CLIMATE CHANGE AND ITS IMPACT ON AGRICULTURE

(A Case Study of Mangalbare VDC, Ilam)

A Thesis Report

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LETTER OF RECOMMENDATION

This is certify that the Thesis Report entitled on **Climate Change and its Impact on Agriculture (A case Study of Mangalbare VDC, Ilam, Nepal)** has been completed by **Mr. Rajeshwar Rijal**, under my full guidance and supervision for the partial fulfillment of the requirement of Thesis report for masters degree of Social Science and Humanities in Rural Development. I hereby recommended this report for its evaluation and approval.

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LETTER OF APPROVAL

This is certify that the Thesis Report entitled on **Climate Change and its Impact on Agriculture (A case study of Mangalbare VDC, Ilam, Nepal)** completed by Mr. Rajeshwar Rijal has been examined by Central Department of Rural Development of University Campus, TU, Kirtipur, Kathmandu, Nepal. It has been declared to be a successful work for fulfillment of academic requirements towards the completion of Masters of Social Science and Humanities in Rural Development.

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ABSTRACT

The climate change in general is the change in rainfall and temperature pattern in any region which affects various other sectors such as agriculture and water resources. This study attempts to find the impact of climate change on agricultural system of Mangalbare VDC, Ilam, Nepal. The investigation includes the analysis of agricultural production system, land use system and analysis of temperature and rainfall data to identify the climate change trend and pattern during the 1993 to 2008.

The analysis of mean temperature shows that, temperature is increasing about 0.98^{o}c in every 14 years (1993-2008). This shows that the warm days are increasing and cold nights are decreasing in the recent years. The analysis of precipitation shows that, the rainfall trend is also decreasing there is 82.8mm difference in annual mean rainfall from 1993 to 2006. This shows that there is slightly changing on climatic parameters in every decade.

Cereal crops, cash crops and vegetable production trend are considered to analyze the climate impacts. Paddy and millet yield shows the positive impact due to increasing temperature and production of other crops such as wheat, maize, cardamom, amriso, zinger, tea, vegetables etc. are decreasing due to rain deficit and problems of diseases. Production system of this region is not only affected by climatic parameters but also affected by availability of natural resources and farming practices. Local people of this area are practicing in mix type i.e. mix of traditional and modern farming system and they are suffering from climate change. So to minimize this problem awareness program and capacity building program should be focused for local people. Agriculture research agencies and government of Nepal should make appropriate policy and implement properly for control the climate borne disaster in future for this region.

TABLE OF CONTENTS

CHAPTER THREE

RESEARCH METHODOLOGY

CHAPTER FOUR

STUDY AREA DESCRIPTION

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS

CHAPTER SIX

SUMMARY CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS/ACRONYMS

ADB	=	Asian Development Bank
AEPC	=	Alternative Energy Promotion Center
CBS	=	Central Bureau of Statistics
CO_2	=	Carbondioxide
DHM	=	Department of Hydrology and Meteorology
FAO	=	Food and Agriculture Organization
FGD	=	Focus Group Discussion
FLOF	=	Glacial Lake Outburst Flood
GDP	=	Gross Domestic Product
I/NGO	=	International/Non Governmental Organization
ICIMOD	=	International Centre for Integrated Mountain Development
IPCC	=	Intergovernmental Panel for Climate Change
MoF	=	Ministry of Finance
NARC	=	Nepal Agriculture Research Council
RD	=	Rural Development
TU	=	Tribhuvan University
UNDP	=	United Nation Development Program
UNFCCC	=	United Nation Framework Convention on Climate Change
UNSIDR	=	United Nation Strategy for International Disaster Management
VDC	=	Village Development Committee
WMO	=	World Meteorological Organization
WRI	=	World Resource Institute

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Climate change refers to the variation in the Earth's global climate or in regional climates over time (UNFCCC, 2001) defines this as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere". Climate change impacts are the consequences of natural and human systems.

It has been universally accepted fact that world climate is changing more vigorously at present than any time period in the past putting greater threats to the wellbeing of human beings as well as earth system. According to IPCC (2007) summary report, eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92] °C is larger than the corresponding trend of 0.6 [0.4 to 0.8] °C (1901-2000). The warming trend over the 50 years 1956-2005 (0.13 [0.10 to 0.16] °C/decade) is nearly twice that for the 100 years 1906-2005 (IPCC, 2007).This changed scenario in the earth climate is challenging both the developing and developed worlds.

The increasing temperature and unusual rainfall, drought, flooding, high rate of snow melting and sea level rise are threatening the sustainable continuity of the living earth. Recently, human activities have been identified as likely contributors to global as well as regional climate change (IPCC, 2006). Temperature is a good indicator of climate change. Precipitation may be of equal or greater importance in terms of monitoring global change in low and mid-latitude regions because of their vulnerability to both water shortages and

quality (Shrestha & Wake, 2000). The global and national data clearly show that the numbers of natural disaster events are increasing in recent years. Socio-economic and environmental losses caused by these natural disasters are also increasing. The increasing trend of all type of natural disasters noticeably reveals that highest portion of natural disasters is contributed by climate related disasters compared to other kind of disasters (UNISDR, 2005).

Climate change is principally due to increase in temperature caused mainly by the combustion of fossil fuels to yield energy. With the rapid industrialization powered by fossil fuels, developed countries are the ones mainly responsible for the global warming. Studies show that developing countries are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001a). In a humid climate like that of Nepal, there will be changes in the spatial and temporal distribution of temperature and precipitation due to climate change, which in turn will increase both the intensity and frequency of extreme events like droughts and floods (Mahtab, 1992). Increases in temperature result in a reduced growing season and a decline in productivity, particularly in South Asia (Pauchuri, 1992). A warming climate would increase water demand on the one hand and would decrease river flows on the other. Reduced river flows will affect the hydropower generation, inland water transport and aquatic ecosystems. Similarly, reduced water availability may create conflicts between users within and among nations.

Vulnerability is the degree to which a system is likely to experience harm due to its exposure to hazards. It is determined by the capacity of a system to anticipate, cope with, resist and recover from the impact of hazard. Exposure to natural hazards of the community is increasing day by day, making it more vulnerable with increasing global change and frequent extreme events.

We are globally interconnected and climate change is considered to be problematic issue for many countries impacting various sectors and areas.

Widespread implications of climate change indicate that climate change is a complex and cross-cutting issue. We know that dramatic changes are still to come and they will result in huge economic cost at community level to regional level. Along with the mitigation approach to climate change and associated risk, mainly for the developing countries, it is coping mechanism developed within the community that counts for risk reduction due to climate change.

According to IPCC report "Global atmospheric concentration of carbon dioxide methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. 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 global warming. The global increase in carbon dioxide concentration is due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture." Human activities are increasingly altering the earth's climate changing it in such a way which is not good for the sustainable continuity of the living planet. Cumulative effects of the human activities on the concentration of the gases are increasing threat to increase disasters and unsustainable livelihood.

Global warming, the quicker warming of the earth enhanced by green house effect, has ultimately brought unavoidable climate change consequences. Warming of the climate system is now unequivocal. It is now clear that global warming is mostly due to man-made emissions of greenhouse gases mostly CO_2 (UNFCCC, 2001).

Developing countries like Nepal are more susceptible to the climate change and its impacts due to their limited capacity to cope with hazards associated with changes in climate (Kates, 2000). Nepal has good reasons to be concerned about climate change. Over two million Nepalese people depend on climate

sensitive sectors like agriculture and forestry for their livelihood (Garg, Shukla, & Kapshe, 2007).

Climate change may alter rainfall and snowfall patterns. The incidence of extreme weather events such as droughts, storms, floods and avalanches is expected to increase. This can lead to loss of lives and severely reduce agricultural production (IPCC, 1998). Climate-induced natural hazards have very serious human implications because they affect the livelihood security of the majority of the population (Swaminathan, 2002). Climate change increases the vulnerability of poor people, affects their health and livelihoods and undermines growth opportunities crucial for poverty reduction (ADB et al., 2003). Extreme events due to man-made climate change would cause forced migration and human resettlement resulting in the damage of the social cohesion including the loss of human lives and physical properties. Nepal is well known for its pronounced geographic verticality due to large differences in the minimum and maximum altitudes. The snowy mountains are situated in the high altitude area in the north. Climate change-induced floods generated in these mountainous areas have significant negative effects on the society and economy of the mountains as well as the plains far downstream.

Vulnerability of the system is "a function of the character, magnitude, and the rate of climate variation to which a system is exposed (IPCC, 2007). In disaster planning, vulnerability is the social, economic and environmental exposure and sensitivity. For community and people adaptation is the process of social learning too. Adaptive capacity is the ability to understand climate changes and hazards, to evaluate their consequences for vulnerable peoples, place and economies and to moderate potential damages to take advantage of opportunities, or to cope with the consequences (Dow & Downing, 2006).

The majority of Nepal's present population depends on agriculture for their subsistence but still about 63% of the agricultural lands are deprived of modern irrigation facilities (FAO, 2004a). All the crop water requirements of the non-

irrigated lands are met solely by rainfall. The increased precipitation variability may create difficulties in cultivating these lands and could result in probable food scarcity for the population. Moreover, the agricultural land currently having irrigation facilities may not have sufficient water during seasons in the future due to climate change. That may result in water stress in the agricultural sector of Nepal. Currently, 93% of Nepal's labor force work in the agricultural sector (FAO, 2004a), which provides about 38% of the gross domestic product (MOF, 2008). However, agriculture is largely at subsistence level. In the rural hills and mountain areas of Nepal, where as much as 70% of the population is poor, local food production sometimes covers just three months of the annual households needs (FAO, 2004c). Changing climate conditions causing soil moisture reduction, thermal and water stress, flood and drought etc are putting the whole agricultural sector at serious risk (ADB et al., 2003).

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, precipitation and glacial run-off. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. Rising carbon dioxide levels would also have effects, both detrimental and beneficial, on crop yields. The overall effect of climate change on agriculture will depend on the balance of these effects. Assessment of the effects of global climate changes on agriculture might help to properly anticipate and adapt farming to maximize agricultural production. The 2001 IPCC, Third Assessment Report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. So it is important to research and understand about impact of climate change on agriculture sector.

1.2 Statement of the Problem

Nepal is a small land lock country having an area of 1,47,181 square kilometer, which is situated between two giant countries China in north and India in East, West and South. Nepal's economy is depends on agriculture. About 21 percent land is cultivated for agriculture and it accounts for about 38 percent of the Gross Domestic Product (GDP). The country is susceptible to disasters including flash flood, GLOF and melting ice in the Mountains, Landslides, floods in the Hills and droughts and inundation in the Terai.

The raising temperature and emission of Co_2 in some extent is helpful in production of major crops. For example: increase in agriculture production by enhancing Photo synthetic process, water use efficiency and soil microbial activities. Decrease in grain filling due to increase in respiration process, fertilizer use efficiencies, desertification, increase in soil erosion etc. cause malnutrition in the world overflowing food due to reducing protein and decrease in minerals nutrients content in a different crops are negative effects (Pathak et. al; 2003).

Traditional rainfall of Jestha and Ashar (mid July) have been shifted in Sharwan and Bhadra in Ilam. It has affecting in the paddy production. Eastern Terai faced rain deficit in the year 2005/06 by early monsoon and crop production reduced by 12.5% on national basis. About 10% of the agriculture land were left fallow due to rain deficit but in mid western Terai faced heavy rain with floods which reduced production by 30% in that year (Regmi, 2007).

Nepal has various types of agricultural zones like plains, Hills, mid- hills high land and Mountains. Changes in agro- zones lead to the change in cropping pattern of zone. Climatic parameters have potential impact to change the ecological distribution of agricultural crops. In this case the farmers of hilly regions are also affecting by climate change but they don't know why their agriculture production pattern is changing? What are the causes of changing agricultural production in existing time? In this scenario, study on the impact of

climate change on agricultural production in hilly region helps to local farmers to know about climate change. And also helps to farmers for agricultural practice with the challenge of climate change. There is necessary to strength about climate change for local people, who are depending on agriculture for their livelihood.

1.3 Objectives of the Study

The general objective of this study is to assess the climate change and its impact on agriculture. Where as specific objectives are:

i) To assess the pattern and trend of rainfall and temperature (climate change) in the study area based on hydro metrological data.

ii) To analyzed the agriculture pattern of the study area.

iii) To assess the impact of climate change on agriculture in the study area.

1.4 Significance of the Study

The research on the climate change with in the country is very less. There is, few national level study and reports can be found and very few on local level for vulnerability to climate change. In case of Nepal, Agriculture is the backbone of Nepalese economy. About 80% Nepalese are depending on agricultural occupation which contributes about 38% of the GDP. But nowadays agriculture sector is affected directly or indirectly by climate change. So the local level study (research) is more relevant than mega-scale study in the country Nepal which has high diversity in natural as well as human system with in a short spatial variation.

Climate change is considered to be problematic burning issue for many countries impacting various sectors like: infrastructure, forestry, agriculture etc. widespread implications of climate change indicate that climate change is a complex and cross-cutting issue. In this scenario local level case studies are vital for policy formulation and adaption. Mountain regions of Nepal are more susceptible to climate change impact and vulnerability. In this context study on vulnerability due to climate change and its impact on agriculture has great significance.

1.5 Limitation of the study

The research study is limited on the following points:-

i) There is lack of enough resources for research.

ii) The time is limited for this research.

iii) Some data were taken from secondary sources.

iv) Study area is small, it could not cover the whole district.

v) Research was based on social survey.

1.6 Organization of the study

The whole study covers in six different chapters. The first chapter shows the introduction of the study. The second chapter consists of review of literature. Chapter three includes the research methodology. Chapter four consists of description of the study area. In chapter five it includes the data presentation and analysis. The last chapter six contains the findings, results, conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

United Nations framework Conventions on Climate Change (UNFCCC) in its Article 1 defines climate change as *a* change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability which may be due to natural internal processes or external force, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2006).

2.1 World Climate Change and Global Warming

The climatic reconstructions from various proxy-methods reveal that the late 20th century is the warmest ever period in the past two millennia. Besides, during the past two millennia, Medieval Warm Period (MWP) was another period of unusually warm weather around tenth to fourteen century. This warming period was followed by the Little Ice Age (LIA). It was a cold period that lasted from about 1550 to about 1850 in Europe, North America and Asia. This period was marked by rapid expansion of mountain glaciers. There was three minima, beginning about 1650, about 1770 and 1850, each separated by slight warming intervals. Only after the end of LIA, the meteorological record keeping began as a regular basis, globally (Thompson, 2006). Studies on long term variations in surface air temperature for the entire as well as for the hemispheres have shown a rising trend during the last few decades (Shrestha et al., 1999). More importantly, it has been observed that the temperature changes

less in moist regions than in arid regions (Ren et al., 2006). Climate models referenced by the IPCC (2007) project that global surface temperatures are likely to increase by 1.1 to 6.40C between 1990 and 2100, under various emission scenarios. Although most studies focus on the period up to 2100, warming and sea level rise are expected to continue for more than a millennium even if greenhouse gases levels are stabilized.

While temperature is considered as a good indicator of climate change, precipitation may be of equal or greater importance in terms of monitoring global change in low and mid latitude regions because of their vulnerability to both water shortage and quality (Shrestha et al., 2000).

Precipitation usually exhibits much greater spatial variability, such that regional differences are even more variable and complex than those of temperature. Analyses of global precipitation variations reveal marked trends in recent decades. For example, rain and snowfall amounts over the middle and high latitudes rose steadily over the past decades, whereas a pronounced decreasing trend occurred in the sub-tropics (Shrestha et al., 2000). The same trends have been projected by IPCC (2007), and they predict that precipitation will decrease by as much as about 20% in the sub-tropics under the A1B scenario by 2100 AD. (Ren et al., 2004) suggested that the precipitation decrease in past decades is one of the basic characteristics of climate change in the Central Himalayas.

Global temperature is increasing by 0.3^0C to 0.6^oC since the last 19^{th} century and by 0.2^oC to 0.3^0C over the last 40 years (1960- 2000) (Xiaodong & Baode, 2000) with indication of more increase in the global temperature in coming days making earths sustainability more vulnerable.

According to the Intergovernmental Panel on Climate Change Synthesis Report (2007) there has been an unprecedented warming trend during the 20^{th} century. 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 1.5-6.0°C is projected for the period to 2100. Forth Assessment Report of IPCC (2007) concluded that "most of the observed increase in globally averaged temperatures since the mid 20th Century is very likely due to 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, 2007).

Scientists predicted through the global climate models that the average global surface temperature increase from 1.4°C to 5.8°C due to presumed doubling of CO_2 concentration in the atmosphere by the end of the 21st century. In the northern hemisphere, precipitation has increased by 0.5% to 1.0% per decade whereas the increase in tropical countries has been 0.2% to 0.3% per decade. The trend over the course of the last century has been uneven, but in the period since 1976 the warming trend is roughly three times that of the past 100 years as a whole (WMO, 2004).

The increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC, 2007) clearly indicates the changing trend in climate. Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 ppm to 379 ppm in 2005, and the average global temperature rose by 0.74° C (UNFCCC, 2007) which supports the fact the global increase in the temperature is mainly due to the excess emission of CO_2 from human induced sources.

2.2 Climatic Scenario of Nepal

Geographically, the climate varies in Nepal from sub-basins in the southern Terai plain to arctic in the Himalaya within a span of less than 200km. Nepal has relatively wet summers and dry winters (Konz, 2003). The climate of the nation is characterized by monsoon circulation, principally easterly winds during summer and westerly from October to May. The eastern Himalayas receive the brunt of the monsoon, which loses its effect as it moves west along the mountains (Konz, 2003). Consequently, there is a distinct moisture gradient from east to west. (Thomas and Rai, 2005) reported that temperatures in Nepal are increasing at a rather high rate, with greatest increases found at higher altitudes. The warming seems to be consistent and continuous after the mid-1970s (Shrestha et al., 1999; Horstmann, 2004). Analysis of maximum temperature data from 49 stations in Nepal for the period 1971-1994 revealed warming trend after 1977 ranging from 0.06 to 0.120C per year in most of the middle mountains and the High Himalayan regions while the Siwalik and Terai (southern plains) regions show warming trends less than 0.030C per year (Shrestha et al., 1999). Distribution of seasonal and annual temperature trends show high rates of warming in the high-elevation regions of the country (Middle Mountains and Himalaya), while low warming or even cooling trends were found in the southern regions. This is attributed to the sensitivity of mountainous regions to climate changes.

The scenario of the global change impacts in the fragile mountains of Nepal and around is greater, the major impacts and threats of global warming are widespread. As a result of global warming, the type, frequency and intensity of extreme events, floods, droughts and heavy precipitation events, are expected to rise even with relatively small average temperature increases. Changes in some types of extreme events have already been observed, for example, increases in the frequency and intensity of heat waves and heavy precipitation events (Meehl, et al., 2005) and such events bring more risk to the people living near to riverside or the marginal community.

Nepal demonstrates diverse geo-physical and climatic conditions within relatively small areas resulting vast biological diversity, therefore, it is an ideal place to study climate change impacts on natural and socioeconomic spheres. In context of Nepal, a few studies have been carried out on vulnerability and risk assessment of natural hazards. However most of them are based on the available information of the past without or in only some extent to climate change and potential future risk of climate change related disasters.

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 global warming.

Different reports from (IPCC, 2001), (IPCC, 2006), (IPCC, 2007), (World Bank 2005), and (DFID, 2006) gives in their reports options and ways to reduce the vulnerability in developing country like Nepal. A number of options can reduce vulnerability in all regions of Nepal to climate change and climate related disasters. Non-structural measures are particularly attractive as they generally involve lower costs than engineering measures and would go a long way towards building capacity for disaster preparedness and water resource management. Such measures include: Developing and implementing land use/zoning policies; maintaining up to date hazard and vulnerability maps; training and capacity building for disaster and water resource management; working with the community to increase public awareness and develop early warning systems and evacuation plans; afforestation and reforestation programs (for reduction in flooding/landslide risk).

In Nepal, in between 1995 to 2002, the totals of 6854 lives were lost by the landslide and flood disasters (ADB/ ICIMOD, 2006) with billions of dollars economic lost of land and infrastructures. In total more than 500000 people were killed by landslides in the 20^{th} century globally. In first 25 weeks of 2003, there were 2000 landslides fatalities in 139 large events, 95% of which occurred in less developed countries (ADB/ ICIMOD, 2006). Because of its location in the central part of the Himalayas and with its fragile geology, steep

slopes, high relief, and intense monsoon climate, Nepal is prone to water induced disasters such as flood and landslides. Over the last twenty years from 1983-2002, flood and landslide caused 6466 deaths and more than US $200 million in damage. In 1993 alone there were more than 1300 lives lost and over US $ 2 million of property and infrastructure destroyed by an individual event recording the highest 24-hr precipitation of 540mm (ADB/ ICIMOD, 2006).

Global sea level rose at an average rate of 1.80 (±0.50) mm per year over 1961-2004, with an estimated contribution of 0.50(±0.18) mm per year from melting glaciers. The projected sea level rise at the end of the 21st century ranges from 0.18 to 0.59 mm per year under the different emission scenarios (IPCC, 2007). This trend of sea level rise will affect coastal regions throughout the world causing flooding, erosion and salt water intrusion into aquifer and fresh water habitants. Thus, even those who live far from the mountains will have to face the consequences of melting glaciers (Hall and Fagre, 2003). Snow melting rate of Nepal's Himalayas is increasing so about 20 Glacier Lakes are risky in Nepal. Which are going to outburst (GLOF), (Annapurna national daily, 2066/5/25). According to UNDP/KERP report the Sapti Koshi River flood in Sunsari district affect about 43,000 Nepalese people in 18 August, 2008, was the heavy disaster of that year.

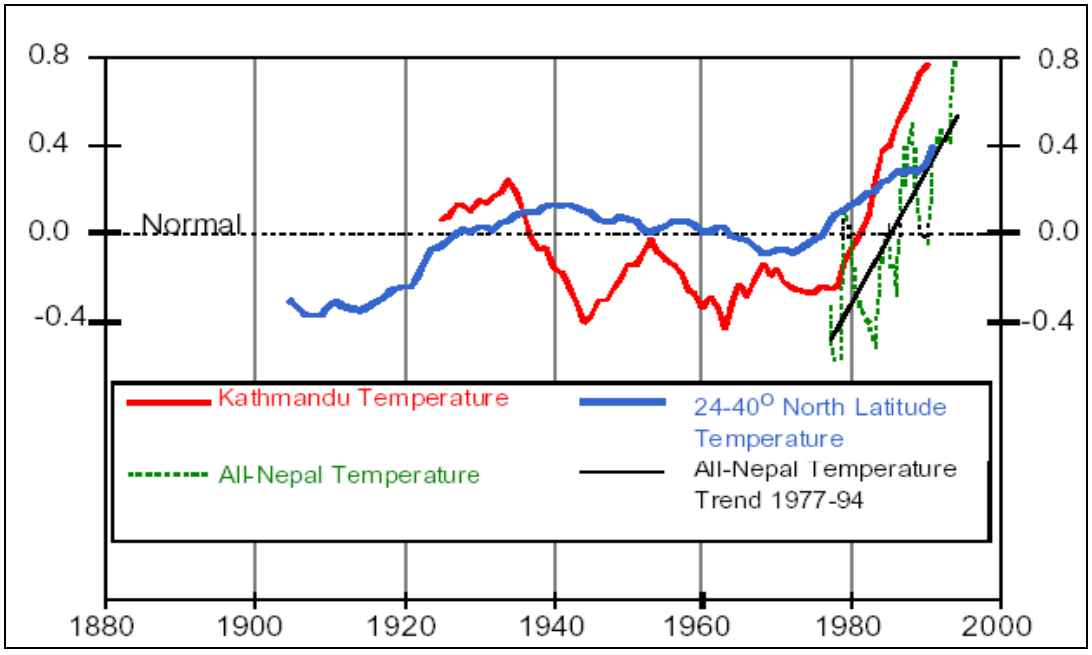
In Nepal, recorded 55 fatalities in 2000, 185 fatalities in 2001 and 345 fatalities in 2002, (Oven et al, 2008) reflecting a rising trend of disasters impact with the economic costs exceeding billions of dollar per year, with remote and rural communities being particularly affected.

An analysis of about 30 years of observed temperature of Nepal has shown that maximum temperatures in Nepal are increasing at an alarming rate (Shrestha et al., 1999). The average warming in annual temperature between 1977 and 2000 was 0.06°C per year. Such warming is found to be more pronounced in the northern high altitude regions of Nepal. Further, warming in the winter is more pronounced compared to other season. Except over western middle

mountainous region, increasing trend is dominant over most of the country for maximum temperature. For minimum temperature, the decreasing trend is observed over the western and west of central mountainous regions and the eastern parts of the country. However, increasing trend is dominant over most of the regions.

Another analysis of daily temperature data for 36 year from 1971 to 2006 using software also shows that both days and nights are becoming warmer and cool days and cool nights are becoming less frequent (Baidya et al., 2008).

The projection of temperature by Organization for Economic Co-operation and Development (OECD) shows a significant and consistent increase in temperature in Nepal for the years 2030, 2050 and 2100 across the various models. This analysis also shows somewhat larger warming in winter months than the summer months. The projected change above the baseline average is 1.2° C for 2030, 1.7°C for 2050 and 3.0°C for 2100.



(Temperature deviation from normal in °C)

Source: Shrestha et al., 1999

Figure 2.2: Comparison between temperatures in Kathmandu and global and all-Nepal temperature.

Analysis of precipitation data from station records all over Nepal does not reveal any significant trends. However, an analysis of daily precipitation data for 46 years from 1961-2006 shows an increasing trend in precipitation extremes. About 73% stations (out of 26 total station selected for the study) exhibited an increase in the annual count of days when precipitation is greater or equal to 50 mm (Baidya et al., 2008).

Nepal is rich in biodiversity and is regarded as a hotspot for some locally and globally important plant and animal species. A recent study projected that doubling of atmospheric CO_2 concentration will reduce Nepal's forest types and habitats and ecosystems will be destroyed. Climate change will also affect productivity of natural ecosystems, particularly provision of environmental services.ss

2.3 Climate Change Policies and initiatives in Nepal

Nepal has taken some initiatives to reduce the GHG emission and mitigate the effects of climate change. Some of them are briefly outlined below.

2.3.1 Institutional strengthening

Nepal showed full commitment to participate and contribute to address the global environmental challenges at Rio de Janeiro in June 1992 through its signing of the UNFCCC on June 12, 1992. Nepal ratified the treaty on May 2, 1994 which came into effect from July 31, 1994 and Nepal responded immediately with the establishment of Environment Protection Council (EPC) under the chairmanship of the Rt. Hon'ble Prime Minister with the objective of integrating environmental concerns into the development process. The EPC initiated the process of formulating the national policy on environment and approved the "National Environmental Policy and Action Plan (NEPAP)" in

1994. In November 1996, GON also established Alternative Energy Promotion Centre (AEPC) under the MoEST. The government of Nepal, realizing the importance of tackling with environmental issues, created a separate Ministry of Environment in 2009.

In the policy and legislative front also, Nepal initiated several measures. It brought Sustainable Development Agenda for Nepal in 2003 to guide the sustainable development path till 2017. Other several policies, strategies, and laws which are relevant to the issues of environmental problems and climate change have been put into force. The major national environmental policies include the National Conservation Strategy, 1988, the Nepal Environment Policy and Action Plan, 1993, the Sustainable Development Agenda 2003. The climate change policy is prepared and in the process of finalization. The Interim Constitution of Nepal, 2006, has, for the first time, recognized "right to clean environment" as a fundamental right of the citizens of Nepal. Environment Protection Act, 1996, Environment Protection Regulations, 1997 and Climate Change Action (formulated), 2066 are the key environmental legislations. The other legislations include Soil and Water Conservation Act, 1982; Water Resources Act, 1992; Industrial Enterprises Act, 1992; Vehicle and Transport Management Act, 1992 and Regulations, 1997 (with first amendment in 2004); Forest Act, 1992 and Regulations, 1995; Local Self-governance Act, 1999 and Local Self-Governance Regulations, 1999 and Ozone Depleting Substance Consumption Regulations, 2001.

Recently, world climate change conference, UNFNCC was finished in Copenhagen, Denmark (Cope15) from 7 December to 18 December 2009. Nepal was also the participant of that conference. Cope 15, concludes the 12 points declaration for climate change. But that declaration is not more beneficial for developing countries like Nepal (THT, Dec. 20, 2009).

2.3.2 Hydrological and Meteorological Observation

Department of Hydrology and Meteorology as a focal point to IPCC maintains nation-wide networks of 337 precipitation stations, 154 hydrometric stations, 20 sediment stations, 68 climatic stations, 22 agro-meteorological stations, 9 synoptic stations and 6 Aero-synoptic stations. DHM analyzes the observed results and publishes them regularly and also maintains database. Considering the extreme topographic characteristics and dense network of streams, the network of meteorological and hydrological station are not representative of the natural processes and there is a great need to strengthen the network (*www.dhm.gov.np*).

2.4 Impacts of Climate Change on Agriculture

Increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. The potential impacts on rain fed agriculture vis-à-vis irrigated systems are still not well understood. The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). The estimate for Africa is that 25–42 percent of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines (McClean, Colin *et al*., 2005). In developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural GDP (FAO Committee on Food Security, Report of 31st Session, 2005). Changes in ocean circulation patterns, such as the Atlantic conveyer belt, may affect fish

populations and the aquatic food web as species seek conditions suitable for their lifecycle. Higher ocean acidity (resulting from carbon dioxide absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs. Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions (IPCC, 2004).

Climate change has direct effects on livestock productivity as well as indirectly through changes on the availability of fodder and pastures. Climate determines the type of livestock most adapted to different agro-ecological zones and therefore the animals that are able to sustain rural communities. Climate change is expected to affect livestock at the species level. For example, if the Himalayas turn warmer, the yak could be restricted to higher altitudes where grass and fodder is less available. Communities will seek other species for production, relying on their own knowledge.

Since changes are relatively slow, there is need to rely more on continuous observations and experience of farmers and their local knowledge. Climate changes will also affect nomadic and transhumant livestock keepers. New routes and pastures will have to be found. The negative impact of ruminants on greenhouse gases emissions can be addressed through changes in animal husbandry including ruminant diets and animal stocking ratios to avoid nitrous oxides emissions. Larger changes in climate can increase costs exponentially (Hahn and Morgan 1999, cited in IPCC 2001a). Historical success in coping with climate variability suggests that some livestock systems could adapt to climate change successfully. Benefits that might be realized during cooler seasons may be less than (negative) hot weather impacts. However, adaptation could entail dislocation costs for certain producers. FAO can assist in monitoring both the direct (animal genetic resources) and indirect (availability of fodder and pastures) effect of climate change on livestock, provide early warnings to the various climatic zones and assist countries in adapting

livestock policies. In addition, FAO can work with farmers who know by experience which types of animal breeds or varieties can best resist changing conditions, to mitigate the negative impact of ruminants on greenhouse gas emissions through recommending animal husbandry changes such as ruminant diets and stocking ratios.

Agricultural outcomes are determined by complex interactions among people, policies, and nature. Crops and animals are affected by changes in temperature and precipitation, but they are also influenced by human investments such as irrigation systems, transportation infrastructure, and animal shelters. Given the uncertainties about where climate change will take place and how farmers will respond, much is still unknown about the effects of climate change on agricultural production, consumption, and human well-being, making it difficult to move forward on policies to combat the effects of climate change (N.C. Gerald, 2009).

In Nepal, eastern Terai faced rain deficit in the year 2005/06 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 (Regmi, 2007). Shifting of climatic zones has been observed in the country. Cold wave in Nepal in 1997/98 had negative impacts on agricultural productivity and showed reduction in the production of crops by 27.8, 36.5, 11.2, 30, 37.6 and 38 % in potato, toria, sarson, rayo, lentil and chickpea respectively (Source: NARC annual reports from 1987/88 to 1997/98).

Around 39% of the land resource in Nepal is covered by the forests. Agriculture stands second in terms of use of land as it covers around 27%. Because of the growing demands of the population, not so satisfactory land productivity and limited opportunities in non-farm activities, expansion of agricultural land continues with each passing year. The demand for water for irrigation in the agricultural sector has increased tremendously. The irrigated

area expanded from 0.439 million hectares in 1984 to 0.88 million ha in 1998. According to studies done by the Department of Hydrology and Meteorology, the average temperature in Nepal is increasing at the rate of approximately 0.06 degrees Celsius per year. Nevertheless, the temperature in the Himalayas is increasing at a faster rate and this can have serious impacts on the country's glacial lakes. Although definitive trends in aggregate precipitation have not been determined, there are evidences of more intense precipitation events. Glacial lake outbursts could also destroy hydro-projects and cause floods and landslides. Contradictorily, glacier retreats have also been recorded which would lead to contracted flow of water during drier seasons. Therefore, because of climate change and the rising temperatures, Nepal could face drier phases during dry seasons with wetter monsoon (as much as three times the current level of rainfall) with chances of flooding and landslides during rainy seasons with subsequent impacts on agriculture and livelihoods(Alan M, Regmi B.R., 2005).

Rice is the second important crop in the world with production of about 525 million tons from about 148 million hectors. It is cultivated within an altitude of 300-2300 meter above sea level. In south Asia, rice production has to be doubled by the year 2020 (IRRI, 2000). Study on increased CO_2 and temperature in NARC at Khumaltar shows the increase of rice yield by 17.07 and 26.58% even at the increase in temperature in chamber by 6.2^{o}C and 7. Greenhouse effect due to doubling carbon dioxide was observed by 1.16^{o}C and produced 9.51% higher than ambient plots. Nitrogen content of the rice was increased by 16.3% due to rise in temperature, but decreased by 9.8% due to doubling of CO_2 (Malla G, 2008).

Wheat production was increased by 41.5 % in the Terai plain, 24.4 % in the hill and 21.2 % in the mountain under the elevated CO_2. The yield however decreased by 1.8% in the Terai but continued to increase by 5.3 % in the hill and 33.3 % in the mountain at 4^{o}C rise in temperature under irrigated condition. The study conducted in India showed that, in subtropical region

there will be small decrease in potential yield by 1.5-5.8% but in tropical zone the decrease will be 17-18% (Agrawal and Kalra, 1994). It indicates that rainfed wheat productivity is likely to suffer more in Terai as compared to the mid-hill's environment in a climate change scenario. The additional rains had favorable impacts on the wheat yield at all levels of temperature rise (Sherchand et al., 2007).

Maize is second major crop in Nepal but the primary crop in the hills. Soil moisture availability during pre-monsoon determines the planting date of maize. The relaying or mixed cropping in the hills are common practices to ensure harvest of the crop. The millet and soybean is widely relayed at mid-altitude whereas groundnut and beans are also used as relay crops for maize. Being a C_4 photosynthetic pathway plant, its grain productivity is less responsive to impacts of increase in atmospheric CO_2 level. Maize production was increased by 9.0% in the terai, 4.9% in the hills and 15.5% in the mountains. However, the yield continued to decline by 26.4 % in the terai, by -9.3% in the hills but increased to 26.8% in the mountains at 4^oc temperature rise. Thus, the response of temperature to maize crop is more favorable in the mountains than in the Terai and hills (Malla G, 2008).

Livestock is a major component of agriculture. It includes poultry, dairy production and raring animals such as cattle, buffaloes, sheep, goats and pigs. It is the major contributor of methane mainly from ruminant animals. It is estimated to be around 365.78Gg from 19.4 million animals in Nepal. Meat and milk products are perishable goods, which require more energy to conserve the products. It is highly sensitive to fluctuation of atmospheric temperature. Increase in temperature by 2^oC would decrease the meat and milk quality, hatchability of poultry and increases the possibility of disease in the livestock. Thus, it increases the probability of vector born diseases in the human society. On the other hand, increase of atmospheric CO_2 will increase the greenery of the land or fodder and pasture for the livestock's. Increase in amount of green fodder helps to boost up meat and milk production. It will ultimately help in

improvement of economic status of Nepalese livestock farmers. However, if CO_2 is increases rapidly, all the living creatures have to suffer from various impacts like diseases and other problems (Malla G, 2008).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

Research design is the plan structure and strategy of investigations of conceived so as to obtain answers to obtain questions and to control variances. A research design is purely and simply for framework or plan for a study that guides the collection and analysis of data. For the purpose of climate change and it's impact on agriculture the study area, the study was based on the exploratory and case study types of research design. The former had applied to agglomerate the accurate information whereas household survey, key informant interview, focus group discussion etc. was done on case study type of research. In addition, descriptive research had been used to present the gathered data.

3.2 Rationale of Selection of the Area

Mangalbare V.D.C. is one of the main agricultural village of the Ilam district. About 90% people are depending on agriculture for their livelihood (village profile, 2062). About 60% land is covered by agriculture land. It is situated in 720m. to 2055m. from sea level. Paddy is the main crop in lower area and cardamom and livestock rearing is the main occupation for high area people. Nowadays agricultural production rate of this area is not fixed. That is why this location is selected to study for climate change and its impact on agriculture.

3.3 Nature and Sources of Data

Mainly primary as well as secondary data were included on the study of climate change and its impact on agriculture. Primary data were collected from field survey where as secondary were gathered from published and unpublished sources, like: books, journals, articles, websites etc.

3.4 Data Collection Tools and Techniques

This study had applied the following data collection techniques and tools:

3.4.1 Households Survey:

A total 72 households were selected randomly for the purpose of household survey (8 households from each ward). To generate the accurate data form the study site, structured and unstructured questionnaires were asked to the sample households. The focus has been given to consider the elder people of that area.

3.4.2 Key Informant Interview:

To inquire the more information about climate change , key informant interview was applied to those who can informed and policy makers of the government of Nepal. Chair person of the Deumai Multipurpose cooperative Ltd. (milk collection center), branch manager of the agriculture development bank, Mangalbare, J.T.A. of the agriculture branch office, Mr. Tara Thapa, local (cash crops) businessman, Mrs Man Maya Limbu, local leader and farmer of the Mangalbare V.D.C. and many more key person of the study area has been asked question about agricultural production of the study area.

3.4.3 Focus Group Discussion:

Discussion was carried out with local stakeholders to get information about the past and present condition of climate, changes in the water resources, their

economic shifting etc. People who have been residing in the study area for at least 15 years were selected for this purpose. The major stakeholders involved in FGD includes, Ama Samuha (mother group), teachers, local politicians, farmers, social workers and other key persons.

3.4.4 Field Observation Method:

Field observation was carried out number of times. During field visit, observation was made about the disasters, vulnerability and agricultural patterns. Photographs of the area were taken to illustrate later. Important observed information was noted for study.

3.5 Data Analysis

The collected data were arranged in systematic form. The data were analyzed on both qualitative and quantitative method. Then findings, results, conclusion and recommendation were compiled and make a final report.

CHAPTER FOUR

STUDY AREA DESCRIPTION

Nepal, a Himalayan mountainous country, situated between two large countries, China in north and India in South, East and West, occupy an area of 1,47,181 sq kilometers which is about 0.03% of Asia continent and 0.003% of world land mass. Situated on the southern slope of the Himalayas, it stretches in between the latitudes $26^0$22' and $30^0$27' north and the longitude $80^0$40' and $88^0$12' East (Chaudhary, 1998). With representation of about one third of the whole Himalayan range (2400 km), it shows unique climate with rugged topography and sharp altitudinal variation from 68 m in south to 8848 m, the world's highest peak in north within a short span of 145 km to 241 km with average of 193 km. Average east west length is about 885 km. About 83 % of the total land of the country is occupied by high mountains and wavy hills while remaining as flat land of Terai. Within this location of the country we can find tremendous climatic, biodiversity and cultural variation.

Politically, Nepal is divided in to 5 development regions, 14 zones and 75 districts. Among 75 districts, Ilam is one of them which is situated in eastern development region, Mechi zone of Nepal. Ilam, a small but queen hill of Nepal with 600m-3636m height. Geographically linked to Darjeeling in the east, Jhapa in the south, Morang and Dhankuta in the west and Panchtar in the north. Ilam district also divided into 48 VDCs and 1 Municipality. Out of these 48 VDCs, Mangalbare is one of them which is second largest agricultural market of Ilam district.

4.1 Location

Mangalbare VDC is about 30 km. west from district headquarter. It lies in 26^{o} 55' 22'' to 26^{o} 29' 57'' north latitude and 87^{o} 48' 09'' to 87^{o} 51' 40'' eastern longitude. It is situated in 720m. to 2055m. from sea level with 30.18 square kilometer area. Geographically, it lies Santidanda and Sangrumba in east, Dhuseni and Eaktappa in west, Chamaita in north and jeetpur in south. The main market of Mangalbare VDC, Mangalbare bazaar is in 1500m. height.

4.2 Climate

This region has geographical variation so the climate of Mangalbare VDC is temperate and sub-tropical. Average temperature of this area is 2^{o}c to 24^{o}c and annual rainfall is about 2000mm.

4.3 Soil Description and Fertility

Soil type of this region is acidic whereas the main elements contain on soil Nitrogen, Phosphorous and Potash is medium and low. Structurally, sandy and clayey and silt can be found, mainly grey colour can be seen on soil. Fertility rate of soil of this area is normal. To increase the fertility rate of soil there should be need to sustainable management of soil.

4.4 Land use System

By using the Geographical Information System (GIS) the total area of VDC is 30.18 Sq. km. whereas the land use system is given below. Which covered with stream/river/gegren.

Table-1 Land use Distribution:

S.N.	Landuse	Covered %	Covered Area (sq km)
1.	Bagar/ Gegren	0.86	0.26
2.	Bari	38.39	11.74
3.	Pasture Land	6.89	2.08
4.	Khet	11.39	3.60
5.	Deteorated Forest	0.89	0.27
6.	New Forest	34.43	10.39
7.	Old Forest	2.82	0.85
8.	Tea Area	3.05	0.92
9.	Bazar Area	0.23	0..7
	Total	100	30.18

Source: Sustainable VDC profile, 2063

4.5 Demographic Situation

According to population census 2058, total population of this VDC was 6858 and population growth rate was 2.04 (CBS 2058). According to household survey 2063, total household of this VDC is 1348 and population is 7404, whereas the population density is 246.3 per square kilometer (Sustainable VDC Profile, 2063).

4.5.1 Population Structure according to Age

In population structure according to age group, there is highest number of population from 16 to 45 years age group.

Table-2 Population distribution according to age group:

S.N.	Age Group(Yrs)	Female	Male	Total	Percentage %
1.	Up to 5 yrs.	404	404	808	11
2.	6-15 yrs.	803	861	1664	22.5
3.	16-45 yrs.	1866	1805	3671	49.5
4.	46-60 yrs.	413	437	850	11
5.	Above 61 yrs.	198	216	414	5.6
6.	Total	3681	2723	7404	100

Source: Sustainable VDC Profile, 2063

4.5.2 Population Structure according to Ethnicity

Total 16 ethnics (castes) are living in this VDC. According to household survey in 2063, population of Bhramin and Cheetry is highest (42.55%) among all population.

Table-3 Population Distribution according to Ethnicity:

S.N.	Ethnicity	Population	Population %
1.	Bhramin/Cheetry	3151	42.55
2.	Rai	1206	16.28
3.	Newar	745	10.16
4.	Limbu	554	7.48
5.	Magar	454	6.03
6.	Tamang	360	4.86
7.	Sunuwar	296	3.99
8.	Sherpa	196	2.64
9.	Bishwakarma	194	2.62
10.	Darji/Nepali	143	1.93
11.	Agrawal	37	0.50
12.	Khawas/Bhujel	36	0.48
13.	Others	32	0.45
	Total	7404	100

Source: Sustainable VDC Profile, 2063.

4.6 Education Level

Education is the key to open the development overheads. It is the foundation of any development activities. This VDC has high level of education in comparison to national level of 54% in total. It has 73.3% of education level (CBS, 2058). According to village profile 2063, there is 86.04% of literacy rate, out of which 90.08% from male and 82% from female.

There is 1 community campus for higher education, 2 higher secondary school (1 government, 1 private with secondary school), 5 lower secondary school (2 government and 3 form private), 8 primary schools and 7 child development centre.

4.7 Education Level according to Ethnicity

In this topic, education level of Mangalbare VDC is categorized by ethnicity whereas population less than 5 years is not included.

Table-4 Educational Situation according to Ethnicity:

S.N.	Ethnicity	Class Level							
		1-5		6-10		Above 10		Illiterate	
		F	M	F	M	F	M	F	M
1.	Bh/Ch.	174	216	287	287	216	352	256	79
2.	Rai	106	118	79	95	27	37	100	35
3.	Limbu	51	60	24	29	7	12	64	24
4.	Newar	52	47	47	60	47	60	61	21

5.	Magar	50	42	36	31	6	17	50	15
6.	Sunuwar	15	21	18	15	6	14	23	10
7.	Tamang	37	37	18	28	1	3	36	13
8.	Sherpa	23	14	5	9	2	6	15	15
9.	Nepali	13	14	5	8	-	2	24	12
10.	Gurung	3	2	-	-	-	-	1	-
11.	Awrawal	3	5	3	5	2	5	1	-
12.	Khawas	1	2	1	5	-	1	7	3
13.	Sarki	1	-	-	-	-	-	-	-
14.	Madesi	-	-	3	3	-	3	-	-
	Total	557	602	544	579	314	514	657	237

F= Female, M= Male, Bh/Ch= Bhramin/Chettry

Source: Sustainable VDC Profile, 2063

Above table-4, shows that there is high literacy rate in less population castes. But also there is about equal literacy rate in all castes.

4.8 Physical and Public Infrastructure Development

Mangalbare VDC is connected with Mechi highway from two sides. Gravel road from Nepaltar, Sankejung and from Rakse. It is connected with national grid of electricity. Mangalbare is in front among other VDC's of Ilam district. There is management of drinking water, telephone service and mobile service. There is also one health centre, many clinics for local people. There are many

social centres like: Cooperative, agriculture development bank, police station etc. for public. But also there is not enough infrastructure of development.

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS

5.1 Population Composition/ethnicity

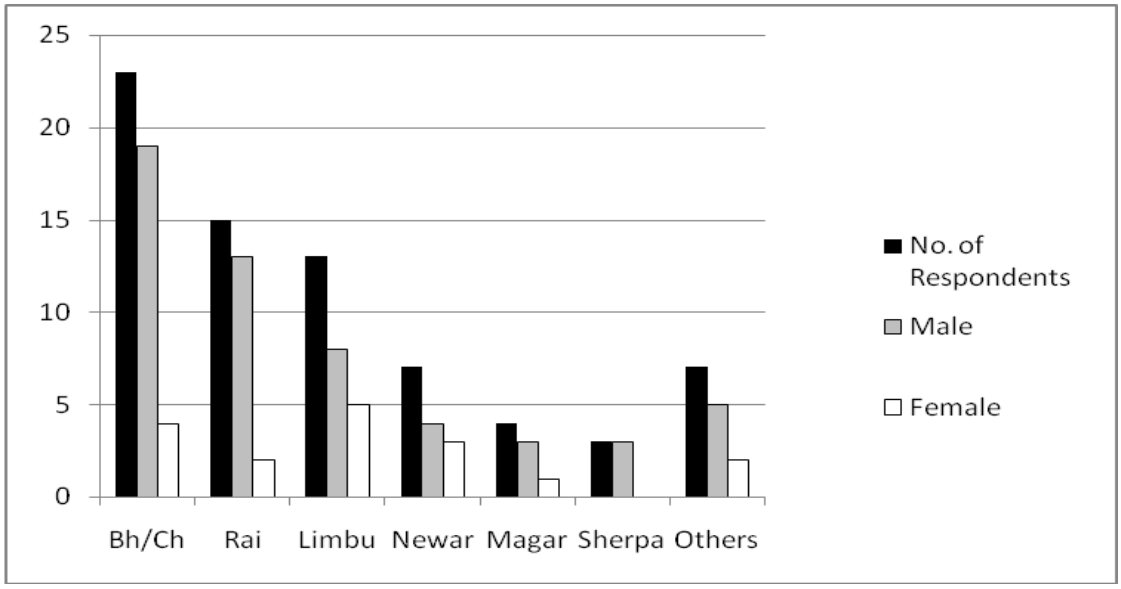
Population is the one of the important aspect of any research. It structures the socio-cultural and economic aspect of the country. Out of 9 wards 72 households/respondents (8 respondents from each ward) was taken randomly for study.

Table-5 Caste/Ethnicity Distribution of Respondents:

S.N.	Ethnicity	No. of Respondents	Male	Female	Percentage %
1.	Bh/Ch	23	19	4	31.94
2.	Rai	15	13	2	20.8
3.	Limbu	13	8	5	18.06
4.	Newar	7	4	3	9.5
5.	Magar	4	3	1	5.56
6.	Sherpa	3	3	-	4.44
7.	Others	7	5	2	9.05
	Total	72	55	17	100

Source: Field Survey, 2009

Above table-5 shows that 31.94% of the total respondent were from Bhramin/Chettry community followed by Rai with 20.8%. This shows that the highest population of Bhramin/Chettry can be found on the study area. The ethnical distribution of respondents can be visualized by the following diagram.



Fig; 5.1 Ethnicity Distribution of Respondents.

5.2 Occupation

The primary (main) occupation of most of the respondents has been agriculture but also some of them have other/alternative occupation. The occupational structure of the respondents is presented in the following table.

Table-6 Occupational Structure by Respondents:

S.N.	Primary Occupation	No. of respondent	Percentage %
1.	Agriculture	62	86
2.	Animal Husbandry	2	3
3.	Business	5	6.9

4.	Service	3	4.1
	Total	72	100

Source: Field Survey, 2009

Above table-6 shows that, among 72 respondents, the primary occupation is agriculture occupied by 86% followed by 6.9% of business. This shows agriculture is the primary occupation of the study area. So most of the people living in this area are depending on agriculture for their livelihood. The main occupation of the respondent can be visualized by the following pie-chart.

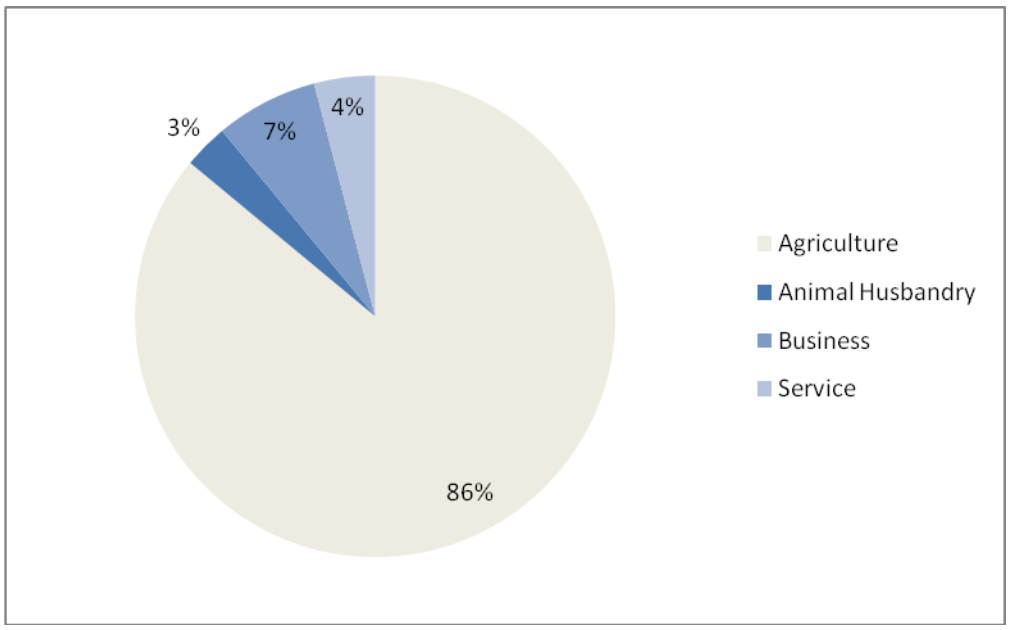


Fig: 5.2 Occupation of respondents

5.3 Private Land use System

Khet, Bari, Amrisobari, Chiya bari, Alaichinbari and private forest are the main using land of this area. Most of the respondents have 27% bari followed by khet 21.54%, 11.30% cardamom bari and others about 40%. On the lower area of this VDC there is mostly khet. On khet farmers produce paddy, wheat,

maize, and zinger. In the middle area of this VDC, there is bari where farmers produce maize, millet, zinger, potato etc. On the upper area we can see forest, chiyabari and pasture land. Present private land use system of this area is given below.

Table-7 Private land use System of the Respondent:

S.N.	Type of Land	Area (Ropani)	Percentage %
1.	Khet	430	21.54
2.	Bari	540	27
3.	Sirubari	203	10.16
4.	Amriso	250	12.5
5.	Cardamom	226	11.30
6.	Tea	132	6.6
7.	Private Forest	81	4.03
8.	Others	142	7.26
	Total	2044	100

Source: Field Survey, 2009

Above data can be also visualized in Pai chart form.

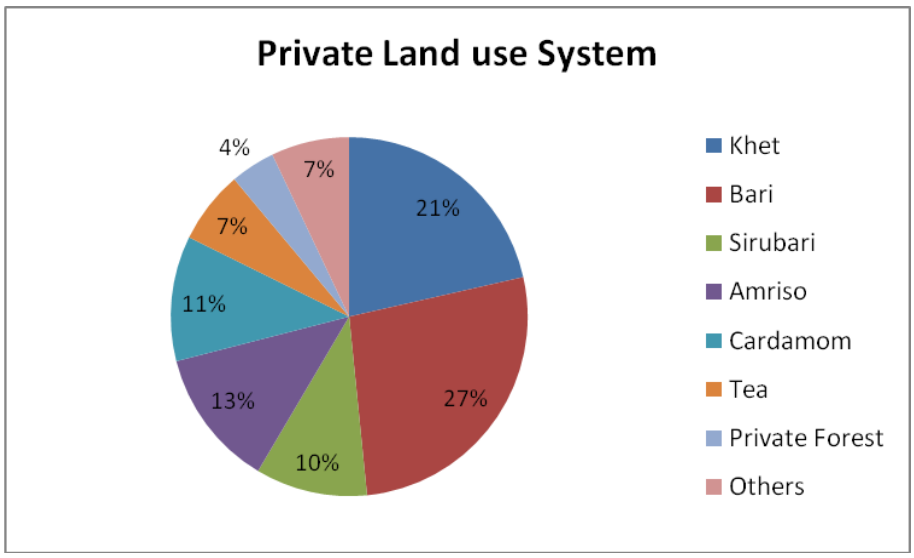


Fig: 5.3, Private Land use System.

5.4 Crop Production Trend

According to VDC profile 2063, about 54% private land is suitable for agriculture accept settlement. The production rate of some crops is increasing whereas most of crop's production is going to decrease.

5.4.1 Cereal Crop Production Trend:

Paddy, maize, wheat and millet are the main cereal crops produced by farmers of this VDC. Crop production trend of previous year and this year is given following.

Table- 8 Comparison of Cereal Crops Production from Previous Year:

S.N.	Crops	Previous year Production (Muri)	This Year Production (Muri)
1.	Paddy	300	350
2.	Maize	375	310
3.	Millet	150	150
4.	Wheat	138	126
5.	Mustard	90	75

Source: Field Survey, 2009

From above data we can see the production trend of paddy and millet is slightly increased but others production rate is decreasing.

5.4.2 Cash Crop Production trend:

Amriso, cardamom, zinger ant tea are the main cash crops produced by farmers of this VDC. Comparison of cash crop production from previous year is given in the following table.

Table-9 Cash Crops Production Trend from Previous year:

S.N.	Crops	Previous Year Production (kg)	This year Production (kg)
1.	Potato	10,000	95,00
2.	Cardamom	5,000	22,00
3.	Amriso	5350	4950
4.	Zinger	12,000	11,600

5.	Tea	3,000	3000
6.	Aakbare	500	400

Above table-9, shows that there is slightly difference in production of crops from previous year to this year, but there is vast difference in cardamom. Most of the plants of cardamom were decayed due to many disease like; phurse, rate, etc. and unavailability of sufficient water.

5.4.3 Vegetable Production Trend:

Cauliflower, banda, carrot, peas, pumpkins, cucumber, etc. are main vegetables produced by the farmers of this area. Nowadays the production of vegetables are also going to decrease due to many diseases, insufficient of irrigation, loss of soil quality.

5.5 Fertilizer and Pesticides use

About 10-15 years ago, chemical fertilizer and pesticides used in this area was in minimum level and quantity of organic fertilizer was high. But, nowadays the quantity of chemical fertilizer and pesticides is increasing due to availability of chemical fertilizer and decreasing the number of domestic livestock. Farmers are using chemical fertilizer for increase production. Mainly they are using chemical fertilizer and pesticides on potato, zinger, akabare, maize, mustard and vegetables.

5.6 Livestock Rearing/Animal Husbandry System

Most of the farmers of this area have their own domestic animals. Farmers are using the waste of animal as fertilizer for their agriculture production. The main purpose of animal husbandry is milk production and meat. Most of the

farmers have cow, buffalo, poultry farming, pig, and goat. On the lower area of the study area there is stall feeding system and on upper area (some place) we can see grazing system also. Livestock distribution pattern according to castes is tabulated on the following table.

Table-10 Livestock Distribution According to Ethnicity:

S.N.	Ethnicity	No. of Livestock				
		Cow	Buffalo	Goat	Pig	Rooster
1.	Bh/Ch.	20	13	15	-	35
2.	Rai	9	4	10	16	40
3.	Limbu	6	6	13	15	32
4.	Newar	6	1	9	4	38
5.	Magar	3	2	10	12	22
6.	Sherpa	7	3	15	6	8
7.	Others	8	-	12	8	19

Source: Field Survey, 2009.

From above table, we can see there is maximum number of cow and goat from Bhramin/Chettry society, whereas pigs and rooster form other society.

5.7 Rainfall (Precipitation) Data Analysis

When enough water vapor collects in cloud it turns into rain. Rain is the commonest form of precipitation. Rainfall pattern of any area shows the climatic condition of that area. So rainfall is the main indicator of climate change. The analysis of rainfall data of Ilam Tea State from 1993 to 2008 AD

is given below, which is the nearest hydro-metrological station from Mangalbare VDC.

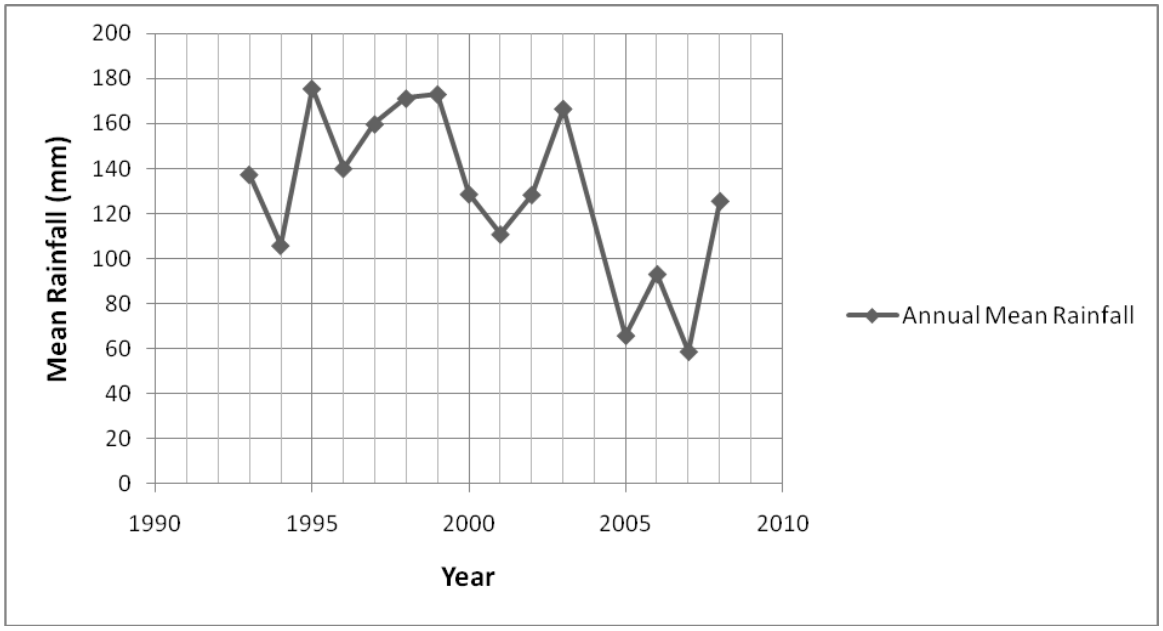


Fig: 5.7 Annual mean rainfall from 1993-2008.

Source: DHM, Kathmandu, Nepal.

From above 16 years (1993-2008) data analysis annual rainfall is not same. 137.42mm rainfall was recorded in 1993 whereas 175.62mm annual rainfall was recorded in 1995, which is the maximum rainfall as recorded in Ilam from 1993 to 2008. Minimum rainfall was done in 2006, only 93.22mm annual mean rainfall was recorded on that year. In 2007, only 58.8mm mean rainfall was recorded on 5 months. Annual mean rainfall of 1993 is 82.4mm more than 2006 annual mean rainfall. It shows that rain fall is decreased in 2006 as compared to 1993. So we can say annual rainfall of the study area is decreasing.

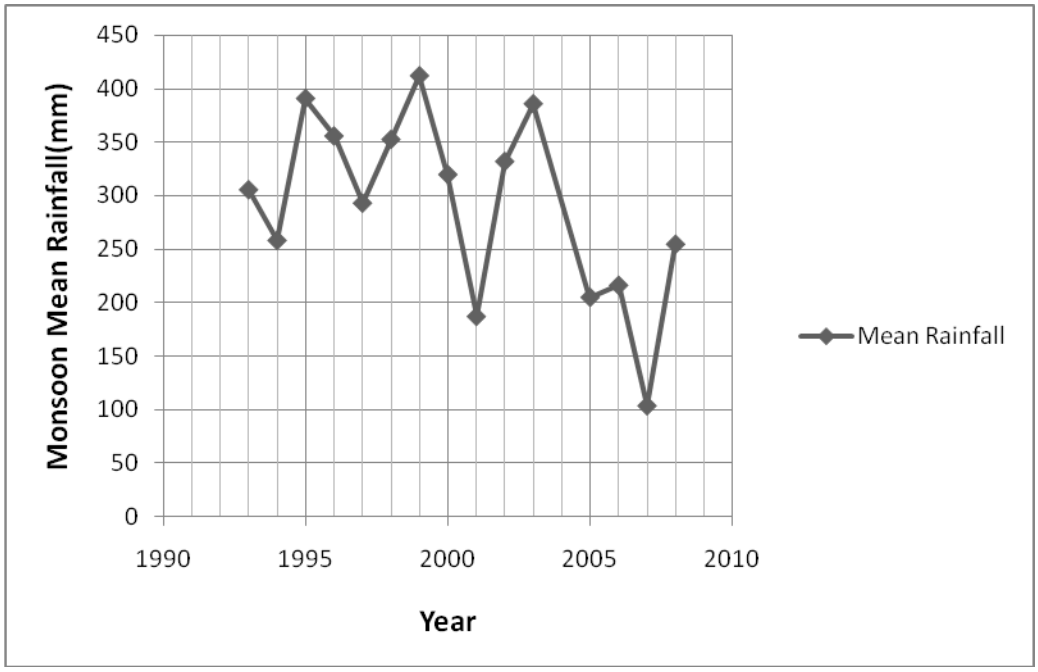


Fig: 5.7.1 Monsoon Mean Rainfall from 1993-2008

Source: DHM, Kathmandu, Nepal.

Analysis of mean rainfall of monsoon season shows that maximum rainfall was recorded in 1999's monsoon, 411.7 mm rainfall was recorded on that year and minimum rainfall was recorded in 2007 only 104.2 mm mean rainfall was recorded on that monsoon season. There is changing pattern of rainfall in every year , i.e. one year increase next year decrease. So the monsoon period is shifting every rainfall decreased year.

5.8 Temperature Data Analysis

Temperature is the degree of hotness os coldness of any object. Temperature is directly related to the climate change. The recent IPCC Fourth assessment Report (2007) states that global warming is unequivocal and the linear warming trend over the last 50 years is 0.13°C per decade. Warming is also being observed in Nepal. Based on the records from 1979, the mean Nepal temperature is increasing at 0.4°C per decade (Regmi, Pandit, Pradhan, & Kovats, 2008). In

this scenario, temperature is the main indicator of climate change. Maximum temperature and minimum temperature may also impact on agricultural system of any region. Temperature of the study area is also not same there is change in maximum and minimum temperature every year. Analysis of maximum and minimum temperature data are analyzed as recorded from Ilam tea state, which is the nearest hydro-metrological station from study area is given below.

5.8.1 Maximum Temperature:

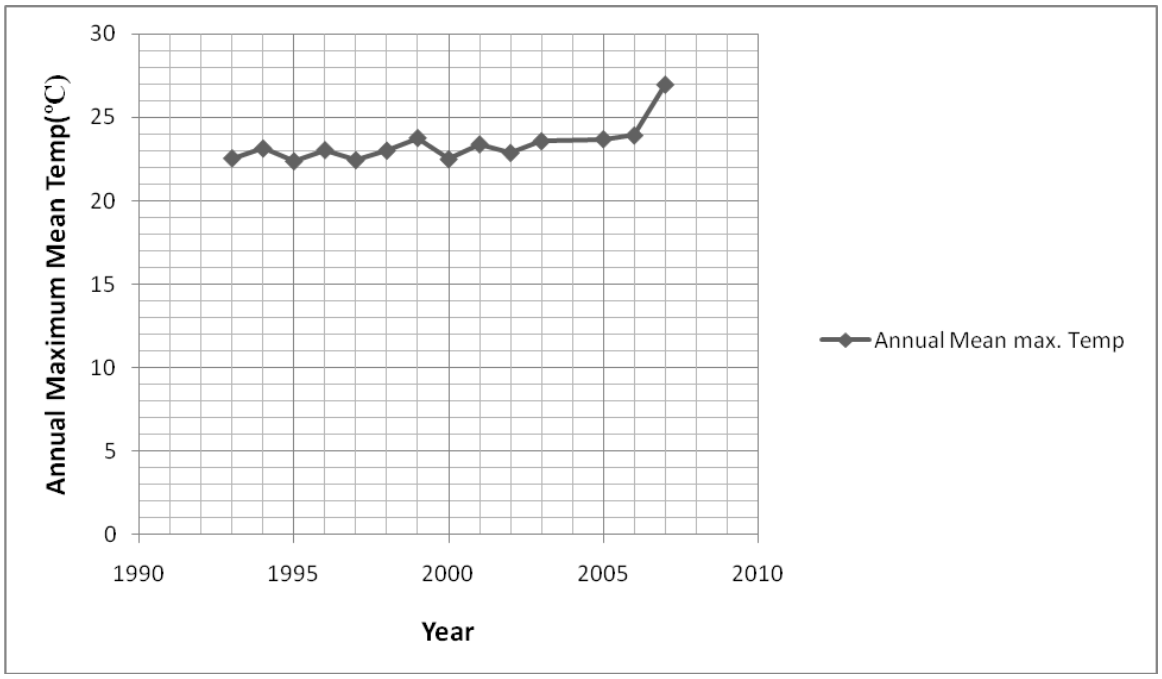


Fig: 5.8.1 Maximum Annual Temperature from 1993 to 2007.

Source: DHM, Kathmandu, Nepal.

From above 15 years data (1993-2007) data analysis of maximum temperature, annual annual maximum temperature 22.75^{o}C was recorded in 1993, whereas 23.93^{o}C temperature was recorded in 2006. In 2007, 26.96^{o}C temperature was recorded on 5 months.it shows that maximum temperature is incresing slightly on every 13 years.

5.8.2 Minimum Temperature:

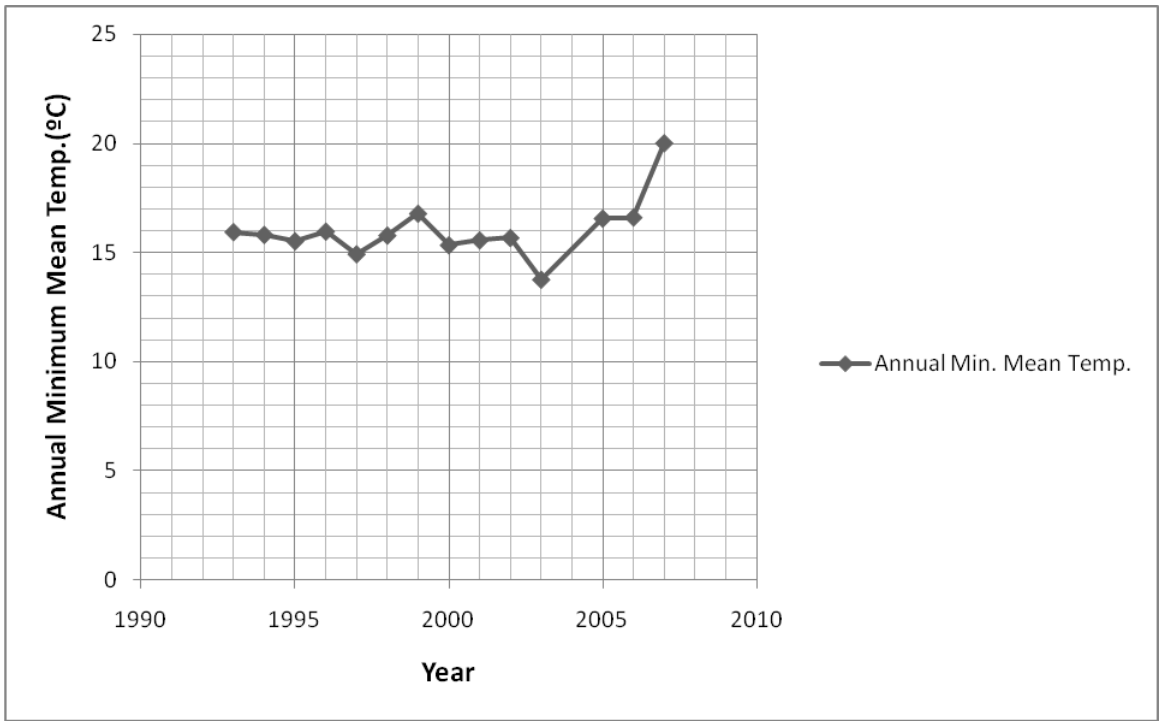


Fig:5.8.2 Minimum Annual Mean Temperarure from 1993 to 2007.

Source: DHM, Kathmandu, Nepal.

From 15 years data analysis of minimum annual temperature as recorded in Ilam tea state, shows 15.94^{o}C temperature was recorded in 1993 and 16.06^{o}C temperature recorded in 2006. In 2007, 20^{o}C temperature was recorded on 5 months. It shows that 0.67^{o}C temperature is increase in every 14 years period.

From the data analysis of temperature, 1.36^{o}C annual maximum temperature is increased in 2006 as compared to 1993. There is incresse in minimum annual temperature also, about 0.67^{o}C temperature is increased in 2006 as compared to 1993. So, this data shows that about 0.98^{o}C temperature is increasing in every 14 years.

5.9 Agricultural production Pattern

Agricultural system of this area is in mix form, i.e. mixture of traditional and mordern. But also farmers are going to adopt mordern technology for cash crops, whereas cereal crop production is traditional. Crop production and animal husbandary system are interrelated to each other. Agricultural distribution system of this area is given below:

Table:11 Agriculture Distribution System:

High Land or Bari	Low Land or Khet	Other Land
Maize-millet-potato	Paddy-wheat-maize	Tree, tea, amriso, cardamom, pasture land etc.
Maize-zinger	Paddy-maize	
Maize/zinger-mustard	Paddy-wheat	
Maize-mustard-vagetable	Maize-mustard-zinger	
Potato-maize	Potato-maize	
Maize-vegetable-potato	Maize-potato/vagetable	

Source: Field Survey, 2009.

From above table-11, we can say that maize is the main product of bari and paddy is the main product of khet. Farmer cultivate zinger on both khet and bari whereas other crops like: potato, mustard, maize etc also produces by farmer on this area of their khet and bari. Private forest, tea, amriso and cardamom are cultivated on other land.

5.10 Impact of Climatic Parameters on Agriculture

On the basis of field survey, there is slightly changing of environmental parameters on the study area. Cold and frosty days are decreasing, rainy season is shifting and days are becoming hot. These parameters help to impact on agricultural system of this region.

According to respondents of the study area, there is changing in production system of agriculture. The production rate of cereal crops like: wheat, maize and mustard is decreasing and the production rate of paddy and millet is going to slightly increasing. Production rate of vegetables and aakabare chilly also decreasing due to problems of many insects. The production rate of cash crops also decreasing, cardamom plant of this area is decayed so production of cardamom is decrease about 50% from previous year. There is problem in tea, zinger, amriso and potato therefore production of these crops are also not fixed. There are many problems in agricultural plants, sometimes rain deficit, sometime heavy rain, flood, frost and long time drought. So we can say climatic parameters are also affecting the crops of this area.

CHAPTER SIX

SUMMARY CONCLUSION AND RECOMMENDATION

6.1 Summary

Nepal is a small, land lock and agriculture based country. National economy is based on agriculture profession of Nepalese people. More than 80% population has been engaging on agriculture for their livelihood and it contributes about 38% gross domestic products of Nepal. Geographical distribution of Nepal is varies on three regions, i.e. Terai, Hills and Mountains (Himalayan region). Terai and hills are suitable for crop production due to climatic condition. Terai is suitable cereal crop lower hill is suitable for cash crop and vegetable production. Himalayan region is suitable for livestock production.

The climatic parameters can impact on agricultural system of any region. Temperature of Nepal is also increasing about 0.06^{o}C temperature is increasing per year in Nepal. In this scenario, snow melting rate of Himalayas is increasing, glacial lakes are going to burst, due to this changing pattern there may effect on agriculture as well as human beings. Temperature and rainfall are the main indicator of climate change so rainfall is also not in continuous pattern in Nepal as well as world. There are many problems due to climate change like: loss of habitat of species, shifting monsoon from Jestha-Asar to Shrawan-Bhadra. Climate change and agriculture are interrelated so climate change can effect directly or indirectly on agriculture. Agriculture is the main income source of Nepalese people that is why climate change may impact on economic situation of Nepalese people.

The study was focused on Mangalbare VDC of Ilam district, where Bhramin, Chettry, Rai, Limbu, Newar etc. castes are resided. Education level of this VDC is about 86% but also agriculture is the main occupation of these people.

About 85% people are depending on agriculture for their livelihood. The infrastructural development of this region is normal, there is no any large industry. Climate of this region is temperate and sub tropical where average temperature is 2^{o}c to 24^{o}c and annual rainfall is about 2000mm. total area of this VDC is 30.18 square kilometer out of this area bari covered about 38.39%. Cereal crops (paddy, maize, wheat, millet and mustard) and cash crops (amriso, cardamom, zinger, potato and tea) are the main crops of this area. Animal husbandry and cereal crop production is the traditional occupation of the people. As a while, agriculture system of this VDC is in mix form (mixture of traditional and modern technology).

Rainfall (precipitation) and temperature are the main parameters of climate change. The changing pattern of rainfall and temperature can impact on agricultural system of any place on both (positive way and negative) way. From 15 years analysis of rainfall there is slightly change in rainfall system per year. The heaviest annual rainfall was recorded in 1995 about 175.62mm rainfall was recorded on that year. The minimum annual rainfall was recorded in 2006 about 93.22mm annual rainfall saw recorded on that year. There is 82.4mm difference in annual rainfall of 1993 and 2006, i.e. in 1993 there was more rainfall than 2006. Mean rainfall of monsoon is also not same there is also difference in rainfall. From data analysis of temperature the warmest year was 2006 about 23.93^{o}c maximum mean temperature was recorded on that year and coldest year was 2003 about 13.77^{o}c minimum annual temperature was recorded on that year. As a whole analysis of above data about 0.98oc temperature is increase in every 14 years. So the temperature and rainfall pattern of this region is not continuous.

Climatic parameters and other natural resources have been impacting on the agricultural system of Mangalbare VDC. Production of some cereal crops like: paddy and millet is increasing slightly due to increase of temperature, seed quality and method of cropping. But production of some cereal crops like: maize, wheat, mustard etc is going to decrease due to rain deficit, sometimes

frost, discontinuous rainfall and many air borne disease. There is affecting on cash crops also production of cardamom is decrease about 50% due to plant decay, rain deficit, and many diseases like: phusre, dhusre etc. and production of other crops like: zinger, amriso, tea, potato and vegetables also not satisfactory due to many problems like: disease, quality of soil and climate. Livestock husbandry system of this region also changing there is decreasing the number of cattle due to hybridization and insufficiency of food resources for livestock.

6.2 Conclusion

The present study is an attempt to analyze the impact of climate change on agricultural system of Mangalbare VDC from the forgoing discussion it is clear that agriculture is the primary occupation of this region. Although business and service (job) is also occupation of some people but agriculture and animal husbandry is major and prominent occupation for their livelihood. Geographical condition, climate, soil type and land use system also helps to agriculture for this area and there is no any infrastructure for alternative source of income. Therefore people of this region are depending on agriculture. From this study the researcher has been concluded on the following points.

Mangalbare VDC is situated in mid hills of eastern Nepal, where bhramin, chettry, rai, limbu, newar and other (16 castes) resided. Education level of this VDC is about 86% but also agriculture is the primary occupation. About 86% people are depending on agriculture for their livelihood. Agriculture and animal husbandry is their traditional occupation. Agriculture and animal husbandry are interrelated to each other so they use animal residue for agriculture as a fertilizer and agricultural residue for animal's fodder. Agricultural system of this area is in transitional phase i.e. mixture of traditional and modern farming system. Most of the farmers of this area is practicing only subsistence farming. Rainfall (precipitation) and temperature

pattern is the main indicator of climate change. From the data analysis, temperature and rainfall of this region is not same. Heaviest annual mean rainfall was recorded on 1995 about 175.62mm mean rainfall was recorded on that year whereas 93.22mm rainfall was recorded in 2006 and 58.8mm mean rainfall was recorded in 2007 on 9 months. Annual mean temperature of this region is not also same. Maximum annual mean temperature and minimum annual mean is temperature also slightly increasing. About 1.36^{o}c maximum temperature is increased in 2006 as compared to 1993 and 0.67^{o}c minimum mean temperature is increased in 2006 as compared to 1993. So we can conclude the days are becoming hot in every 14 years period.

Climatic parameters (rainfall and temperature), quality of soil, using pattern of fertilizer and pesticides, quality of seeds also affecting the agricultural (farming) system of study area. Production of some cereal crops like: paddy and millet is slightly increasing whereas production of other crops like: wheat, maize etc. is decreasing due to soil quality, use of chemical fertilizer and pesticides, many disease problems and quality of seeds. Production of cash crops (cardamom, amriso, zinger, tea and potato) is also decreasing due to many climatic problems, quality of soil, and air borne disease. Not only on crops there is problem on vegetables production due to many problems. There is changing on livestock farming system of this area, decreasing the number of cattle due to hybridization of local species and insufficiency of grass for cattle. Due to these many problems on existing agriculture some farmers are attractive on alternative farming. They are practicing to change their farming system. They are started to plant medicinal plant instead of cardamom and amriso, some are increasing poultry farming and pig farming in stead of other cattle. At last we can conclude that, climatic parameters are not only responsible for agricultural production of that region other factors like: availability of resources, use of fertilizer and pesticides, quality of seed and quality of soil also affecting on agriculture of this area.

6.3 Recommendations

In this study, the following recommendations have been made on the basis of findings. These recommendations may be useful for the future researcher, local farmer and policy makers on the local level and national level.

- Most of the people of this area are engaging on agriculture but most of them don't know about climate change so there is necessary to aware about climate change.
- The traditional pattern of agricultural system of this area should be modernized by using modern tools, technology and highly productive crops and healthy seeds.
- Using chemical fertilizers and pesticides is increasing on agriculture it may harm on crops, environment and human health so farmers must be discouraged encouraging them to use organic fertilizers and pesticides for better production and soil conservation.
- Local people of this area should conserve the natural resources, sources of water because availability of natural resources also helps to agricultural system of any region.
- Production of crops of this area is decreasing due to climatic parameters and other factors. It may cause food scarcity so government and related agencies must be bring concept about food security and try to solve this problem.
- Government of Nepal and related agencies must be promotes to the local farmers for alternative source of income and new farming system for this area.
- Cardamom plant of this area is decayed due to many diseases like: phurse, dhurse etc. so the district agriculture office should help to provide new seed and should give subsidy for cardamom plantation.

- Agriculture is the backbone of Nepalese economy but it is affecting by climatic parameters and other factors like: decreasing fertile land, traditional agricultural system etc. so government of Nepal should promote the whole agricultural system for bright future of nation.

- Climate change and global warming is the burning and problematic issues for world with Nepal, but rich and advanced countries are the main responsible for global warming so government of Nepal and related agencies must be try to solve this problem by intergovernmental interaction, by making many policies and institutional strengthening.

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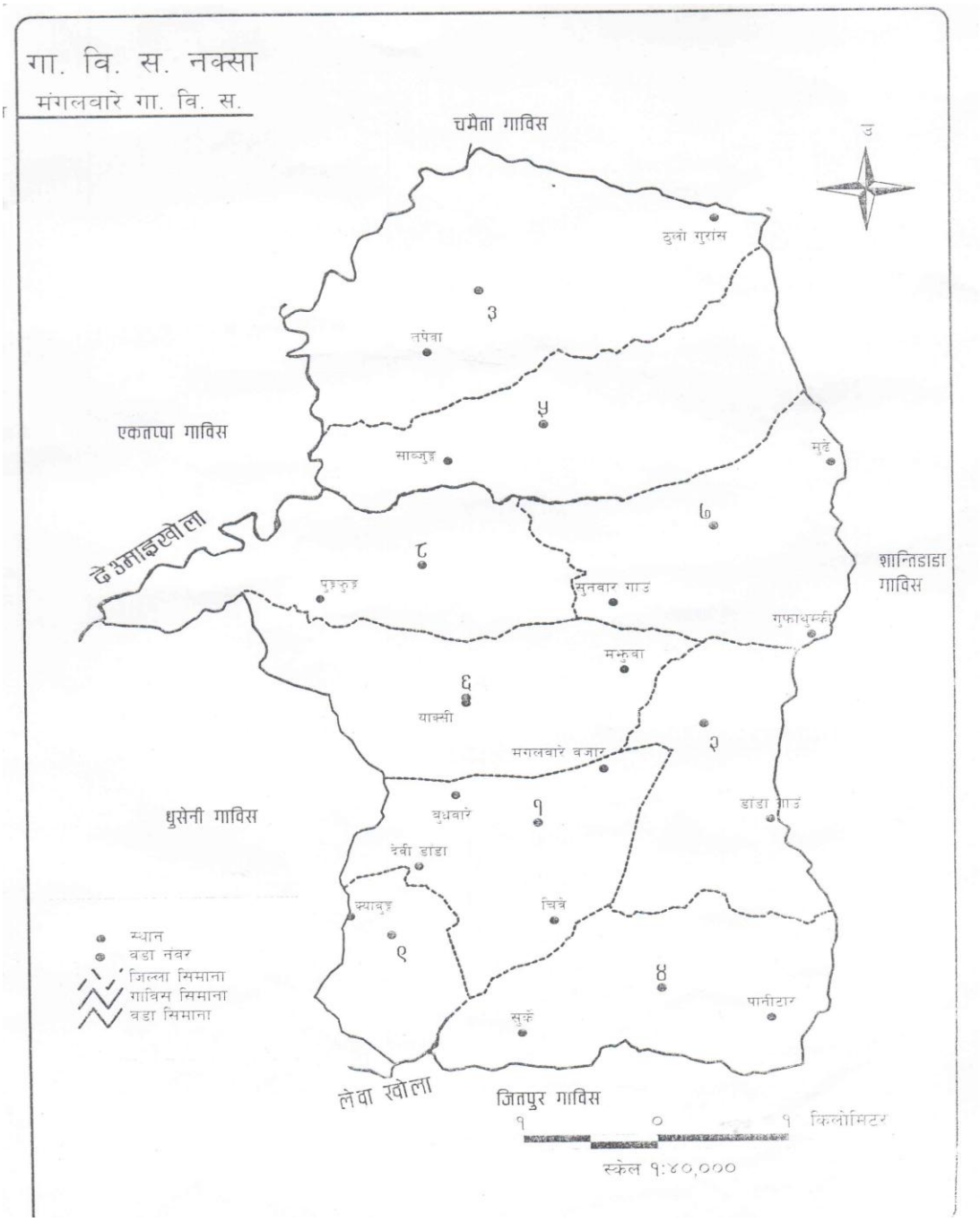
ANNEX –I

Map of Study Area



ANNEX-II

Questionnaire Model

General information:

a. Name of the interviewer ……...…… b. Date…….. c. Time……

d. Name of the Respondent (Optional)…….…….. e. VDC…….

f. Ward No……. g. Tole…… h. Sex…….

i. Age…….. J. Ethnicity……. k. Occupation……

l. Marital Status……..... m. Number of family…….

Socio economic:

a. Do you have own land?

Yes …..1 No…..2

(If no, refer to b)

b. So, how do you landless?

……

……

c. If, yes please give me information about your land.

Kind of land	Area (Ropani)	Own use	Used by others	Cost/Ropani (in Rs.)
Khet				
Bari				
Pasture land				
Forest				
Amrisobari				
Chiyabari				
Sirubari				

d. Crop Production Trend (Previous Year)

Kinds of Crops	Cultivated Area (Ropani)	Production (Muri)	Selling Price (Rs/Muri)	Production Trend		
				Increasing	Decreasing	Same
Paddy						
Wheat						
Maize						
Millet						
Others						

e. Cash Crops Production Trend (Previous Year):

Kinds of Crops	Cultivated Area (Ropani)	Production (Kg)	Selling Price (Rs/Kg)	Production Trend		
				Increasing	Decreasing	Same
Cardamom						
Amriso						
Ginger						
Tea						
Aakbare						
Potato						
Others						

f. Can you tell me, the changing pattern of agriculture production during last ten years?

Crops / Change	Paddy		Wheat		Maize		Millet	
	Increasing	Decreasing	Increasing	Decreasing	Increasing	Decreasing	Increasing	decreasing
Area (in Ropani)								
Fertilizer/Pesticides Use								

Irrigated area (Ropani)								
Production Rate								

For cash crops

Crops / Change	Cardamom		Amriso		Ginger		Akabare		Potato		Tea	
	Inc	Dec	Inc	Dec	Inc	Dec	Inc	Dec	Inc	Dec	Inc	Dec
Area (in Ropani)												
Fertilizer Use												
Irrigated area (Ropani)												
Production Rate												

g. How many Livestock do you have?

h. Did you change your livestock farming system in last ten years?

i. Using system of fertilizer and pesticides.

a) Chemical b) Organic c) Mix

j. Do you know any environmental changes in the following cases from last ten years?

Parameters	Increasing	Decreasing	Same	Do not know
Rainfall				
Windstorm				
Snowfall				
Cloudy days				
Hailstone				
Flood				
Landslide				
Erosion				

h. Did you feel those things?
    a. Extreme hot days.
    b. Extreme cold days
    c. Winter are less cold and frosty
    d. Days are becoming hot.

i. Do you think these parameters have impact in your agricultural production?
    a. Yes
    b. No
    c. Don't know

j. Do you change your agricultural practice due to change of climate pattern?
    a. Yes
    b. No

If yes, how?
    a. Early cultivation of crops
    b. Change in farming tendency (livestock and crops)
    c. Diversification of crops.

Thank You

ANNEX-III

Rainfall and Temperature Data

Rainfall (mm) data as recorded form Ilam tea state:

Latitude (deg/min): 2655
Longitude (deg/mm): 8754
Elevation: 1300m.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Mean(mm)
1993	21.5	3.4	11.8	90.5	191.8	313.3	369.3	347.7	233.0	50.6	16.3	0.0	137.425
1994	33.6	39.2	7.5	16.3	148.6	281.2	314.9	288.4	135.6	0.0	2.6	3.0	105.908
1995	13.6	13.8	24.8	18.4	88.4	464.8	537.8	435.3	277.0	17.4	155.8	14.4	175.625
1996	42.8	6.2	27.2	51.4	61.0	295.0	545.6	520.7	100.9	30.8	0.0	0.0	140.1333
1997	10.4	27.2	10.4	174.6	49.6	249.4	230.9	642.0	488.8	4.0	0.0	70.8	159.841
1998	0.0	2.0	124.4	166.9	99.2	329.9	561.5	418.8	2240.	106.8	21.8	0.0	171.275
1999	0.6	0.0	0.0	38.5	122.6	440.2	516.6	567.4	266.2	124.2	0.0	1.4	173.141
2000	8.2	0.1	0.0	54.4	275.2	379.6	309.8	332.2	186.7	16.4	0.0	0.0	128.716
2001	0.0	24.5	0.0	34.5	97.2	168.4	254.2	230.0	188.5	333.4	0.0	0.0	110.891
2002	23.6	0.0	13.4	65.6	92.8	303.0	584.1	347.4	83.2	28.6	0.0	0.0	128.475
2003	16.6	41.2	33.4	79.8	73.6	387.1	784.2	297.4	101.9	148.8	0.0	36.6	166.683
2005		0.0	30.0	50.4	119.9		290.6		41.9	60.2	0.0	0.0	65.888
2006	0.0	1.2	31.1	67.5	156.6	183.7	327.7	197.9	121.2	11.6	5.6	14.6	93.225
2007		87.0	8.0	27.3	51.4		206.0	54.6	86.5		5.7	2.1	58.8
2008		0.0	33.0	0.0	176.6	317.9	186.3	338.6	79.5		0.0		125.7

Maximum and Minimum Temperature (^{o}C) as Recorded from Ilam Tea State:

Maximum Temperature (^{o}c):

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Mean
1993	15.9	17.3	21.9	26.5	27.0	25.4	24.7	25.4	24.0	23.8	21.6	17.3	22.57
1994	18.2	17.3	22.1	25.4	26.6	25.8	26.4	26.2	25.8	23.9	21.7	18.5	23.158
1995	14.1	18.8	21.6	24.7	24.9	25.3	25.0	24.7	25.0	23.7	21.3	19.7	22.4
1996	15.4	195	23.3	26.3	25.4	25.0	24.4	25.3	26.1	24.1	22.7	19.3	23.066
1997	16.3	16.5	22.4	22.5	25.6	25.8	26.0	25.8	24.7	24.3	21.6	18.1	22.466
1998	16.6	18.8	20.5	24.3	26.3	26.2	25.0	24.9	25.5	25.1	22.8	20.4	23.033
1999	18.9	22.6	24.4	26.8	25.2	26.1	25.5	25.0	25.1	23.9	22.0	19.9	23.783
2000	16.7	17.0	22.0	25.4	25.4	25.8	25.1	24.6	24.5	24.5	20.7	18.5	22.516
2001	16.7	19.5	23.4	26.0	26.0	26.5	26.0	26.4	25.1	24.6	21.8	18.9	23.408
2002	16.9	19.9	22.8	27.7	25.4	25.1	24.6	25.6	25.4	24.3	22.6	18.5	22.9
2003	16.8	17.9	20.7	25.3	26.3	25.8	25.3	26.0	25.2	23.8	21.1	18.9	23.591
2005		18.7	22.6	25.0	25.1	26.8	25.9		27.1	24.5	21.8	19.6	23.71
2006	18.2	21.2	23.4	25.5	26.5	26.5	26.7	27.5	25.6	26.1	21.6	18.4	23.933
2007					26.3	27.4	26.8	27.0	27.3				26.96

Minimum Temperature (^{o}c):

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual Mean
1993	8.7	10.0	13.7	18.1	19.8	19.8	20.0	19.9	19.2	17.5	14.3	10.3	15.941
1994	10.0	9.1	14.2	16.7	18.5	20.0	20.6	20.4	19.5	16.4	14.1	10.3	15.816
1995	7.7	11.5	13.3	16.1	17.4	19.3	19.8	19.9	18.9	16.9	14.1	11.4	15.525
1996	8.7	11.3	14.5	17.7	17.8	19.2	19.8	20.2	19.8	17.5	14.2	10.9	15.966
1997	7.7	8.3	13.3	14.5	17.6	19.2	20.2	20.1	18.5	16.1	13.4	9.7	14.933
1998	8.1	10.4	11.4	14.9	18.4	20.1	19.8	20.1	19.5	18.4	15.8	12.5	15.783
1999	10.7	14.3	16.2	18.9	18.2	20.2	20.3	19.7	18.9	17.5	14.5	12.0	16.783
2000	9.4	9.0	13.6	16.2	17.8	19.2	19.4	19.1	18.0	17.8	13.7	10.9	15.341
2001	9.0	11.0	14.1	17.2	17.4	19.0	19.6	19.6	18.2	16.7	14.2	10.8	15.566
2002	9.1	11.8	14.7	15.8	17.9	19.5	19.3	19.5	18.7	16.4	15.3	10.1	15.675
2003	8.5	9.3	11.9	14.9	15.2			19.9	18.3	16.7	12.9	10.1	13.77
2005		11.3	15.0	17.1	17.8	20.2	19.7		20.0	17.5	14.6	12.4	16.56
2006	10.7	13.7	15.4	16.6	18.3	20.2	20.6	20.6	19.7	18.0	13.7	11.0	16.608
2007					19.3	20.3	20.8	19.5	20.1				20

ANNEX-IV

Photographs

Zinger Plant

Amriso

Cardamom Plant

Aakabare Chilly

Tea Garden

Rayo Saag