coping mechanism. Their risks to food insecurity are greatly increased in the event of any change in rainfall pattern leading to declining crop yields and crop variety. It has therefore, become necessary to find some adaptation measures at local level that will significantly reduce effect of climate change on agricultural productivity and minimize potential risk.

The main aim of the study is to identify the impacts of climate change on agriculture. Based on the case of the local peoples of Bardiya, this study intends to capture the extent of local people's awareness and perceptions of climate variability and change and the types of adjustments they have made in their farming practices in response to these change.

1.2.OBJECTIVES

The main objective of this research is to study the impact of climate change on agriculture in Bardiya District.

Specific objectives

- To study the trend of temperature and precipitation variation in Bardiya district.
- To find out relation between climatic variations and agriculture production of major crops.
- To study people perception and impacts of climate change on agriculture.
- To document agricultural adaptation measures practiced to combat the impacts of climate change.

1.3.RATIONALE OF STUDY

Climate change has become one of the greatest threats to environment conservation and livelihood initiatives. An increased emission of green house gases into the atmosphere has made the condition even worse. Even though Nepal's population is 0.4% of world population and responsible for contributing only 0.025% of green house gases into the atmosphere ((NAPA/MOE, 2010), it is among the most vulnerable countries to climate change impacts (Tiwari *et* al., 2012). Nepal temperature is increasing at an average rate of 0.06 ^{0}C (Shrestha, 1999 and Malla, 2008). The rate is even higher in the Himalaya (0.08 ^{0}C) as compared to Terai (0.04^{0}C), imparting adverse impact on various sector such as forest biodiversity, agriculture, water resource, food security and other. The various impacts of climate change are already observable and it is poor people, women, and marginalized communities who are as always in the frontline to face these problems. Hence, the study is conducted addressing climate change issues, without which it would be naïve to ensure that the livelihood of people would be secure.

Indeed, several studied has been carried out associated with the impact of climate change in Himalayan region (Bajracharya *et* al., 2007), but very limited studied are done in Terai. Bardiya district is one of the affected areas where climate disaster likes floods, erosion, extreme cold and drought are common and obviously consequences are on agriculture but what are these impacts and how they are affecting local communities is very essential part to know. Therefore, the study is carried out in order to understand people perception to various environmental changes that helps to make them aware to introduce various technique and adaptive measures to cope with.

1.4.SCOPE OF STUDY

There are very few agro-climatic studies being carried out in the remote areas of Nepal, especially low land remote areas. In case of Nepal, lack of research and credible evidence is the major challenge for fighting with the impact of climate change. So, to fill up this gap and understand phenomena of climate change and its impact, it is necessary to conduct the study at micro climatic level. Furthermore, this study helps to find out the present agricultural condition in selected VDC of Bardiya District. The findings of such studies will further help for other such studies in the future.

A huge proportion of population of Bardiya district derives their livelihood from the farm. Since agriculture is the major activities in this region, the study helps to identify positive and negative impacts of climate change in terms of agriculture.

Understanding of people's perception in relation to various environmental changes help to understand how people are experiencing and responding to climate change. This also makes them aware to introduce various technique and adaptive measures for sustainable production of agriculture.

1.5.LIMITATION OF STUDY

The research is a case study conducted in Kalika VDC of Bardiya district. The village comprise of large number of household and population. Also the field work was done in the month of Jestha, the time where there was frequent occurrence of Loo. This made difficult to interact with many number of locals because it was difficult to do survey afternoon (11 am to 4 pm). Survey time was in the morning and evening. So, considering the accessibility and limited time for research, only 5% of household is sampled for household survey.

VDC level data was not available for the production of major crops so it was collected for whole district.

Furthermore, since the research is a case study of a particular settlement, the study alone cannot generate complete idea about climate change, its impact and adaptation measures in whole Terai region. However, the result and conclusion drawn here can applies to the some places having similar conditions (similar climatic condition and livelihood pattern) and therefore cannot be generalized. More intensive research should be conducted to generalize whole Terai region of Nepal.

The temperature and precipitation data of some years were found to be missing in station, which may affect the result of the study.

CHAPTER 2

LITERATURE REVIEW

2.1. CLIMATE CHANGE AND GLOBAL PHENOMENON

Climate change refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007).

The temperature increased is widespread over the globe. Eleven years from 1995-2006 rank among the 12th warmest years in the record of global surface temperature since 1850. The global temperature of earth surface is increasing at an average rate of 0.74 °C since the late 1800s. The rate of warming over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16] °C) is nearly double that for the 100 years from 1906 to 2005 (0.74 [0.56 to 0.92] °C). Land region have warmed at faster rate than the oceans region. There is consistent increase in sea level due to warming. IPCC (2007) has projected that over the last 50 years, cold days, cold nights and frosts have become less frequent while hot days, hot nights and heat waves have become more frequent. The frequency of heavy precipitation events has found increased over last 50 years.

The precipitation trend also varies across the globe. Over the period of 1900 to 2005, the precipitation shows increasing trend in eastern parts of North and South America, northern Europe and northern and central Asia whereas precipitation shows decreasing trend in the Sahel, the Mediterranean, southern Africa and parts of southern Asia(IPCC 2007). Moreover, IPCC(2007) projects that there will be a general increase in the intensity of heavy rainfall events in the future and an overall decrease by up to 15 days in the annual number of rainy days over a large part of the South Asia.

2.2. CLIMATE CHANGE IN NEPAL

Climate change is impacting Nepal rather disproportionately compared to its size and its own meager contribution of green house gases (Karki et al., 2009). Though Nepal's contribution to green house gases is insignificant (0.025%), it is highly vulnerable to climate change impacts (NAPA/MOE 2010). The rapidly retreating glaciers, rapid rise in temperature, erratic rainfalls

and increase in frequency of extreme events such as floods and drought like situation are some of the effects Nepal is facing during the last few years (Karki et al., 2009). Nepal climate's is highly influenced by the Himalayan mountain range and the South Asian monsoon (NCVST 2009). With the marked spatial and temporal variation, the average annual rainfall is 1800mm. The monsoon is more in east and declines at it moves toward west. Temperature varies with altitude and seasons. Temperature and precipitation have been the major climate variability and observed changes over time.

Temperature: The temperature of Nepal has been increasing at an average of 0.06 °C/ year and that in Terai and Himalayas was 0.04°C and 0.08°C/year respectively (Shrestha et *al*, 1999). With an average of 0.06°C, a rise in temperature (1975 to 2006) by 1.8 °C has been recorded in Nepal in last 32 years (Malla, 2008). Warming was higher than average in more than 12 years and 2006 was the warmest year (Malla, 2008). The mean annual temperature is predicted to increase further by an average of 1.2 °C by 2030, 1.7°C by 2050 and 3°C by 2100 (OECD, 2003). Similarly, NCVST (2009) study using GCM and RCM projects the mean annual temperature to increase by 1.4°C by 2030, 2.8°C by 2060 and 4.7°C by 2090. Same studies show that increment in temperature is higher for winter compared to the summer and monsoon seasons. In terms of spatial distribution, the NCVST (2009) study shows that increment in temperature over western and central region is higher as compared to eastern Nepal.

Precipitation: Malla (2008) has revealed that Nepal is experiencing more erratic pattern of precipitation. The precipitation is increasing in the range of 15-20% across the country in summer months (OECD 2003). However, winter precipitation shows almost no change in western Nepal and up to 5 to 10% increase in eastern Nepal. NCVST (2009) study projects further increase in monsoon and post monsoon rainfall as well as an increase in the intensity of rainfall and a decrease in winter precipitation. Observation has shown that region and seasons with high rainfall are recording increase in rainfall and becoming wetter and vice versa (GON, 2004).

2.3. CLIMATE CHANGE EFFECTS IN AGRICULTURE

Regmi (2007) reported that eastern Terai faced rain deficit in the year 2005/06 although rainfall started early due to decrease in rainfall intensity and crop production reduced by 12.5% on national basis. Nearly 10% of agricultural lands were left fallow due to rain deficit but at the

same year, mid western Terai faced heavy rain with floods resulting significant crop damage and crop production was reduced by 30% in the year.

IPCC (2007) reported that in mid and high latitudes, crop productivity is projected to increase for local mean temperature increases up to 1-3 °C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increase (1-2 °C), which would increase risk of hunger.

In a study report, "climate change adaptation on livelihood of women farmer" by action aid Nepal, in Banke and Bardiya district in 2007, farmers had experienced that their livelihood were changing with alteration in flood pattern and rainfall. They were forced to divert to off farm activities as they were no more reliant on agriculture. In the same report, a 53 year elderly farmer stated that the rice production of paddy and winter crops had decreased by 10% and 15-28% respectively in recent 10 years in that area.

Aydinalp and Cresser (2008) has mentioned that the effect of climate change on crop yield vary latitudinally. Crop yield generally enhanced in higher latitude whereas in low latitude and dry land area especially those reliant on rain fed, non-irrigated agriculture most negative effects are foreseen affecting crop yield.

Study done on CO2 enrichment technology at Khumaltar revealed that the yield of rice and wheat increased by 26.6% and 18.4% due to double CO2, 17.1% and 8.6% due to increase in temperature respectively. A crop simulation model to study the effects of CO2, temperature and rain in National Agriculture Research Centre (NARC) record showed positive effect in yield of rice and wheat in all regions, but negative effect in maize especially in Terai. Study further shows that increase in temperature and CO2 levels may also have hidden hunger problem in human by lowering essential nutrients contents in food crops. The study has also mentioned that increase in temperature cause more damage in agriculture in Terai region and will be more favorable for agriculture in Hills and Mountain (Malla 2008).

Khanal (2009) revealed that rise in temperature may bring beneficial effects on productivity in higher altitude and at the same time, can worsen the agricultural production in lower altitude (plain) where temperature in already high. Higher temperatures affect both physical and chemical

properties of soil. Increased temperature may accelerate rate of releasing CO2 resulting in less than optimal conditions of net growth. When temperatures exceed the optimal level for biological processes, crop often respond negatively with a steep drop in net growth and yield. Heat stress might affect the whole physiological development, maturation and finally yield of cultivated crops.

Tiwari *et* al (2009), in the study "Local People's perception on climate change, its impact and adaptation practices in Himalaya to Terai regions of Nepal" has reported that the annual temperature of Terai is increasing at the rate of 0.02°C. People have perceived increased in temperature, low rainfall, late onset of monsoon and more number of drought in Terai. Study also found out decreased in water sources, ground water, and increased siltation and sedimentation in recent years in Terai.

In a summary bulletin of Nepal food security bulletin (Issue 31, 2011); it has reported that the Western hilly district including Surkhet had seen the loss of more than 30% of summer crops because of late/insufficient rainfall and hailstorm in some region. The people have to cope up with the situation by consuming less preferred food, reduce the size of meals and even sell the household assets to buy the food.

The study "Climate change and agriculture : A nepalese case" by Mandip Rai has revealed that the yield of rice would increase with increase in temperature up to 4°C and precipitation up to 20% and beyond that yield would continue to decline. In case of maize, it was found that increased in temperature would lead to decreased in yield and with wheat, the result was mixed.

2.4. ADAPTATION TO CLIMATE CHANGE

IPCC (2001) defines adaptation to climate change as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." There are basically two responses mechanisms to address climate change impacts: Mitigation and Adaptation. For developing country like Nepal, adaptation is the best and appropriate option in order to make the community able to fight against climate change impacts.

Khanal (2009) has reported that organic agriculture could be climate change resilience farming systems for adaptation to climate change. Organic agriculture is also reported to be more

efficient and effective in reducing GHGs (CO_2, CH_4 and N_2O) emission mainly due to the less use of chemical fertilizers and fossil fuel.

Tiwari *et* al (2009), in the study "Local People's perception on climate change, its impact and adaptation practices in Himalaya to Terai regions of Nepal" has mentioned adaptation measures practiced by local people to cope with changing scenario such as community forest management, planting trees and grasses, crop diversification, use of water sources, use of high yielding varieties, chemical fertilizers and pesticide, replacing local varieties crop with hybrid crop.

Prasai (2010) on National Issue Paper in Agriclture Sector (Adaptation) has identified and suggested adaptation strategies to cope up with the climate change related risk. Promotion of organic based farming, use genetically adaptive varieties, crop diversification, agro forestry and forage development, promoting biogas, managing livestock are proposed adaptation measures for adaptation scenario. Besides, increase irrigation capacity and drought tolerant varieties, disease resistant plant, crop rotation, improving land management practices, integrated pest management and improving education for farm workers are relevant for Nepal's agriculture.

Manandhar et al (2011) in their study "Adapting cropping system to climate change in Nepal: a cross- regional study of farmers' perception and practices" conducted in Rupandehi (lowland) and Mustang (upland) of Western Development Region, have reported that farmers have perceived climate change in both the region and local people in low land has adapted to changes by shifting from local to modern hybrid varieties, changes cropping calendar, cropping sequences and planting method. Farmers have increased the frequency of manual weeding and have practiced soil conservation technologies such as zero tillage and surface seeding. The study found out that farmers in Nepal are capable of quick responding to climate change, but their adaptation measures are short-term and may be inadequate to cope with long term effects of climate change.

Thapa and Baral (2013) in his study infers that agriculture is the major affected sector due to climate change. The study result that there is increase in the frequency of flooding, level of inundation and the duration of submergence of crop over time in the last 10 years. So to adapt to increasing drought hazard risk, the action such as shallow tube well for irrigation and cultivation of zero tillage lentil in paddy field are suggested while the action such as cultivation, plantation of trees, cultivation of drought tolerant crop such as paddy are suggested to adapt to increasing flooding risk.

The study “Fighting climate change: Human solidarity in a divided world” suggested that the negative impacts of climate change can be limited by changing the crop and crop varieties, better management of water and irrigation system, adapted planting schedules and tillage practices and better watershed management and land use planning.

The study “Adaptation to climate change: improving livelihoods amidst multiple hazards” conducted in Chitwan District’ has suggested strategies such as building shallow tube wells and water collection wetlands, raising awareness and skills, providing services in agriculture and livestock, construction of embankments along rivers, installing flood warning mechanism and also providing disasters management support and emergency fund with local governments to minimize communities risk to disasters.

The study “Sustainable agriculture practices and technologies in Nepal”, suggested for sustainable agriculture practices such as biogas, harvesting of water in rainy seasons, use of solar energy to dehydrate perishable fruits, vegetables and food, micro irrigation programme such as treadle pump, drip irrigation technologies, improved water mills, resource conservation practices, co-operatives for sustainable commercial agriculture and many other measures.

In a study submitted to National Adaptation Programme of Action NAPA/Ministry of Environment/ Government of Nepal by Shambhu Charmakar, it is observed that people have developed irrigation channels to support during cultivation of rice. In case of food deficit, peoples adapt by importing food from market. It is also observed that people use insecticide and *titepati* in their agricultural farming to treat increasing number of pest and insect.

CHAPTER 3

MATERIALS AND METHODS

3.1. STUDY AREA

Bardiya district lies in Bheri zone in Mid-western Region of Nepal. It covers total area of 2025 square kilometers and lies west of Banke district, south of Surkhet district, east of Kailali district. To the south lies Uttar Pardesh, India. It constitutes of 1 municipality and 31 VDC. The lowest region of this district is Gularia which lie at the height of 138 masl and highest region is Chepang, at height of 1279masl. It has total population of 426,576. Total number of household is 83,176 with average household size of 5.13. Most of Bardiya lies in fertile Terai plains, with majority of land covered by agriculture and forest. Bardiya district is regarded as one of the food secured district of Nepal. More than 80% of populations in Bardia district are farmers and are engaged in agriculture. The district headquarters is Gulariya, which lies on Babai River. The Karnali River, one of the Nepal's largest rivers divides into many branches when it reaches the plain. The westernmost branch of Karnali forms the boundary between Bardia and Kailali district. The eastern branch of Karnali is called Geruwa. Talking about climate of bardiya, the region is too cold during winter and too hot during summer (DDC, 2013).

In Bardiya district, Kalika VDC was selected as research site where the detailed study on local people perception on climate change, impact and adaptation in agriculture was carried out. The VDC lie in a plain area with humid subtropical climate. It lies within latitude of 28^{o}11'643"N and longitude of 081^{o}26'229"E (SAFBIN, 2012). The major source of livelihood of people residing here is agriculture. The total area covered by VDC is 3125 ha, of which total agricultural land is 2233 ha. Irrigated land cover 1772 ha and non irrigated land cover 780 ha (DDC, 2013).

Table 3.1: VDC profile of Kalika VDC

VDC	Household	Population		
		Total	Male	Female
Kalika	3,131	13,553	6,416	7,137

(Source: National Planning and Housing Census, 2011)

The study area was purposively selected because the area is one of climate change stricken area. Study has shown that region is receiving changes in the temperature and rainfall pattern over the past few years. Floods and drought are the frequent problem faced by the local communities. The district is also identified as one of the vulnerable site for the impacts of climate change by vulnerability assessment conducted by National Adaptation Programme of Action (NAPA 2010). At the same time, indigenous and poor communities reside there, who are highly vulnerable group to climate change.

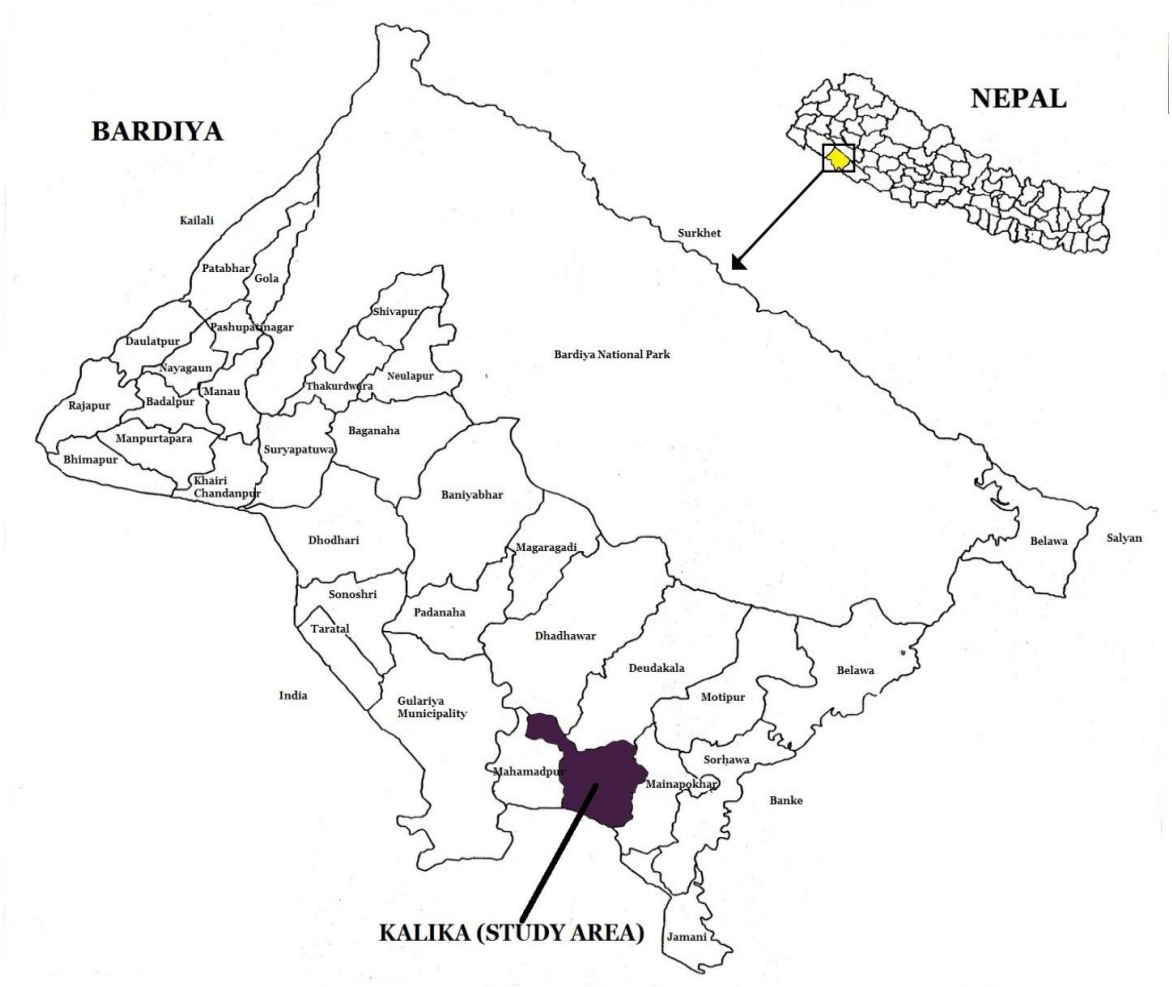

Fig 3.1: Map of Bardiya district highlighting Kalika VDC

Source: www.google.com

3.2. METHODOLOGY

Both qualitative and quantitative research techniques were applied to gather the information related to objectives. Two sources of data were used in the study: primary and secondary. Primary data include all the information and data collected in field survey while secondary data include data obtained from study of different published and unpublished literatures and documents.

3.2.1. PRIMARY DATA COLLECTION: The major elements of this methodology include household questionnaire survey, focus group discussion and key informant interviews.

People's perception of climate change

To gain an understanding of people perception towards climate change and its impact on agriculture and to document measures adapted by local people to cope with it, household questionnaire survey were conducted in Kalika VDC of Badriya district. Semi-structured and open-ended questionnaire were used to gather detailed information on people's perception of climate change, its impact and adaptation measures. Household were selected through a simple random sampling technique. The sample included 4.8% of the households (150 out of 3131) in the study sites in Bardiya District.

Focal group discussion (including elders, male and female members) and key informant interviews (including teachers, village elders, government officials, Ngo staff, influential individuals and experts) was conducted to cross check and to retrieve information on farmers' experience of climate change, problem in farming practices and different adaptation measures adopted.

3.2.2. SECONDARY DATA COLLECTION

For the collection of secondary data, review of statistical and annual report, district and VDC profile, journals articles, online articles, other published and unpublished documents were done.

Temperature and precipitation data

Monthly temperature and precipitation data was collected from Department of Hydrology and Meteorology of Government of Nepal. All the available station data in Bardiya was attempted to

study so as to cover the micro climate of the region. But due to data unavailability, only three meteorological stations were taken. Precipitation data was collected from Chisapani, Rajapur and Rani Jaruwa Nursery stations and temperature data was collected from Chisapani and Rani Jaruwa Nursery stations. This includes 26 year data from 1986 to 2012 for each meteorological station.

Agricultural data

Production data of different crops i.e., rice, wheat and maize were collected from Central Bureau of Statistics. This includes 26 year data from 1986 to 2012.

3.3. DATA ANALYSIS

The overall data was processed and analyzed using computer software packages such as MS Excel and SPSS 17(Statistical package for Social Science).

Household data analysis

The data collected was analyzed quantitatively using descriptive statistics such as sum, percentage and frequencies and was expressed in bar and graphs. The descriptive statistics were used to describe the respondent socio-economic condition such as sex, age, farm size etc. Descriptive statistics were used for simplistic presentation.

Climatic data analysis

Temperature and precipitation data was analyzed as they are the significant climatic parameters. Descriptive statistics such as sum, mean, relative frequencies, percentage, linear regression was used in studying the trend of rainfall and temperature change. Temperature data was available as monthly mean of daily maxima and minima. Missing data for few months was replaced by mean using MS Excel. The data on precipitation and temperature was averaged using arithmetic mean method to obtain average precipitation and temperature of the district. From the available data, average annual and seasonal trend for both temperature and precipitation was analyzed.

Pearson's correlation (r) was used to express relationship between different quantitative variables.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. CHANGE IN CLIMATIC VARIABLES IN BARDIYA DISTRICT

4.1.1. Trend of precipitation

The rainfall intensity, amount and distribution have great importance in agriculture sector (NARC annual report 2011/2012). Data analysis clearly suggests that the trends are changing. The trend analysis based on annual precipitation record of 1986-2012 at 3 stations clearly showed that Chisapani has the highest increasing precipitation trend of 0.3233mm/yr. On the other hand, Rani Jaruwa Nursery station, which is the nearest station to study area, has decreasing trend of 1.0921 mm/yr. From this, we can assume that study area has negative trend of precipitation.

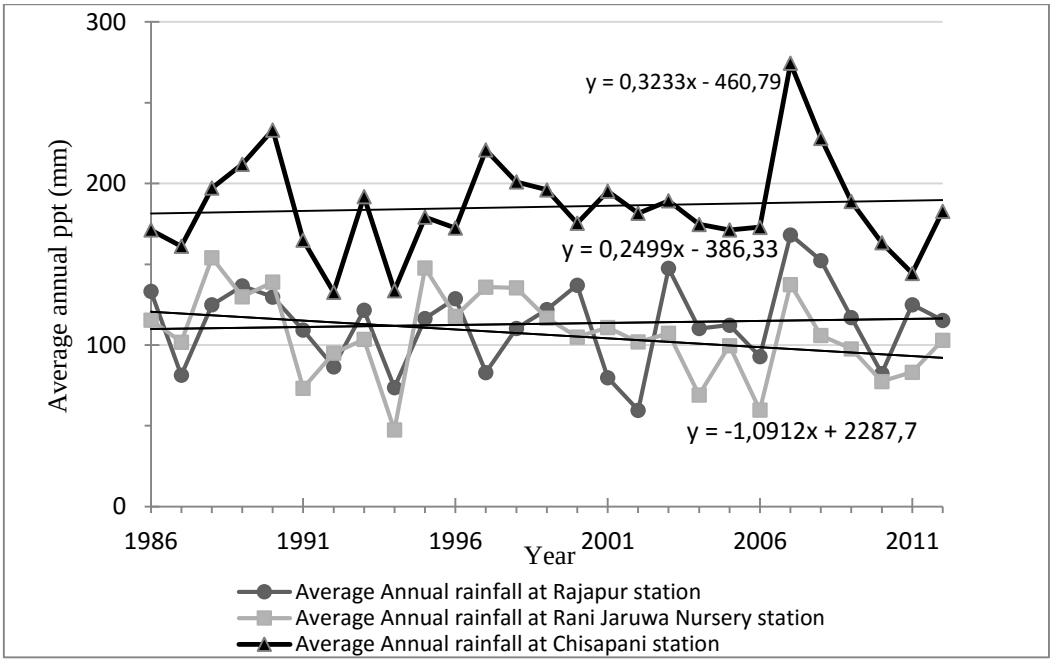

Fig 4.1: Trend of average annual precipitation at Chisapani, Rajapur and Rani Jaruwa station (1986-2012)

The recorded data on rainfall shows that about 86% of total rainfall occurs during monsoon (June-September). The graph of seasonal rainfall pattern shows a slight increasing trend in post-monsoon (Oct-Nov) precipitation, but in contrast a decreasing trend in monsoon (June-Sept) precipitation, pre-monsoon (Mar-May) and winter (Dec-Feb) precipitation. The graph of total

annual rainfall also shows decrease in last 26 years. It confirms farmers' perception of changing rainfall pattern.

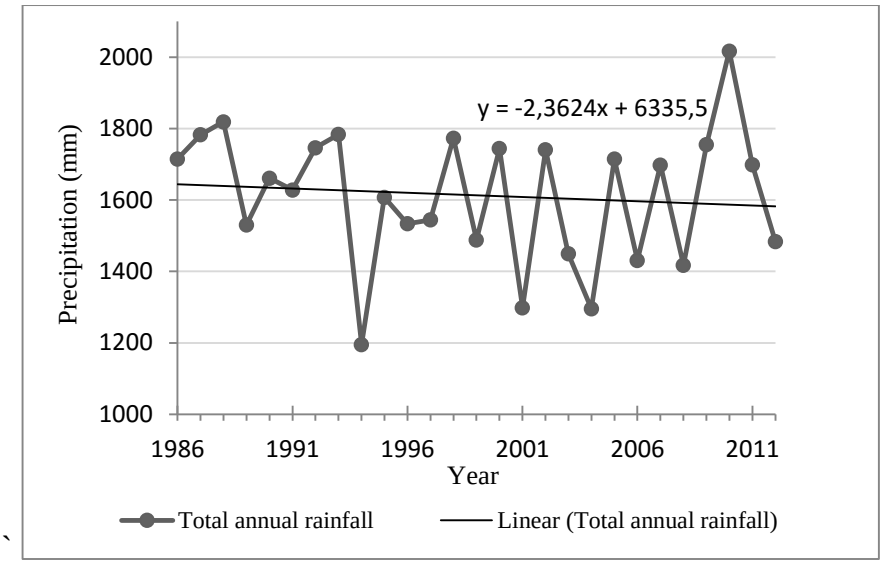

Fig 4.2: Trend of annual precipitation variation in Bardiya (1986-2012)

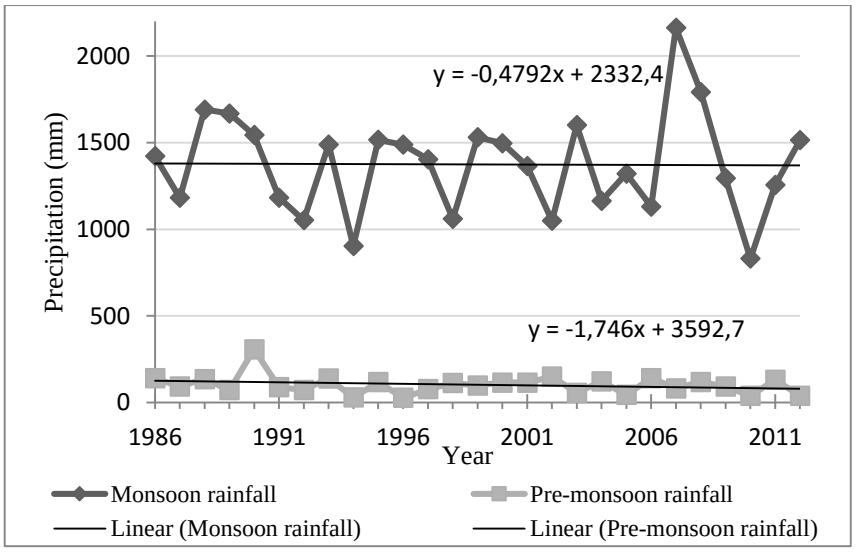

Fig 4.3: Monsoon and pre-monsoon rainfall variation (1986-1012)

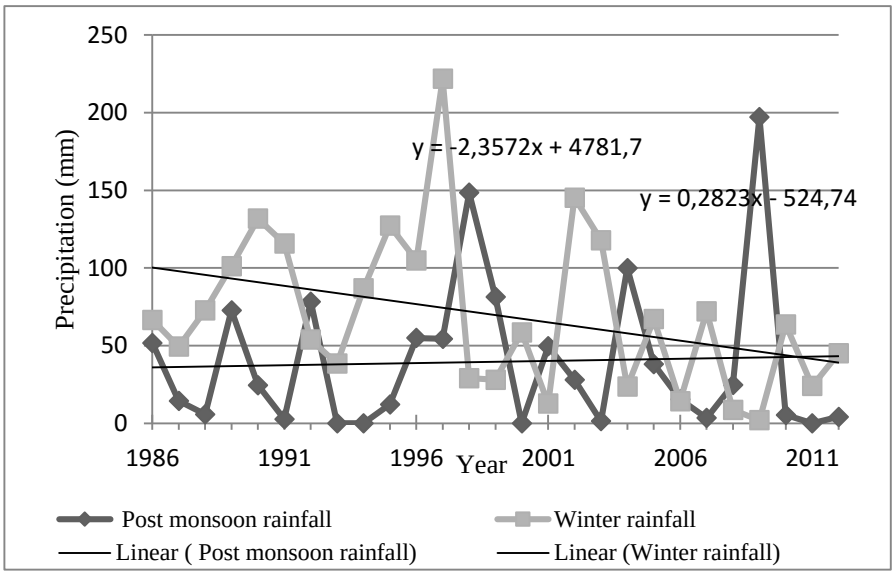

Fig 4.4: Post monsoon and winter rainfall variation (1986-2012)

4.1.2. Trend of temperature

The average annual temperature in Rani Jaruwa Nursery station and Chisapani station is found to be increasing. The trend line has clearly indicated that the average annual temperature in both Rani Jaruwa Nursery station and Chisapani station has positive trend of 0.04°C per year and 0.02°C per year respectively.

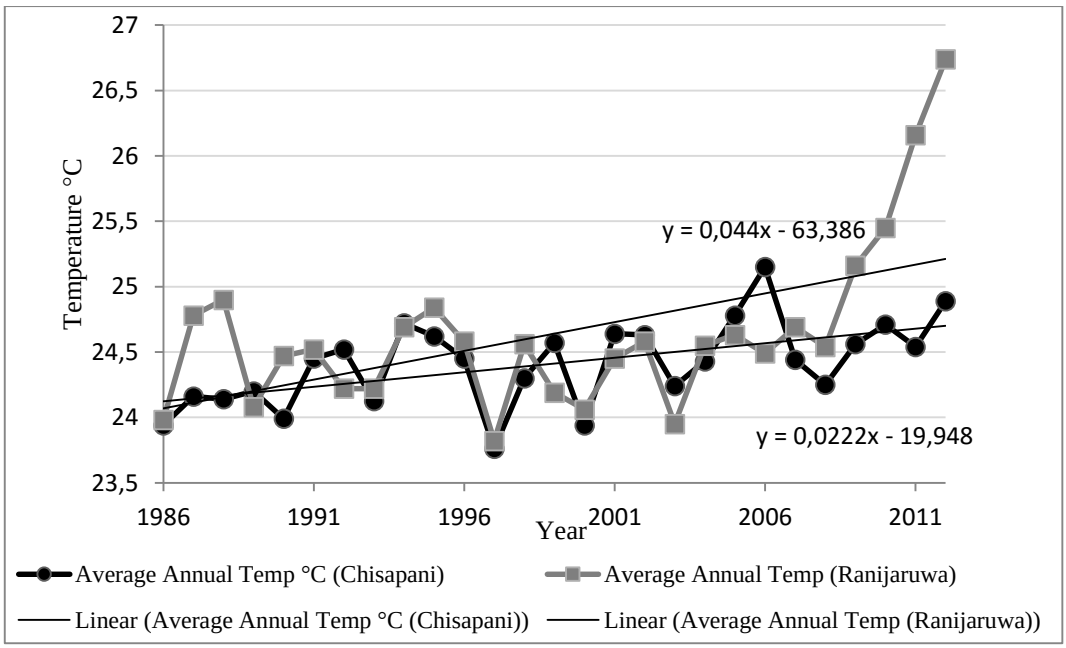

Fig 4.5: Trend of average annual temperature at Chisapani and Rani Jaruwa Nursery station (1986-2012)

Average annual maximum temperature data and minimum temperature data revealed increasing trend by 0.034°C and 0.031°C annually. Mean annual temperature has increased by 0.033 °C. The highest maximum temperature recorded was 31.5 ^{0}C in the year 2012 and the lowest maximum temperature recorded was 29.1 ^{0}C in the year 1997. The highest minimum temperature recorded was 20.1^{0}C in the year 2012 and the lowest minimum temperature recorded was 18.1^{0}C in the year 1987.

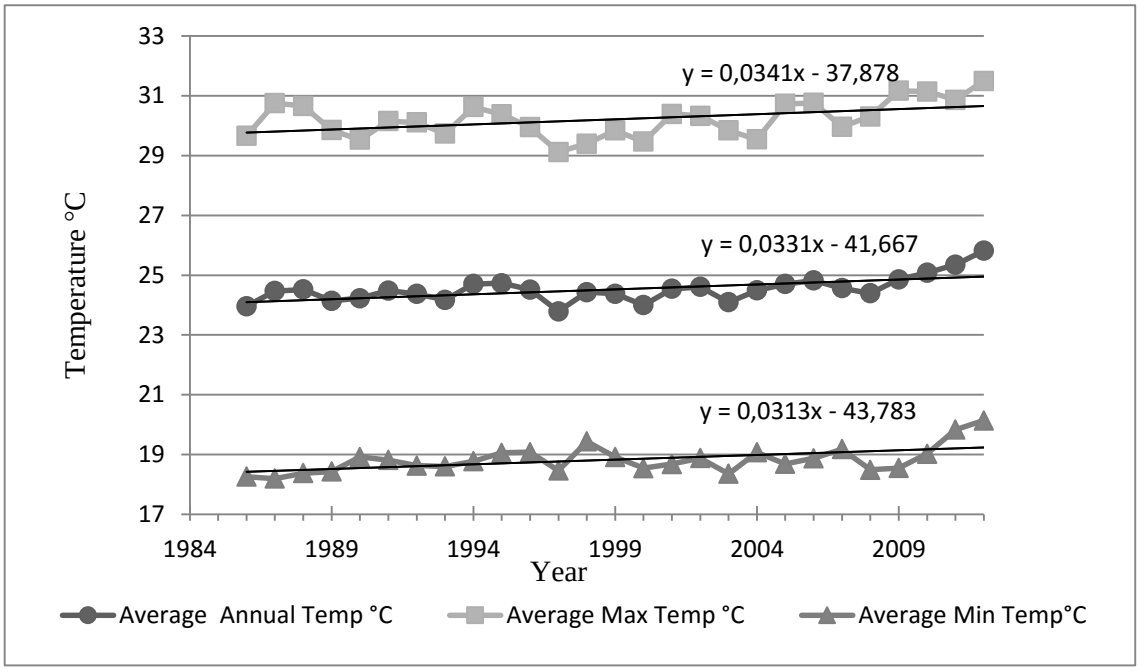

Fig 4.6: Trend of annual, maximum and minimum temperature in Bardiya (1986-2012)

4.2. AGRICULTURE PRODUCTION AND CLIMATE CHANGE

4.2.1. Crop production scenario in bardiya district

Data on productivity at VDC level was not available, so data for whole district was used for analysis. Over the last 26 years (1986-2012), the variation in crop productivity is shown in Fig. 4.17, Fig. 4.18 and Fig. 4.19. It shows that the productivity of rice, wheat and maize has increasing trend over the years.

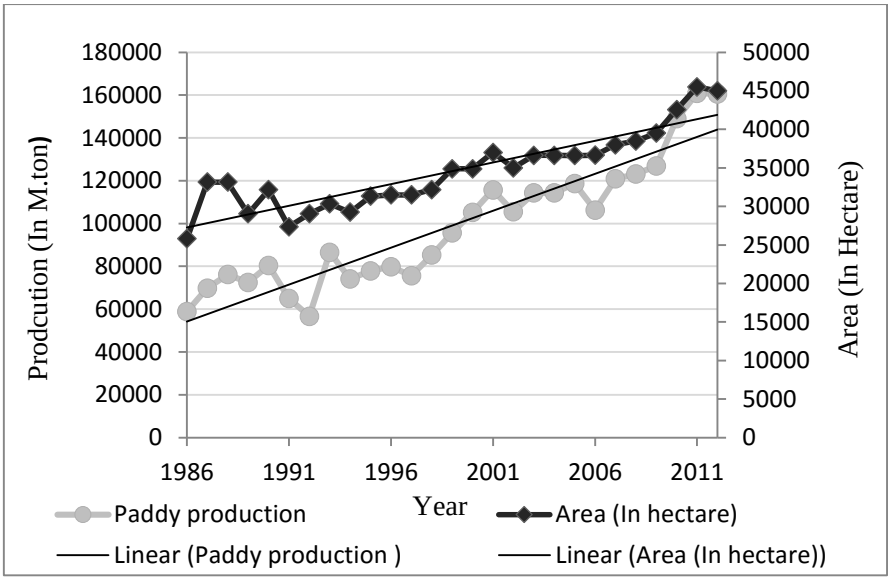

Fig. 4.7: Variation of crop productivity (paddy) and crop area

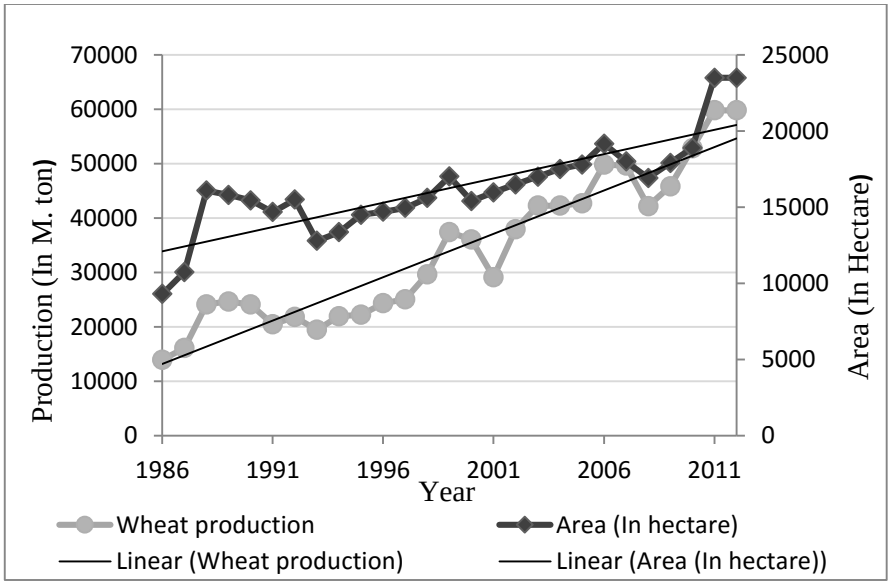

Fig. 4.8: Variation of crop productivity (wheat) and crop area

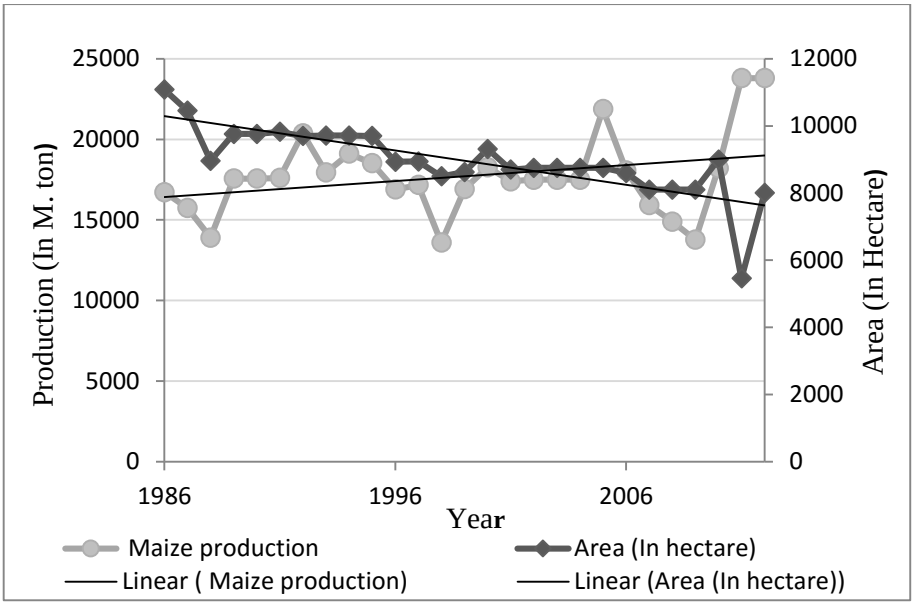

Fig. 4.9: Variation of crop productivity (Maize) and crop area

As shown in fig: 4.7 and 4.8, rice and wheat has shown an increasing production with increase in crop area. In case of maize, though crop area has decreased, maize has shown slight increase in production. Besides, improved agriculture practices such as the use of improved and hybrid varieties, improved irrigation system and efficient use of chemical fertilizer could be the reason for increasing production.

In Bardiya district, undoubtedly rice seems dominant in terms of area been allocated and production, followed by wheat whereas maize production shows stagnant over the years. So, we can say that rice is most suitable crop for production in this region as compared to other. Because, Bardiya lies in plain area, its geology favors for rice production. Besides, fertile soil, optimum level of rainfall and temperature required by crop has further favors its production.

4.2.2. Relation between climatic parameters and crop production

The relationship between temperature and rainfall with productivity of major crops was analyzed, using Pearson correlation technique where the crops are the dependent variables and temperature and rainfall, independent variable. Twenty six years (1986-2012) data on mean temperature, maximum and minimum temperature during growing seasons was correlated with 26 years data on annual productivity of major crops i.e., Rice, Wheat and Maize. Similarly, 26 years (1986-2012) data on precipitation of growing seasons was correlated with 26 years annual productivity of the same crops.

In Bardiya, growing seasons for rice is June-November, for wheat it is November-May and that of Maize is January-June. Pearson correlation revealed a statistically positive significant correlation ($p<0.01$) between productivity of rice with the average mean and maximum temperature during growing season of rice. However, strong positive correlation (0.618) was observed with maximum temperature. So, increase in maximum temperature favors the growth of rice.

Wheat shows statistically positive significant correlation ($p<0.01$) with average mean and minimum temperature during growing period of wheat. Wheat also shows statistically positive significant correlation ($p<0.05$) with maximum temperature during growing season of wheat. However, strong positive correlation (0.685) was observed with average annual temperature. So, increase in average annual temperature favors better the growth of rice.

Similarly, relationship between average mean and minimum temperature during maize growing period and productivity of maize crop showed statistically significant but weak relationship.

The correlation between temperature and crop yield all show a positive relationship. This means that increase in temperature is favorable for the growth of rice, wheat and maize and as the temperature increases, productivity of rice, wheat and maize also increases.

However, besides temperature, there are also other environmental factors responsible for the growth of crops. We can say that increasing productivity of major cereals crop may be also due to various measures adapted by farmers in their farming practices. Use of improved and hybrid varieties, use of drought tolerant and high yielding varieties, improved irrigation system, use of

fertilizer, could be the reason for increasing productivity. Every year increase in area for cultivation may also lead to increase in production.

In the relationship between rainfall and the selected crops that is rice, wheat and maize yield statistically significant relationship was not observed. However, rice shows positive relationship while wheat and maize shows negative relationship.

This means that combination of rainfall and temperature has great influence on crop productivity but however other environmental factor such as soil fertility, type, seed variety and technology etc should also be put into consideration.

4.3. FARMERS AND CLIMATE CHANGE

4.3.1. Demographic characteristics of study area

The total of 150 respondents from 150 different household were selected as sample for household survey. 55% percent of total respondent were male and 45% percent were female. People of study area were friendly and highly co-operative, so it was not so difficult to deal with respondents and gather idea from them. However, there was some difficulty understanding languages of ethnic group (Tharu). Respondent were categorized on the basis of age-group. Out of total respondents, 60% were between 45-55 years old followed by 55-65 years old (30.7%) and 65 above (9.3%).

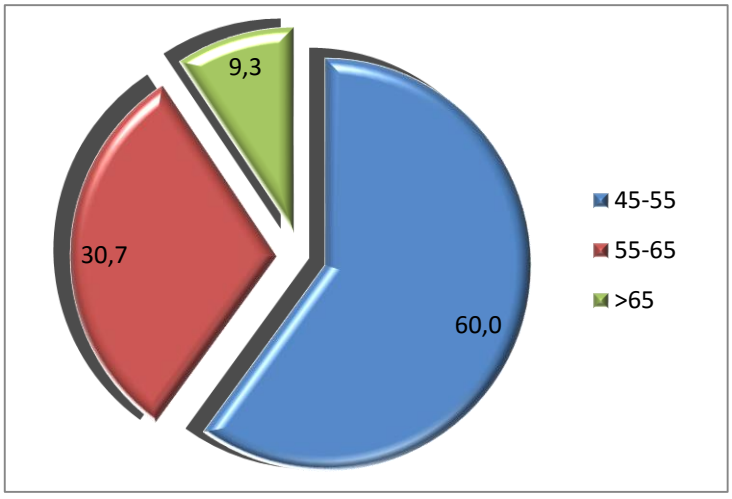

Fig 4.10: Age group of respondents

The total population of 150 sampled houses was 1069. The average size of household was 7.12 with the maximum number reaching up to 28 and the lowest number to only 2.

Table 4.1: Profile of respondent

VDC	Total population	Household characteristics	
		Total HH size	Average HH size
Kalika	1069	150	7.12

The ethnic diversity of study area is presented in pie chart. Tharu communities are the ethnic group's indigenous to Terai and are in majority in Bardiya district. The data reveals that the study area contained majority of Brahmin and Chhetri followed by Tharu, then Dalit communities, then Magar, Newar, Gurung and Sherpa.

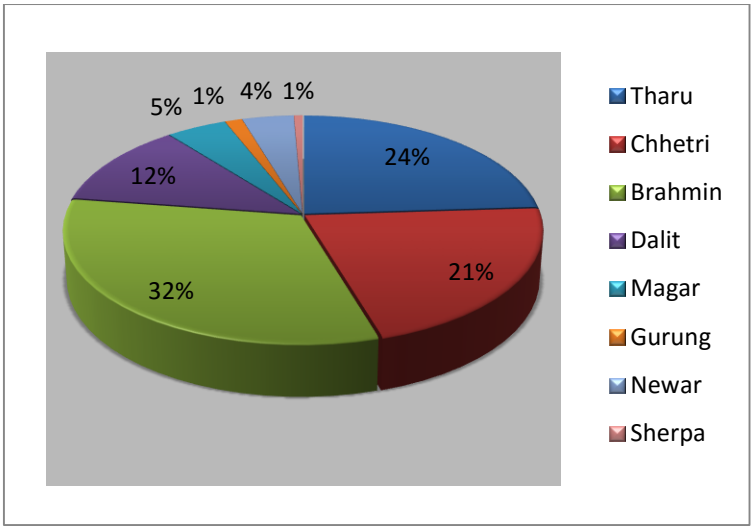

Fig 4.11: Ethnic diversity of respondent

4.3.2. Land holding and farm characteristics of study area

Land holding pattern largely varies among the respondents. The range of landholding was 2 katta (0.06 ha) to 5 biga (3.4 ha). About 52.7% of total respondent possessed land between 0.31-0.68 hectare, followed by 29.3% possessing land more than 0.68 hectare and 18% possessing land between0.034-0.3 hectare. The study has revealed that majority of respondent in the study area are small and marginal farmers with land holding size less than 2ha (60 katta).

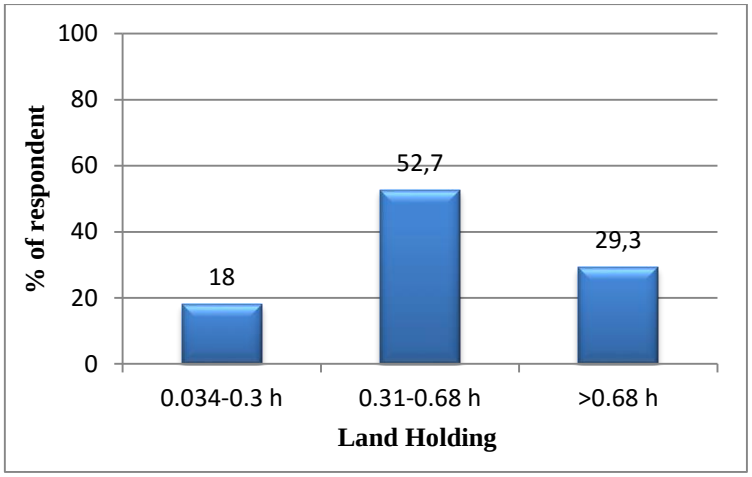

Fig 4.12: Land possess by respondent

Agriculture is the mainstay of people living in this area. All of the respondents are engaged in agriculture and it is their main source of livelihood. Very few numbers of respondents (18%) has owned livestock. The reason is many people are poor in study area and they cannot afford to own livestock, to rare and care them. Increasing deforestation and decreasing labor force are also for reasons for decreasing number of livestock

Rice is the major grown food crops followed by wheat, maize and lentil. The cropping system in the study sites is rice based. Rice is planted in the monsoon seasons, wheat in winter, and maize in spring and lentil in winter. Farmers usually follow rice-wheat, rice-lentil, rice-mustard, rice-mustard- maize, rice-potato-maize cropping sequences. Vegetables such as potato, tomato, pumpkin, brinjal, mustard are also grown. Farmers have also started cultivating off-seasons vegetables to earn more money.

Drought is the frequent problem occurring in this area and they cope with this situation by using Kulo (canals) for irrigation .The place where Kulo has not reach, alternatives such as pumping or boring is used. However, only the financially well off farmers have such irrigation facilities while other poor farmers rely on monsoon for cultivation.

4.3.3. People's perception on change in temperature

The result indicates that 81 percent of the total respondents perceived long-term changes in temperature. Most of them (57 percent) perceive that temperature has been increased while 24

percent noticed the contrary, a decrease in temperature. While few respondent 19 percent have not noticed any change in temperature.

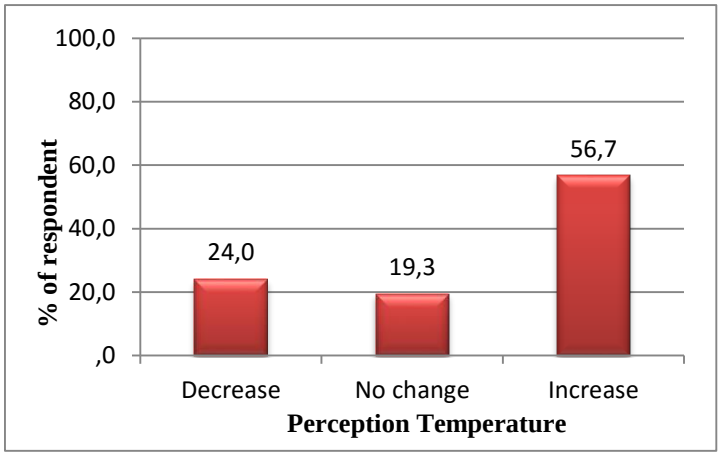

Fig 4.13: People's perception on change in temperature

4.3.4. People's perception on change in precipitation

The study revealed that 67.3 percent of total respondent noticed decrease in the amount and duration of rainfall while 9.3 percent noticed increase in the amount and duration of rainfall with 23.3 percent experiencing not any change. Similarly, 41.3 percent of total respondent observed decrease in the number of rainy days while 27.3 percent observed increase in the number of rainy days and 31.4 percent of respondent experiencing no any changes. Almost 65 percent of the respondent noticed a change in the timing of rainfall, with rains coming either earlier or later than expected. Majority of respondent observed that the monsoon on which Nepalese agriculture depends is coming late and is also shorter. 54.7 percent experienced increased in the occurrence of drought whereas 38 percent has mentioned that occurrence of drought has decrease because of irrigation facility. Almost all respondent found decrease in water sources in recent years. 42 percent observed increased frequency of heavy rainfall in short periods. 78 percent mentioned about decreasing flood intensity and 10 percent experienced increase in flood intensity while 12 percent experienced no changes.

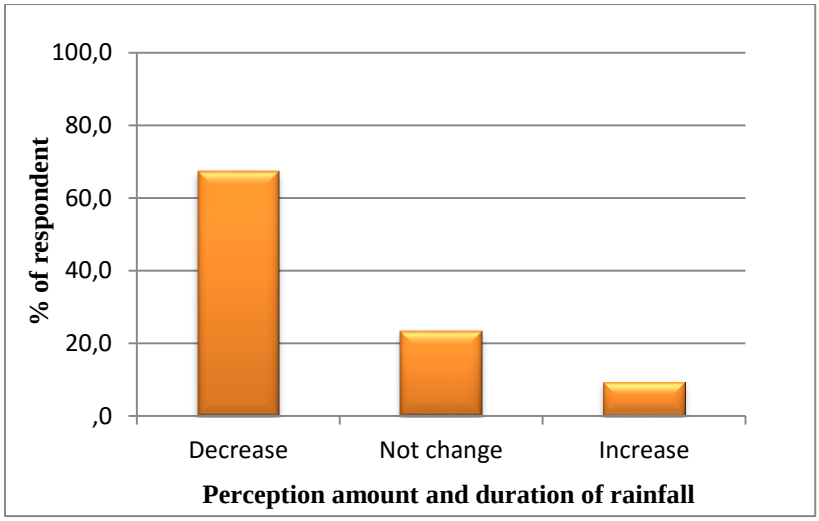

Fig 4.14: People's perception on amount and duration of rainfall

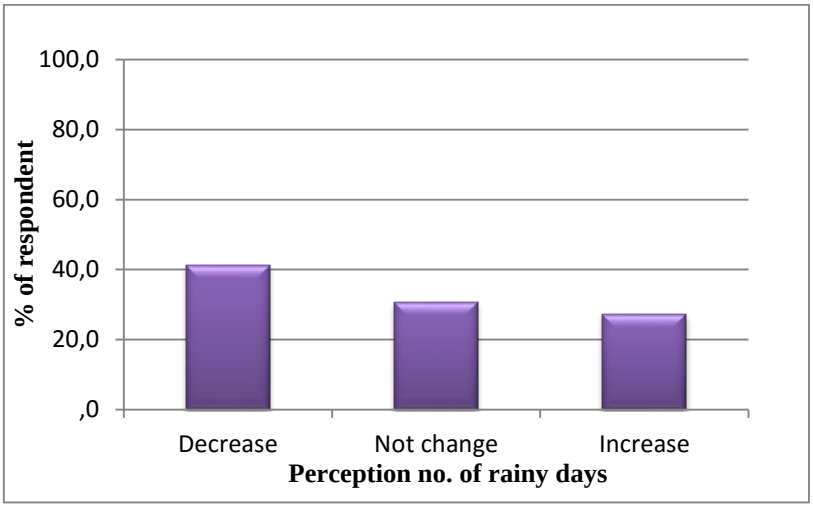

Fig 4.15: People's perception on no. of rainy days

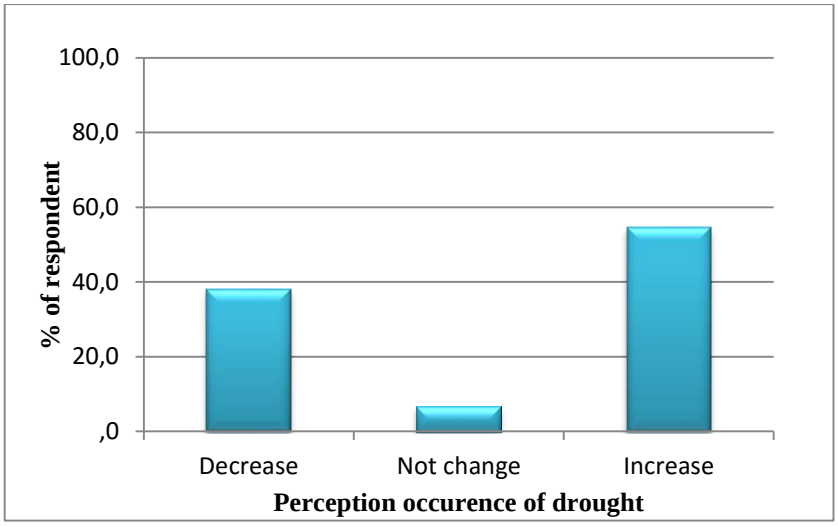

Fig 4.16: People's perception on occurrence of drought

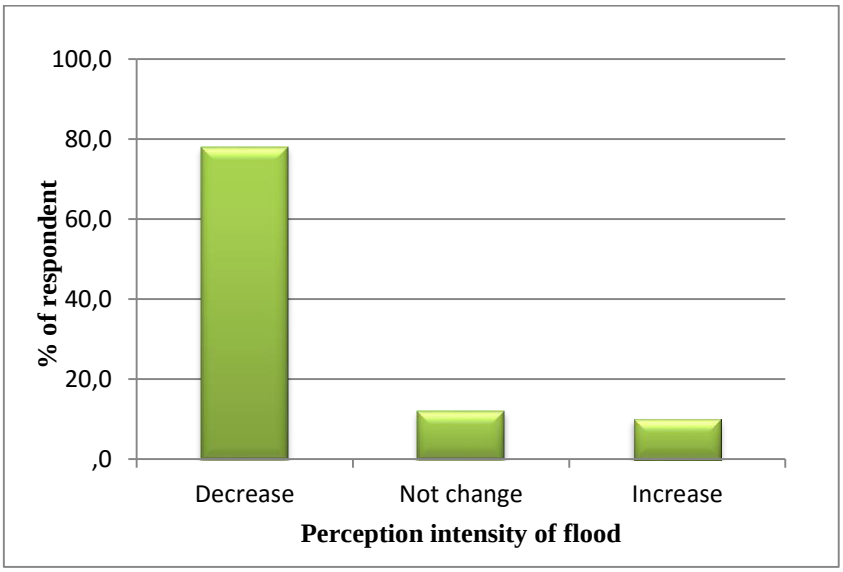

Fig 4.17: People's perception on intensity of flood

Though majority of people may not know the term "Climate change", but they have personally experienced impacts of climate change in one way or other. The study revealed that out of total respondent surveyed, only 40% of respondent know the term "Climate change". Some respondent mentioned that they know the term "Climate change" from mass media and through conversation with other farmers.

Most of people perceived climate change as increase in temperature and decline in rainfall. Some perceived it as flooding while some as drought. Few respondents agrees that human beings are

the cause of changes as a result of increase in population, cutting of trees, increase in the number of large industries and factories, more use of plastic. Respondent from study areas reported that heat waves (*Loo*), which used to occur during the month of "Baishak" in past years, has now been delayed by one month and occurs in the month of "Jestha" and its frequency of occurrence has also increased. Many respondents felt changes during winter seasons, giving the reasons based on experienced in their daily life like less use of warm clothing, lesser winter period. Dense fog which used to occur for one and half month in past years now occurs about 15 days only. People claimed that they were not using mosquito net in winters 10 to 15 years ago. But now, mosquitoes trouble indifferently in both the summer and winter season.

Farmers in the study areas have experienced an increasing trend of untimely and erratic rainfall. Many of the respondents are unanimous about a decrease in the volume of the rainfall. Farmers mentioned that plastic umbrella or bamboo umbrella ("Syako" or "Ghum") which they used to carry every time in the past because of continuous rainfall and high intensity rainfall, now they have stopped using it. Many of the respondents have complained about fluctuation in the monsoon rainfall pattern and decreasing trend and unpredictability of winter rainfall. Farmers responded that the onset of seasons has become unpredictable with monsoon starting later. Within monsoon, there are period of high and low rainfall, sometime pouring heavily causing flood and sometime just a short fall. There are times when onset of monsoon is delayed whereas there are periods or years of timely start of monsoon.

Farmers in the study area can still remember the severe drought that occurred in the years 2028, 2036, which led to famine. Farmers do remember floods that occurred in the year 2060/2061. Farmers also reported about hailstones that occurred last year, which they experienced for the first time at an interval of 40 years. They also reported that due to persistent drought many water bodies/sources have dried up which has made their life more vulnerable.

4.3.5. Climate change impacts on agriculture

Farming being the major occupation of this region, locals feel themselves to be highly affected by the change. Fluctuation in the monsoon rainfall pattern has made it difficult for the farmers to predict the monsoon and carry on smoothly the timely cropping practices. Farmers have complained that planting of rice which in the past complete by Shrawan now, it last till end of Bhadra. They have also complained about delayed in the planting season of maize due to erratic

rainfall. They have mentioned that in the past, they used to plant maize two times a year. Now they plant only one time in spring. Some farmers mentioned that because of less rainfall in winter and sometime no rainfall at all, the yield of winter crops (wheat) is low and some had given up wheat farming because of low germination of wheat seeds due to lack of adequate moisture.

Most of the respondents have experienced changes in agro biodiversity and farming system. Many local varieties of different crops have disappeared due to their low productivity in recent years, especially of rice. Farmers are pursuing more on improved varieties and hybrid varieties of crops to increase production and local cultivars are becoming extinct. Out of total respondent, 59.3 percent of the respondent experienced increase in production while 38.7 percent experienced decrease. The increase in the production of crops was due to adoption of improved and hybrid varieties of crops, more use of chemical fertilizers, irrigation through boring and pumping and change in the cultivation practices. The decrease in production was due to inconsistencies observed in rainfall pattern that led to delayed sowing of crops, decreasing the yield. In addition to that, poor farming practices, lack of technical knowledge of cultivation could also be responsible for low yield. About 93% of respondent use chemical fertilizers to increase the productivity. They mentioned that use of chemical fertilizer has become a kind of compulsion; otherwise productivity goes down. They also mentioned that with the decreasing context of forest and pasture, number of cattle and buffaloes has decreased in the farm household. This has resulted in shortage of farmyard manure which has further increases their dependency on chemical fertilizers.

Some respondent observed change in the flowering time of Cauliflower, which now flowers in 50 days instead of 90 days. Some also explained about unusual phenomena they observed in the agriculture system such as short stalk of maize, thickening of lemon peel and less juicy, ripening/fruiting of guava almost in all seasons. Farmers have experienced appearance of new weed species such as *Ageratum conyzoides* ("Ghande jhar"), *Cyanotis cristata* ("Kane jhar"), *Centella asistica* ("Ghortapre") and invasive species such as *Eupatorium adenophorium* ("Banmara") which are becoming dominant in the crop field. Farmers have also complained about increasing number of pest especially Grasshopper and Armyworm in the crop field which has created havoc since last two years and are cause for declining productivity.

4.3.6. Adaptation measures

Rice is major crop in the study area and rice based cropping system is predominant, making farmers dependent on reliable and sufficient amount of water. But, decreasing and untimely rainfall is the biggest threat to rice growers. Financially well-off farmers have irrigation facilities, which make them somewhat independent of the vagaries of rainfall. They are using various technologies such as treadle pump, electric machine irrigation, diesel/kerosene pump set in dry period that limit their problem of water supply during cultivation. But, poor farmers practice rain fed cultivation and their field are left fallow during dry season or dry years. Farmers also expressed that drought was the major problem and if irrigation facilities provided, major climate change impact will be minimized.

Some farmers have given up wheat farming due to lack of adequate and timely rainfall in winter. In place of wheat, farmers have planted other crops like lentil and mustard.

Drought is the most frequent problem face by the people in Kalika VDC. To adapt against climatic hazards of drought and erratic rainfall, most farmers have shifted from local varieties to improved varieties such as drought resistant varieties. Local productivity is often affected by flood due to its location in low lying area.

Similarly, to adjust with the climatic proximity of drought and late rainfall, most of the farmers have change in cropping calendar, cropping pattern and planting method.

The outbreak of diseases, pest and weed infestation has increased with the increase in temperature and frequent incidence of drought. Farmers have no alternative besides applying chemical pest and weed control ignoring its hazardous effects. However, some farmers who do manual weeding have increased its frequency. But, repeated use of such chemicals has, however, enhanced the resistivity of pest, further increasing the demand of more chemical use.

Majority have started off season's vegetables production to as to earn more income than cereal crops. Some farmers have practiced vegetable farming in plastic tunnel and mulching. Few farmers were found practicing organic farming and IPM.

Caritas Nepal, an NGO present in the study area, is currently running SAFBIN project that mainly focus small scale farmers to strengthen their capacity to pursue adaptation measures in

farming system in context of climate change. This organization has facilitated local people by providing employment opportunities, raising awareness about climate change, providing training, providing quality seeds, developing technical knowledge on improved practices of cultivation, etc. However, local people are not getting any support from governmental levels.

Table 4.2: Disappeared or rare and newly introduced cultivars of different crops

Crops	Disappeared and rare varieties	Newly adopted varieties
Rice	Dariya, Bhadaiya, Janaki, IR-24, Sabitri (rare), Sattha dhan (rare)	Radha-4, Sukhadhan 1, Sukhadhan-2 and Sukhadhan-3 (drought tolerant) US-312 and Pyneer (hybrid), Sava mansuli, Makwanpur, Surbir, Supremesona, Saurav and Tilki (fast maturing crops)
Wheat	-	Gautam (good productivity), Bijaya (good productivity), Brikuti (drought tolerant)
Maize	-	Pyneer-33/35

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Statistical analysis of climatic parameter have shown changing scenario in Bardiya district of Nepal. Trend of temperature shows an increasing trend in average annual temperature. There is also a noticeable change in rainfall pattern. Average annual precipitation is in decreasing trend. Erratic rainfall is continuing and monsoon and winter rainfall is decreasing. Erratic pattern of rainfall is increasing the occurrence of drought and side wise side floods as well. Problems of soil fertility and irrigation management have also increased and farmers have even lost some local cultivars of crops that were unable to adjust to the changing environment. Similarly, an erratic rainfall and increasing temperature have promoted the incidence of insect pests and diseases directly affecting the growth and development of crops thus affecting production. However, statistical analysis has indicated increasing productivity of major cereals crop in recent years. Study shows that temperature and rainfall greatly influence productivity of major cereals crops however, considering other environmental factors as well.

The responses reported by local people on climate variability are in line with climatic data records. Indeed, local people in the study area are able to recognize that the temperature has increased and there has been reduction in the volume of rainfall. If the change continues in the same manner and timely appropriate adaptation strategies are not developed, agriculture sector will suffer greater risk in the days to come. The changing scenario has however force local people to find measures to secure their livelihood. Few example of adaptation strategies are found in the study area such as adoption of new and high yielding crops, changes in cropping pattern and planting time, application of pesticide and chemical fertilizers. Farmers are also using irrigation technologies such as treadle pump, electric machine irrigation, diesel/kerosene pump set to cope with impacts of climate change. Diversified vegetable farming and off-season vegetable production in plastic houses is an additional adaptation measures. These adjustments are however, autonomous and short-term that has helped them to some extent but it seems important to plan sustainable adaptation strategies and make farmers prepared to cope with the increasing effects of climate change in coming days.

With the impacts of climate change becoming increasingly more potent, it is clear that effective actions must be taken to improve livelihoods. As it is clear to all, studies on climate change in communities of Terai Arc Landscape-Nepal are lacking, so it is recommended to generate different kinds of effective research program because impact of climate change is clearly open to all and a kind of evidence is also provided by our study. Off-farm income earning opportunities should be improved so that community becomes empowered to enable them to act for lessening the adverse impacts of climate change. There is limited awareness among the farmers to understand climate change scenarios, address issues and conduct long term planning. Increasing knowledge of farmers on climate change and making them aware of new technologies and innovations to adapt to changes whilst maintaining agriculture production is crucial to increase resilience to climate change.

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APPENDIX A: Research question

Sample no.:

Date:

PART 1: GENERAL INFORMATION

Last name / surname:	First name(s):	female □ male □
Age:	Occupation:	
Family structure:	No. of persons in household:	
VDC's name:	Ward no.:	

Please specify income source to support livelihood in your household.

Source of Income	**At present**	**10 years ago**	**20 years ago**	**30 years ago**
Agriculture				
Horticulture				
Livestock				
Tourism				
Service				

Other (Please specify):

……

PART 2: CLIMATE CHANGE ISSUES

1. Have you ever heard of the term Climate Change?
   a. Yes b. No c. No idea

If yes, what is it?

……

……

2. Have you experienced any significant change in the weather pattern over the last 30 years?

Climate Variables	Observation		
Temperature	-	same as today	+
Summer season temperature	□	□	□
Winter season temperature	□	□	□
Precipitation	□	□	□
Summer monsoon	□	□	□
Winter rainfall	□	□	□
No. of rainy days	□	□	□
Amount and duration of rainfall	□	□	□
Extremes events			
Heavy rainfall events	□	□	□
Less rainfall events	□	□	□
Floods	□	□	□
Droughts	□	□	□
Cold wave/ Sheetlahar	□	□	□
Heat wave/ Loo	□	□	□

3. Did you and your family face any difficulties because of such changes?

……

……

4. What measures have you put in place to cope with those changes?

……

……

PART 3: AGRICULTURAL INFROMATION

5. How much land do you have?

   a. 0-0.25 ha b. 0.26-0.5 ha c. 0.51-1ha

   d. 1.1-2 ha e. >2 ha

6. Please fill following table:

Cultivated land types	**Types of crop you grow**	**Cropping season**
Rain fed land (Bari)		
Irrigated land (Khet)		
Other (Please specify)		

7. How do you define quality of your soil in terms of types, color and fertility?(Tick the answer)

Types of soil	**Color of soil**	**Fertility of soil**
Sandy (Balaute)	Black	High
Clay(Chimte)	Brown	Medium
Loamy(Domat)	Yellow	Low
Others:	Others:	Others:

8. Do you use any kind of fertilizer in your land?

   a. Yes b. No c. No idea

9. If yes, how do you supply nutrient in your land?

   a. By use of chemical fertilizers

   b. By use of natural fertilizers (manure/compost)

10. Name of chemical fertilizers that you use in your field?

    a. ……..

    b. ……..

    c. ……..

    d. ……..

Part 4: CLIMATE CHANGE AND AGRICULTURE

11. What are major crop do you grow?
    a. Rice
    b. Wheat
    c. Maize
    d. Lentil

    Other (Please specify): …….

12. What are the impacts of climate change in your crop productivity?

    ……..……

    ……...……

13. What is the impact of climate change in your local production?

Crops	Production (kg/ hectare) At present	Production(kg/ha) in past years		
		30 years	2 0 years	10 years
Rice				
Wheat				
Maize				
Lentil				
Other				

14. If productivity is declining, what could be the major cause for decreasing productivity or what are the major causes of damage?

    a. Increasing temperature
    b. Sudden/ Untimely rainfall
    c. Heavy rainfall
    d. Less amount and duration of rainfall
    e. Floods
    f. Drought
    g. Insect and diseases
    g. Other (Please specify): ……..…

15. If productivity is increasing, what do you think the cause for increasing productivity?

a. Rise in temperature
b. More rainfall
b. Less rainfall
d. Use of fertilizers
e. Adopting new crop varieties
e. Other: …….

16. Did you adopt any new crop varieties in your field?

a. Yes
b. No

If yes, do list the name?

- ……
- ……
- ……
- ……
-

17. What is the main reason for adopting those new varieties?

a. Drought tolerant
b. Diseases/Pest tolerant
c. Good quality
d. Other: ……

18. What measures (for example, use of different crop varieties, build water harvesting schemes, change in timing of production activities, irrigation) in your farming have to put in place to adapt to the changes in climate and why?

Crop varieties	**Adaptive measures**	**Reason behind adopting those measures?**
Rice		
Wheat		
Maize		
Lentil		
Others		

APPENDIX B: Checklist for Focus Group Discussion

1. What do you think climate change is?
2. What are the changes in temperature and precipitation been observed over past few years?
3. What are the effects of changes in temperature on agriculture?
4. What are the effects of changes in precipitation on agriculture?
5. What is the amount of crop produce in Bardiya annually (in the past and now)?
6. Is the productivity increasing or decreasing with climate change?
7. What are measures adopted by the people to combat these changes?
8. Has the farmers adopted any new crop varieties?
9. What are main reasons for adopting those new varieties?
10. Has farmers done any changes in their farming practices to cope with climate change?

APPENDIX C: Climatic parameter and annual production correlation matrix

Table 1 **Correlations matrix**

		Rice productivity	Tmax rice growing season	Tmin rice growing season	Tavg rice growing season	Rainfall rice growing season
Rice productivity	Pearson Correlation	1	.618**	.212	.522**	.078
	Sig. (2-tailed)		.001	.289	.005	.699
	N	27	27	27	27	27

**. Correlation is significant at the 0.01 level (2-tailed)

Table 2 **Correlations matrix**

		Wheat productivity	Tmax wheat growing season	Tmin wheat growing season	Tavg wheat growing season	Rainfall wheat growing season
Wheat productivity	Pearson Correlation	1	.431*	.652**	.685**	-.376
	Sig. (2-tailed)		.025	.000	.000	.053
	N	27	27	27	27	27

*. Correlation is significant at the 0.05 level (2-tailed)

**. Correlation is significant at the 0.01 level (2-tailed)

Table 3 **Correlations matrix**

	Maize productivity	Tmax maize growing season	Tmin maize growing season	Tavg maize growing season	Rainfall maize growing season

Maize productivity	Pearson Correlation	1	.193	.484*	.414*	-.070
	Sig. (2-tailed)		.334	.011	.032	.730
	N	27	27	27	27	27

*. Correlation is significant at the 0.05 level (2-tailed)

**. Correlation is significant at the 0.01 level (2-tailed)

APPENDIX D: Photos

Plate 1: Key informant interview (SAFBIN)

Plate 2: Key informant interview (DADO)

Plate 3: Interview with local people 1

Plate 4: Interview with local people 2

Plate 5: Focus group discussion 1

Plate 6: Focus group discussion 2

Plate 7: Occurrence of drought

Plate 8: Straw mulching

Plate 9: Crop damage due to crop infestation