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

A Project Report

Submitted in partial fulfillment of the requirements for

the Bachelor's (Honors) Degree in Environmental Science

By

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DECLARATION

I, Preety Pradhananga, 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 programme. 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

Climate change is a global challenge, which directly hits the agro-ecosystem. Climate change has strong effect on developing countries such as Nepal where adaptive capacity is low and agriculture is highly dependent on climatic factors which influences crop production. A study was carried out in Latikoili VDC of Surkhet district primarily with an objective to identify impacts of climate change in agriculture. The study examines people's perception on climate change and assesses existing adaptation practices on agriculture. Primary data was collected through semi-structured and open- ended questionnaire through household survey, key informant survey and focus group discussion. Climatic and agricultural data of 29 years were collected from Department of Hydrology and Meteorology and Central Bureau of Statistics respectively.

The statistical analysis of climatic data revealed that the trend of temperature has increased and rainfall has been characterized by large inter annual variability with substantial decrease over past 29 years. The analysis revealed that local people's perception is in accordance with climatic records. The Pearson's correlation analysis showed that temperature is statistically positively significant ($p<0.01$) whereas rainfall didn't show statistically significance with the productivity of rice, wheat and maize. The descriptive analysis technique examined farmer's perception and most of the respondent perceived change in climate and farming system in their locality such as delay of monsoon, erratic rainfall pattern, increased temperature resulting drought associated with decrease in water sources, shifting in cultivation, planting and flowering time. Local cultivars have disappeared enhancing pest proliferation and low production.

The study revealed that farmers have been practicing adaptation measures such as adapting improved seed varieties, IPM techniques, and multiple cropping systems to combat climate change. However, poor and marginalized group were unaware regarding climate change impacts and adaptation measures. Sharing information and raising awareness among the locals can be done to cope with climate change impact and enhance 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
GDP	Gross Domestic Product
GON	Government of Nepal
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
M. ton	Metric ton
Mm	Millimeters
MoPE	Ministry of Population and Environment
NAPA	National Adaptation Programme of Action
NARC	National Agriculture Resource Council
NCVST	Nepal Climate Vulnerability Study Team
SAF-BIN	Strengthening Adaptive Small Scale Farming System in Rain-fed areas in Bangladesh, India and Nepal
SPSS	Statistical Package for Social Sciences
UNFCCC	United Nation Framework Convention on Climate Change
UNDP	United Nation Development Programme
VDC	Village Development Committee

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Global warming and climate change are the great concern of today since they affect the ecosystem of the world. Exponential growth of CO_2 and other greenhouse gases in the atmosphere is causing climate change (IPCC, 2007) affecting agriculture, forestry, human health, biodiversity, mountain to aquatic ecosystems which has been very important issue of discussion and debate in recent years. Sea level rise, polar ice melting, glacier melting, extreme weather events such as storms, floods, droughts and heat waves, changes in morphology, physiology, reproduction, species distribution, community structure, ecosystem and species evolutionary processes in marine, freshwater and terrestrial biological systems, change in crop production patterns, spread of infectious diseases and pests are some of the incidences likely to happen as a result of climate change (IPCC, 2007).

Climate is one of the main determinants of agricultural production. Throughout the world there is significant concern about the effects of climate change and its variability on agricultural production which is complex. Temperature and precipitation are the two factors that govern agricultural production. Depending upon the temperature regime and crop, high temperatures can lead to low yields due to increased development rates and higher respiration. In environments where low temperatures are experienced lead to limiting production, global warming could lead to a beneficial lengthening of the growing season and temperatures close to optimal for adaptation. Higher temperatures eventually reduces yield of desirable crops while encouraging weed and pest proliferation. Changes in precipitation pattern increases likelihood of crop production decline.

Agriculture is the major land use across the globe. Total land area in Nepal is 147,181 km square. 76 % of the population depends on this sector (NPC, 2010). Within agriculture, it is the rain fed agriculture that will be most impacted by climate change. Agricultural land is rain fed in our country and therefore highly vulnerable to weather conditions. Summer monsoon is the only source of water for agriculture. The annual seasonal variation consists of March – May (pre-monsoon), June- September (monsoon), October- November (post- monsoon) and December –February (winter). Rainfall in Nepal occurs due to the southeast monsoon which lasts between the months of June and September. About 80% of the rainfall occurs during monsoon making the remaining months dry. Monsoon rain is higher in the east and decreases as it approaches to the west.

Likewise, temperature is an important weather parameter that will affect productivity of rain fed crops. Atmospheric temperature in Nepal is rising at a rate higher than the global average, with a 1.8^{o}C increase between 1975 and 2006. Nepal's temperature is increasing at high rates 0.06^{0} Celsius per year compared to the global scenario (GON/MOE, 2066 B.S). Precipitation has become increasingly unpredictable; while biodiversity depletion, deforestation, increased frequency of extreme weather events have all negatively affected agricultural production. As the majority of Nepalese engage in smallholder farming which is susceptible to weather volatility, a greater portion of the population will be directly affected by climate change. High level of poverty will restrict the adaptive capacity of Nepalese farmers. Rural communities are also experiencing the increment in temperature and are facing extreme weather events such as erratic rainfall, longer drought, landslides, floods both in terms of magnitude and frequency that ultimately leads to climate change impacts in their daily life mostly in the field of agriculture, forestry and natural resource management.

This study helps to assess adapting measures based on people's prevailed traditional knowledge, skills and experiences. Such farmers' adaptive innovations, techniques, methods and processes based on their own knowledge, skills can prevent devastating climate change impacts which are location specific and community specific. These innovations can be documented so that other communities from distant locations get benefits from these adaptive initiations. Surkhet is one of the districts practicing rain fed agriculture. Surkhet lies in the mid western region of the country which has valleys and mid hills upland area. The district experiences humid sub- tropical climatic regime as well as less amount of rainfall and the onset of monsoon is later. Thus, varying temperature and precipitation affects the overall cultivation pattern. Thus, this study assesses the trend of temperature and precipitation analysis and its relation with agricultural productivity, people's perception on changing climate and type of adjustments people have made on agricultural production to combat changing climate.

1.2 Rationale of the study

Nepal demonstrates a diverse geo-physical and climatic conditions within a relatively small area. It is, therefore, an ideal place to study climate change and its impact on nature and socioeconomic factors. In most parts of the country agriculture is still rain-fed. In the present context, fluctuating

weather and erratic pattern of rainfall has been a constant threat to the farmers leading to drought, flood, land slide, increase in pest number resulting decline in crop production. The resulting low yield of crop production has left Nepal highly vulnerable to climate change. The limited understanding of the impacts of climate change and lack of localized research have proved to be a major challenge for the Nepalese agricultural sector as it struggles to cope and adapt with the changing nature.

Taking Latikoili VDC of Surkhet district as reference this study intends to study the perceptions of climate change among local farmers and the types of adjustments they have made in agricultural practices in response to the changing climate.

1.3 Objectives

The main objective of this research is to study the impacts of climate change on agriculture and adaptation measures practiced by farmers, using Latikoili VDC of Surkhet district as the case-study.

Specific objectives

The specific objectives of this research are as follows:

- To analyze the trend of temperature and precipitation
- To find the relation between climatic variations and agricultural productivity of major crops.
- To study people's perception on climate change and its impact on agriculture.
- To assess agricultural adaptive measures practiced to combat the effects of climate change.

1.4 Scope of the study

Since very few agro-climatic studies have been done in Nepal among which several studies have been carried out associated with the impact of climate change in Himalayan region (Bajracharya et al., 2007), and very limited studied are done in Terai and mid hills, the findings of the study will be helpful for further researchers. In context of Nepal, lack of research is the major challenge for fighting with impact of climate change. Community and household level studies gives information about perception, local knowledge and adaptation measures which provides basis for development

of strategies to fight climate change locally. This research seeks to investigate impact of climate change in agricultural livelihood and adaptation measures adopted by local people.

1.5 Limitations of the study

VDC level data wasn't available for production of major crops so it was collected for whole district. DHM data for temperature was used from one station because of the missing data from other stations for few years. Rainfall data for few months were not available, hence monthly mean of 29 years were used and calculated accordingly. The study was conducted in only one VDC because of time constraints. 3% of the household survey was done because of the distance of villages, upland areas and transportation facility. This study alone cannot generate complete idea about climate change, its impact and adaptation measures. It provides general information about specific regions. More intensive researches should be conducted to generalize the whole region of Nepal.

CHAPTER II: LITERATURE REVIEW

2.1 Climate change

Climate is defined as average weather conditions (over a period of typically 30 years or more) and can be determined on a regional or global basis. Therefore if the variability of weather changes, this is what we understand as climate change. Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, that persists for an extended period, typically decades or longer, whether due to natural variability or as a result of human activities (IPCC, 2007).

United Nations Framework Convention on Climate Change defined climate change as 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.

2.1.1 Global climate change

According to (IPCC, 2001) there has been an unprecedented warming trend during 20th century. The average temperature of the earth's surface has risen by 0.74°C since the late 1800s (IPCC, 2007). IPCC mentioned that the average surface temperature has increased since the beginning of

Industrial Revolution in the mid 1700s. The current average global surface temperature of 15°C is nearly 0.6°C higher than it was 100 years ago. Most of the increase has been the consequence of human activity. A further increase of 1.5-6°C is projected from the period to 2100. Fourth Assessment Report of IPCC (2007) concluded "most of the observed increase in anthropogenic greenhouse gas concentrations". The average atmospheric CO_2 concentration has increased from 280 ppm in 1850 to 365 ppm at present, and could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates (IPCC, 2001).

From 1900 to 2005 precipitation (rain, sleet and snow) increased significantly in parts of the Americas, northern Europe, northern and central Asia, but declined in the Sahel, the Mediterranean, southern Africa and parts of the southern Asia. Intense precipitation events result in increased flood, landslide and mudslide damages that will increase risks to human lives and properties. Globally there is an increasing trend of climate related disasters. Between 2000 and 2004 an average of 326 climate disasters was reported each year (UNDP, 2008). Record of disaster event between 1991 and 1999 shows that climate related disaster event were 104.

2.1.2 Climate change in Nepal

Nepal as a part of the globe cannot remain untouched to this global change. Nepal's climate is influenced by the Himalayan mountain range and the South Asian monsoon (Mani, 1981; NCVST, 2009).The impact of climate change on agriculture seems to be varied with the temperature and precipitation in different climatic zones. It experiences wide range of climates varying from sub – tropical in the south to the alpine type in the north with a pan of less than 200 km. Although Nepal is responsible for only about 0.025% of total annual greenhouse gas emissions of the world (Karki, 2007), it is experiencing the increasing trends and the associated effects of climate change.

Temperatures are likely to increase more in high mountain areas than elsewhere (Shrestha et. al.1999). It already observed increase in dry period, intense rainfall, flood, landslides, forest fires, glacial retreats and GLOF threats (Shrestha, 2007). Studies have shown that Nepal's temperature increases 0.04-0.06degree Celsius annually (MoE, NAPA 2010). Nepal has experienced 12^{th}warmest years on record in the period from 1975 to 2007 among which studies found out that year 2006 was the hottest. The temperature in the Himalayas is increasing at a faster rate, which is resulting serious impacts on the glacial lakes-the sources of water for Nepal. Himalayan glacier

melt and retreat have been documented by various studies. Fifteen Glacial Lake Outburst Floods (GLOF) events have been documented in Nepal (Ives, 1986; Yamada, 1998). The event was occurred in 1985, when Dig Tsho, a lake in the headwaters of the Koshi River, breached after an avalanche and slid into the river, overtopping the dam. The event destroyed hydro-electricity projects, bridges, houses and farm land not only in Nepal, but also to Bihar state of India (NCVST,2009).

Unlike temperature trends, precipitation does not reveal any significant trends (Shrestha *et al.,* 2000). The inter- annual variation of rainfall particularly precipitation in monsoon is so large that observed trends are very uncertain and could be a part of natural cycles (MoEnv, 2010). Based on data from Sharma *et al.* (1947 to 1993) found that the precipitation trend in Koshi basin shows an increasing trend while eastern and central parts of Nepal face a negative trend of less than 700 mm per decade. Annual average precipitation is decreasing at the rate of 9.8 mm per decade (MoPE, 2004). Precipitation shows no change in western Nepal and up to 5-10 percent increase in eastern Nepal during winter. Summer precipitation is projected to increase for the whole country at the range of 15 percent to 20 percent. Monsoon extremes have been observed in recent years. Nepalgunj in western Nepal recorded the ever highest rainfall of 336.9 mm in 24 hours, on August 27, 2006 (SOHAM, 2006).With the marked spatial and temporal variation, the average annual rainfall is 1800 mm.

2.2 Climate change and agriculture

Agriculture concerns the relationship between the natural environment and human society. The agricultural sector is at the core of environmental concerns over the management of these natural resources. Currently as results of climate change natural resources are threatened, arable lands are being lost to erosion. As water system is affected by climate change; agriculture will be one of the sensitive sectors to induced impacts in Asia. It is reported that the crop yield in many countries of Asia has declined (IPCC, 2007). Malla (2008) in his study mentioned that changing temperatures and erratic rainfall pattern are affecting crop production in Nepal. Agricultural productivity is likely to suffer severe losses because of high temperature, severe drought, flood conditions, and soil degradation.

Combating climate change is vital to the pursuit of sustainable development. Climate change will have disproportionate impact on poor people in rural areas where livelihoods of the majority depend on land resources. For agricultural production to be sufficient to meet the demands of the ever-growing human population all over the world, the impact of the changing climate on the sector must be well understood and integrated into the future planning and practices (IPCC, 2007b).

2.2.1 Agriculture in Nepal

Approximately 65 percent of arable land in Nepal is rain fed and only 24 percent has access to irrigation systems, making the sector highly vulnerable to climate variability. Land under irrigation increased from 583 900 ha in 1981/82 to 1 254 272 ha in 2012 (MOAD, 2012). Most irrigable land is found in Terai region of Nepal. The limited irrigation in the mid-hills and mountains is mainly small-scale surface irrigation and micro-irrigation. The largest share of total crop production comes from the Central Region (nearly one-third), followed by the Eastern and Western Regions. The Terai contributes about 56 percent of annual cereal production. Vegetables cultivated as cash crops in a few areas of the mid-hills with the aim to access to markets.

Studies have been done in Nepal with regard to agriculture in Terai, mid hills and mountain region. Haris *et al.* (2013) studied that under changed climate, wheat yield decreased whereas the yield of winter maize increased due to warmer winters and enhanced CO_2 compared to baseline. In addition to this, duration of both crops was found to decrease owing to higher temperature. It was found that under changed climate, wheat yield decreased whereas the yield of winter maize increased due to warmer winters and enhanced CO_2 compared to baseline. In addition to this, duration of both crops was found to decrease owing to higher temperature.

Baul *et al.* (2013) conducted a study and found that almost all farmers perceived that summers are becoming hotter and longer while 81% of the interviewed responded that winters are becoming warmer and shorter. Meteorological data corroborates the farmers' perceptions. Annual and monsoon seasonal rainfall was highly variable over the last 30 years. The reduction in wheat production due to shorter winters and insufficient post- monsoon rain was evident. Changes in annual rainfall pattern and resulting water shortage also lowered millet production. The appearance of advancing phonological development in trees and earlier ripening of crops were often cited as impacts of change in climate.

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 main summer crops of Nepal are paddy, maize and millet, which comprise nearly 80 percent of total national cereal production. In 2009, according to MOAD estimates, paddy production was 0.5 million tonnes less (equivalent to 11 percent) than it was in 2008. This significant reduction was mainly due to the late arrival of the monsoon, which delayed crop planting. Maize, the second largest crop, suffered a production decline of 4 percent. Millet achieved a minor increase, of 2.3 percent, but this was not enough to compensate for the losses in paddy and maize because millet accounts for a very small share of national cereal production.

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 CO_2 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.

Regmi *et al*. (2008) mentioned that due to the changing climate: changes in agriculture, such as loss of local land races of crops and domestic animals, changes in cropping sequences, scarcity of water due to drying up of wells, and increasing incidences of disease and pest have also been noticed.

(Regmi,2007) in NARC annual report mentioned that Eastern Terai faced rain deficit in the year 2005/2006 by early monsoon and crop production reduced by 12.5 % on national basis. Nearly 10% of agro-land were left fallow due to rain deficit but Mid-western Terai faced heavy rain with floods, which reduced production by 30% in the year Early Maturity of the crops due to increase in temperature may help to have crops in the same crop cycle.

2.3 Adaptation to climate change

Since the Third Assessment Report (IPCC, 2001), policy-makers and the scientific community have increasingly turned their attention to climate change impacts, vulnerabilities and associated risks that may be considered 'key' because of their magnitude, persistence and other characteristics (Schneider *et al.,* 2007). Then, the policies and practices have been focusing on the adaptation aspect to address the climate change concentrating on reducing the impacts and vulnerability of people induced through its events. Then, vulnerability and adaptation assessments were identified as vital tools for developing countries to evaluate and implement responses to climate change (UNFCCC, 2007).

Adaptation is "the adjustment in natural and human systems in response to actual and expected climate stimuli or their effects, which moderated harm and exploits beneficial opportunities" (UNFCCC, 2009).

Responses to climate change are of two types: mitigation and adaptation measures. Mitigation measures to reduce human contributions to climate change. Adaptation to climate change is essential to complement climate-change mitigation, and both have to be central to an integrated strategy to reduce risks and impacts of climate change (Adegoke *et al.,* 2007).Adaptive measures should be introduced at strategic level and local level involving farmers. The adaptive measures such as choosing suitable drought tolerant of stress tolerant variety, integrated pest management activities, crop diversification and diversifying the source of incomes through off-farm and on-farm activities should be introduced to combat climate change (Bordoni, 2009).

Manandhar *et al*. (2010) conducted a study which revealed that most farmers perceive climate change acutely and respond to it, based on their own indigenous knowledge and experiences, through both agricultural and non-agricultural adaptations at an individual level. In order to capture some variability, a comparative study was performed in two different ecological regions: Terai (lowland) and Mountain (upland) in the western development region of Nepal. The study focused on perceptions of farmers, and on adaptations to climate change by farmers. Information was collected from both primary and secondary data sources. Climate data were analyzed through trend analysis. The study also shows that farmers are aware about changing climate and there is a need

to go beyond the individual level, and to plan and provide support for appropriate technologies and strategies in order to cope with the expected increasing impacts of climate change.

Sharma (2010) conducted a study in agricultural livelihood of indigenous community in high hills of Sankhuwasabha district and observed that new cultivars of crops have been introduced to increase the agricultural productivity. Stone walls are constructed to prevent landslides. Local irrigation canals are being constructed in drought periods which helped people to combat climate change.

Charmakar (2010) submitted a report to National Adaptation Programme of Action (NAPA)/Ministry of Environment/ Government of Nepal; it revealed 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 titepatiin their agricultural farming to treat increasing number of pest and insect.

LI-BIRD (2009) has reported that several adaptive measures have been identified. It has suggested that the communities risk to disasters can be minimized through integrated approaches of managing local resources and increasing local resilience capacity. These strategies include 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.

CHAPTER III: MATERIALS AND METHODS

3.1 Study area

The study was carried out in Surkhet district of Bheri zone in the Mid-western Development region of Nepal. The district lies within $28^0$36'N and $81^0$38'E and covers the total land of 2451 km^2.The district headquarter is Birendranagar.Surkhet Valley lies in the Inner Terai Valleys of Nepal. Bordering districts are Jajarkot, Dailekh, and Achham to the north, Bardiya and Kailali to the south, Salyan district to the east, and Doti to the west. Surkhet has total land holding area of 249016 ha which is occupied by forest, pasture and barren land. The total agricultural land covers 37444 ha and non agricultural land covers 14756 ha. The district has one municipality and 50 VDCs. The population of Surkhet is 350804 with a population density of 143 per sq km. The majority of people are Bhramin and Chettri followed by Newar, Magar, and Tharu. Surkhet has moderate climate. The district experiences humid sub- tropical climatic regime. The annual maximum and minimum temperature of the area are 38°C and 5°C respectively. Monsoon brings sufficient rainfall during the rainy season (DDC, 2013).

The detail study on perception of local people on climate change, impact on agriculture and types of adjustment they have made on agricultural practices was carried out in Latikoili VDC of Surkhet district which lies within $28^0$32.543'N and $81^0$36.107'E (SAF-BIN ,2012) and covers the total area of 65.9 km^2.The total area covered by VDC is 3125 ha, of which total agricultural land is 1796 ha. Irrigated land covers 1038 ha and non irrigated land covers 758 ha. The majority population in Latikoili resides in agriculture and livestock. The study site was purposively selected because 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). Mostly, indigenous and poor communities reside here and impacts of climate change such as drought, flood, hailstone, cold waves were observed in the study area.

Table 3.1: VDC profile

VDC	Area(km^2)	Population	Population density	Total household
Latikoili	65.9	19963	303 per sq km	4330

(Source: National Planning and Housing Census, 2011)

District map of Nepal

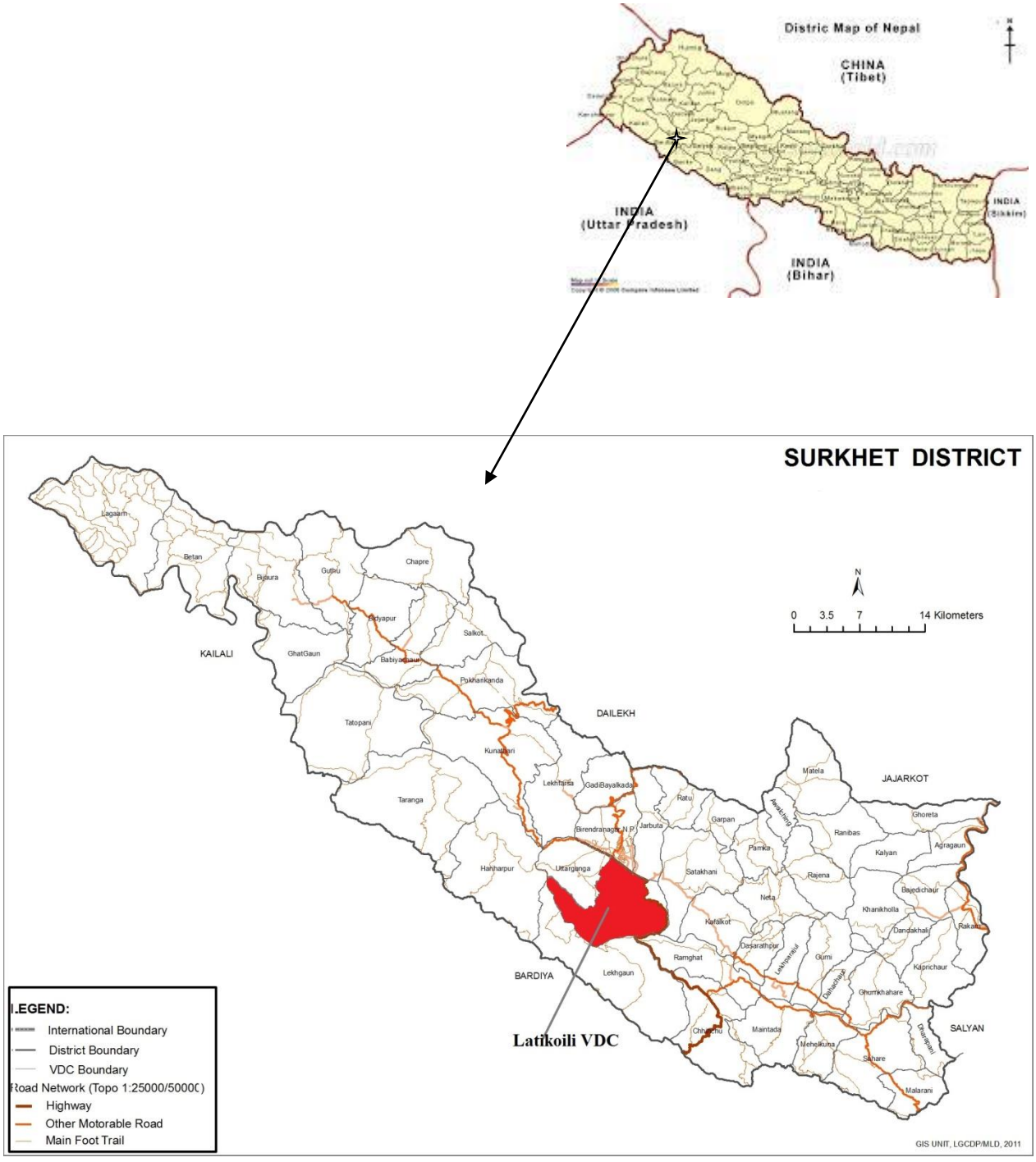

Figure 3.1 Map of Nepal and Surkhet district highlighting Latikoili VDC
(Source: www.mapofworld.)

Google map

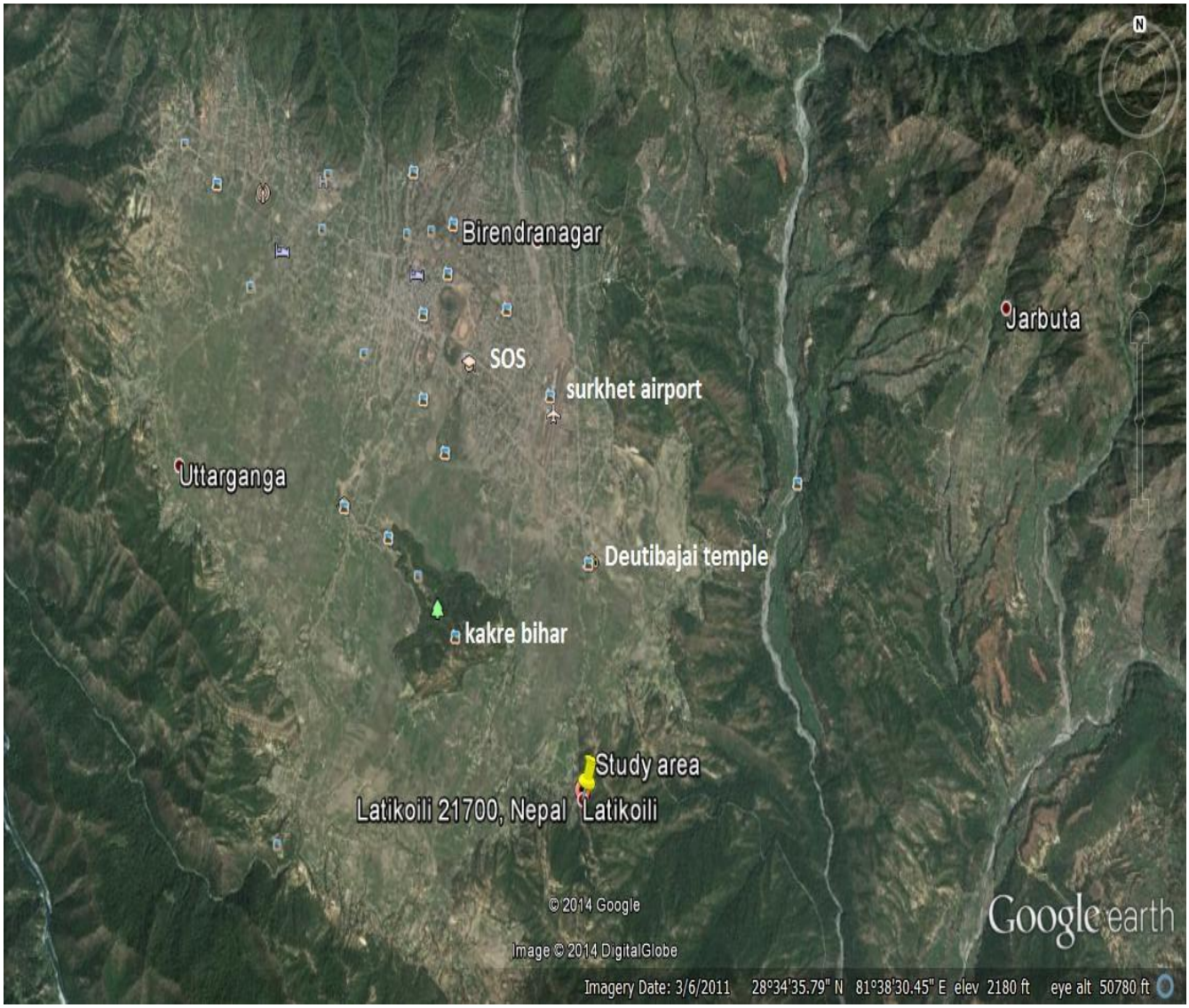

Figure3.2 Study area: Latikoili VDC (Source: Google earth)

3.2 Methodology

3.2.1 Data collection:

Qualitative as well as quantitative methods were adopted throughout the study. Primary and secondary data sources were used throughout the study.

3.2.1.1 Primary data

The methodology includes primary data collection through household survey with semi structured and open-ended questionnaire, key informant interview and focus group discussion within a selected VDC.

Random sampling with certain criteria is selected to perceive people's perception regarding climate change as well as agricultural information. Key informants such as teachers, IPM trainers, agro vet, and aged people are considered.12 key informants interview were taken with the datasheet and pre-tested semi structured questionnaire among those who have more knowledge in farming practices and were residential in that place for more than 25 years. 3% of the households were interviewed which covered 150 respondents. Female participants were interviewed mostly as females were highly involved in farming and agricultural practices. Focus group discussion was applied to get the baseline information about the study area, to understand community perception, understand individual's perception on climate change, impacts on agriculture, agricultural practices and type of adjustment they have made to combat climate change. Informal discussions were done with farmers and local residents to obtain further more information.

3.2.1.2 Secondary data

The secondary data with regard to temperature and precipitation of 29 years (1984-2013) were collected from Department of Hydrology and Meteorology, Babarmahal. The objective of this study equally demands overall productivity of major crops in Surkhet district. Thus, secondary data with regard to agricultural productivity of 29 years were collected from District Agriculture Development Office, Surkhet and Central Bureau of Statistics, Thapathali, Kathmandu. This study was conducted to find out the trend of temperature and precipitation and correlate it with agricultural productivity.

3.2.2 Data Analysis

Both qualitative and quantitative analysis was done to the data collected from primary and secondary sources. The data on weather parameters (precipitation and temperature) was collected from DHM from three meteorological stations in a district. Missing data for few months was replaced by mean using MS Excel. Precipitation data was collected from Pusma camp, Birendranagar airport and Jamu (Tikuwa Kuna) stations and temperature data was collected from Birendranagar airport meteorological stations and was averaged using arithmetic mean method to obtain average precipitation and temperature of the district. Data on precipitation and temperature from 1984 to 2013 was analyzed. The meteorological data of Surkhet district from 1984 to 2013 is plotted using various types of charts such as line graph and scatter graph. Also the temperature and precipitation trend analysis is done using various statistical tools such as trends, extremes and inter annual variations. For the analysis of temperature, annual mean temperature with maximum and minimum temperature is plotted and the trend is analyzed. For the analysis of precipitation, annual precipitation is analyzed. Also, monsoon precipitation and non monsoon precipitation trend is analyzed. Comparative study was done among climatic data and agricultural data to find out the climatic variability in agriculture using Pearson's correlation in SPSS 17.0 package.

Data collected from household survey were compiled, tabulated and the data were statistically analyzed using SPSS tool, MS Excel to know about people's perception on climate change. The descriptive statistics were used to describe the respondent's socio-economic condition such as sex, age, farm size. The graphs are plotted using bar diagrams, pie charts. The adaptation measures are documented from the information gathered from household survey, key informant interview and Focus Group Discussion.

CHAPTER IV: RESULT AND DISCUSSION

4.1 Overview of study area

4.1.1 Demographic characteristics of study area

Of the 150 respondents from respective households, questionnaire survey was conducted. 55 % of total respondent were female while 45 % were male. The total population of the respondent was 873 with the average household size of 5.82.Very few and aged respondents could not respond to the questionnaire easily and could not remember the past events. Respondent were categorized on the basis of age-group. Respondents over 40 years of age were considered. Out of total respondents, 23.33 % were above 65 years of age , 22 % were 50- 55 years , 19.33 % were 45-50 years , 18.67% were 55-60 years followed by 60-65 years old (8.67 %) and 40 -45 years (8 %) shown in figure 4.1.

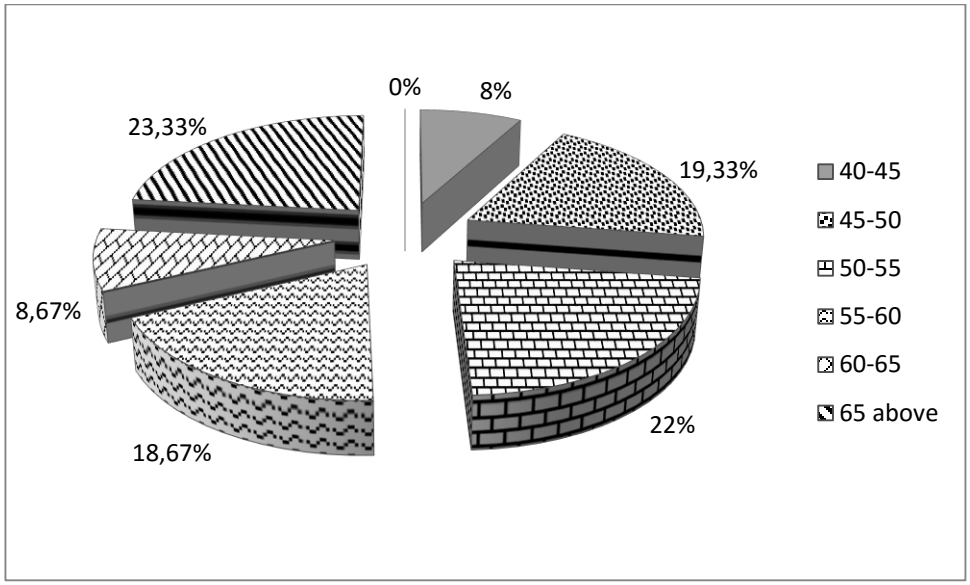

Figure 4.1 Age group of respondent

Out of 150 respondents, the study revealed that the majority of settlement in the study area is Bhramins, Chettri, Tharu followed by Newar, Tamang and others which is shown in figure 4.2.

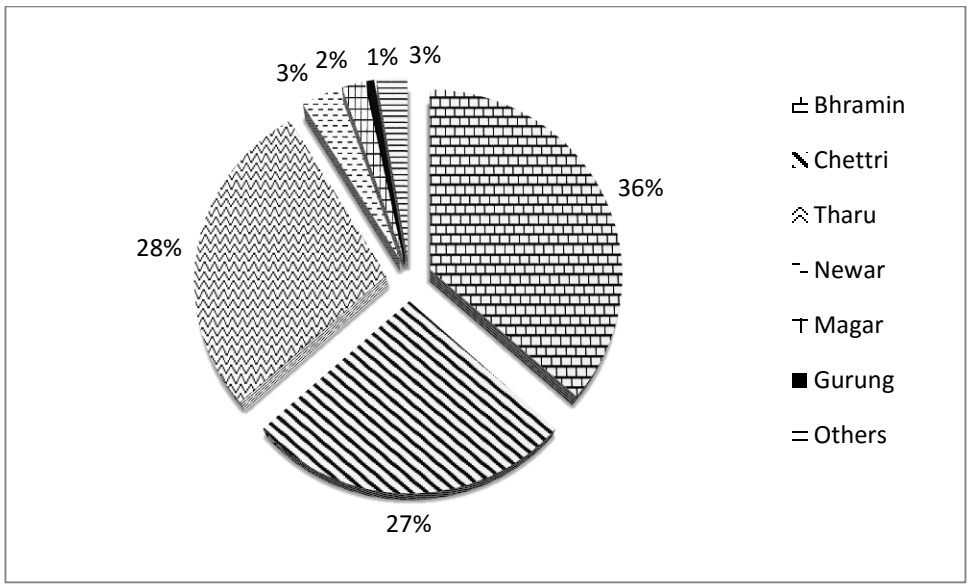

Figure 4.2 Ethnic diversity of respondent

4.1.2 Land holding and farm characteristics

Land holding pattern varies with the available land. There was a large variation in land holding among the respondents as shown in figure 4.3. The range of landholding varied from 2 katta (0.068 ha) to 2 bigga (1.36 ha). The study revealed that about 8% of the total respondent had land of more than 0.68 ha. 29.3% of total respondent had land between 0.034-0.136 ha, 26.7% between 0.17-0.272 ha, 20.7 % between 0.306-0.408 ha, 8.7% between 0.442-0.544 ha and 6.7% of almost 0.68ha. It revealed that majority of respondent in the study area were small and marginal farmers with limited land holding size.

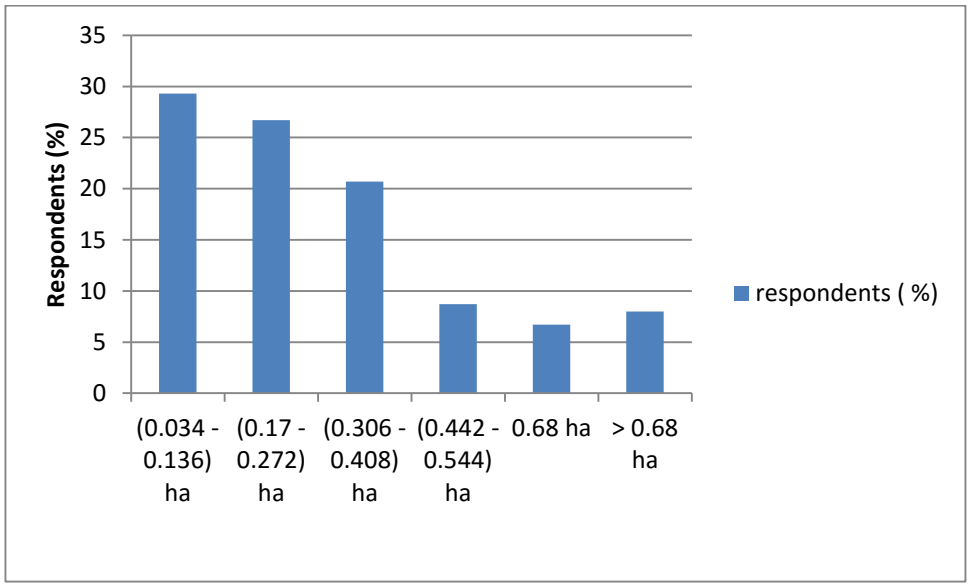

Figure 4.3 land holding of respondent

The cultivable lands in the study area were of two types: Bari-the rain fed upland leveled or sloping terraces, Khet - the leveled terraces, generally located near streams. 78.66 % of the total cultivated land was Khet, 4.66 % was Bari and16.66 % was Khet and bari among respondents. In bari, people mostly cultivated vegetables, lentils and maize whereas in khet, people cultivated rice, wheat and maize, lentils. Rice is the major cereal crops grown followed by wheat, maize and lentil. Rice is planted in summer monsoon, maize in spring and wheat, lentil in winter. Farmers have practiced multiple cropping systems such as rice- lentil, rice - mustard, rice- lentil- mustard, rice – wheat or maize. Off seasonal vegetables were also cultivated. Yield of crops had large variation among respondents.

4.2 Trend of climatic variables in Surkhet district

4.2.1Trend of temperature in Surkhet district

The record of temperatures from 1984-2013 showed an increasing trend (figure 4.4). The annual mean temperature in Surkhet is 21.89 ^{0}C. From 1984-2013, the mean temperature has increased by 0.0343 ^{0}C per year. The highest maximum temperature recorded was 38.6 ^{0}C in the year 2012 and the lowest maximum temperature recorded was 33 ^{0}C in the year 2006 and 2007. The highest minimum temperature recorded was 6.4 ^{0}C in the year 1992 and the lowest minimum temperature recorded was 3.7 ^{0}C in the year 2007. The mean maximum temperature is increased by 0.0414 ^{0}C per year and mean minimum temperature is decreased by 0.0402 ^{0}C per year.

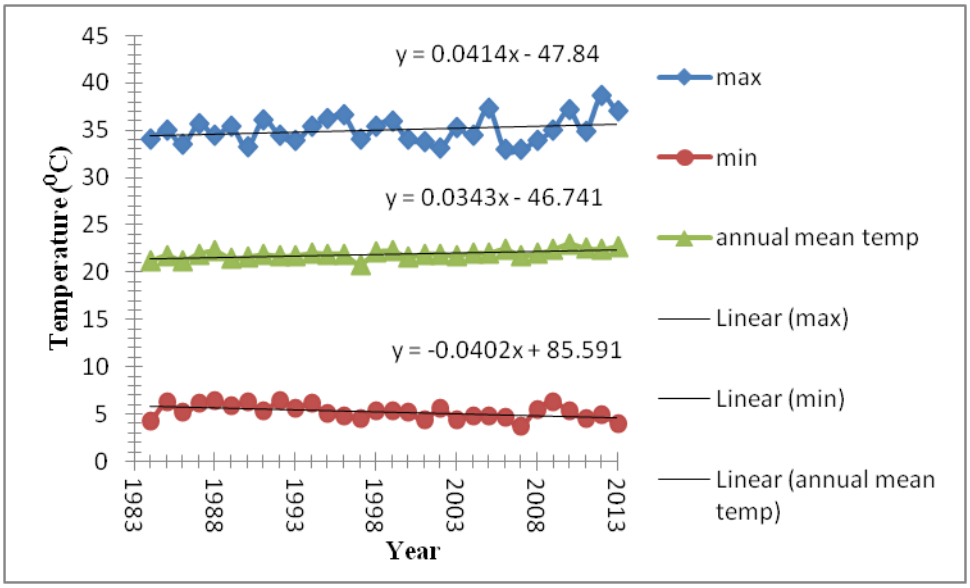

Figure 4.4 Annual variation of temperature in Birendranagar airport (1984 – 2013)

4.2.2 Trend of precipitation in Surkhet district (1984- 2013)

Precipitation data from three meteorological stations reveals the decreasing trend (figure 4.5). In a study conducted by Chalise (2001) stated that on the meso-scale, the impact of climate is mainly due to local topographic characteristics with dry inner valleys receiving much less rainfall than the adjacent mountain slopes as a result of the lee effect. Therefore in my study the trend analysis based on annual precipitation record of 1984-2013 at three meteorological stations clearly showed that pusma camp has the highest precipitation trend of 3.964 mm per year compared to other two meteorological stations.

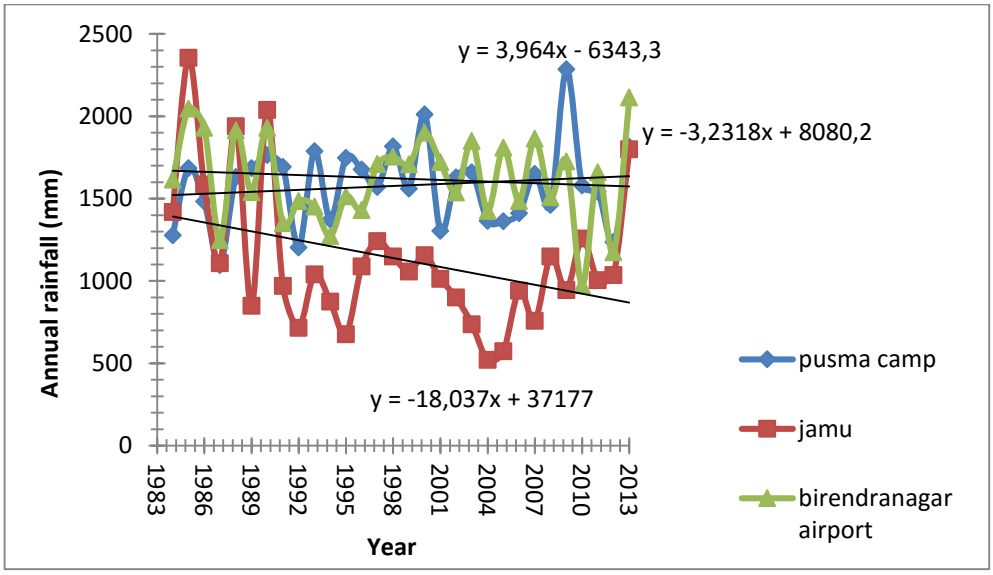

Figure 4.5 Trend of precipitation in three meteorological stations, Surkhet (1984-2013)

The precipitation data from the three meteorological stations were averaged for average annual precipitation as shown in figure 4.6. The record of annual, monsoon and non monsoon precipitation (pre- monsoon, monsoon, post- monsoon) from 1984-2013 showed a decreasing trend with large fluctuations (figure 4.7, 4.8). The annual mean rainfall is 1443 mm. From 1984-2013 the mean annual rainfall has decreased by 5.7 mm per year. The amount of annual rainfall is decreasing and the pattern is becoming erratic. Highest rainfall (2028.53 mm per year) was recorded in 1985 whereas the lowest (1103.06 mm per year) was recorded in 2004.The mean monsoon rainfall is 1179.95 mm per year and mean non monsoon rainfall is 280.74 mm per year.

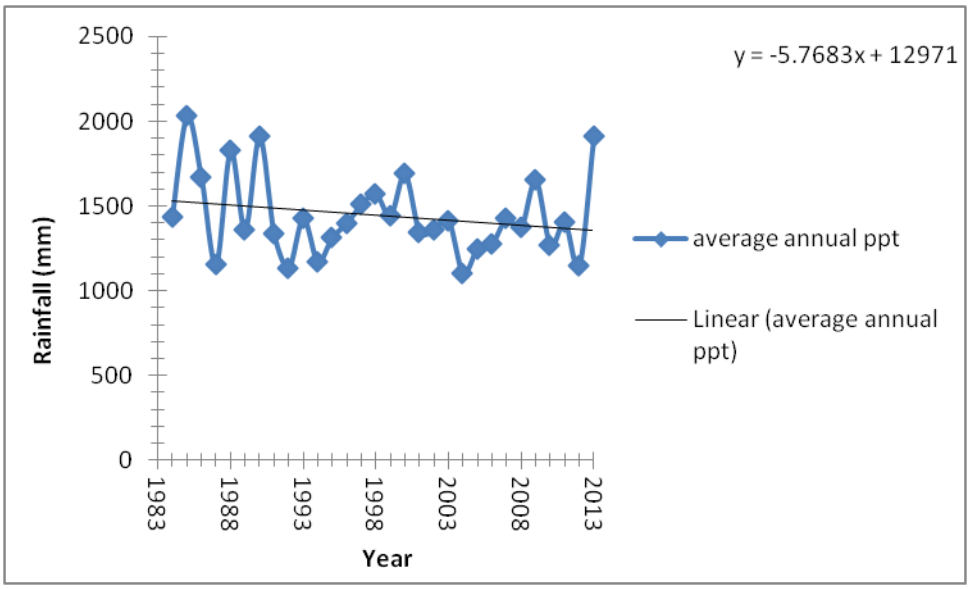

Figure 4.6 Annual variation of precipitation in Surkhet (1984 – 2013)

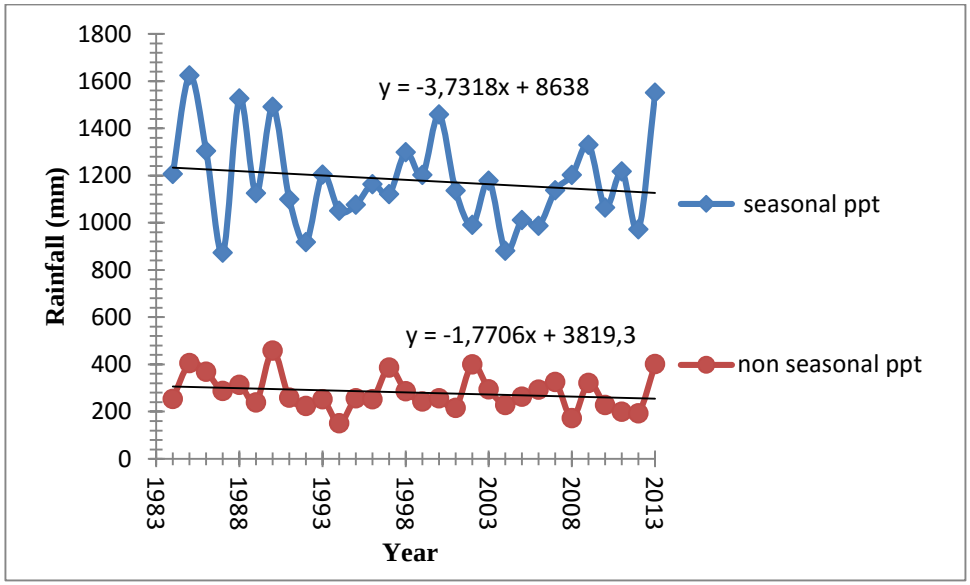

Figure 4.7 Annual monsoon and non seasonal rainfall in Surkhet (1984-2013)

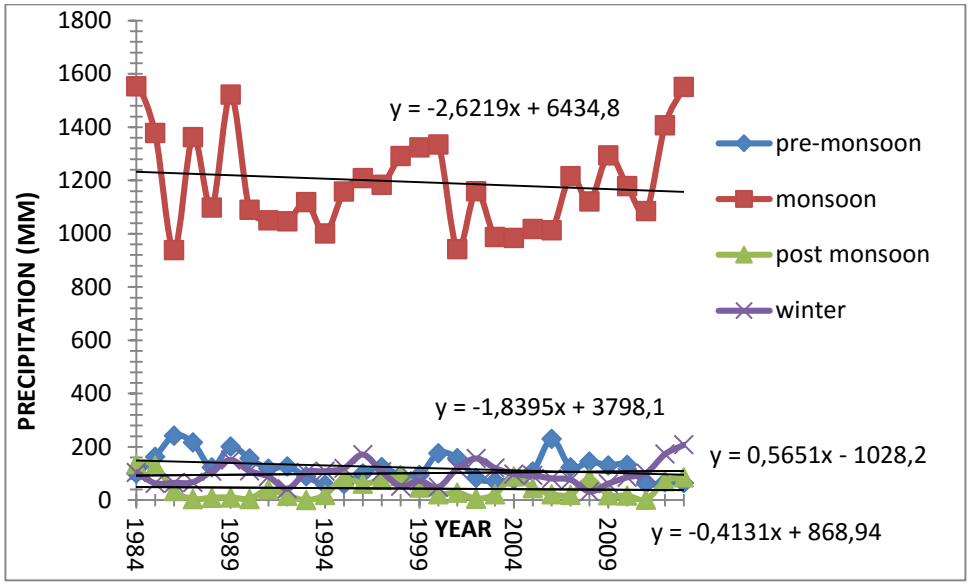

Figure 4.8 Trend showing pre-monsoon, monsoon, post-monsoon and winter precipitation (1984-2013)

4.3 Agricultural production and climate change

4.3.1Crop production in Surkhet district

Agriculture on Surkhet is rain fed. Farmers depend on monsoon precipitation for agricultural activities. The major crops grown were rice, maize and wheat which require optimal temperature and precipitation for its growth and development. Data on crop production at VDC level was not available, so data for the whole district was used for analysis. Over the last 29 years (1984-2013) showed a variation in crop production. Crop yields were declining in some areas due to adverse climatic conditions and climate change extremes such as drought, flood, hailstorm, cold waves during cropping season. Besides, traditional agricultural practices are still being followed which results in declining crop production whereas increase in crop production is due to improved agricultural practices such as use of chemical fertilizers, improved varieties of seed, drought tolerant varieties as well as the increase in crop area.

The variation of crop production along with crop area is shown in figures (4.9, 4.10, and 4.11). Linear trend line of annual production of the major crops (rice, maize and wheat) indicates increasing productivity. In the study area the increase in the productivity of rice, wheat and maize is due to use of improved seed varieties, irrigation facility, use of chemical fertilizer and drought tolerant varieties with the increase in crop area. The crop area is increasing because of deforestation activities. In some years the production of rice, maize and wheat is decreasing with the decrease in

the crop area because of flooding, landslide and excess rainfall recorded in some years. In Surkhet, rice, wheat and maize production shows increase in production with the proportional increase in crop area and improved agricultural practices.

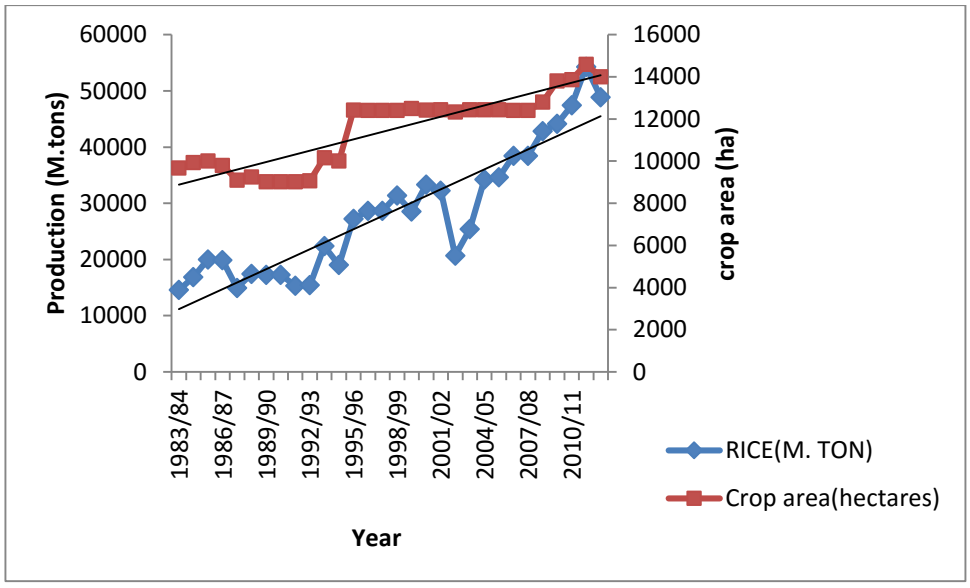

Figure 4.9 Variation of rice production and crop area in Surkhet (1983-2013)

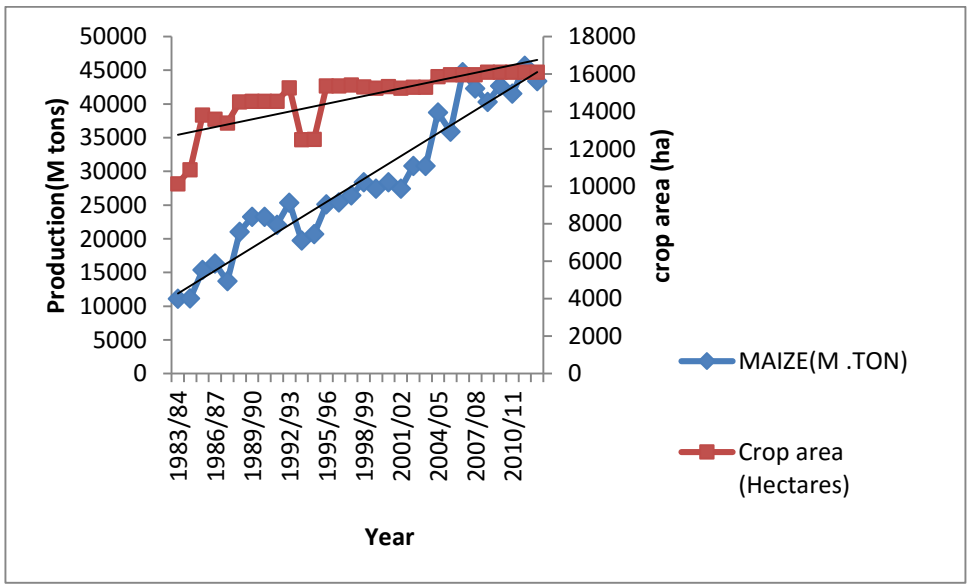

Figure 4.10 Variation of maize production and crop area in Surkhet (1983-2013)

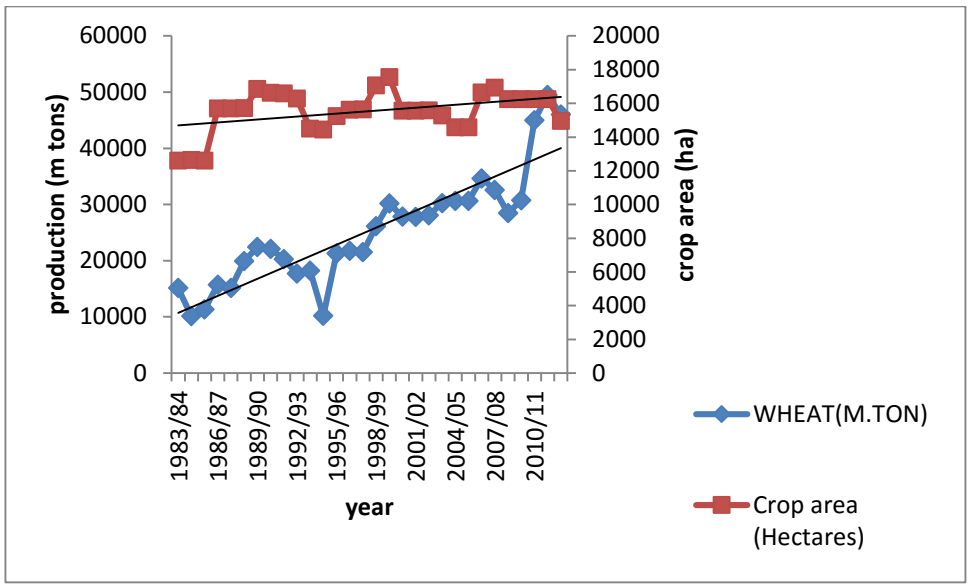

Figure 4.11 Variation of wheat production and crop area in Surkhet (1983- 2013)

4.3.2Correlation between production and climatic parameters in Surkhet district

The relationship between temperature and precipitation with crop production was analyzed using Pearson's correlation. Based on the cropping calendar; the growing season for rice is June - November, similarly growing season for wheat is November-April and growing season for maize is May- October in Surkhet. Twenty nine years (1984-2013) data on maximum temperature, minimum temperature and mean temperature of growing seasons and annual productivity of rice, wheat and maize was correlated using Pearson's correlation. Similarly, data from (1984- 2013) on precipitation of growing seasons was correlated with annual productivity of rice, maize and wheat.

There was statistically significant positive correlation between productivity of rice and maximum annual mean temperature of growing season of rice ($p<0.01$). In the relationship between rainfall and rice yield statistically significant relationship was not observed. However, productivity of rice shows negative relationship with rainfall.

Wheat also showed statistically significant positive correlation with maximum temperature and annual mean temperature during the wheat growing period ($p<0.01$). This shows that there is increase in production of wheat with the increase in annual mean temperature. In relationship between rainfall and wheat yield statistically significant correlation was not observed. The production was wheat shows negative relationship with rainfall.

Similarly, statistically significant positive correlation was observed between maximum temperature, average annual mean temperature and productivity of maize during maize growing period ($p<0.01$). This shows that there is increase in production of maize with the increase in annual mean temperature. There was no statistically significant correlation with rainfall. The production of maize shows negative relationship with rainfall.

The analysis of rice, wheat and maize productivity showed statistically significant positive correlation. This indicates that maximum and annual mean temperature is favorable for rice, wheat and maize production. In relationship between rainfall and the productivity of cereal crops that is rice, wheat and maize; statistically significant relationship was not observed. Therefore, rice, wheat and maize negative relationship. The trend of precipitation was found to be decreasing but precipitation has no significant impact on crop production.

4.4 Farmers perception

4.4.1 People's perception on climate change

The descriptive analysis showed that only 34.67% of the respondents were aware about the term climate change of which 55.76% of the respondents were female. This indicates that about 65.33 % of the farmers were unaware of the term climate change though they have experienced the changes. Moreover, respondents perceived change in the microclimate of the locality. People were aware about the term "climate change" as they have heard it through television, radio and newspaper. Study revealed that most of the respondents were residing in the study area for more than 25 years and had long time experience of climatic trend.

Table 4.1: Changes in microclimate as perceived by respondents

Responses	Increased (%)	Same (%)	Decreased (%)
Temperature	87.3	10	2.7
Precipitation	1.3	-	98.7
Length and duration of rainy days	1.3	-	98.7
Heavy rainfall events	34	12	54
Flood	29	20	51
Drought	89.3	8	2.7
Cold waves	90.7	2.7	6.7

Out of 150 respondents 90 % of the respondents perceived long term change in the temperature. Most of the respondents (87.3%) have perceived increase in temperature which is in accordance with the climatic data. 2.7 % perceived decrease in temperature while few respondents (10 %) have not noticed any change in the temperature. The study revealed that 98.7 % of total respondent noticed decrease in the amount and duration of rainfall while 1.3 % noticed increase in the amount and duration of rainfall. Similarly, respondent observed decrease in the number of rainy days Almost 98 % of the respondent noticed a change in the timing of rainfall, with rain coming either earlier or later than expected. Majority of respondent observed that the monsoon season, which is an important time for agriculture has shifted. 89.3 % experienced increased in the occurrence of drought because of lack of rainfall and lack of irrigation facility whereas 2.7% has mentioned that occurrence of drought has decreased. Almost all respondent found decrease in water sources in recent years which have become drier.34%observed increased frequency of heavy rainfall in short periods.51 % mentioned about decreasing flood intensity and 29 % experience increase in flood intensity while 20 % experienced no changes. Respondents revealed that cold waves and frost have increased since past few years (Table 4.1).

Majority of farmer were not familiar with the term "climate change" despite experiencing changes in climate over years. Farmers have experienced increasing temperature. Farmers stated that the rainfall pattern has changed. There were few evidences which support the climate is changing. Shrawan was known as "Kalo ratri" because of excessive and heavy rainfall in monsoon. Over the past few years, farmers used to carry an umbrella "Syaku "with them while working in the field. They used to experience heavy and timely rainfall. At present, monsoon has been delayed and rainfall has become erratic. According to the farmers, rainfall has become unpredictable. Farmers' perceived prolonged drought associated with decrease in water sources. In the year 2028 B.S people had faced famine. Similarly people have experienced hailstone in 14th Mangsir 2041 B.S that have damaged the field declining rice production and vegetables. Due to the delay of monsoon in 2069 B.S. people were unable to transplant rice cultivation. People have suffered from frequent flooding in the past that used to wear away villages. But in the present context, flooding event has decreased. 2070 B.S had good rainfall in monsoon and the production was good.

4.5 Impact on Agriculture

Agriculture is the mainstay in the study area and more than 90% people were indulged in agriculture. Farmers of Latikoili VDC mostly rely on rain water for agricultural activities. Few of them are facilitated by irrigation, motor pumps, hand pumps and well while rest of the others totally depends on rain water. Reservoirs and river's water level have decreased due course of time. Because of out- migration, human resources working in agricultural land have decreased. According to the farmer's perception in many of the crops, disease and pest infestation has been intensified and erratic pattern of rainfall has been observed as key problems in affecting the crop production and productivity.

Rice is the major cereal crop in the study area. Farmers cultivated rice in summer monsoon (Mid – June). They have reported that due to the delay in monsoon, they were forced to shift the transplanting date depending upon the onset of monsoon decreasing the yield potential. Sowing and harvesting periods of the crops have changed. Farmers revealed that weather pattern is unpredictable so the yielding has become unpredictable accordingly. Farmers in the study area have faced the frost damage in wheat during its initial growth stages. Owing to frost, the wheat is leading to low yield in the study area. Low production of wheat was observed in the study area. Wheat requires a lot of water. Due to the erratic pattern and decrease in the rainfall there was occurrence of drought. Farmers were unable to grow wheat in the study area. Timely plantation has become difficult so cultivation of monsoon maize has been delayed. Winter crops were affected due to lack of rainfall leading to drought. Hailstone damaged vegetables such as cucumber, potato in the year 2012. According to farmers few crops have declined from the study area such as madaley kakro (cucumber), kodo (millet) due to lack of rainfall.

Buffalo, cow, poultry, and goat were the major livestock in the study area. Only 34 % depend on livestock because mostly poor and marginalized people reside in the study area. Moreover, outmigration is the other cause which lacks labor force for grazing and raring livestock. People reported cow manure; natural fertilizer is used less so they have shifted to efficient use of chemical fertilizers for enhancing production. About 62% of respondent used chemical fertilizers to increase the productivity. They reported that the increase in crop production is because of efficient use of chemical fertilizers, adopting improved seed varieties resulting in poor soil quality after few years with decreasing production. Farmers stated that local seeds have declined.

Farmers perceived lengthening of drought period. The water sources have dried up. People were unable to extract groundwater for irrigation. Farmers agreed to the changes in weather pattern which were responsible for disease outbreak. New pests were found damaging crop production. In rice, grasshoppers, borer, caseworm, leaf roller, termites and stink bugs were major pest problems; where as in wheat, termite infestation is high. Likewise, frequent occurrence of loose smut, bacterial leaf blight and blast is a problem in rice, whereas in wheat, smuts and black rust are diseases of frequent occurrence. Heavy rainfall and hailstones were major problem during harvesting time.

4.6 Adaptation activities of local people for agricultural livelihood

At the study area, erratic pattern of rainfall, increase in atmospheric temperature, lack of water sources, increasing pests, long drought periods, declining production, incidence of plant diseases, new pests were found to be the measure threats in maintaining agricultural livelihood. Low productivity of cereal crops, drought and lack of water sources has increased food security in rural Nepal. Usual winter rains have vanished since last 12 years in Nepal (Dahal, 2008). Thus, farming has become difficult. Therefore, adaptation measures should be introduced in an area.

There were some local adaptation measures adopted in response to observed risks and hazards related to climatic and non climatic factors. Most of the coping activities were based on local knowledge and innovations, because most of the respondents were not aware about impacts of climate change. Depending upon the cropping calendar, farmers have started changing their cropping pattern. People have shifted from paddy cultivation to maize and millet due to delay in monsoon. Farmers have been practicing multiple cropping systems such as rice- lentil, rice – lentil – potato. People have shifted to subsistence vegetable farming instead of cultivating cereal crops. People grow off seasonal vegetables to improve their livelihood. They make use of plastic tunnels to maintain the temperature of the tunnel during winter season hence increasing vegetable yield.

Local irrigation canals (Kulo) are being constructed to irrigate agricultural land in drought periods. Due to prolonged drought water sources have become drier. Hence, few farmers have preserved waste water in a plastic pond and they make use of it in their farming area. They lack groundwater system. Only the houses nearby the riversides make use of motor pump and use water for irrigation.

IPM techniques have been introduced and adapted in few areas instead of using insecticides. Improved varieties of seed have been introduced to increase agricultural productivity. Drought tolerant varieties have been introduced to increase production which requires less water for crop cultivation. Local varieties were found to be disappearing from Latikoili VDC. Farmers experienced low production from local varieties. Improved seeds have replaced local varieties of seed because improved variety requires less water for cultivation. According to the farmers, adapting new varieties have increased agricultural productivity.

Table 4.2: Local and improved varieties of cereal crops

Crops	Local varieties	Improved varieties
Rice	Manusuli, Bindeshwori	Tara, Radha -4 , Sukha 1, Sukha 3, Dadhamansuli , US 312, Prithivi
Wheat	Rato gahu, seto gahu	Gautam , Bijaya, Arun -2
Maize	Local	Pioneer, Rampur composite

Moreover, SAFBIN a project under Caritas Nepal at the study area have provided extensive services: trained farmers on distance plantation, cropping system, techniques such as use of plastic ponds to conserve water, plastic tunneling to maintain temperature during winter season, drip irrigation, bottle irrigation, composting, straw mulching to provide moisture to soil, make use of bio fertilizers instead of chemical fertilizers in project research areas. Many untrained farmers have learnt the techniques from trained farmers and have adapted. There is a trend of changing varieties of crops, local races of crops are becoming rare, therefore should be preserved.

CHAPTER V: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Trend of temperature showed an increasing trend with increasing mean annual temperature. The trend of average annual precipitation is decreasing and the pattern has become erratic. The timely rainfall is important for agriculture else it has negative impacts. There is noticeable change in rainfall pattern with the untimely rainfall, which is associated with long droughts and calamities such as landslides, flood occasionally. Soil fertility and irrigation facility are the major problems. Local cultivars have started disappearing from the study area as farmers were unable to adjust changing environment. Study concluded that the production of rice, maize and wheat is increasing with the increase in the crop area. In addition the increase in production is due to improved varieties of seed, agricultural inputs for good production and it is increasing accordingly. In the study area, people were aware of the term climate change knowingly or unknowingly and have experienced changes in climatic extremes. The study indicates the impacts of climate change were seen in agriculture and biodiversity. Disappearance of local varieties of crops, shift in planting time of rice, increased frequency of plant diseases, appearance of new weed species, lengthening of drought, forest fires provide evidence of the changing scenario of the study site. The changing scenario has forced local people to find measures to secure their livelihoods.

The study revealed that the people's perception on climate change is in accordance with the climatic data. In the study area, farmers could recognize increasing temperature and decrease in the volume of rainfall. If the changes continue and timely adaptation strategies are not adapted agricultural sector will suffer the risks in future. Farmers have started adapting agricultural practices knowingly or unknowingly. Adaptation of new crop varieties such as drought tolerant varieties, multiple cropping system , conservation of waste water by constructing plastic pond, shift in cultivation from cereal crops to cash crops, irrigation techniques , use of plastic tunnel for vegetable production have been introduced in study area. However, poor and marginalized group were unaware regarding climate change impacts and adaptation measures. Raising awareness and sharing information among the locals can be done to adjust with climate change impact and enhance agricultural livelihood.

5.2 Recommendations

As climate change is occurring at a faster rate due to increase anthropogenic activities and most vulnerable are those who have less resource to adapt. More researches relating climate change and perception needs to be done, especially to aware local people about changing climate and its impact. Empowering communities with information, technological skills, education and employment is the best way to address vulnerability. A location wise action-research is therefore necessary to identify and document climate change impacts and adaptation strategy. It provides a clear direction for future research and for development planning and adaptation management programs in different ecological regions.

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APPENDIX A: Survey Questionnaire

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**	**Before 20 years ago**
Agriculture		
Livestock		
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

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

Climate Variables	Observed in the last 30 years		
Temperature	-	same as today	+
Summer season temperature	□	□	□
Winter season temperature	□	□	□
Precipitation	□	□	□
Summer monsoon	□	□	□
Winter monsoon	□	□	□
No. of rainy days	□	□	□
Amount and duration of rainfall	□	□	□
Extremes events			
Heavy 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)		

7. Have you ever tested your soil?
   a. Yes b. No

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

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

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?
……...
……

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				

13. 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): ……

14. 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: …….

15. Did you adopt any new crop varieties in your field?
    a. Yes
    b. No
    If yes, do list the name?
    - ……
    - ……
    - ……
    - ……

16. What is the main reason for adopting those new varieties?
    a. Drought tolerant
    b. Diseases/Pest tolerant
    c. Good quality
    d. Other: ……..…

17. 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		

18. What are the crops you are not been able to cope in regards to climate change?

APPENDIX B: Focus Group Discussion

1. According to you what is climate change? How do you define it? Where did you hear the term from?

2. Experiences of climate change?
3. What are the major crops cultivated?
4. Is the growing season of crop shifting? If yes, in what ways?
5. How many times do you cultivate?
6. Do you use fertilizers/ chemicals? IF yes, what amount?
7. Are there any new varieties of seeds given for cultivation?
8. What should be done for enhancing more production?
9. What are the pests that you find in crops?
10. Adaptive measures adopted?
11. What do you suggest?

APPENDIX C: Correlation of cereal crop productivity and climatic parameters

Correlations

		Rice production	T max	T min	T avg	Ppt
Rice production	Pearson Correlation	1	.729**	-.040	.587**	-.059
	Sig. (2-tailed)		.000	.834	.001	.757
	N	30	30	30	30	30

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

Correlations

		Wheat production	T max	T min	T avg	Ppt
Wheat production	Pearson Correlation	1	.688**	-.196	.493**	-.230
	Sig. (2-tailed)		.000	.300	.006	.221
	N	30	30	30	30	30

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

Correlations

		Maize production	T max	T min	T avg	Ppt
Maize production	Pearson Correlation	1	.613**	.085	.568**	-.208
	Sig. (2-tailed)		.000	.655	.001	.271
	N	30	30	30	30	30

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

APPENDIX D: Photos relevant to project work

Plate 1: Occurence of drought

Plate 2: Pest problem in maize crop

Plate 3: Respondent interview

Plate 4: Respondent Interview

Plate 5: Key informant interview (DADO)

Plate 6: Key informant (Sister Rosita)

Plate 7: Focus Group Discussion 1

Plate 8: Focus Group Discussion 2

Plate 9: Plastic pond

Plate 10: Composting and straw mulching

Plate 11: Drip irrigation

Plate 12: Bottle irrigation