Impacts of Climate Change on Production of Cash Crops in Annapurna Conservation Area

(A Case Study from Lwang Ghalel Village Development Committee, Kaski District)

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Pokhara, Nepal

A thesis submitted to Tribhuvan University, Institute of Forestry as a Partial fulfillment of the requirement for the Degree of Bachelor of Science in Forestry

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January 2011

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TRIBHUVAN UNIVERSITY
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Letter of Acceptance

This thesis entitled **"Impacts of Climate Change on production of cash crops in Annapurna Conservation Area"** a case study from Lwang Ghalel Village Development Committee, Kaski district) of kaski district) submitted by Chhatra Bahadur Khadka has been accepted as a partial fulfillment for the requirement of B.Sc. Degree in the Institute of Forestry, Pokhara Campus under Tribhuvan University and recommends for necessary action.

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Declaration

I, Chhatra Bahadur Khadka, hereby declare that this thesis entitled "**Impacts of Climate Change on Production of Cash Crops in Annapurna Conservation Area"** (A Case Study from Lwang Ghalel Village Development Committee, Kaski district) , is based on primary information and all the sources of information used are duly acknowledged . This thesis should not be used for the purpose of awarding any academic degree to any other university.

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Abstract

Climate change has now become a global issue for the inhabitants of the earth. This research entitled "**Impacts of Climate Change on Production of Cash Crops in Annapurna Conservation Area"** was carried out in Lwang Ghalel V.D.C., Kaski district of Nepal with an objective to document the perception of local people towards climate change impacts and their responses, to analyse the production of cash crops annually and relation to climate change, assess the impacts of climate change on production of cash crops and to determine the adaptation measures used by local people against the climate change on cash crop production in Lwang Ghalel V.D.C. of Kaski district . Cash Crops such as tea, Amriso, cardamom were the main production of the study area. Primary data were collected from household survey with semi-structured questionnaires, interview with key informants, group discussion, formal and informal discussion with random sampling method. Thirty years Meteorological data (Rainfall and temperature) was collected to study the rainfall and temperature pattern and different published and unpublished literatures were used for collecting secondary data. Data were analysed using Ms-Excel and SPSS-11.5 and presented using tables, graphs and diagrams. The rainfall pattern seemed to be increased at the rate of 2.74 mm/year while the mean annual maximum and minimum temperature seemed to be increased by 0.064^0C/year and 0.01^0C/year respectively. 24% of the respondents told that tea was affected more from climate change than Amriso, Cardamom and Coffee. 65% of the respondents told that Amriso was the best adapted species from climate change due to its spreaded roots. Out of 50% respondents who gave response, 20% of the respondents told that the reason for decrease in production of cash crops annually was due to lack of management of market and draught. Awareness on climate change causes, impacts and adaptation, draught resistant varieties of seedlings should be distributed and reforestation and afforestation programs should be distributed to adapt with climate change.

Keywords: Impact assessment, Climatic condition, Rainfall pattern, Landuse pattern, Adaptation strategy

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List of Abbreviations and Symbols

ABTRACO Agri-Business and Trade Promotion Multi-Purpose Cooperative Limited

ACAP Annapurna Conservation Area Project

ADB Asian Development Bank

B.Sc. Bachelor in Science

Ca Calcium

CAMC Conservation Area Management Committee

CAMR Conservation Area Management Regulation

CCNP Climate change National Policy

CEN Clean Energy Nepal

DHM Department of Hydrology and Meteorology

DOC Department of Customs

DoFSC Department of Forest and Soil Conservation

FAO Food and Agriculture Organization

FYM Farm Yard Manure

GDP Gross Development Product

GLOF Glacial Lake Outburst Flood

IFAD International Fund for Agricultural Development

IPCC Intergovernmental Panel on Climate Change

K Potassium

K_2O Potassium dioxide

Kg Kilogram

LFP Livelihood Forestry Programme

LOS Level of surface

MoAC	**Ministry of Agriculture and Co-operative**
MoEST	**Ministry of Environment, Science and Technology**
Ms	**Microsoft**
N	**Nitrogen**
NGO	**Non-Governmetal Organization**
NRs	**Nepali Rupees**
NSCDP	**National Spice Crop Development Programme**
NTNC	**National Trust for Nature Conservation**
P	**Phosphorous**
P_2O_5	**Phosphorous Pentoxide**
SPSS	**Statistical Package for Social Sciences**
UCO	**Unit Conservation Office**
UNDP	**United Nations Development Programme**
UNFCCC	**United Nations Framework Convention on Climate Change**
USA	**United States of America**
V.D.C	**Village Development Committee**
VP	**Vegetative propagation**

CHAPTER I

1.1 Introduction

Nepal is richly endowed with numerous agricultural crops and plants. The variation in temporal, altitudinal, topographical and aspects has made agricultural such biodiversity possible **(Shrestha, 2007)**. About 21% (3.2 million hectares) of the total land area of Nepal is used for cultivation and the principal crops are rice (45%), maize (20%), wheat (18%), millet (5%) and potatoes (3%), followed by sugarcane, jute, cotton, tea, barley, legumes, vegetables and fruits. Historically, hills have remained homeland for traditional agriculture but there has been rapid migration of people to Terai owing to high population pressure in the fragile hill ecosystem. Hills occupy 42 percent of the land area of the country. This region includes valleys and terraced slopes in hills. It has low land to man ratio as compared to Terai.

The agricultural crops grown in Nepal are broadly divided into two groups; food crops and cash crops. The major food crops are paddy, maize, wheat, millets, barley, pulses and potato. Paddy, being the most important crop of Nepal, covers 55 percent of the land allotted to food crops. Cash crops occupy 18 percent of the arable land. Important cash crops include sugarcane, jute, tobacco, tea, cotton and cardamom. Most of these crops are produced in the Terai. Legume crops grown in the country include lentil, pea, cowpea, soybean, chickpea, green gram and black gram. Mustard, rapeseed, linseed, groundnut etc. are some important oilseed crops. In fruits, citrus, apple, walnut, mango, banana, peach, plum and pear are common. Vegetable crops include cucurbits, solanaceous species such as tomato, potato, legumes and some leafy vegetables such as green mustard. Spices and agro-forestry crops are also common. About 80% of paddy is produced in the Terai region of the country. Maize, millet and potato are basically hill crops **(ABTRACO, 2008)**.

Observed data indicates consistent warming and rise in maximum temperature at an annual rate of 0.04 – 0.06º C **(MoE, NAPA 2010).**High mountains are warming faster (0.08^0C per year) than lower hills and the plains (0.04^0C per year). This change has brought about major new challenges; its severe impact is seen on local natural resources, biodiversity and environment, leads to changes in geophysical, biological and socio-economic systems **(Burton *et al.*, 2002).** In particular, glaciers in the Himalayan region are retreating rapidly. Similarly, changes in forestry and vegetation systems have also been reported. Various studies have shown that the impacts of climate change are evident on forests, water resources, agriculture and other sectors in Nepal. The livelihood of more than 80% local people of mountain region is heavily depended on climate sensitive sectors such as agriculture, forest, and livestock and on the other natural resources such as water and biodiversity. They get food, fodder, fibre, medicine, water and income from forests, grasslands and agricultural land for their livelihoods. For these reason, Nepal is identified as highly vulnerable country to Climate Change **(Silwal, 2009).** In developing countries, the impact of climate change on land use patterns has affected in wider level that the vulnerable households that have nominal access to technology; have to engage in broader suite of activities, the safety net function of environment resources which make poorer households more resilient to frequent severe climate changes. The possibilities for increasing adaptive capacity, especially for poorer and more vulnerable households pursuing livelihood strategies is a crucial action to be immediately implemented in time **(Gauchan, 2010).**Agriculture production is a

player of both physical and socioeconomic worlds: it is very much dependent upon environmental variables and is in turn an important agent of environmental change and a determinant of market prices **(Rosenzweig and Hillel, 1995)**. Enhanced CO_2 level, increase global temperature, altered rainfall pattern; affected soil erosion (which are components of climate change) will affect agriculture ecosystems and food security **(Rosenzweig and Hillel, 1995)**.

Nepal has expressed its commitment through international conventions and treaties to develop national strategy for the adaption through the climate change induced impacts. Therefore, it needs to have detailed information and knowledge about community level adaptation from climate induced risks. Documenting climate change is important for various reasons. Agriculture manufacturing, commerce, and all other human endeavours would require drastic adjustment if the world's climate were to change greatly within a generation **(Critchfield, 2003).** Understanding the potential impact of climate change on agriculture in Nepal is critical for two reasons. First, the existing system of food production is highly climate sensitive because of its low level of capital and technology. Second, agriculture is the main source of livelihood for majority of the population. If agricultural production is adversely affected by climate change the livelihoods of even greater number of people will be at risk **(Dahal *et al.*, 2010).**Since the cash crops such as Tea, Amriso, Cardamom, Banana, Coffee, Cucumber etc. play a significant role in the economic upliftment of the local people, the impacts of climate change on production of the cash crops should be known. So, to document those impacts and the perception of the local people towards climate change, research is needed to carry out in such areas and possible adaptation measures is needed to be identified.

1.2 Objectives

1.2.1 General Objectives

- To assess the impacts of climate change on production of cash crops and local people's adaptation measures against climate change in Lwang Ghalel V.D.C. of Kaski district.

1.2.2 Specific Objectives

- To document perception of local people about climate changes impacts and their responses.
- To analyse the production of cash crops annually and relation to climate change.
- To assess the Impacts of climate change on production of cash crops.
- To determine the adaptation measures used by local people against the climate change on cash crop production.

CHAPTER II

LITERATURE REVIEW

The climate on the earth has undergone many changes in the past and this is entirely natural. However, the rate at which the climate has been changing over the past 50 years has led to a consensus amongst scientists that this recent change is likely to be as a result of man,s acitivities.This is what we refer to as 'Climate Change'. Other related terms are the 'greenhouse effect' and 'global warming' **(Silwal, 2009).** The impact of global warming is already being felt by the most vulnerable-the world's poorest people and countries and its impact is severe on Nepal because of the geographical and climatic conditions, high dependence on natural resources and lack of resources to cope with the changing climate. Developed countries are mainly responsible for global warming and they need to take concrete steps and actions to reduce their greenhouse gas emissions. However, as climate change will affect everybody, the entire global community needs to work together to address this major problem **(CEN, 2003).**

2.1 Climate change in global context

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 processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use**" (IPCC, 2001).**The average temperature of the earth's surface has risen by 0.74 degree Centigrade since the late 1800s **(IPCC, 2007)**. The climate has always been changing, throughout the history of the Earth. Between 2500 B.C. and 2300 B.C., for example, the climate in the present Sahara changed rapidly from a situation in which wheat, barley, millet and guinea corn could be cultivated into a situation in which only livestock could be kept **(Curtin *et al.*, 1978).**Under a business as usual scenario, greenhouse has emissions could rise by 25-90 percent by 2030 relative to 2000 and the Earth could warm by 3^0c this century. Even with a temperature rise of 1-25^0c the IPCC predict serious effects including reduced crop yields in tropical areas leading to increased risk of hunger, spread of climate sensitive diseases such as malaria and an increased risk of extinction of 20-30 per cent of all plant and animal species. By 2020, up to 250 million people in Africa could be exposed to greater risk of water stress **(UNFCCC, 2007)**. Natural changes in climatic conditions have resulted in Ice Ages and relatively warm periods in temperate regions while wet periods have intermitted with dry periods in Africa **(Kemp, 1994).** Over a decade ago, most countries joined an international treaty –the United Nations Framework Convention on Climate Change-to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. Recently a number of nations have approved an addition to the treaty, called the Kyoto protocol, which has more powerful measures emission reduction targets for industrialized countries.

According to **(IPCC, 2001)**, there has been an unprecedented warming trend during the 20^{th} century. The current average global surface temperature of 15^0Cis nearly 0.6^0C higher than it was 100 years ago-most of the increase has been the consequence of human activity. A further increase of 1.5-6^0C is projected fro the period to 2100. Fourth Assessment Report of **IPCC (2007)** concluded that "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)**.

2.2 Climate Change in Nepal

Nepal is a land-locked country situated in the central part of the Himalayas stretched between $26^0$22' and $30^0$27'N latitudes and $80^0$12' E longitudes. The total area of the country is 147,181 km2 that is made up of five physiographic regions **(LRMP, 1986)**: High Himal, High Mountain, Middle Mountain, Siwalik (the Churia Range), and the Terai. Observed data indicates consistent warming and rise in maximum temperature at an annual rate of 0.04 – 0.06º C (MoE, NAPA 2010).Although Nepal has a negligible share in global emissions of greenhouse gases, it is particularly vulnerable to climate change due to its fragile mountain ecosystem. Nepal's major natural resources, biodiversity and water are at the forefront of climate vulnerability. Response to climate change in Nepal is growing gradually. Action to reduce human contribution to the changing climate are slowly happening but they so far seem too few and too limited to make difference to climate change **(Lemons *et al.*, 2007).** Nepal signed the United Nations Framework Convention on Climate Change (UNFCCC) on June 12, 1992 and ratified it on May 2, 1994, and made effective since July 31, 1994. But UNFCCC focused more on mitigation rather than adaptation.

Nepal as a part of the earth cannot remain untouched to this global change. 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 warming. It already observed such as increase in dry period, intense rainfall, flood, landslides, forest fires, glacial retreats and GLOF threats **(Shrestha, 2007).**

Developing countries are more vulnerable to the effects of climate change due to its high dependence on climate-sensitive sectors like glaciers, agriculture and forestry, and its low financial adaptive capacity **(Karki, 2007)**. 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 the 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 *et al.*, 2007)**. The ongoing climatic change and changes those are projected to occur in the future are likely to occur in the future in different sectors like, Water resources that include glacial fluctuation, hydrological regime, GLOF; Agriculture sector; Flora and Fauna; Health sector; and Livelihood **(MoEST, 2008)**.

Nepal's economy is overwhelmingly dependent on agriculture. Approximately 40% of the country's GDP came from agriculture in 2000; down from 52% in

1990.Agriculture also provides a livelihood to nearly 81% of the labour force. In addition, because Nepal is a major tourist destination, a significant fraction of foreign earned income is independent on the country's natural resources .Tourism receipts in 2000 amounted to 15% of exports. A heavy reliance on tourism and agriculture makes Nepal's economy very sensitive to climate variability **(World Bank, 2002)**. Nepal is among the highly vulnerable country to climate change impacts. Fast receding glaciers of the Himalaya have been the major concern, as they have been the prime source of water to more than a billion populations living in Nepal and other south Asian nations. While increasing attention has been placed on glacial lake outburst floods in Nepal, less attention has been given to other effects of climate change on local communities in terms of changes in water availability, agriculture, forest resources as well as on economy and livelihood **(Pandit, 2009).** Nepal is known to be highly disaster prone and sensitive to the consequences of climate change. Although no discernible long term change in climate has been observed, a study by the Department of Hydrology and Meteorology revealed that the average temperature in Nepal is increasing at a rate of approximately 0.06 degree centigrade per year **(Shrestha *et al.*, 1999; CCNP, 2009)** .The temperature difference are most pronounced during winter season and least after the summer monsoon begins **(Shrestha *et al.*, 2000)**. Consistent with the global trend, the temperature is increasing at a faster rate in higher elevations compared to the lower elevations. Notably; the rate of warming is greater in the western half of the country compared to the eastern half. Unlike temperature trends, no evidence of change in aggregate precipitation has been noted though studies have shown an increased variability and intensity of rainfall in some regions of the country. Significantly glacial retreat as well as aerial expansion of glacial lakes in the high mountain region has also been documented in recent decades and there is a higher likelihood that such change is related to rising temperature **(Agrawal *et al.*, 2003).** Glacial retreat not only contributes to the variability in river and stream flows but also can be an additional source of risk to agriculture. Annapurna Conservation Area is known for its rich biodiversity and most attractive trekking destination among the tourists. However, climate change has threatened the richness of the region though details of the effects are yet to be known **(Pandit, 2009)**.

2.3 Introduction to Cash crops and relation to Climate change

A readily saleable crop that is grown and gathered for the market (as vegetables or cotton or tobacco) is called the cash crop **(Collins English Dictionary).** Major cereals are rice, maize, wheat and millet of which rice is the main staple food. Sugarcane, oilseeds and potato are categorized as cash crops. Apple, oranges, mango, banana etc. are the main fruit crops. Potato, cabbage, cauliflower, beans, tomato, etc. are major vegetables and there is increasing trend of growing vegetables in the areas with road and market facilities **(Manandhar, 2009)**. According to the report by ACAP, the major cash crops grown in the Lwang Ghalel V.D.C. are tea, coffee, cardamom and Amriso (**Tiger grass**). Tea, ***Camellia sinensis*** or ***Camellia assamica*** meaning Chinese tea and Assam tea and belongs to the plant family Theaceae. Cardamom (***Amomum sabulatum Roxb)***, is an herbaceous perennial cash crop, and also referred to as "Queen of Spices". It is cultivated in an altitude range of 600 m and 2,000 m above sea level where annual rainfall is between 1,500 to 2,500 mm and the temperature varies from 8° C to 20° C. Large

cardamom can grow properly in cool, humid and shaded area of altitudinal range from 700 to 2100 m from the mean sea level **(NSCDP, 2009).** It is a climate sensitive crop and the favorable climatic condition for its best production is temperature between 4 to 20 º C, annual rainfall of 2000 to 2500 mm and more than 90 % humidity **(NSCDP, 2009).** It is a moisture loving crop and requires sufficient water supply throughout the year however, water logging may damage the crop if drainage is not maintained properly. Direct exposure to the sunlight is injurious to this crop and also removes the moisture content from soil. Therefore, proper maintenance of shade tree is very important in large cardamom farm. Hail, frost, snow fall and storm are the other climatic hazards to the crop **(Chapagain, 2011)**. Amriso is commonly known as Tiger Grass in English and its scientific name is ***Thysanolaena maxima Roxb.O.kuntze.*** It lies in the family Gramineae and is a perennial tufted grass. It flowers from January-May. Among these cash crops, people grow Tiger grass rather than other cash crops because it is best adapted to the changing environment and production is more. Lwang, a study site falls in the Mardi Watershed.Mardi watershed received about 4390 mm of rainfall during the year 2001. About 83% of total rainfall occurs during the monsoon period, June to September. The annual mean temperature is about 12^0 c. The monsoon climate varied from hot and dry sub-tropical in valleys to alpine at higher elevations. The initial and final infiltration rate of Bari land was higher compared to other land uses **(Awasthi, 2004)**.

2.4 Adaptation strategies

According to **Easterling *et al.*, 2007**, adaptation can be both autonomous and planned. Depending on subjective assessment of risks and vulnerability, households make certain adjustments in their choice of technologies and production and consumption decisions called autonomous adaptation. It includes implementation of existing knowledge and technology in response to the perceived changes in climate. Matlon and Kristjanson (1998) grouped autonomous coping strategies into three categories: (1) ex-ante risk-management options (2) in-season adjustment of crop and resource management options and (3) ex-post risk management options. Mostly located inn areas of ecological fragility and vulnerability, they tend to have an extensive knowledge base to draw upon in coping with adverse environmental conditions and shocks **(IFAD, 2001)**. The challenge is to ensure that the enabling means embodied in a new climate change agreement will encourage the agriculture sector and its farmers to generate these benefits under increasingly adverse conditions shaped by global financial, food and fuel insecurity **(FAO, 2009)**. Timely and appropriate adaptation clues will promote local people to change farming technology, season of cropping, choice of crop, prevention from health hazards, etc.

In order to address the possible impacts of climate change adaption practices should lay emphasis on sustainable development. Adaptation strategies will be more successful if they are identified and developed by local actors because they are likely to be consistent with local priorities, norms, goals, and institutions **(Newton *et al.*, 2005)**. Local actors and institution has to be involved in mainstreaming as they play the key role in knowledge transfer and policy

development. Management adaptation required differs as vulnerabilities differ **(Ogden and Innes, 2008)**.

Climate Change will have wide-ranging effects on the environment and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. Changes in rainfall pattern are likely to lead to severe water shortages and /or flooding. Melting of glaciers can cause flooding and soil erosion. Rising temperatures will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases will potentially severely increase rates of extinction for many habitats and species (up to 30% with a 2^0 c rise in temperature **(UNFCCC, 2007)**.

The term adaptation refers to actions taken to adjust to the consequences of climate change, either before or after impacts is experienced. Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events of people who rely on Climate-dependent resources for their livelihoods. Adaptation occurs in physical, ecological and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realize new opportunities **(Adger *et al*., 2008)**. There are many options and opportunities to adapt. These ranges from technological options such as increased sea defences or flood-proof houses on stilts, to behaviour change at the individual level, such as reducing water use in times of drought and using insecticide-sprayed mosquito nets. Other strategies include early warning systems for extreme events, better water management, and improved risk management, various insurance options and biodiversity conservation. Thus adaptation strategies should be implemented in the national and global level against the impact of climate change.

CHAPTER III

METHODOLOGY

3.1 Research Design

First of all the interested area of study was selected. Then the literature about the study area was collected and problem was identified. Appropriate methods and methodology was identified and site was selected for doing the research. Then primary data was obtained from the field survey while secondary data were collected from published and unpublished literatures. Then data was analysed using both primary and secondary data using statistical tools like SPSS 11.5 and Ms-Program like Ms-Excel. After interpretation was done after the analysis, report was prepared.

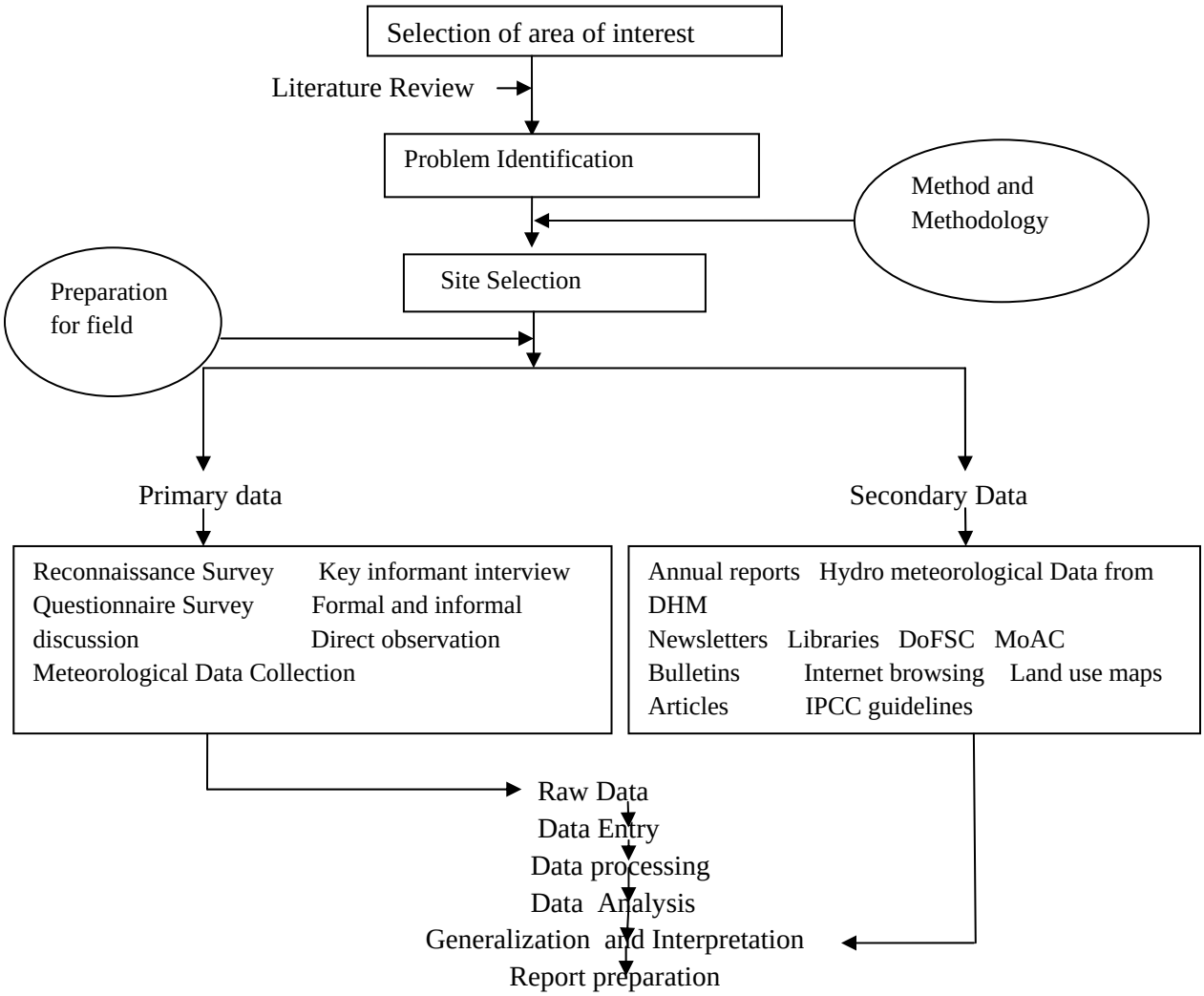

Figure 1: Flow Sheet of Research Design

3.2 Study Area Description

Lwang, a Gurung village situated in front of the Macchapuchre Himal, at the top of the Mardi and the Indhi streams of Kaski in the Annapurna Conservation Area was selected as a study site for this research work. It is a naturally beautiful village located along with the south-east facing slopes. ACAP consists of 7 UCOs consisting of 57 V.D.Cs. CAMC has been formed as per CAMR 1996 in all the 57 V.D.Cs **(ACA, 2009/12)**. Lwang Ghalel Village Development Committee consists of 9 wards .Among 9 wards; the research was taken on ward number 1,2,3,4. Lwang village lies on ward number 2 and 3, whereas Edikhola lies in ward number 1and Koleli lies in ward number 4. Lwang is situated at about 1300 meters form sea level. It is about 3 to 4 hours walk, 11 kilometres far, from the nearest motor able road head called, Milanchowk of Hemja **(Gurung, 2010)**. Like in other places, agriculture and animal husbandry are the major sources of income of the people. Gurungs, Brahmins, Chhetris, Dalits are the major castes in this V.D.C. This study site falls under the Annapurna Conservation Area which was declared as conservation area and given authority of management to ACAP of NTNC by Government of Nepal in 1986 **(Gurung, 2010).**

The major cash crops grown in the study area are tea, Amriso, cardamom, cucumber and banana. Tea is grown in ward number 2 and 3 whereas Amriso is grown in ward number 1 and 4 while cardamom is grown more in ward number 4. In 1996, the first tea plantation was carried out in fallow lands of Lwang.99 households of Lwang village planted tea in their fields by 2008(35% households excluding tea farming).Land use pattern of Lwang's tea farmer is 1.65hactre per household in which tea plantation covers 15% which is 0.25hactre per household **(Gurung, 2010).** Besides this, people cultivate rice in the monsoon season of June/July.

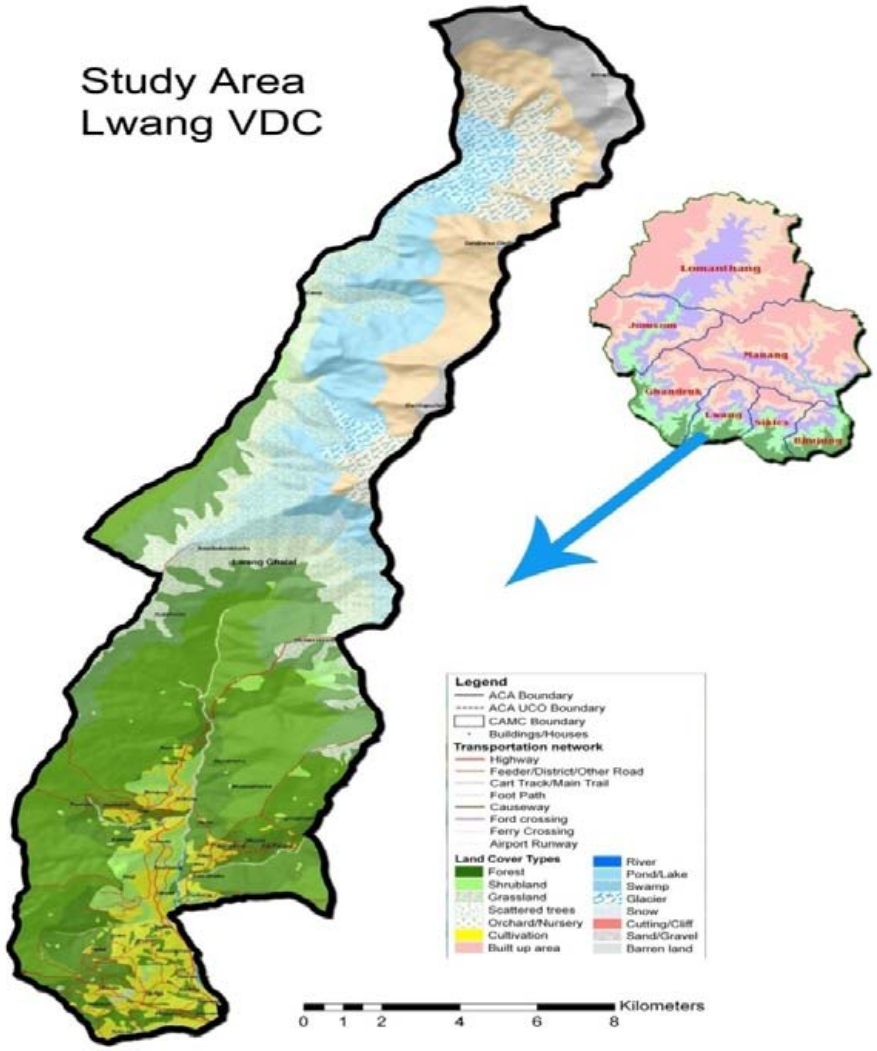

Figure 2: Location of the study area

3.3 Land use pattern/Potential VDCs for Tea Cultivation

The Landuse pattern of Lwang Ghalel CAMC consists of 72.2% of forest,5.5% of Shrubland ,25.3% of Grassland,10.2% of Agriculture,37.1% of Barren land, 2% of sand Gravel,12.6% of Glacier without ponds and Snow **(ACA, 2009/12)**.

Figure 3: Landuse Pattern of ACAP

Figure 4: Potential VDCs for tea cultivation

3.4 Methods

3.4.1 Sampling Design

Among the 9 wards of the Lwang Ghalel V.D.C, 4 wards were randomly choosen. Lwang Ghalel CAMC consists of 993 households **(ACA, 2009/12)**. The sampling intensity choosen was 23%, so from the ward numbers 1, 2, 3 and 4, a total of 101 households were taken for the household survey to fill the questionnaire.

3.4.2 Data collection

3.4.2.1 Primary Data Collection

The primary data was collected through reconnaissance survey, key informant interview, questionnaire survey, formal and informal discussion, direct observation and Meteorological Data Collection.

i. ***Reconnaissance Survey*****:**

It was carried out for rapport building; general field observation of production of cash crops and then sketch map was prepared for each working.

ii. ***Key Informant Interview*****:**

To develop further idea of the study site, informal discussion and interview with key informant was done. Model farmers, teachers, villager elders, UCOs staff and other knowledgeable persons were taken as the key informants. The interview was focused about the change in climate pattern, disasters caused by climate change, impacts of climate change and its possible adaptation measures.

iii. ***Questionnaire Survey*****:**

Among the 9 wards in Lwang V.D.C, 4 were choosen randomly.23% of households of 4 wards was taken from a total of 993 households of 9 wards. The questionnaire survey was focused on the major cash crops grown in the area, change in production of cash crops due to climate change, factors affecting the production of cash crops, change in livelihood of people due to the production of cash crops and possible adaptation measures against the effect of climate change on production of cash crops.

iv. ***Formal and Informal Discussion*****:**

Formal and Informal discussion was carried out with different ethnic group and in different tole.

v. ***Direct Observation*****:**

Direct observation was carried out around the research sites for additional information and the field verification.

vi. ***Meteorological Data Collection*****:**

Three meteorological stations respectively Lumle, Ghandruk and Siklesh were choosen to obtain the 30 years rainfall pattern data and temperature.

3.4.2.2 Secondary Data Collection

Secondary data were obtained from annual reports, newsletters, bulletins and relevant articles and ACAP libraries and information office, Department of Forest and Soil Conservation (DoFSC), Ministry of Agriculture and Cooperatives (MoAC), Lwang Unit Conservation office (UCO) of the ACAP, related reports on climate change from IOF library, etc. Internet browsing was done for the additional information. Besides these, Intergovernmental Panel on Climate Change (IPCC) good practice guideline and framework was also used. Rainfall and temperature data in the study was used from the publication of Department of Hydrology and Meteorology (DHM) and Narayani Basin Office, Pokhara. Land use map from the Annapurna Conservation Area Project (ACAP) office was used for the identification of agriculture land use portion. Map of study area was taken from the ACAP office.

3.4.3 Data Analysis and Interpretation

All the quantitative data were entered in the Statistical Package for Social Science (SPSS) .Microsoft-word; Microsoft-Excel and SPSS Program were used for data processing, analysis and interpretation of the information collected through questionnaire survey and interview. The results were then represented in the form of tables, graphs, charts and pictorial devices. The information obtained from the questionnaire was analysed by using SPSS software. Rainfall and temperature data was analysed by using Microsoft Excel for trend analysis and regression. Land use map was used for the interpretation of the agriculture land use of Lwang CAMC. The rainfall and temperature data obtained from the Narayani Basin Office, Pokhara were analysed using the Ms-Excel in the form of rainfall and temperature curves.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 General Information of the Study Area

From the research study, it was found that the number of the male respondents was 76 with 75.2 % and the number of the female respondents was 25 with 24.8%. The majority of the respondents were Gurung with 32.7 %.Majority of the respondents were literate with 66.3% and illiterate with 33.7%. The main occupation of the respondents was agriculture with 83.2%.

4.2 Information on Climatic Condition

4.2.1 Rainfall Analysis of the study area

The mean annual rainfall curve of the nearest stations (Ghandruk, Lumle and Siklesh) showed that there was highest rainfall in the year 2003 A.D. with the value 5,032 mm/year and with lowest rainfall in 1992 A.D. with the value 3,375 mm per year. The five years interval of rainfall curve showed that the rainfall pattern slightly increased during first five years i.e. 1980-1985.The curve showed slight decreasing trend and then increased during 1985-1990. There is great amount of decreasing rainfall pattern during 1990-1995.During 1995-2000, the rainfall pattern increased at first and then decreased. During 2000-2005 there is greater amount of rainfall pattern while from 2005-2009 there is decreased rainfall pattern at first and then increased rainfall pattern and then again decreased. Altogether the rainfall curve showed irregular rainfall pattern during 1977-2009. The linear trend line of average mean annual rainfall from 1977-2009 showed that the rainfall pattern was increased at the rate of 2.74mm/year.

The station Lumle, which lies at the southern part of ACA, has an increasing trend in annual precipitation pattern; increasing pattern further followed by winter post monsoon, pre-monsoon and monsoon seasons with the value of 4.3mm/decade,32.7mm/decade,48mm/decade and 205 mm/decade respectively. Siklesh station has shown decreasing trend in annual precipitation of 125mm/decade. Ghandruk station also showed the tremendous decreasing trend of average annual rainfall. The rate of declination is much pronounced in this station, which is nearly 333 mm/decade. The trend analysis based on annual rainfall record 1977-2007 at three stations clearly shows that Lumle has an increasing trend of rainfall whereas Sikles and Ghandruk the nearest station has the negative trend of rainfall pattern **(Pandit, 2009).**

Although the study area did not have any climatology stations, but the three stations were close to the study area. So, we can assume that the rainfall pattern can be demonstrated by these three stations Ghandruk, Lumle and Siklesh.

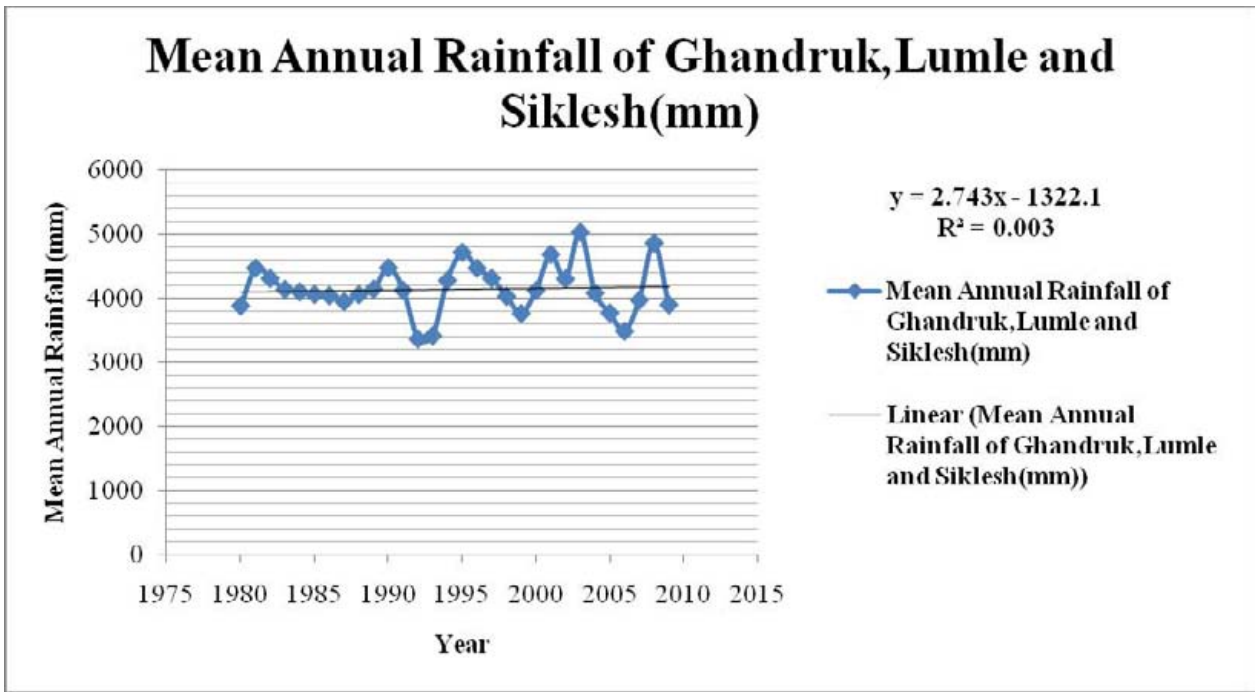

Figure 5: Mean Annual Rainfall trend at Ghandruk, Lumle and Siklesh Station (DHM, 1977-2009)

The recorded data in kaski on rainfall from 1979 to 2007 showed about 69 percent of the rainfall occurred during Monsoon. Pre-monsoon (Jan-May) rainfall trend did not show great variations, but during the last few years of the study (2003 to 2006) there was a substantial decrease in the amount of rainfall especially in monsoon. And again in 2007 this rainfall trend was found to be increased. These strongly indicate that local people in such scenario couldn't predict the usual rainfall pattern **(Bhusal, 2009).**

4.2.2 Temperature Analysis of the Lumle

The mean annual maximum temperature was highest in the year 2009 A.D. with temperature of 21.95^0C and the highest value of the mean annual minimum temperature is in the year 2006 A.D. with the temperature of 12.88^0C. The linear trend line (figure 6) showed that mean annual maximum temperature has increased by 0.064^0 C per year and mean annual minimum temperature has increased by 0.01^0 C per year. This increase in temperature has supported the evidence of Climate Change.

The trend of temperature increase in Lumle Station was much higher in winter as compared to other season. The temperature trend line of winter follows the steeper path making the difference nearly 3.7^0C in the interval of 30 years resulting average rate of 1.1^0C/decade, while the other season show trend of 0.33^0C/decade **(Pandit,2009).**

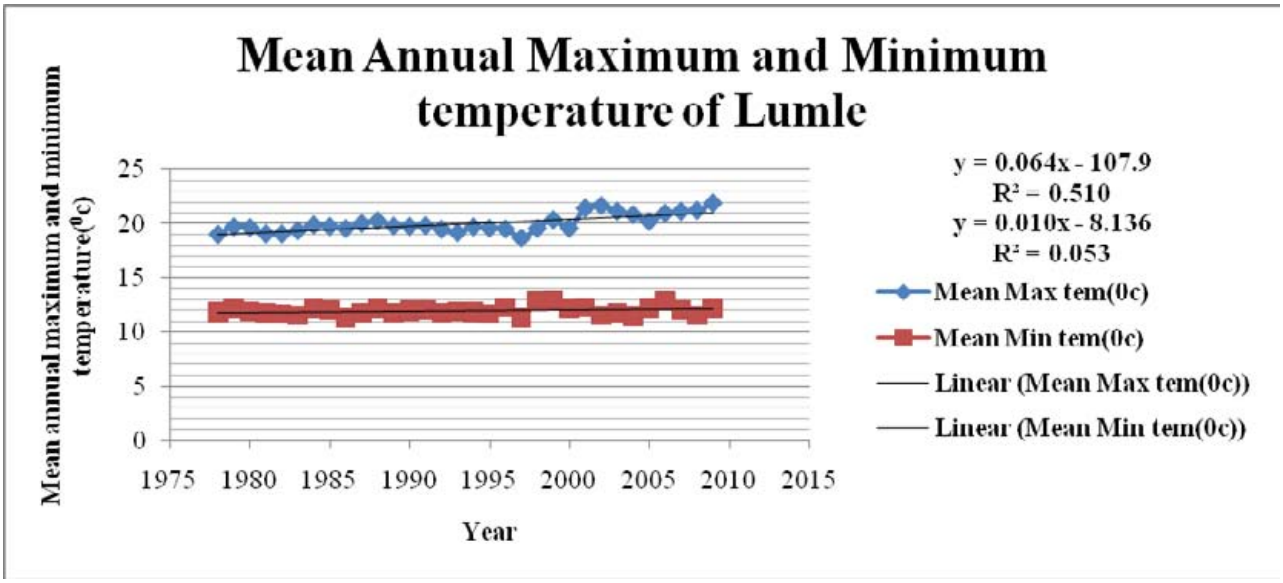

Figure 6: Mean annual maximum and minimum temperature at Lumle Station (DHM, 1977-2009)

The statistical record of temperature data from Lumle between 1978 and 2007 showed an increasing trend, with the increase mostly in the winter. During the period of 30 years, the temperature has raised by around 1^0C **(Bhusal, 2009)**. (**Shrestha *et al*.,1999)** in a study based on an analysis of temperature trends from 49 stations for the period 1977 to 1994 indicate a consistent and continuous warming in the period at an annual rate of 0.06^0 c. Similarly ,a study conducted by **Practical Action (2009),** using data from 45 weather stations for the period 1996-2005,indicate a consistent and continuous warming in maximum temperatures at an annual rate of 0.04^0C. The result showed that local peoples' perception seemed to be agreed with the statistical record in the region.

4.3 Knowledge and Perception on Climate Change

55% of the respondents knew about the climate change by extension agents like radio, television, newspapers etc., 39% by experiences whereas rest 6% didn't know about it. All the respondents told that the amount and intensity of rainfall was low in the study area. Most of the respondents told that before 10 years, falgun (February/March) was the month to start monsoon but at present the monsoon starts at ashad. 58% respondents and 40% respondents told that months in which temperature increased were Baishak (April/May) and Chaitra (March/April) respectively whereas 20% and 79% respondents told that months in which temperature decreased were mangsir (November/December) and Poush (December/January) respectively.

Regarding the past and present variation in temperature and rainfall pattern, 79 (92.9%) of the respondent said that, temperature is in increasing order while rainfall is in decreasing order, while 3 (3.5%) of the respondent said temperature has been decreased. Regarding the perception on change in temperature pattern of the area, 88.2% reported of less cold and frosty winters while 61.2% reported of hotter summer. Among 85 respondents, 72 (85%) reported that elder and children feel more comfortable, 21 (25%) reported that vegetable production is increased

while 3(4%) reported of improvement in tourism and business sector due to the warmer winter. Regarding the perception on Snowfall pattern change, among 85 respondents 78(91.8%) said that the snowfall has decreased, while 45(52.9%) said that the snowfall timing has been disturbed leading to unusual and untimely snowfall **(Pandit, 2009).**

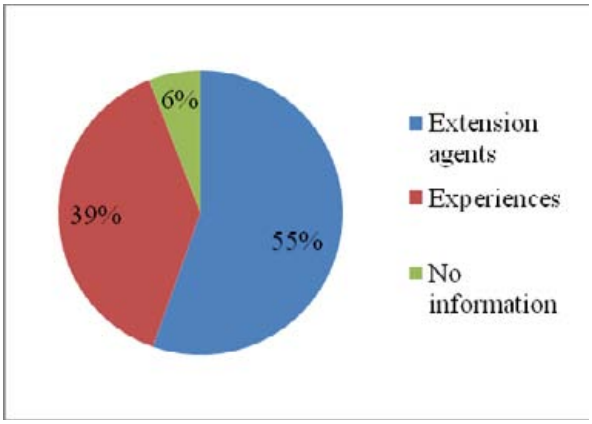

Figure 7: Response towards source of information on Climate Change

4.4 Production, Marketing and Climate Change

4.4.1 Cash Crops and Climate Change

It was found that the major cash crop grown in the ward number 1 was Amriso, tea in ward number 2 and 3 and Amriso in ward number 4. So, it can be said that the major cash crops grown in the Lwang Ghalel V.D.C. was tea. The majority of the respondents told that they had grown the cash crops since 15 years.

Three types of land were found in the study area. They were respectively khet, Bari and Kharbari. The cash crops were grown in Bariland. It was found that the major cash crops grown by respondents were tea with 45.5%, and then Amriso with 17.8 % and rest others with small area.

Table 1: Major cash crops grown by respondents

Cash Crops	Cash crops grown in percent
Amriso	17.8
Amriso, Cardamom	1
Amriso, Banana	1
Amriso, Alaichi	1
Amriso, Banana	5
Amriso, Cardamom	4
Amriso, Cauliflower, Cardamom	1
Amriso, Cucumber	8.9
Amriso, Cucumber, Beans	1
Amriso, Cucumber , Cardamom	1
Amriso, Tea	3
Amriso, Tea, Cardamom	1
Tea	45.5
Tea, Amriso	7.9
Tea, Coffee	1
Total	100

Table 2 showed that the majority of respondents i.e.36.6% told that the main reason for change in flowering, fruiting and harvesting time of cash crops was snowfall. Tea was most affected cash crop from snowfall.

Table 2: Reasons for change in flowering, fruiting and harvesting time

Snowfall (%)	**Delay in flowering (%)**	**Lack of rainfall (%)**	**Rolling of leaves (%)**	**No Response (%)**
36.6	**17.8**	**14.9**	**1**	**29.7**

Figure 8 showed that reasons for decrease in survival rate of cash crops were defective seedlings, lack of knowledge of planting and draught.

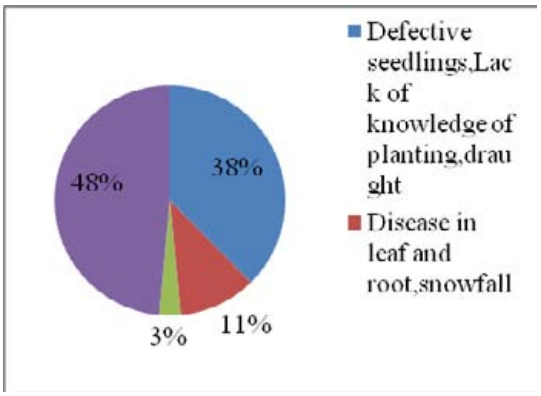

Figure 8: Response towards reason for decrease in survival rate of cash crops

Table 3 showed that Gandhe Jar (*Ageratum conizoides)* was the major new species found in the farm land. It is a tropical weed and is indicator of climate change since it is

found in increasing temperature. Since some of the cash crops like tea, coffee are grown in small amount in farmland , the weeds like Banmara and Gandhe Jhar were found in farmland. They affected the growth of the cash crops. Since they are tropical weeds, they are also indicators of climate change because they are found in site of cold climate.

Table 3: Response towards new species invaded in farmland

Gandhe Jhar(*Ageratum conizoides)*	**Banmara(*Eupatorium adenophorum*)**	**Both**	**No response**
62.4%	**13.9%**	**14.9%**	**8.9%**

Local peoples' responses and verification in the field provided evident of invasive species like ***Ageratum sps (Nilgandhe***, which is not edible for livestock***), Ageratina adenophora (kalo Banmara), Chromolaena odorata (Seto Banmara)*** and these weeds are taken as a major causes of declining cereal production, grass coverage and reduction of perennial local herbs **(Bhusal, 2009).**

4.4.2 Soil moisture/water availability

All the respondents told that there was decrease in soil moisture and water availability for cash crop cultivation. Also drinking water and ground water level along with number of natural springs were decreased.

Figure 9 showed that the major source of water supply was forest streams. The rest others were rainfall and water tank.

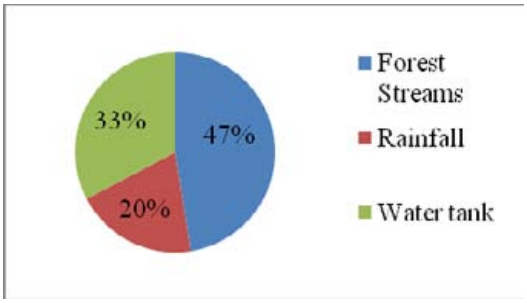

Figure 9: Response towards source of water supply

According to the respondents, in the past the sources of drinking water were Spring/mul (93%), river (2%) and Dhunge Dhara (2%) but at present 98% reported of being supplied by the community managed tap system **(Pandit, 2009).**

4.4.3 Production of cash crops and relation to Climate Change

It was found that tea was grown in more area than other cash crops and Amriso was produced more than other cash crops. Since Amriso grow easily and give immediate benefits, people in the Lwang V.D.C cultivate more Amriso.

Table 4: Area of Cash Crops grown and amount of production annually

Name of cash crops	Area(Ropani)	Production
Amriso	185	31,240 brooms
Tea	224	9,342 kg/year
Cardamom	25	125 kg/year
Banana	4	-
Coffee	1	-

Nepal is the world's top producer of large cardamom (*Amomum sublatum* Roxb.) followed by India and Bhutan (Product Chain Study-Cardamom, MoAC 2008). In 2009/10, the total production is 5233 Mt.ton from14001 hectare area and in 2008/09, the production was 7,037 Mt.ton from 14,370 ha **(MoAC, 2009/10)**. Commercial cultivation in Nepal started in around 1953 from Ilam and was introduced from Sikkim, India. At present, its commercial cultivation spread over 37 districts of Nepal **(NSCDP/MoAC, 2010)**.

Figure 10 showed 27.7% of the respondents told that increase in production of cash crops was due to good variety of seedlings, more adapted to draught and increase in demand whereas 51.5% of the respondent told decrease in production.

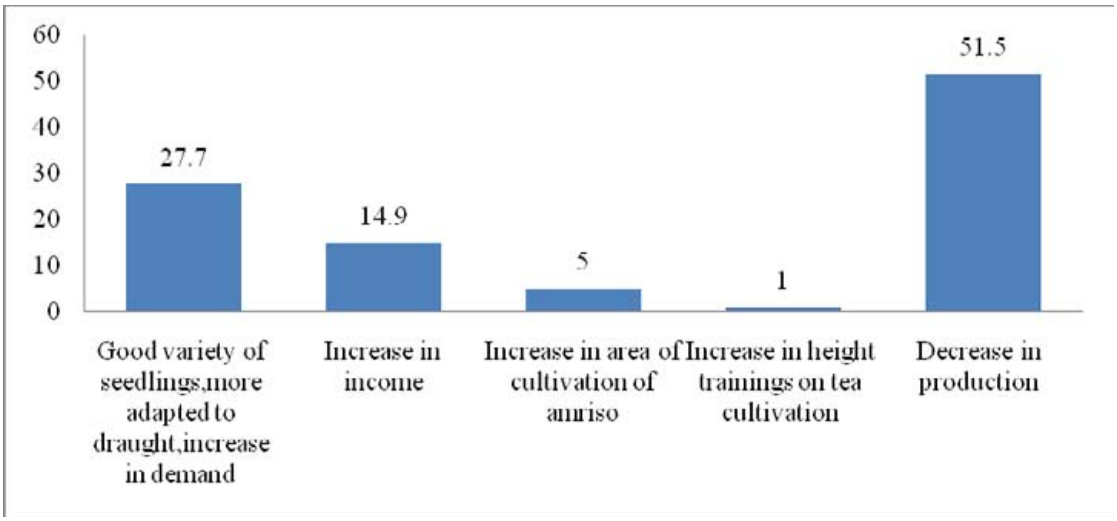

Figure 10: Response towards reasons for increase in production of cash crops

The majority of the respondents i.e. 37.6% of the respondents told that decrease in production of cash crops annually was due to defective seedlings, lack of knowledge of planting and draught whereas 48.5% of the respondents did not give any response.

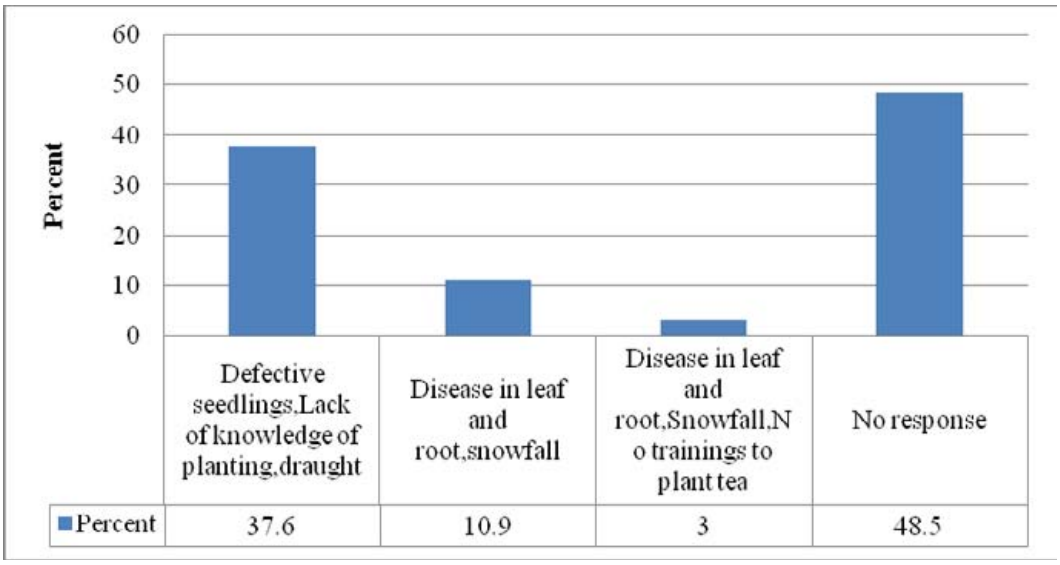

Figure 11: Response towards reasons for decrease in production of cash crops annually

Tea leaves collection and tea production in a year (kg.) rapidly fell down after year 2007 comparing to previous years due to lack of proper manuring to plants, insufficient pruning and huge leakages of tea leaves while Annapurna Tea cooperative reported to be long drought in winter and 500 kg of tea was damaged due to lack of electricity **(Gurung, 2009).** The study showed similarity with above findings.

The majority of the respondents i.e. 54% of the respondents told that reasons for increase in problems of water supply were due to decline in source of water whereas 15% told lack of water storage.

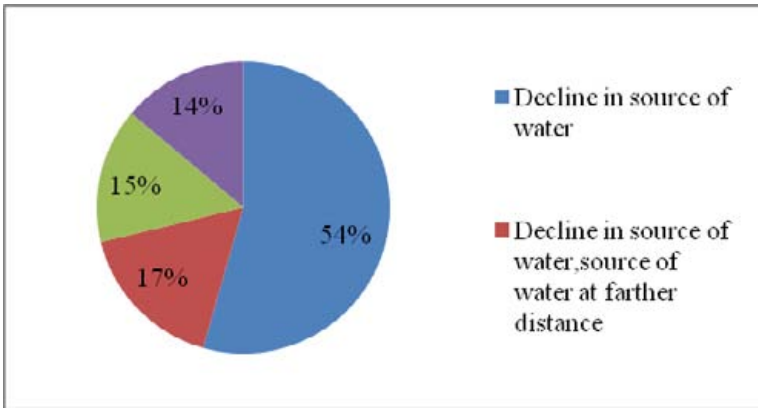

Figure 12: Response towards reasons for increase in problems of water supply

Majority i.e.49% of the respondents sold their cash crops to both ACAP tea factory and local market whereas remaining least i.e. 2% of the respondents sold their cash crops to ACAP tea factory.

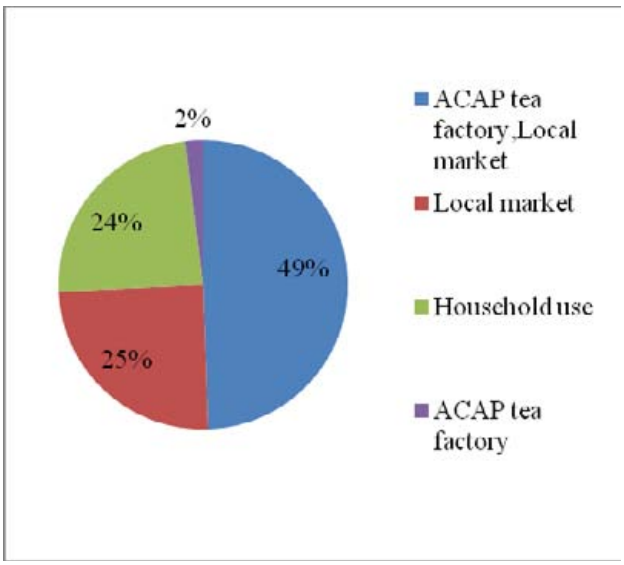

Figure 13: Places of selling the cash crops of selling the cash crops

According to a study by **(Gurung, 2010)**, 30% of the tea supply went to foreign market, 20% was kept in stock, 41% of the tea used to go to domestic market and 9% of the tea supply was sold to local market.

Most of the large cardamom produced in the country is exported to India (more than 97 %) and other countries **(DOC, 2010)**. It is the 11th major exporting commodity with share of 1.92 % in the country's total export. It is the third major agricultural product after lentils (6th with 6.14 %) and Tea (10th with 1.96 %) in share of total national export by value **(Chapagain, 2011).**

It was found that there was greater difference of income of Amriso within ten years, than was tea and cardamom respectively. Due to this difference in income people grow more Amriso than tea and cardamom.

Table 5: Change in annual income by selling cash crops

Name of cash crops	Annual income before 10 yrs.(NRs.)	Annual income at present (NRs.)	Difference (NRs.)
Amriso	44,000	7,60,600	7,16,600
Tea	34,500	3,03,100	2,68,600
Cardamom	5,00	8,000	7,500

It was found that majority of the respondents i.e. 80.2% of the respondents told there was increase in contribution of cash crops in household income, 8.9% of the respondents told there was decrease in contribution of cash crops whereas remaining 10.9% told that there was not any change.

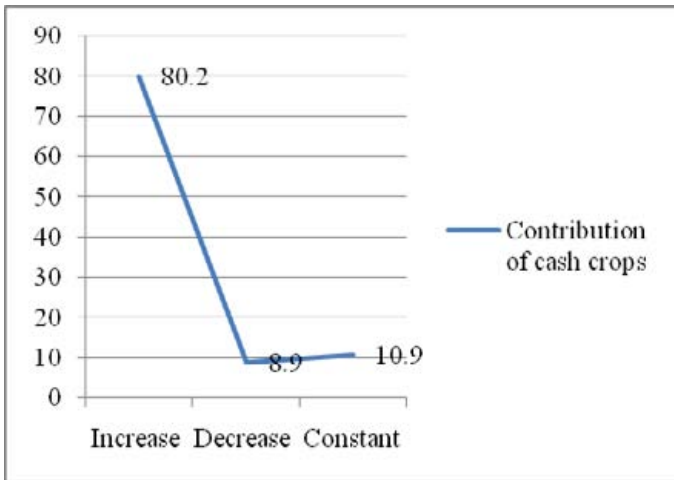

Figure 14: Contribution of cash crops in household income

12 people are employed by year round job because of and establishment of tea processing plant in Lwang **(Gurung, 2010).**

The contribution of the cash crops in the respondent's economy is 16.32%, farm sources contribute 20.626% whereas off farm sources contribute 79.374% in the respondent's economy.

Table 6: Contribution of cash crops in household income last year

Income source	Income(NRs.)	Percent (%)
Cash Crops	11,51,950	16.32(cash/Grand total)
Farm sources	14,55,900	20.626(Farm/Grand total)
Off farm sources	56,02,600	79.374(Off farm/Grand total)
Grand Total	70,58,500	100

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4.5 Impact Assessment

84.2% of the respondents told that the major impact of Climate Change was seen in farmland. After the farmland, the impacts seen were soil erosion, loss of cash crop production whereas there was not any change in agricultural implements. But 42% of the respondents told that the number of cash crops growing in a year was increased. The reason behind it may be increase in income due to selling of cash crop like amriso.

Out of total respondents, 27% expressed the lack of manpower as the cause, while 82% expressed the weather extremities and climate induced impacts as the cause of decreased

agricultural production. According to the local people, the most prevalent natural disaster in the area was landslide and flood. On specification, 64% reported landslide and 20% reported flood as one of the major natural disaster affecting agriculture and livelihood in the community. Regarding the query of impacts of disaster 41% of the respondents reported destruction of crops, 39% reported of reduced agriculture and 8% reported of agricultural land loss in the landslide. Other problems were the unwanted weeds occupying the farmland, intervening the agriculture. One of the most noticed weed was Gandhe Jhar (***Ageratum conizoides)***. The local people reported that the invasion was much noticed in last two three years. Even though they tried a lot to remove the weed time to time, they were not able to get rid of the problem **(Pandit.2009).**

Table 7: Response towards different types of impacts

Response	Increase (%)	Decrease (%)	Constant (%)
Soil erosion	57.4	25.7	16.8
Loss of cash crop production	52.5	18.8	28.7
Landslide	27.7	59.4	12.9
Number of cash crop growing in a year	42.6	40.6	16.8
Change in agricultural implements	35.6	64.4	-
Impacts of Climate Change in farm land	84.2	15.8	-

Out of the 50% respondents who gave response, majority of the respondents i.e. 24% told that tea was affected more from Climate Change. Then amriso, cardamom and Coffee were respectively affected by Climate Change.

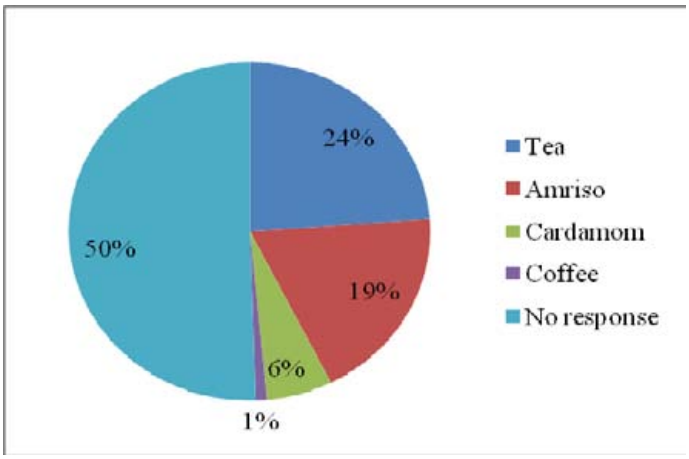

Figure 15: Response towards major cash crops affected from Climate Change

It was found that the amount loss in tea in 4 wards was Rs.27, 750 and in Amriso was Rs. 26,900 and in Cardamom was Rs. 6,900.The disease found in tea was “Sindure”

which affects the tea leaves whereas in Cardamom was viral diseases *Chirkey* (mosaic streak) and *Furkey* (bushy dwarf).*Chirke* affects leaf whereas *Furkey* affects steam.

Table 8: Amount loss in cash crops production by disease

Name of cash crops	Amount loss(NRs.)
Tea	27,750
Amriso	26,900
Cardamom	6,900

4.6 Adaptation Strategies

Adaptation measures were studied at two levels: Household level and Farm level.

4.6.1 Household level

Among the total respondents, all of the respondents told that there was no change in household structure or position. 73.3% of the respondents told there was occurrence of mosquito whereas 26.7% of the respondents told there was not occurrence of mosquito. Mosquito occurs only in tropical climate. So, it can be said that the temperature is rising in the study area.

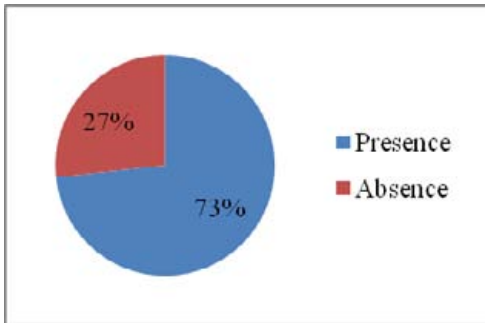

Figure 16: Response towards occurrence of mosquito

4.6.2 Farm Level

Respondents did not change in cropping pattern, planting time and variety of crops. But 84.2% of respondents wanted to adopt improved technology in farmland to adapt Climate Change, 84.2% of respondents wanted to use Green House Plastic House, all respondents used Farm Yard Manure (FYM) in farm, 83.2% of respondents used Chemical fertilizer, 84.2% of respondents used in-situ manure, 73.3% of respondents used pesticides and

68.3% of respondents did water source protection and 67.3% of the respondents did improvement and soil conservation activities.

Table 9: Response towards adaptation strategies in farm land

Response	Change (%)	Constant (%)
Change in cropping pattern		100
Change in Planting time	27.7	72.3
Change in variety of crops	2	98
Adoption of improved technology in farmland to adapt Climate Change	84.2	15.8
Use of Green House Plastic	84.2	15.8
Use of FYM	100	
Use of Compost	84.2	15.8
Use of Chemical fertilizer	83.2	16.8
Use of in-Situ Manure	84.2	15.8
Use of Pesticides	73.3	26.7
Water Source protection and improvement	68.3	31.7
Soil Conservation activities	67.3	32.7

65.3% of the respondents told that Amriso was the best adapted species to climate change,21.8% of the respondents told that teas was the best adapted species to climate change whereas 12.9% of the respondents told that they did not know about it.

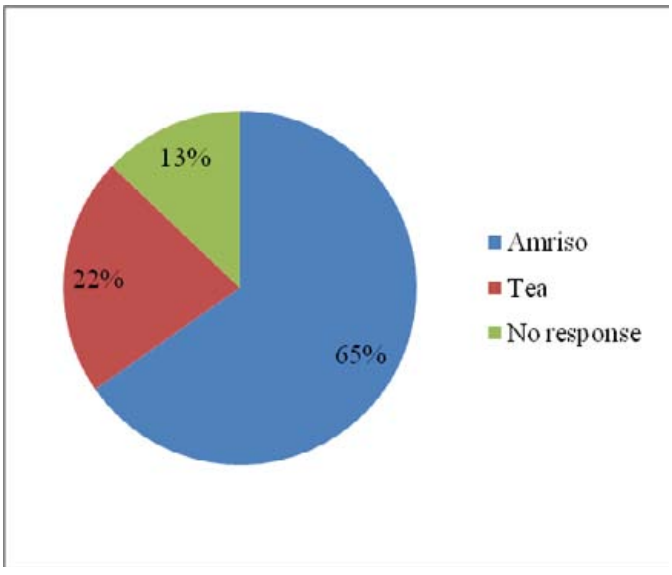

Figure 17: Response towards best adapted Cash Crops to Climate Change

36.6% of the respondents told that conserving the forest streams and 31.7% told provision of water tanks to manage water source while rest 31.7% did not have any idea.

Table 10: Response towards ways of managing water source and improvement

Ways	Percent (%)
Conserving forest streams	36.6
Provision of water tanks	31.7
No Idea	31.7

39.6% of the respondents told construction of dam and plantation as ways of soil conservation activities, 11.9% told provision of water tanks, 16.8% told terrace cultivation while 31.7% did not have any idea.

Table 11: Response towards ways of soil conservation activities

Ways	**Percent (%)**
Construction of Dam and Plantation	39.6
Provision of water tanks	11.9
Terrace Cultivation	16.8
No Idea	31.7

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Information on climatic Condition

- Mean Annual Rainfall of the three stations Ghandruk, Lumle and Siklesh showed irregular rainfall pattern during 1977-2009.
- Mean annual maximum and minimum temperature seemed to be increased annually.

5.1.2 Knowledge and Perception on Climate Change

- The majority of the respondents knew about the climate change and the source of the information was extension agents like radio, television.
- The monsoon seasons before 10 years were Jeth (May/June), Magh (January/February), and Falgun (February/March) whereas at present majority of the respondents told it was Ashad (June/July).
- The temperature raising months were Baishak (April/May) and Chaitra (March/April) while temperature decreasing months were Mangsir (November/December) and Poush (December/January).

5.1.3 Production, Marketing and Climate Change

- The major cash crop grown in ward number 1 was Amriso (***Thysanolaena maxima),*** in ward number 2 and 3 was tea (***Camellia sinensis***) and in ward number 4 was amriso, cardamom (***Amomum sabulatum***) and cucumber.
- There was change in flowering, fruiting and harvesting time of cash crops and the reason which was the major was snowfall.
- New species Banmara (***Eupatorium adenophorum***) and Gandhe Jhar (***Ageratum conizoides***) was found in farm land which was the shifting of the vegetation from tropical climate to cold climate.
- There was decrease in survival rate of cash crops and the reason was defective seedlings, lack of knowledge of planting seedlings and draught.

- There was decrease in soil moisture, water availability, drinking water, ground water level and number of natural springs to cash crops cultivation.
- Tea was grown in greater area than other cash crops.
- There was increase in area of growing cash crops.
- Amriso was produced more than other cash crops.
- There was decrease in production of cash crops annually.
- There was increase in problems of cash crops production.
- Majority of the respondents sold their cash crops in the ACAP tea factory and local market.
- There was increase in sale of cash crops.
- There was greater difference in annual income before 10 years and at present in Amriso than other cash crops.
- The contribution of cash crops in household income was increased.

5.1.4 Impact Assesment

- There was increase in loss in production of cash crops due to soil erosion
- There was decrease in occurrence of landslides.
- There was decrease in number of cash crops growing in a year.
- Impacts of climate change in farmland was seen and the major impact were draught that has caused decrease in production of cash crops and there was invasion of weeds in the farmland
- Tea was affected more than other cash crops from climate change
- "Sindure" in tea leaves was major disease found among all cash crops.
- *Chirke* (mosaic streak) and *Furkey* (bushy dwarf) were the disease found in cardamom plant.

5.1.5 Adaptation Measures

- The frequency of mosquito occurrence was greater in the study area meaning rising in temperature and climate change has occurred.
- Amriso was the best adapted cash crops in the study area because it had spreaded roots which can escape draught
- Majority of the respondents want to adapt improved technology in farmland to mitigate climate change

- The kinds of support needed were trainings on climate change and economic support to adapt technology.
- Majority of the respondents used Farm Yard Manure (FYM), Compost, Chemical fertilizers and in-situ manure to improve soil fertility.
- Respondents conserved forest streams and water tanks as a means of water source protection and improvement
- Construction of dam, plantation and terrace cultivation was major soil conservation activities done by respondents of the study area.

5.2 Recommendations

- Awareness on the climate change causes, impact and adaptation must be given through the training programs.
- Draught resistant varieties of seedlings should be distributed to the farmers in order to cope with the climate change.
- Reforestation and afforestation programs should be done on the denuded hills and conservation of water resources should be done to reduce the demand of water supply.
- Research on impacts of climate change on production of cash crops and adaptation practices should be promoted.

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