

**FARMER'S PERCEPTION AND ADAPTATION MEASURES OF RICE
CULTIVATION UNDER CLIMATE CHANGE AND VULNERABILITY
CONTEXT IN NAWALPARASI DISTRICT**

ANISHA GIRI

Exam Roll No: 57

TU Registration No: 1-2-44-2-2009

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ANISHA GIRI

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APPROVAL SHEET

This research report, here to, entitled “**FARMER’S PERCEPTION AND ADAPTATION MEASURES OF RICE CULTIVATION UNDER CLIMATE CHANGE AND VULNERABILITY CONTEXT IN NAWALPARASI DISTRICT**” prepared and submitted by **Ms. ANISHA GIRI**, in fulfillment of requirement of the Undergraduate Practicum Assessment (UPA) for the **Bachelor of Science in Agriculture**, is hereby accepted.

.....
Asst. Prof. Chandra Kant Dhakal
Advisor, Advisor Committee

Date:

.....
Asst. Prof. Thaneshwar Bhandari
Member, Advisor Committee

Date:

.....
Lal Prasad Amgain, PhD
Campus Chief, Lamjung Campus
Date:

Accepted as fulfillment of requirement of the Undergraduate Practicum Assessment Course at
Final Year for Bachelor of Science in Agriculture

.....
Prof. Gopal Bahadur K.C., PhD
Assistant Dean (Academics)
Institute of Agriculture and Animal Science
Tribhuvan University
Date:

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ABBREVIATIONS AND ACRONYMS

AIACC	American Institute of Architects California Council
APP	Agriculture Perspective Plan
CBS	Central Bureau of Statistics
CEN	Clean Energy Nepal
CIA	Central Intelligence Agency
CO ₂	Carbon dioxide
°C	Degree Celsius
DADO	District Agriculture Development Office
DDC	District Development Committee
DFO	District Forest Office
DHM	Department of Hydrology and Meteorology
DLSO	District Livestock Service Office
DOI	Department of Irrigation
EMF	Energy Modeling Forum
FAO	Food and Agricultural Organization
Fig	Figure
GDP	Gross Domestic Product
GHGs	Green House Gases
GoN	Government of Nepal
ha	Hectare
HDR	Human Development Report
HH	Household
IAAS	Institute of Agriculture and animal Science
ICAO	International Civil Aviation Organization
ICIMOD	International Centre for Integrated Mountain Development
IFPRI	International Food Policy Research Institute
INGO	International Non-Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute

KIS	Key Informant Survey
MOAD	Ministry of Agriculture Development
MOF	Ministry of Forestry
NGO	Non-Governmental Organization
NPC	National Planning Commission
NWRP	National Wheat Research Program
OLS	Ordinary Least Square
Ppm	Parts Per Million
PRA	Participatory Rural Appraisal
%	Percentage
SAFBIN	Strengthening Adaptive Small scale Farming Systems in rainfed areas in Bangladesh, India and Nepal
SPSS	Statistical Package for Social Science
TU	Tribhuvan University
UNFCC	United Nation Framework Convention on Climate Change
VDC	Village Development Committee
WFP	World Food Programme
WWF	World Wide Fund for Nature

ABSTRACT

This research was conducted during June-August 2014 to examine the perception of rice growing farmers to changing climatic context in Pithauli and Rajahar VDC of Nawalparasi district. A purposive sampling technique was applied and 70 households were sampled and conducted interview schedule with the help of structured questionnaire. Further, key informant survey was carried out including the members of DADO, DFO, DDC, owner of agro-vet and leading farmers. FGD was also conducted to triangulate the findings of the collected data. Findings of the study revealed that 57% answered as 'yes' on climate change effect on rice. The result showed that farmers experienced erratic rainfall both in frequency and intensity, 96% reported increase in temperature and 85 % observed delayed on set of monsoon with shorter lasting period. Similarly, increased number of drought days, scarcity in surface and groundwater, invasion of new pest, diseases and new plant species were other climate induced constraints in rice farming. Furthermore, rice farming and management practices i.e. seed sowing and germination date, transplanting date, flowering, fruiting and maturity period was adversely affected. Farmers reported the shorter flowering and fruiting period and hence shorter maturity period. Major adaptation practices to cope with these adversities involves use of water source, cutting bunds, use of pesticides, bio-pesticides, more manures were practiced by local people. However, farmers reported the increase of yield of rice and the reasons behind it was the use of hybrid varieties along with more manures. Multiple regression analysis was done to analyze the factors affecting rice production using climatic and non-climatic variables. It was found that area under rice cultivation, maximum temperature and average rainfall had positive and significant impact on rice production, however, minimum temperature had negative but significant impact on rice production. This implies that lowered minimum temperature during grain filling and maturity is undesirable. Formulation of holistic approach and development of cost effective climate change adaptation strategies to increase the resilient of smaller holders farmers were recommended to improve their livelihood.

Key Words: climate change, Adaptation, FGD, Household survey, Rice

CHAPTER 1: INTRODUCTION

1.1. Background

In Nepal, majority of the population are small land holding farmers where almost 80% remain in rural areas, 65% people are involved in agriculture. Nepal is one of the least developed countries in the world with low GDP of US\$562. It is estimated that approximately 25% of the populations live below poverty line as US\$1.25 per day. Agriculture is dominant sector in Nepal. It accounts more than 75% of human resource involvement and contributes to 33% of GDP (MOF, 2014). However, the contribution of agricultural sector to the national economy is challenged by its vulnerability to climate change. Climate change is a phenomenon due to emission of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization resulting variation in solar energy, temperature and precipitation (Upreti, 1999).

Climate change is considered to be one of the most serious concerns to sustainable development with adverse impacts on environment, agriculture, economic activity, natural resources and physical infrastructures (ICAO, 2012). Since 1750, the time of the industrial evolution, carbondioxide (CO₂) has increased by 31%, methane by 151% and nitrous oxide by 17% (Dahal, 2009). The rising concentrations of Green House Gases (GHCs) are leading to climate changes in the climate. Since the developed countries are mainly responsible for global warming but the impact of changes will be felt by the entire community. The poor country, like Nepal, is likely to suffer most due to limited resources to cope with and adapt to the effects of climate change. (Regmi et al. 2010). Natural resources including water, biodiversity, agriculture and other important components such as food security and human health will be the most affected aspects by the climate change impact (Dieudonne, 2001). An average size of ownership of agricultural land in Nepal is 0.85ha per household, but majority (45%) owns less than 0.5ha. since only limited land has irrigation facilities, agricultural production is highly dependable on favorable weather conditions, mainly on the monsoons timing and availability of rain water. A late or erratic monsoon causes losses of crops and resulted into food insecurity. This situation makes the agriculture sector one of the most vulnerable to climate change in Nepal. Agriculture in Nepal is totally dependent on weather and climatic conditions. Increasingly, unusual changes in climate as rising temperature, irregular monsoon, intensity of rainfall and its patterns are being noticed in

Nepal. FAO (2007b) has given two types of adaptation measures as autonomous and planned in its framework on adaptation to climate change in agriculture, forestry and fisheries. It is found that awareness about changing climatic trends have strong implications in terms of future ability to adapt to climate change. The subsistence farming economy is affected due to changes in the reliability of stream flow, a more intense and potentially erratic monsoon rainfall, and the impacts of flooding. Decline in rainfall from November to April adversely affect the winter and spring crops. Decline in food production has threatened to the food security of people. Food security is the state achieved when food systems operate such that “all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life”(FAO, 2007).

Climate variability has resulted into shifts in agro-ecological zones, prolonged dry spells and higher incidence of pest and diseases. Extreme climatic condition has led to increase incidence of fire in recent years affecting more than 50,000 people and loss of large areas of productive forest land. While agricultural productivity of Nepal already remains to be one of the lowest in South Asia. Sensitivity of food production to climate change is greatest in developing countries due to less advanced technological buffering to droughts and floods (Parry et al., 1998). Climate variability is an important aspect of the risks of crop production. Most of the climate change scenarios include more intense and more variable precipitation events. Such changes in precipitation may have significant impacts on agricultural systems. Precipitation changes not just have the direct impacts on plant growth but also an important indirect impact resulting from potential changes in soil erosion (Doering *et al.*, 2002). In this context farmers from the developing countries like Nepal are highly affected. The food insecurity condition is increasing day by day due to this health condition of poor farmers are being worse off. They don't have accessibility to foods, if they able the quality of food is not desirable, which induces the nutritional food insecurities. This type of food insecurity is more common in terai regions of Nepal. Climate change and its effects are inevitable so it is very important to get ready to adapt to the changes at community, national and international levels. Appropriate adaptation technologies must be developed making the best use of community's traditional and local knowledge to cope the effects of climate change. Economic diversification can also be an important adaptation strategy for the developing countries to reduce the dependence on climate sensitive resources (UNFCCC 2007). Adaptation to Climate Change may include many measures. AIACC has given

some general recommendations to adapt to climate change as (1)create conditions to enable adaptation, (2)integrate adaptation with development, (3)increase awareness and knowledge, (4)protect natural resources etc. Sustainable organic agriculture can help to reduce the risk of drought, irregular rainfall events with floods, rising temperatures and soil erosion and increase the productivity of agro-ecosystems.

1.2. Statement of problem

Climate change and agriculture are interrelated process. Long drought, scanty and erratic rainfall, increasing numbers of floods and increasing temperature in the area indicate the dreadful impacts of climate change on agriculture which certainly lower the agricultural production and further accelerate in the food shortage.

Rajahar and Pithauli VDC are main season rice growing VDCs of Nawalparasi district. There are many reports of weather effect in different time period. Some farmers reported excess rainfall at seed sowing time and some reported water deficit during rice transplanting. Water deficit in plantation time delayed in rice plantation that ultimately reduced rice yield. Moreover they lack different climate change adaptation and mitigation strategies which have further added to a range of factors that contribute to increased vulnerability and poverty. Farmers in this area have been practicing some changes in agricultural pattern and practices to cope with the effects of changing climate. In this area, there has not been documentation on climate change vulnerabilities context in that district. There has not been any study regarding perception on climate change. It is necessary to carry out the research on the adaptation measures followed by the farmers and recommend the suitable one.

1.3. Objectives

The general objective of this study was to assess the perception and adaptation of rice farmers under climate change and vulnerability context in Nawalparasi district.

However the specific objectives were:

1. To measure community perceptions on climate change before and after project intervention;

2. To map climate change adaptation measures undertaken by the communities with or without support
3. To determine relationship of climate change and socioeconomic factors affecting rice yield.

1.4 Rationale of study

Nepal is an agricultural country and most of the farmers are dependent on rain-fed agriculture for their livelihood. Increasing temperature, change in precipitation pattern together with the loss of local genetic diversity is hitting hardest to subsistence farmers following traditional farming system, indigenous and marginalized people. Subsistence and resource poor farmers do not have adequate resources for effectively responding to the impacts of climate change, and highly vulnerable to its negative consequences. The study explain about what the likely impacts on agriculture and food security, how people are responding to them, and what are the potential roles of the local government and other development partners are in adaptation efforts in vulnerable sectors. There is an immediate need to address the impact of climate change issues and related hazards to plan the coping strategy with emerging uncertainties. Rather, farmers have already started adopting different adaptation measures to cope with the effects of climate change on agriculture. Thus, it is imperative to study whether the adaptation measures undertaken by farmers are effective to cope with the impacts of climate change on agriculture or not and further prioritized the potential impacts and identifies the effective adaptation strategy through participatory approach with the local communities. The major implication of this study will be the guidance for formulation of climate responsive development programs that will help to enhance production and productivity in adverse conditions to ensure food security.

This study will enhance to analyze effects of climate change on agricultural productivity of Nawalparasi (Rajahar and Pithauli VDCs) exploring alternative economic potential measures to cope from farmers' level. This study will also elaborates the more attention of the researchers, governmental offices and different other related organizations to design and implement suitable agro- ecological projects and programs.

CHAPTER 2: LITERATURE REVIEW

2.1 Global climatic change context

Climate refers to the average weather and represents the state of the climate system over a given time period. Climate changes over time may be due to natural variability or as a result of human induced increases of greenhouse gases in the atmospheres and is reflected in the variation of the mean state of weather variables including temperature, precipitation and wind (Orindi and Siri, 2005). Available data show that air temperature near the earth surface rose by 0.74 °C from 1906 to 2005 and scientists estimated it could be increased as much as 6.4 °C on average during the 21st century (IPCC, 2007).

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 effect everybody, the entire global community needs to work together to address this major problem (CEN, 2003).

The Millennium Ecosystem Assessment (2005) established that agricultural intensification has met the rising demand for food in most parts of the world, but that significant trade-offs have been associated with these increases. In particular, water and nutrient cycling, biodiversity and carbon stocks have been negatively affected; while emissions of greenhouse gases and habitat fragmentation have increased. In turn, environmental degradation exacerbates some of the drivers of climate change and further undermines the sustainability of agriculture.

2.2 Climatic pattern of Nepal

Nepal has a wide range of climate from tropics to alpine regions. There are four seasons in Nepal namely spring, autumn, summer and winter. The study carried out by the Department of Hydrology and Meteorology have shown that the average temperature in Nepal is increasing at the rate of approximately 0.06 degrees celcius per year. According to Malla (2008), the rise in temperature is due to solar radiation absorbed by glacial lakes as well as radiation absorbed by land because of snow melting in the Himalayan region. The maximum temperature of the year

occurs in May or early June and starts decreasing rapidly from October and reaches the minimum of the year in December or January. The average rainfall of the country is 1,500mm. Nepal receives abundant rainfall, but the distribution throughout the year is of great concern with regards to the occurrence of floods, landslides, and other extreme events. Same report indicates that erratic rainfall events (i.e. higher intensity of rains but less number of rainy days and unusual rain) with no decrease in total amount of annual precipitation have been experienced. Most floods occur during the monsoon season when heavy precipitation coincides with snowmelt in the mountains. The annual mean precipitation is around 1800 mm in Nepal with 80 percent of it occurring during the monsoon season (June to September).

2.3 Nepal's share in climate change

Nepal has a negligible share in the global emission. According to the National Communication Report recently prepared by HMG, net emission of CO₂ was about 9.747 tonnes and the net emission of methane was estimated to be 0.948 tons in 1994. In addition, annual emission of carbon monoxide (CO) rose slightly from 0.638 million tons/year (mt/yr) in 1990 to 0.693 mt/yr in 1996 with the exception of 2.14 mt/yr in 1994. This fluctuated for sulphur dioxide (SO₂) with 11 mt/yr in 1994 and 0.028 mt/yr in 1996. A similar situation has been observed for nitrogen oxides (NO₂) and TSPs (CBS, 1998). Based on these estimates, there is no change in the amount of carbon (only 292 tons/yr) released by deforestation activities. However, carbon released from fuel burning increased by over 60 per cent (from 4.7 to 7.4 mt/yr) between 1985 and 1998. Estimates also indicate that while the total emission of carbon dioxide (CO₂) was only 0.2 mt in 1990, it will reach 2.07 mt by 2030. This indicates that the per capita emission of 42.6 kg of CO₂ in 1990 was from the use of petroleum products such as kerosene and diesel and this will reach 220.6 kg by 2030 (MoPE, 2000).

2.4 Climate change scenarios of Nepal

According to available data, average annual mean temperatures have been increasing in Nepal by 0.06°C between 1977 and 2000 and these increases are more pronounced at higher altitudes and in winter. For precipitation, the trends are less certain but there is evidence of increasing occurrence of intense rainfall events, and an increase in flood days and generally more variable river flows (Oxfam International Nepal, 2009). Number of rainy day is decreasing 0.8 per year. Nepal's Initial National Communication Report on Climate Change to UNFCCC mentions

increased seasonal and annual air temperature over the last few decades. Observed annual trend of temperature rise per decade is 0.41°C while seasonal rising trend for temperature during pre-monsoon, monsoon and winter periods are 0.43°C , 0.43°C and 0.37°C per decade respectively (MoPE, 2004). In the case of Nepal, it was found that temperature in Nepal is increasing at a high rate. The warming seems to be consistent and continuous after the mid 1970s. The average warming in annual temperature between 1977 and 1994 was 0.060°C/yr (Shrestha *et al.*, 1999). The GCM projections indicate a potential increase in temperature over Nepal of $0.5\text{--}2.0^{\circ}\text{C}$ with a multimodal mean of 1.4°C by the 2030s, rising to $3.0\text{--}6.3^{\circ}\text{C}$ with a multimodal mean of 4.7°C , by the 2090s. For precipitation GCMs project a wide range of changes, especially in monsoon: -14 to 40 % by the 2030s increasing -52 to +135 % by the 2090s (NCVST, 2009). This projection suggests that Nepal's agriculture will face many challenges over the coming decades due to climate related variability.

Another study conducted in the vicinity of Tsho Rolpa Glacial Lake in Dolakha District suggests that mean temperature is increasing annually by 0.019°C with an increase in average summer temperature of 0.044°C . This is causing rainfall to increase by 13mm per year, while the number of rainy days is decreasing by 0.8 days per year. Consequently, river flow is increasing at $1.48\text{m}^3/\text{s}$ per year, which is about 1.5 times higher than increased precipitation. High increases in summer river flow provide further evidence that high summer temperatures are leading to fast glacial melt/retreat (Dahal, 2006).

Communities of different parts of Nepal have already begun experiencing unusual changes in weather patterns. Some of them are happy with these changes; for example, farmers of Mustang and Manang districts have noticed improved apple sizes in recent years. But others face hardship; for example, water leakage into traditional houses has increased, which people feel is due to new precipitation patterns (Dahal, 2005).

Romily and Singh (2009) in ADB's Strategies and Program Assessment, have indicated that high inter-annual variability, and that maximum temperatures in Nepal are progressively increasing in line with global and regional records. From 1977 and 1994, the mean annual temperature is estimated to have increased by 0.06°C , and is projected to increase by another 1.2°C by 2030, 1.7°C by 2050, and 3.0°C by 2100. Days and nights are becoming warmer and cool days and

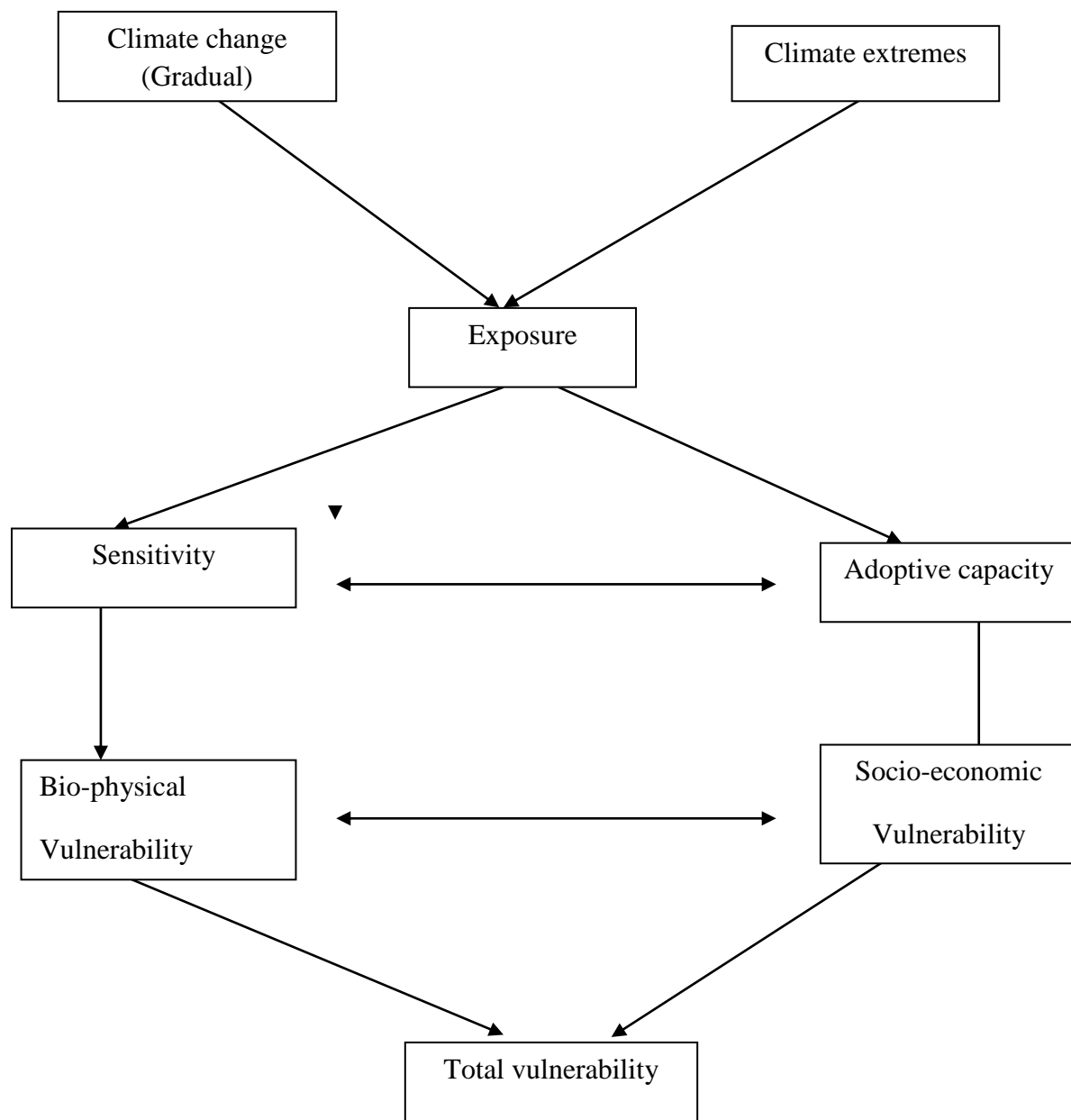
nights are becoming less frequent. Precipitation extremes show an increasing trend in intense precipitation events at most recording stations.

2.5 Vulnerable communities

According to the Third Assessment Report of the IPCC, vulnerability is defined as: The degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (IPCC, 2001). Vulnerability can thus be defined as a function of exposure, sensitivity, and adaptive capacity, or:

$$\text{Vulnerability} = f(\text{exposure, sensitivity, adaptive capacity})$$

In the IPCC report, exposure is defined as the nature and degree to which a system is exposed to significant climatic variations; sensitivity is defined as “the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli¹; and adaptive capacity is defined as the ability of a system to adjust to climate change (including climate variability and extremes), to moderate the potential damage from it, to take advantage of its opportunities, or to cope with its consequences.



(Source: Deressa *et al.*, 2008)

Figure 1. Conceptual framework to vulnerability

According to Human Development Report (2007) for Nepal, the poor, marginalized and disadvantaged groups of people are more vulnerable to the climate change impacts in Nepal. The livelihoods of most poor people depend on natural resources and climate sensitive sectors such as agriculture, forestry and fisheries. They have few options for diversifying livelihoods away from

these sensitive sectors and reducing vulnerability. Poor people often do not have enough assets to sustain or rebuild livelihoods after the impact of hazards, because of low financial resources, poor health, lack of clean water and sanitation, weak physical infrastructure and remoteness from government services. Lack of access and ability to use technology reduces their speed of recovery and options for livelihood strategies.

According to Raut (2006), the most vulnerable ecological and socio-economic systems are those with the greatest sensitivity to climate change and the least ability to adapt. Nepal is closely linking climate change adaptation to poverty alleviation, in addition to maximizing synergies with other environmental concerns such as land degradation, biodiversity, and disaster reduction. Nepal's major natural resources, biodiversity and water, are at the forefront of climate vulnerability.

Crop yields and changes in productivity will vary considerably across many regions because vulnerability of climate change depends on physical, biological and socioeconomic characteristics. Low-income populations dependent on isolated agricultural systems are particularly vulnerable to hunger and severe hardship. These populations are usually food deficient, and therefore even a marginal decline in yield could be very harmful. The most negative effects are foreseen in dry land areas at lower latitudes and in arid and semi-arid areas, especially for those reliant on rainfed, non-irrigated agriculture. Many of these at-risk populations are located in South, Southeast Asia and Africa (Aydinalp and Cresser, 2008). There is also a strong indication that marginal agriculture and farmers may be most vulnerable both to short term variations of weather and longer term changes of climate whether or not they are located in resource-poor countries. This may be compounded when farming is practiced at or near the edge of its appropriate climatic region.

2.6 Climate change and crop production in Nepal

The crop yields have strong association with the amount of rain it receives on right time. The pattern of precipitation has been noticed fluctuated for the past 30 years in Nepal (Shrestha *et al.*, 2000). A study (2008) shows that local communities from Chitwan have experienced the change in the climate in the recent years. About 95% people mention drought and erratic rainfall patterns as the main indicators of this change. The increase in temperature and availability of irrigation

water are negatively related. Research finding shown that, if the temperature is increased by 1⁰c the effectiveness of the irrigation is decreased by 10 % (Pradhan, 2007). The destruction of land by floods and landslides, and subsequent declining land productivity, compels people to occupy forest areas, cultivate steeper land and look for alternative means of living (Gurung and Bhandari, 2008). It is reported that all Nepal temperature is increasing steadily and 32 years temperature data analysed showed about 1.8⁰c increase from 1975-2006 and in 2006 was reported warmest year in record (shrestha *et. al.*, 2012). From the trend observed between 1976 and 2005 it is expected that the regions with already high precipitation will receive more rainfall and those with low precipitation will see further decrease (Practical action, 2010).

The uniform rise of rainfall will have positive impact on overall agriculture but skewed rise (extreme event) will have negative impact on soil nutrient loss, flood damage and erosion. Increase in temperature and occurrence of erratic rainfall are expected to lead to a 30% decrease in crop yields in central and south Asia by the mid-21st century (UNDP, 2006). However at a higher latitude, crop yields should increase because there will be a decrease in frost and cold damage. A case study conducted in Manang and Mustang shows that farmers are benefited to the changing climatic condition for the short time as they are growing new vegetables like Cauliflower, Cabbage, Chili, Tomato, Cucumber and the new plant species that grow previously at lower altitude can be grown at present day (Dahal, 2007). A study concluded by climate change research centre of Purdue University had concluded that there would be 10-15 days delay on onset of monsoon due to climate change in South Asian countries including Nepal in 2009 (Kantipur Daily, 2009). About 80% of water in Nepal is used for irrigation. Vulnerability of rice yield showed that at 4⁰C increase in temperature and 20% increase in precipitation, there could be yield increase only from 0.09 to 5.5% and beyond that the yield would continue to decline. With maize, it was found that increased temperature would lead to decreased yield (Rai M., 2008). Due to the excessive drought and high temperature, there was drying of almost 50% of rice seedlings, maize, millet and soybean in most part of the country (Kantipur News, June 22, 2009). 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 agri-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, 2007b). Early Maturity of the crops due to increase in temperature may help in destruction of existing cropping pattern. Shifting of climatic zones has been observed in the

country. Extinction of local basmati rice varieties, some local wheat, maize and other agricultural crops was also observed. Research study showed that Nepal had the highest level of agricultural productivity in South Asia in the early 1960s, but, its agricultural productivity was the lowest in the Subcontinent by the early 1990s (Tiwari, 2002).

Sowing date of wheat in arid, semi- arid, dry sub-humid, moist sub-humid and humid zones will shift towards cooler months with climate change. The shift in the sowing date towards cooler months can offer an opportunity to offset the likely impacts of climate change. With each advance in sowing date the growing season length decreases compared to the previous sowing, in the baseline as well in the climate change scenarios. This suggests that alteration in the sowing date might not interfere with other crops grown during the remainder of the year, but might offer an opportunity of some additional time that can be utilized for land preparation or to grow an additional crop. Apart from this, cultivars that can take benefit of shorter durations will be beneficial. Because of high economic concerns associated with adaptation option, it will be comparatively easy to adopt the alteration in sowing date as it will most probably be at no cost decision (Sultana and Iqbal, 2009).

An analysis done by the Nepal Agriculture Research Council using simulation models for major crops such as rice, wheat and maize suggested that rice yields might increase under elevated CO₂ and 4°C increase in the Terai (lowland) (3.4%), hills (17.9%) and mountains (36.1%). Similarly, wheat production might increase by 41.5% in the Terai, 24.4% in the hills and 21.2% in the mountains under elevated CO₂, but there would be a significant decrease in production with a 4°C rise. Maize yields were expected to increase in the hills and mountains, but decreased in the Terai with 4°C rise (Gautam, 2008).

Over the past three years, the delay in monsoon season experienced in Nepal has changed the cropping pattern and crop maturity period. It has delayed the planting and harvesting season by a month, which has in turn affected rotation practices. The delay in monsoon season has also made thousands of hectares of farm land fallow and reduced production due to lack of water. Earlier onset and earlier retreat of monsoon has been noticed in Nepal in recent years. If that is going to be the regular pattern, people will have to respond accordingly to adapt to the changed weather phenomenon. The farmers will have to carry out earlier plantations. If they stick to their traditional farming calendar, it is sure to lead to crop disaster and famines. Fruits are flowering

unusually earlier and winter ended earlier. Weather-related extreme events like excessive rainfall, longer drought periods, landslides and floods are increasing both in terms of magnitude and frequency. More floods and glacial lake outbursts are expected to destroy irrigation and water supply systems, roads, bridges, settlements and productive land. Flood related deaths will increase. Land degradation will reduce crop productivity and put more pressure on remaining fertile land. In the dry season, increased evaporation will lead to water scarcity. Soil moisture deficits, droughts, fire and possible pest outbreaks will decrease crop yields. It is perceived that climate change will have major impacts on ecosystems, land and water resources, health, and major economic sectors such as agriculture in days to come (HDR, 2007).

Farmers follow a traditional cropping system, relying on rainwater and the seasons. In the past four decades, the agricultural productivity of major grains in Nepal has gone from being the highest in South Asia to the lowest. Since 1960, the number of global Weather related disasters have increased fourfold, real economic losses seven fold, and insured losses (WWF Nepal, 2006).

The pattern of precipitation has been noticed fluctuated for the past 30 years in Nepal (Shrestha et al, 2000). Due to over and under precipitation, crop production is highly uncertain. The actual monsoon month and the main rice-planting month, July, is becoming drier. A research conducted by Lobell and Field (2007) by using first difference approach showed that at least 29% of the variance in year-to-year yield changes was explained by the change in minimum, maximum and precipitation pattern for all crops.

The delay in monsoon season has also made thousands of hectares of farm land fallow and reduced production due to lack of water (Regmi and Adhikary 2007). Some farming communities (from Bardiya and Kanchanpur districts) have related the loss of local landraces to climate change. They state that local landraces require a longer rainy season and that in the past 15 years the duration of rainfall has decreased.

2.7 Literatures on adaption against climate change impacts

Nepalese smallholder farmers are largely poor with limited access to external resources and are likely to be particularly vulnerable to climate change. The farming in Nepal is characterized by mixed farming and livestock production systems, which have rich diversity. Forest, home

gardens, agroforestry (with richness of fodder trees) and productive fields all embed diversity rich maintenance and use practices that increase adaptability and reduce vulnerability. Communities maintain rich species and intraspecific crop diversity both to help manage climatic adversity and meet their other needs (Jarvis *et al.*, 2008).

In South Asian countries, particularly India, Nepal and Bangladesh, farmers are already adapting to changing conditions by using traditional seed exchange practices that are part of established seed systems. Farmers can also use their knowledge of abiotic stress tolerance and adaptability in their materials and work with plant breeders to develop varieties that are adapted to changing local conditions and possess improved yields and quality (Jarvis *et al.*, 2007).

Crop diversification is one effective way for communities to cope with increased flooding and the threat to their land is by growing a range of new and different crops that have a higher market-value. By introducing crops that are more resilient to the changes in rainfall patterns, crop diversification also allows alternative crops to be cultivated at different times of the year, despite of changes to the weather (Practical Action Nepal 2008).

2.8 Climate change in rice production

Early Maturity of the crops due to increase in temperature may help in destruction of existing cropping pattern. Shifting of climatic zones has been observed in the country. Extinction of local agricultural crop varieties was also observed. Research study showed that Nepal had the highest level of agricultural productivity in South Asia in the early 1960s, but, its agricultural productivity was the lowest in the Subcontinent by the early 1990s (Tiwari, 2002).

IRRI (2006) suggests that rice production in Asia has already been affected by climate change, which could eventually slow efforts to reduce poverty in the region. It also suggests that to continue to meet the demand for rice in the region, yields will have to be doubled over the next 50 years, but global warming will make rice crops less productive with increasing temperatures. Due to over and under precipitation, crop production is highly uncertain. The actual monsoon month and the main rice-planting month, July, is becoming drier. A study in Kabilash VDC in Chitwan, Nepal shown that farmers could not transplant rice in two consecutive monsoons of 2004 and 2005 because of excessive drought (Gurung, 2007). An analysis done by the Nepal Agriculture Research Council using simulation models for major crops such as rice, wheat and

maize suggested that rice yields might increase under elevated CO₂ and 4°C increase in the Terai (lowland) (3.4%), hills (17.9%) and mountains (36.1%) (Gautam, 2008).

Due to the excessive drought and high temperature, there was drying of almost 50% of rice seedlings, maize, millet and soybean in most part of the country (Kantipur News, June 22, 2009). The Intergovernmental Panel on Climate Change's Third Assessment Report also confirmed that CO₂ enrichment under field conditions consistently increases biomass and yields in the range of 5–15%, with CO₂ concentration elevated to 550ppm. Levels of CO₂ that are elevated to more than 450ppm will probably cause some deleterious effects in grain quality.

(Erda *et al.*, 2005) The reduction of rice production in the past years can be closely linked to the abnormal rainfall received in those years. Agricultural production, of which 36.5% is rain fed until 2002 (DOI, 2007), and mainstay of over 80% Nepalese (CBS, 2001) is badly affected by the change in precipitation (Tiwari, 2002).

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Study area

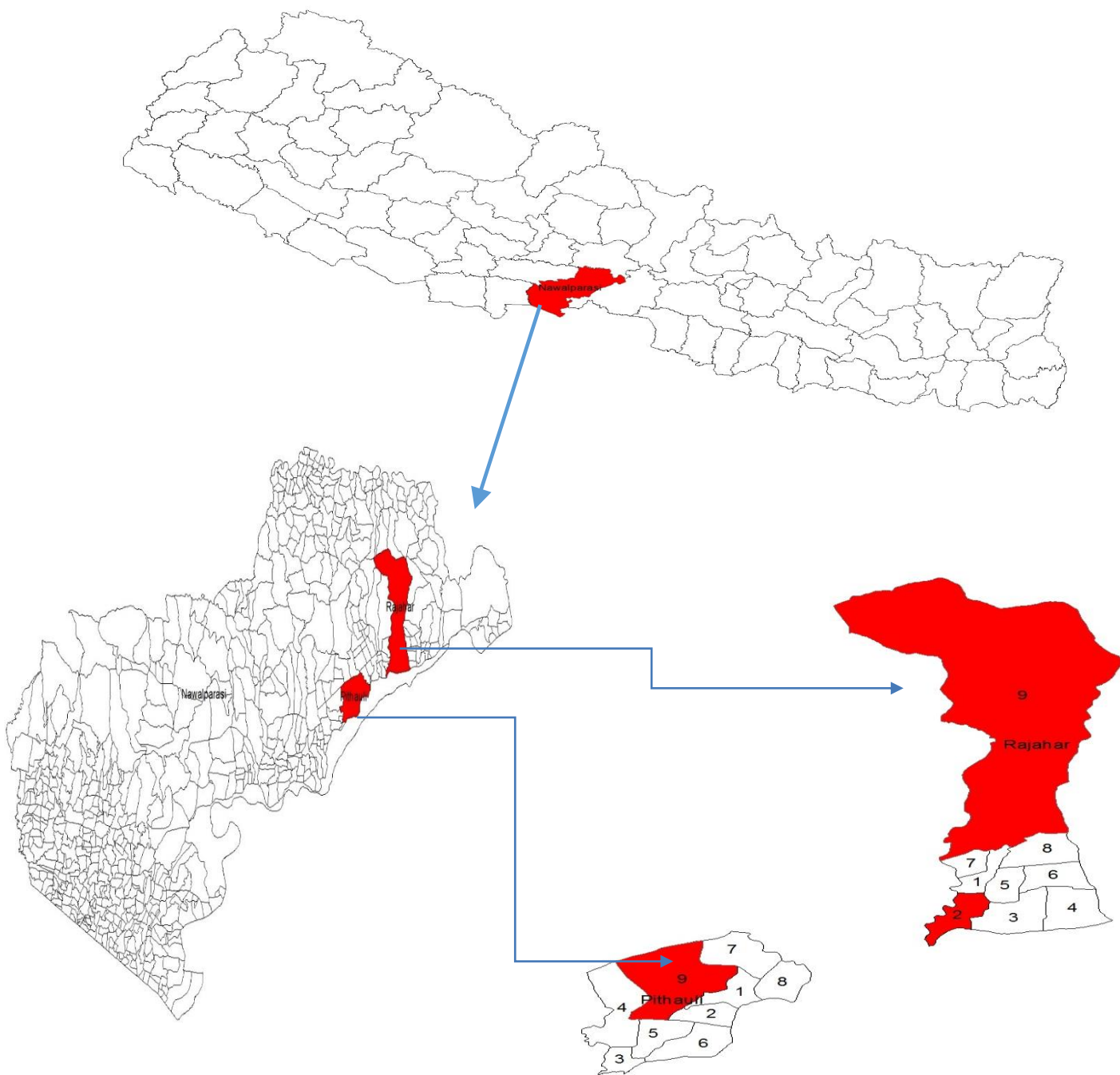
The study was conducted in Pithauli (ward no 9) and Rajahar (ward no 2 and 9) VDCs of Nawalparasi district as in this district unpredictable but intense rainfall is creating flood havoc which is likely to be the result of changing rainfall patterns causing changed river flows interacting with human intervention. These two VDCs were purposively selected as Caritas SAFBIN project intervention areas.

Nawalparasi (27°40'00" to 83°55'00") lying in Lumbini zone of Western Development Region, has an area of 2,162km² and population 643,508. People from different ethnic groups like Brahmins, Chhetris, Tharus and Newars dwell here and thus it is the district of mixed culture. People here chiefly rely upon traditional occupations like agriculture and animal husbandry to support their livelihood. The maximum temperature lies between 20.5° c to 36°c while annual rainfall is recorded to be 2145mm in average. Rice is the major crop grown in this area and as a result of erratic rainfall pattern; farmers have been facing problems as excess rainfall at seeding time and water deficit during transplanting of paddy. There has been delay in planting time and changes in rice yield due to late planting. Farmers in this area have been practicing some changes in agricultural pattern and practices to cope with the effects of changing climate.

Table 1. Household, population and total area of study site

District/VDC	Household	Total population	Male	Female	Total area (Km ²)
Nawalparasi	128,793	643,508	303,675	339,893	2162
Pithauli VDC	1,851	8,201	3,733	4,468	15.1
Rajahar VDC	2,426	11,119	5,108	6,011	39.2

(Source: CBS, 2011)



(Source: www.wikipedia.com, 2014)

Figure 2. Map of Nepal and Nawalparasi showing study district

3.2 Type of data and source

3.2.1 Primary data and its source

Study used both primary and secondary data. Requirement of primary data was felt to measure the perception analysis because secondary data were insufficient to get from the past studies. Primary data was collected through household survey, focus group discussion and key informant survey. Generally before and after approach was used to collect information gap in a decade in order to quantify the changes in climatic factors and their effect on rice farming.

3.2.1 Secondary data and its source

The secondary information were collected through reviewing different publication mainly produced by Li-Bird, NARC, MOAD, CBS, and weather data from meteorological station, NWRP (NARC) and also from DADO Nawalparasi, ICIMOD and other relevant organizations. Time series data regarding the climate variability, climate change impacts and the adaptation techniques were particularly important for this research are collected from DHM (Department of Hydrology and Meteorology), Kathmandu.

3.3 Techniques of primary data collection

3.3.1 Sample size, sampling population and sampling procedure

The subsistence farmers, poor and marginalized people were selected for this study. About 70 farmers from two VDCs were selected randomly. The samples were collected randomly in order to collect information on perception of farmers towards climate change, its effects and the changes adapted by farmers in cropping patterns & practices. The respondent were selected about the age of 40 years, since they provide the valuable information regarding the past trends of the climatic hazards.

3.3.2. Setting questionnaire and its pre-testing

In order to collect primary information from the selected respondents, a set of questionnaire was prepared. Number of questionnaires setting was depended on number of specific objectives so, coordination schema was used to breakdown mapping variables (Appendix 1). The major variables to be included in interview schedule were household socio-economic characteristics; major livelihood systems; pattern of rainfall; pattern of temperature; change in water supply;

drought; flooding; incidence of insect, pest, weeds; indigenous adaptation strategies to cope with the effect of climate change etc.

The pre-testing of the questionnaire was carried out by administering the designed interview schedule to the at least 5% farmers in that district, out of the sampled VDC. Finalization of structured questionnaire was completed by taking due consideration of the suggestion obtained during pre-testing (Appendix 9).

3. 3. 3 Data collection method

Household survey was done during June 2014 to August 2014. Seventy respondents were selected and prepared a list with the help of Caritas-SAFBIN district team. These respondents were interviewed one by one by visiting their home primarily based on the farmers' convenience. Interview was conducted with the household head, who was generally the oldest and the most experienced person in household affairs. Structured questionnaire was used to ask question and filled up of questionnaire set with the respondent's information (Appendix 1)

Focus Group Discussion (FGD) was conducted to supplement and triangulate information gathered from the household interviews and other sources. It was performed after completing the field survey with help of the semi-structured checklist to verify the result obtained from field survey, to know the various experience and coping strategies related to climate change (Appendix 2). In the FGD, key participants were the local farmers representing ethnic groups and both male and female were included. At least 7 farmers were participated in FGD.

Key informant survey was conducted by interviewing lead farmers, agro-vet shop keepers, DDC and DADO staffs and Caritas-SAFBIN staffs based on prepared checklist to validate information and dynamics of climate change effect on rice (Appendix 3,4,5,6).

3.4 Data entry, tabulation and analysis

As soon as household survey, FGD and KIS finished, the information were cleaned, and coded as per requirements of the Excel and Statistical Package of Social Science (SPSS). For example response on temperature effect on rice reported by the respondent was coded by: 1 for increase, 2 for decrease, 3 for do not changed and 4 for do not know. Similar codes were prepared for

different requirement of data entry process of SPSS. All codes were described under variable view menu of SPSS.

Data analysis was done by using SPSS computer software packages (version 16) and MS Excel. The cross-section data, being collected, were analyzed using descriptive and inferential statistics. Statistical tools for descriptive analysis were frequency count, mean, standard deviation, maximum and minimum value. chi-square test and correlation was used to measure the significance of relationship. Variables like sex of household head, ethnicity, education attainment, occupation, family size were considered for the descriptive analysis. Simple statistics such as percentage and frequency count were used to analyze the socio- economic data gathered from household survey. Microsoft excel was used for producing descriptive statistics in form of bar diagrams, pie charts and tabular form.

Quantitative analysis: Predictions of the yield changes with climatic variables, from regression models based on historical climatic and yield data for specific crops are relatively accurate

$$\Delta Y = \beta_0 + \beta_1 \Delta R + \beta_2 \Delta T_{\max} + \beta_3 \Delta T_{\min}$$

Where, ΔY is change in yield of i^{th} year, β_0 is the constant term.

β_1 , β_2 , and β_3 are coefficient of respective climate variables rainfall (R) , maximum temp & minimum temp, respectively.

Climatic data analysis: Monthly temperature and monthly rainfall data of nearby station for the periods of 31 years (1980-2010 AD) for Nawalparasi district collected from Department of Hydrology and Meteorology were taken as independent variables. Researchers considered June-November as major rice growing months and only average of temperature, and rainfall data of that period was taken into account. Rice yield of the same period was assumed as annual yield of the district. Thus, dependent variable was considered for rice yield and its independent variables were climatic (temperature) and non-climatic (area of cultivation).

The linear trend between the time series data (y) at time (t) is given in the equation below:

$$Y_t = a + bX_i \text{-----}(1)$$

where, y_t = yield at year t , X_i = independent variables temperature or rainfall, t = time (year). “a” and “b” are the constants and slope coefficients estimated by the principle of ordinary least square (OLS) estimator.

Testing level of significance was applied for hypothesis testing by using t-test and f-test, R-squared test, and respective probability (p)-value. The null hypothesis (H_0) of no change in any effect of individual coefficients (by t-test), no "goodness of fit" of the model (by using f-test and R^2) were tested. At $(n-1)$ degree of freedom (df). If calculated value of t , f exceeds $t_{0.05}$ (tabulated value of t at 5% level of significance and $n-1$ df), we say that the difference between mean of sample and mean of parent population is significant at 5% level, if it exceeds $t_{0.01}$ the difference is said to be significant at 1% level. Chi-square (X^2) test was tested to measure the normality of the model. Also, measuring relationship of various responses are also tested by using X^2 test. This test of significance is applied only to frequencies from expected frequencies and is defined as follows:

If $X^2=0$, observed and theoretical frequencies agree exactly. The larger the value of X^2 the greater is the discrepancy between observed and expected frequencies. If the calculated value exceeds the tabulated value 5% level only then we infer a significant difference between the observed and expected frequencies. If the calculated value exceeds the tabulated value at 1% level we infer a highly significant departure.

Trend analysis: Side by side trend analysis method was used to explain average annual production, average annual maximum temperature, average annual minimum temperature and average annual rainfall

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Socio- economic characteristics of data

The major inhabitants of the Pithauli VDC were the Janajatis while that of Rajahar were Brahmins. Among the respondents 78% respondents were female and 22% were male. Majority of respondents were literate only (57.36% Pithauli and 71.37% in Rajahar) (Appendix 7). The major means of livelihood in study site was found agriculture which accounts 85.6% depending on agriculture, followed by remittances (Appendix 8). The major activities in agriculture are production of cereal crops at subsistence level and integrated farming system together with the production of pulses in significant amount. About 10% people had remittances as the major means of survival although their second major means of income was agriculture. Similarly, study shows that about 83% farmers have food sufficiency whole round the year (Appendix 9).

Table 2. Land holding size of households

S.N	land holding farmers	Percentage of households
1	Large (>1 ha)	12
2	Medium (0.5-1 ha)	36
3	Small (<0.5 ha)	52

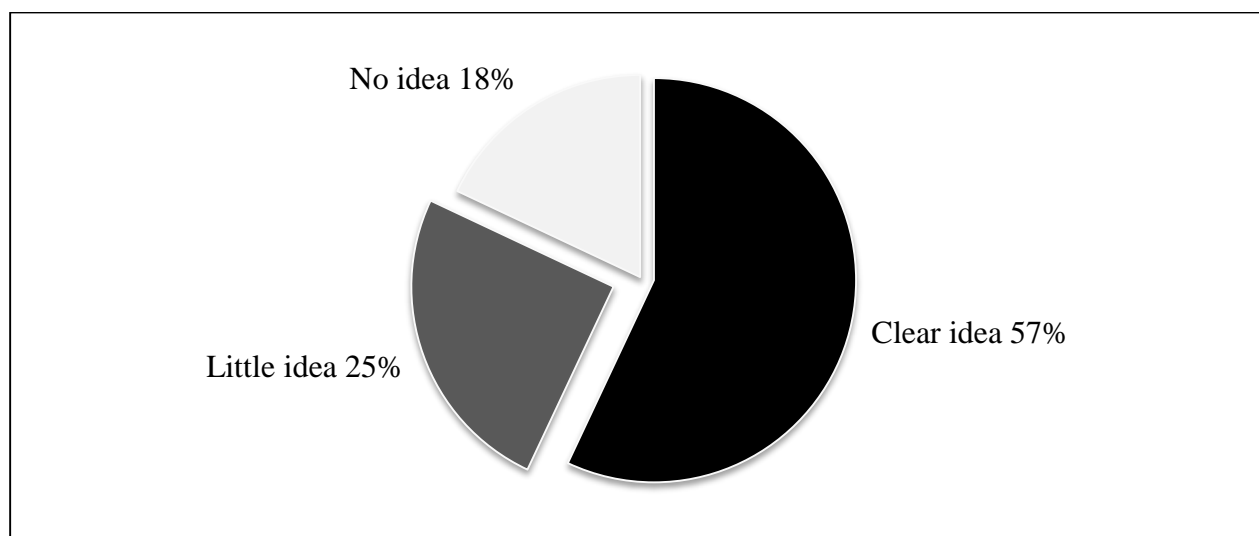
The results revealed that majority (52%) of farmers were small farmers with total land holding less than 0.50 hectare while only 12% of sampled farmers had land more than 1 hectare.

4.2 Climate change perception analysis

4.2.1 Knowledge of climate change impacts at farming level

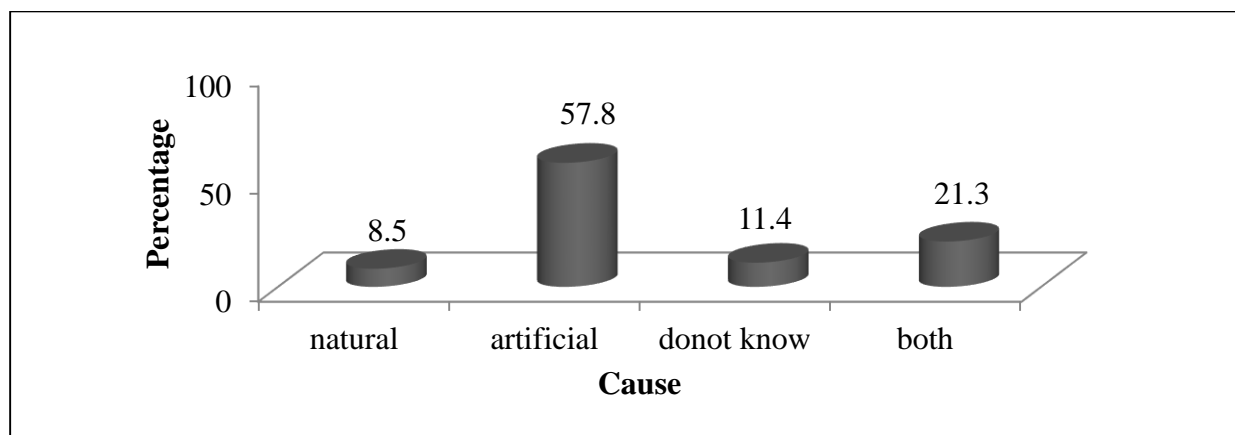
The farmers were asked for their knowledge of climate change, whether they had clear, medium or unclear ideas about the climate change and its influence in farming communities. The study across the research site was found that 18% respondents were unclear about the climate change and only 15% respondents had clear idea about climate change while 67% know only little of the climate change as shown in fig1. With VDC wise comparison, respondent of Pithauli VDC have highest frequency on clear knowledge on climate change followed by Rajahar VDC.

Most of the respondent(57.8%) reported that the climate change as a result of human activities while 8.5% reported the climate change is natural and 21.3 % reported that climate change is natural and the human activities adds as in fig 3.



(Source: Field survey, 2014)

Figure 3. Perception of people about climate change in the study VDCs



(Source: Field survey, 2014)

Figure 4. Causes of climate change

4.2.2 Indicators of climate change at farming level

This study revealed that many indicators of climate change had been seen or felt by farmers across the research site. Increase in temperature, change in precipitation pattern, increase in winter drought , decrease in wind, drying of water resources and disease/pest outbreak in the crop field were the major indications of climate change felt by the farming communities in the survey sites. Almost all the respondents felt the increase of temperature, change in precipitation

pattern and prolonged drought as the main indicators of climate change. Most of the farmers respond that monsoon rainfall has shifted more than one month with greater variability in the study area.

4.2.3 Loss of local landraces

From the FGD, it was found that the locally available species of many crops are in threat of extinction in the study sites. Mainly the species which were grown locally from ancient time period were replaced by the high yielding and early maturing varieties. Long duration varieties were replaced by the short duration varieties. Like rice varieties Radha, Sabitri are being cultivated in only limited area at present. Low productivity and requirement of high amount of water during its growing period had forced farmers to adopt species that are drought tolerance i.e sookha1, sookha2, sookha3 with higher production (supported by the SAFBIN). Similarly in the flood prone areas , Sworna sab 1 was being adopted. In recent years, farmers are attracted in OR variety and similar drought tolerant varieties of rice replacing the various varieties Gorakhnath, Sama mansuli, Mansuli, Sona mansuli, Sarju-52, Hardinath-1,etc.

4.2.4 Weather parameters

The analysis of the result showed that 95% of the respondent said that warming days had been increasing, rainfall pattern become unpredictable, seasons may have been changing, above 85% of them reported that the monsoon started latter than 10 years back, more than 96% has felt longer drought period at present than compared to past 10 years and only more than 2% experienced no change in drought condition (see table 3). In Nepal, average temperature increase was recorded as 0.06 °C per year and that in Terai and Himalayas was 0.04°C and 0.08 °C /year ,respectively (Shrestha *et al.*,1999). It was found that 70% respondents said that the monsoon started later as compared to 10 years earlier so they were forced to plant rice after the proper cropping schedule (Table 4).Due to these factors, the sowing date and transplanting days shifted earlier and the crop matures earlier than a decade back.

Table 3. Experience of farmers to changing weather parameters in Nawalparasi

Type of weather	increased	Decreased	no change	don't know
Temperature	66(94.28)	1(1.43)	1(1.43)	2(2.86)
monsoon intensity	4(5.72)	60(85.71)	5(7.14)	1(1.43)
monsoon frequency	3(4.29)	60(85.71)	6(8.57)	1(1.43)
drought length	67(95.71)	1(1.43)	2(2.86)	0.00
drought frequency	68(97.14)	0.00	2(2.86)	0.00
Hailstone	4(5.72)	41(58.57)	19(27.14)	6(8.57)
Humidity	11(15.71)	24(34.29)	18(25.71)	17(24.29)
Wind	7(10.00)	30(42.86)	26(37.14)	7(10.00)

(Source: Field survey, 2014)

Table 4. Perception of farmers towards changing rainfall attributes

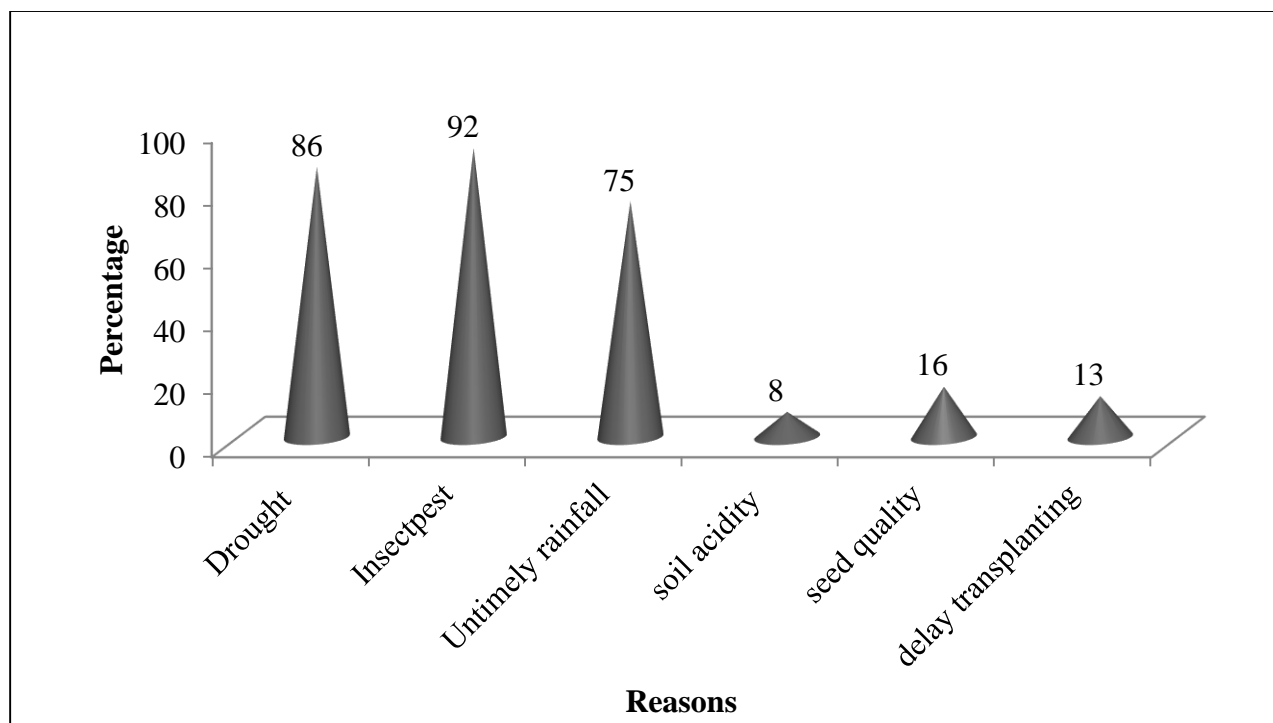
Weather pattern	Earlier/Short	Later/Long	No change	Don't know
Time of pre monsoon	2(2.86)	49(70.00)	9(12.86)	10(14.28)
Duration of pre monsoon	54(77.14)	2(2.86)	5(7.14)	9(12.86)
Timing of main rainfall	1(1.43)	57(81.42)	3(4.29)	9(12.86)
Duration of main rainfall	61(87.15)	2(2.86)	4(5.71)	3(4.28)
Timing of post rainfall	1(1.43)	58(82.86)	7(10.00)	4(5.71)
Duration of post rainfall	61(87.15)	1(1.43)	4 (5.71)	4(5.71)

(Source: Field survey, 2014)

4.3 Effects of climate change on rice cultivation

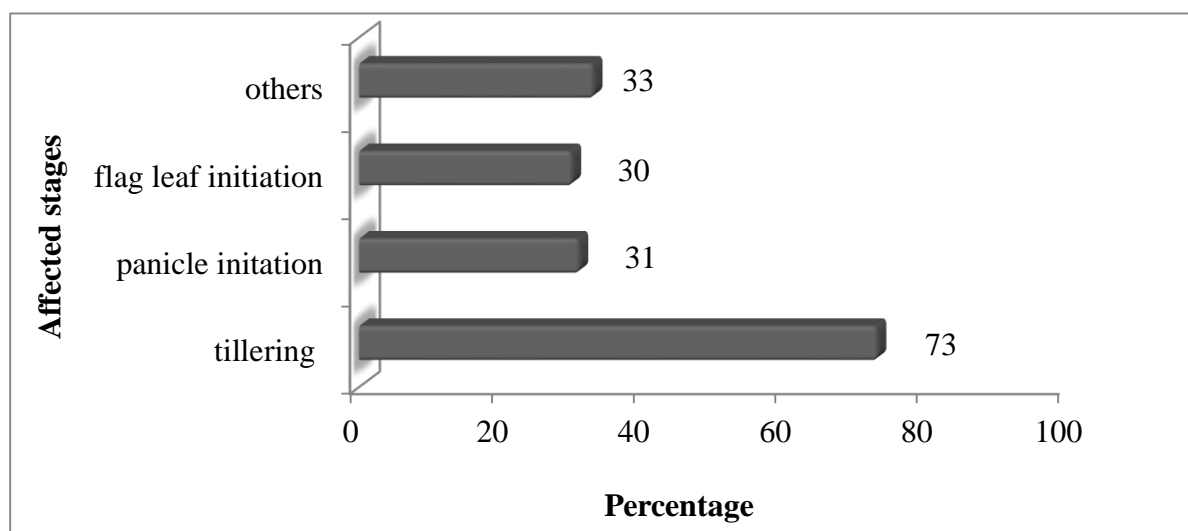
Almost all the farmers responded that the climate change had major effect on rice farming. According to the farmers, the major reason for the failure of rice farming were drought, insect pest, untimely rainfall and various other factors. The seedlings of the rice was damaged by the insectpest and drought mainly. More than 80% of the farmers experienced the occurrence of new pest and weeds were not seen previously. 92% of the respondent reported insectpest as a major reason for the losses in productivity of rice followed by drought (86%) and erratic rainfall (75%). The most affected stage of the rice reported was tillering (73%) followed by panicle initiation (31%) and flag leaf initiation(30%). The main reasons for the increase of the insectpests as compared to 10 years earlier were the secondary pest outbreak(41%), hybrid variety(33%) and the rise in temperature(26%) according to the farmers perception(Appendix 10). The most common insects reported paddy stemborer (*Scirpophaga incertulus*) ‘Gabaro in nepali’ which affects by boring on central shoot of paddy seedling and tiller.(See in appendix 15). And other insect pest reported by the farmers were leaf folder, bugs, leafhoppers,etc. Similarly, there was an increasing trend of various diseases and the no. of weeds.

According to the farmers, the use of more manures (58%) along with the hybrid variety (52%) was the major cause for the increase in no of diseases and weeds (Appendix 11). The frequently reported disease in this district was Rice blast (*Pyricularia oryzae*). Similarly, as compared to past 10 years back, the field preparation takes about a month but nowadays less time is provided for ploughing and other activities before transplanting due to which the earlier weeds gets less time to decay completely leading to large no of weeds after transplantation.



(Source: Field survey, 2014)

Figure 5. Reasons of loss in productivity of rice in Nawalparasi, 2014



(Source: Field survey, 2014)

Figure 6. Affected stage of rice

Table 5. Showing change in rice crop growth activities due to climate change

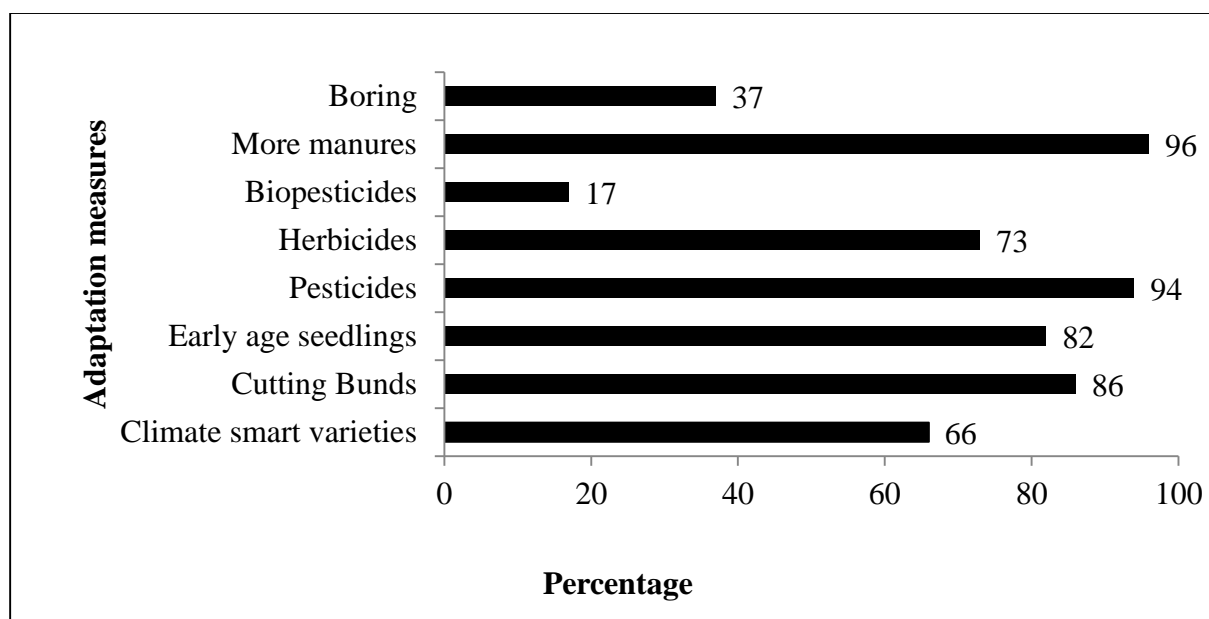
Stage	Earlier/short	Late/long	No change	Don't know
seed sowing date	2(2.86)	53(75.72)	15(21.42)	0.00
seed germination date	54(77.14)	4(5.72)	11(15.71)	1(1.43)
transplanting date	18(25.35)	39(54.29)	11(15.49)	2(2.81)
flowering date	52(74.28)	2(2.86)	13(18.57)	3(4.29)
flowering period	59(84.28)	0.00	10(14.29)	1(1.43)
maturity period	66(94.29)	0.00	4(5.71)	0.00

(Source: Field survey, 2014)

The Table 5 depicts that due to the untimely rainfall there is delay in sowing time by 1 month while there is earlier seed germination and flowering. The sowing and transplanting date was found to be later due to the delayed onset of monsoon while flowering, fruiting and maturity period were observed to be shorter which according to the farmers may be due to the high temperature and use of hybrid varieties. They have short maturity period and matures earlier than the 10 years back.

4.4 Climate change adaptation strategies at farm level

Figure 7 depicts major climate change adaptation measures applied by the farmers. Of these, 96% of the farmers used more manure, followed by use of pesticides (94%) and cutting bunds (by 86% respondents). More than two third (82%) respondents were transplanting the early aged seedlings and only least farmers (17%) were using the bio-pesticides. Focus group discussion revealed that logic on adopting these practice were: use of more manure supports on moisture conservation, use of pesticide for saving crops from insect and disease, and removal of more water by cutting bunds.



(Source: Field survey, 2014)

Figure 7. Major climate change adaptation measures of the farmers

Use of more manure: Farmers in the survey sites ranked the use of more manures as the foremost best coping strategy against climate change vulnerability context. Focus group discussion revealed that the use of more manures supports on moisture conservation.

Use of pesticides: Pesticidal use was ranked as the second best option of climate change adaptation in farming level. The farmers had misconception that the chemical pesticides are the “medicine” to their crops not a “poison”. So they had been using the pesticides the pesticides haphazardly without knowing the appropriate dose and time of application. This leads to the large increment in number of insect pest. According to the farmers, this may be either the result of increase of temperature or the use of hybrid variety. Most of the farmers were using the pesticides so the organic farmers not using the pesticides were also forced for using pesticides.

Cutting Bunds: During heavy rainfall the water in the field remains accumulated where cutting bunds found to be best. The water remains accumulated for longer duration due to the clay soil in Pithauli VDC.

Early aged seedlings: Farmers used to transplant a month old seedlings previously (10 years before) but 21-23 days old seedling were transplanted nowadays due to the erratic rainfall and increase in temperature.

Climate smart varieties: Farmers are attracted towards the climate smart varieties. Varieties like Sukhkha-1,2,3 found to be suitable for coping the climate change vulnerability under water scarcity. Similarly, Swornasab in the flood prone areas.

Crop diversification: The untimely rainfall is the major problem of the farmers. Due to which they were forced to cultivate the other crops rather than rice in the unfavourable season.

Water harvesting technique: More than 80% of the total annual rainfall in Nepal is received during the rainy season (June – September). The rainfall is erratic and the crops in dry season face seasonal drought. Water harvesting becomes essential to support livelihood activities throughout the year which reduces impact of drought.

4.5 Relationship of climatic and non-climatic factors on rice yield

The relationship of climatic (rainfall, maximum temperature, and minimum temperature) and non-climatic (area of paddy production) in rice yield was analysed for correlation coefficient test estimation and multiple regression analysis by using time series data analysis of 31 years (1980-2010). Calculated mean yield of rice and mean area of cultivation showed 2.4 ton per hectare per hectare. The standard deviation analysis showed larger variability in rice yield, rice area and rainfall data but not much variability in temperature change (0.33).

Table 6: Descriptive statistics of climatic and non-climatic data

Variables	N	Mean	Std. Deviation
Rice yield in mt	31	166483.94	49172.08
Ricearea (ha)	31	68632.33	3435.78
Max tem (June-Nov) average	31	32.12	0.34
Min tem (June-Nov) average	31	22.76	0.33
Rainfall (mm) six month average)	31	341.60	61.51

Table 6 depicts relationship of explanatory variables on explained variable (yield). Rice area (ha) showed significant relationship on yield (mt). If 1 unit change in area (ha), the yield of rice would increase by 10.7 units (mt) keeping other climatic variables constant. Calculated t-test statistics showed significant relationship at 1% level ($t = 6.7$ at probability 1%). The relationship of maximum temperature during June to November on rice yield also showed positive

relationship, keeping other factors constant. The t-statistics was also significant at 1% level. However, minimum temperature had negative relationship and t-test value was not significant. It means increasing minimum temperature would reduce rice yield. Six month averaged rainfall pattern had positive relationship on yield and it was also significant at 5% level ($p= 0.021$) meaning that rainfall increase by 1 unit would increase yield by 260 unit.

Table 7: Regression coefficient and their significance level

Model	Coefficients ^a			t	Sig.
	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta		
(Constant)	-1786716.58	572285.31		-3.122	.004*
Rice area	10.731	1.61	.750	6.654	.000**
Max tem (June-Nov) average	57229.18	20203.38	.388	2.833	.009**
Min tem (June-Nov) average	-31214.49	21561.64	-.208	-1.448	.160
Rainfall (mm) six month average)	260.32	106.19	.326	2.451	.021*

a. Dependent Variable: Rice yield in mt

Note: * shows p -value at 5% and ** shows p -value at 1%

The model summary in table showed $R^2= 68\%$ meaning that 68% variability was explained in the model. F-test statistics ($F= 13.85$) showed significant model i.e. "goodness of fit" of the estimated model. (Appendix 12)

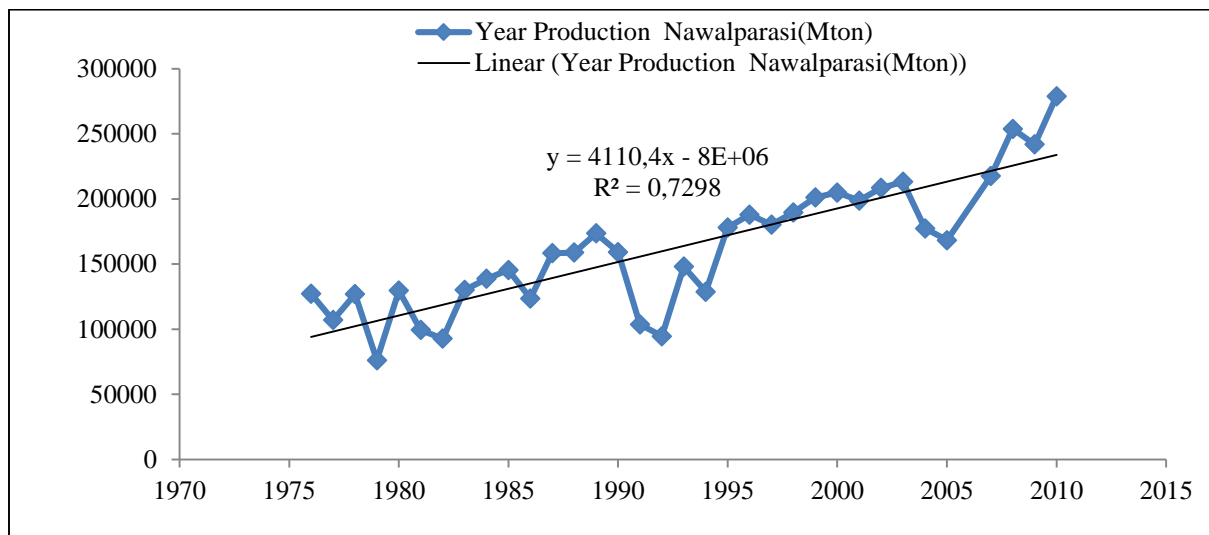
Thus, identified model was:

Yield = $-1786717 + 10.7$ (rice area) + 57229 (max^m temp) - 31215 (min^m temp) + 260 (rainfall).

Durban and Watson statistics (= 1.13) showed positive autocorrelation. In this respects, regression coefficient estimators would be spurious. However, correction of these errors are out of capacity of researcher.

4.6 Trend analysis of climatic factors over time

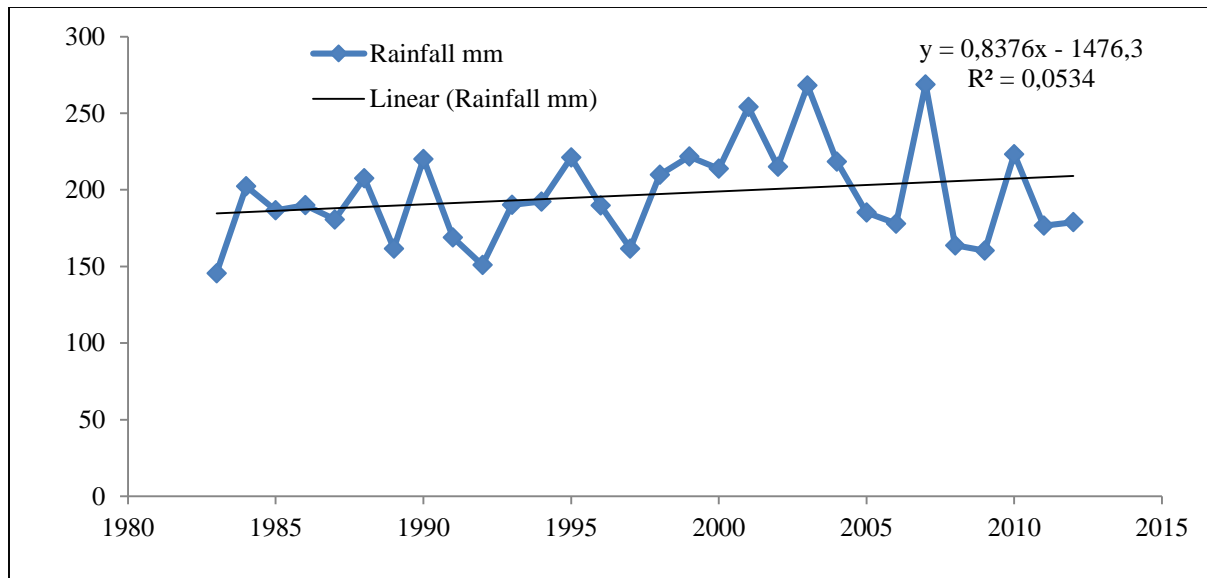
With the observation of the 38 years of rice production in the Nawalparasi district i.e. from 1975–2013, regression analysis was done. The increased trend of rice production was observed for last few years. The result further revealed that maximum yield was noticed in 2013. It was found that the model has R-square of 0.73 indicating that the trend line 73 percent well fitted. Similarly, trend line shows that with the increased in one year the 4110 Mton rice production would be increased in Nawalparasi District (Fig 8).



(Source: MOA,2011/12)

Figure 8. Trend of rice production in Nawalparasi district

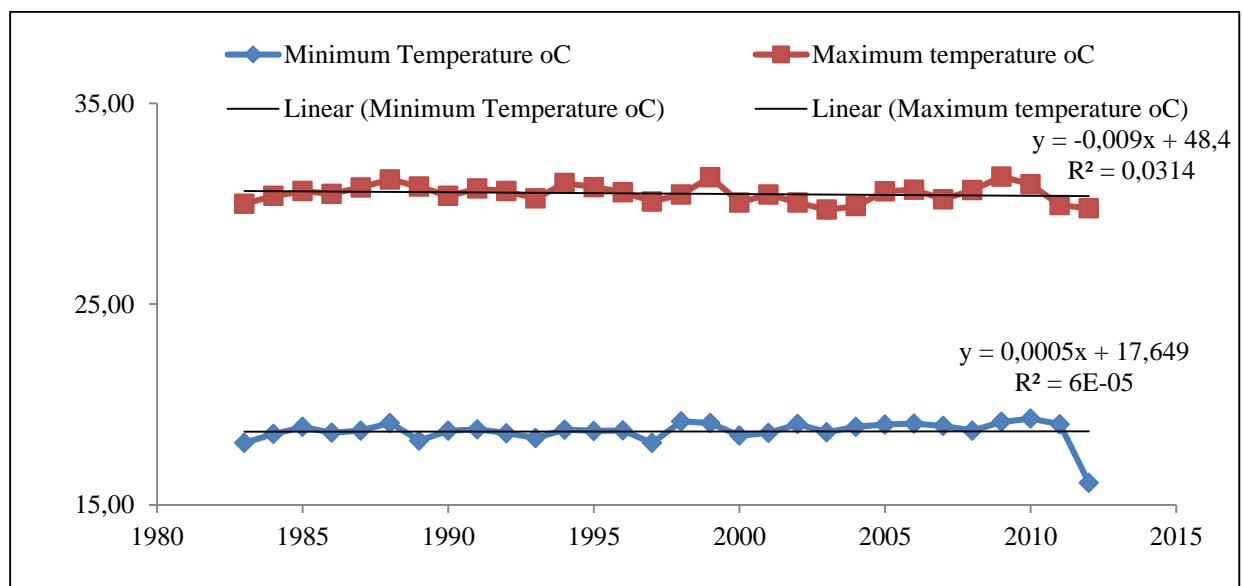
The study found that the productivity of rice and rainfall of rice goes in same direction in Nawalparasi district. The trend line of rainfall plotted for last 30 years indicated that rainfall pattern was somewhat erratic but in the increasing trend. It further shows that with the one year increment in year the rainfall would increase by 0.84 mm.



(Source: DHM, 2012)

Figure 9. Trend line of rainfall in rice in Nawalparasi district

The study found that the productivity of rice and temperature goes in same direction in Nawalparasi district. The results infer that increased trend of temperature was observed in the Nawalparasi district. Specifically, 0.009°C increased temperature was noticed with per unit increment in year while analyzing the trend of temperature of Nawalparasi for last 32 years.



(Source: DHM, 2012)

Figure 10. Temperature trend in flowering period of rice in Nawalparasi district

4.7 ORGANIZATIONS INVOLVED

Study showed that almost all the farmers under caritas group have a good understanding about the climate change. Caritas had been carrying out the various programmes related to the climate change since 4 years. As the farmers were greatly affected by the impacts of climate change, Caritas was in the way of finding out the remedy of the adverse condition that the farmers were facing. So they performed different variety trials at the farmers field with the active participation of the farmers. According to the Caritas annual report 2012, *Sukhadhan1*, *sookhadhan2* and *sookhadhan3* were the preferred drought resistant varieties in the drylands. Similarly in the flooded areas also, Caritas had been providing *Swornab sab* variety. The farmers reported that the line sowing transplanting of the rice with 2-3 seedlings per hill with wide spacing was the best methods of planting of rice.

Study revealed that the Caritas along with other organizations were supporting merge technologies option in hybrid seed support, training and planting techniques. They were encouraging for the combined rice+duck farming providing the 25 duckling to each farms (especially in Rajahar VDC). The farmers were satisfied with this merge farming as it devoid the use of manures and fertilizers and the rice crops seem more developed than the rice alone. Similarly, various activities were carried out by the DDC in this district i.e. afforestation in landslide areas, focusing the farmers towards the production of cash crops and trees plantation on road areas.

CHAPTER 5: SUMMARY AND CONCLUSION

5.1 Summary

Nepalese farming system being rainfed, traditional and subsistence type, farming communities of Nepal are in great threat for vulnerability of climate change impacts. Increasing temperature, change in precipitation pattern together with the loss of local genetic diversity is hitting hardest to agriculture production in Nawalparasi district which has lowered food availability in the area, thus increasing food insecurity.

A sample of 35 households from each of VDC namely Pithauli and Rajahar were randomly selected, thus a total of 70 respondents constituted the sample sizes. Other primary data collection methods were conduction of four FGDs and KIS. Secondary data were collected from published and unpublished sources. The pattern of climatic variation, indicators of climate change in district was studied as well as the effect of temperature and rainfall pattern on rice crop analyzed.

It has been found that rainfall variation in Nawalparasi district is becoming more erratic and variability in recent years. About 94% farmers had experience the rise in temperature. It was found that 85.1% respondents were experiencing the decreasing trend of monsoon and winter season rainfall in both magnitude and duration. More than 95% respondents across the study sites had felt longer drought period at present than compared to past ten years and only 2.86% respondents had experienced no change in drought condition.

Change in seasonal calendar of various crops; delay in planting time; low production and productivity of crops; occurrence of insect, pest and diseases; drying of water resources and loss of biodiversity are the major impacts seen in study area. Change in rainfall pattern and shift in monsoon season in the study sites had created trouble for most of the farmers to plant their crops in appropriate time. Most of the farmers were experiencing shift in monsoon season by more than one month therefore; they were forced to plant on proper cropping schedule.

Multiple regression analysis found that area under rice cultivation, maximum temperature and average rainfall had positive and significant impact on rice production, however, minimum

temperature had negative but significant impact on rice production. This implies that lowered minimum temperature during grain filling and maturity is undesirable.

The production of Nawalparasi district was increasing in recent years. It was found that about 98.89% of total respondents had faced the increasing trend of production. The major cause was found to be the use of high yielding i.e. hybrid variety along with more manures and synthetic fertilizers. Farmers have the concept that the yield of the rice directly depends upon the synthetic fertilizer (esp.urea) provided.

5.2 Conclusion

From above summary it is revealed following conclusion:

- Respondents have positively as well as negatively perceived on climate changes. Rising trend of temperature and fluctuating pattern of rainfall, in major, had negative role in rice productivity losses. Transplanting in late time but harvesting early than that ten years (shorter flowering, fruiting and maturity period), researcher can conclude reducing growing degree day of rice cultivation in the study area.
- Respondents are unanimously practicing few adaptation strategies in rice cultivation which are low cost but insufficient. They were in intermediations stage in adopting any adaptation strategies. Kindly response of farmers on changed climate change, farmers are not feeling yield loss because of use of hybrid seed. CARITAS-SAFBIN were supporting merge technologies option in hybrid seed support, training and planting techniques. There is inadequate awareness even among the professionals working in governmental and non-governmental organizations, both at grass roots and at national level.
- Thirty-one year data analysis depicted that climatic factors like maximum temperature, rainfall and minimum temperature had positively as well as negative effect on rice yield.
- The climate smart varieties *Sookha-1*, *Sukha-2* and *Sukha-3* and *Swornasab1* were found to be superior in the drought and flooded areas respectively.

5.3 Policy recommendations

Climate change is real and underway. Farmers practicing different coping and adaptation strategies in their farm based upon their experience to tackle changing climate but it seems important to plan sustainable adaptation strategies and make farmers prepared to tackle the emerging impacts of climate change in forthcoming days.

The researcher identified that climatic factors have positive effect on yield of rice. It means past efforts and future efforts have to face same problem if not faced. Study faced data problem of rice production of last 20- year. In this respect, some other findings could get. Thus, researcher request CARITAS-SAFBIN to focus integrated research methods: undertaking both socio-economic variables as well as experimental variables (scientific variables) in a form of large sample and verifying the results of this study. The findings are suggested to implement in the study area.

Researcher suggests raising more awareness of climate change and its negative as well as positive impacts to SAFBIN project beneficiaries and concerned stakeholders. Otherwise, because of prompt adaptation case if happened, more adaptation cost has to be invested by the respondents. Each rice grower must learn proper adaption knowledge and skills.

REFERENCES

- Aydinalp, C. and M. S. Cresser. 2008. The effects of global climate change on agriculture. *American-Eurasian J. Agric. & Environ. Sci.* 3 (5): 672-676.
- Bhandari, D and G.Gurung,. 2007. Building the Resilience of Communities: To Cope with Climate Change Impacts in Nepal. *Nepal Up in Smoke: time for action on climate change.* (LI-BIRD: Nepal).
- CBS. 1998. A Compendium of environment statistics of Nepal. Central Bureau of Statistics, HMG/Nepal.
- CBS. 2011. Population Census. Central Bureau of Statistics, Kathmandu, Nepal.
- CEN. 2003. Climate Change: a Nepalese perspective. CEN fact sheet 2. Clean Energy Nepal (CEN), Kathmandu, Nepal.
- CIA World Fact Book. 2009. Nepal economy 2009. Available at: http://www.theodora.com/wfbcurrent/nepal/nepal_economy.html. Retrieved at: 26 Nov. 2009.
- Dahal, N. 2005. Perceptions of climate change in the Himalaya. *Tiempo Climate Change Bulletin*, August 2005.www.tiempocyberclimate.org/newswatch/html
- 2006. Implications of climate change in Nepal: Some observations and opportunities. Paper presented at 23rd Warden Seminar, November 2006 held in Pokhara, Nepal.
- Dieudonne, G. 2001. Afrique: le continent le plus vulnérable, *Bulletin Africain* 14. <http://www.enda.sn/Bulletin%20Africain/011%20Goudou%20&%20Isabelle.pdf>
- DOI. 2007. Irrigation database. Department of Irrigation, Kathmandu. Available at: <http://www.doi.gov.np/idb.php>. Retrieved at: 14 November, 2009.
- Ebi, K.L., R. Woodruff, A. V. Hildebrand and C. Corvalan. 2007. Climate change related health impacts in the Hindu Kush–Himalayas. *EcoHealth* 4;264-270.
- EMF (1999). Special Issue on Green House Gas Emission Projection by Energy Modeling Forum, *The Energy Journal*,
- FAO 2007Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities, Available online at <http://ftp.fao.org/docrep/fao/009/j9271e/j9271e.pdf>
- Gautam, A. K. 2008. Climate change impact on Nepalese agriculture and strategies for adaptation. Paper presented in NAPA workshop organized by LI-BIRD and Biodiversity International. Pokhara, Nepal. 23 December 2009.
- Hall, D.C., and J.V. Hall. 1984. Concepts and Measures of Natural Resource Scarcity with a Summary of Recent Trends. *Journal of Environmental Economics and Management* 11 (4); 363–379

- HDR. 2007. Climate change and human development – risk and vulnerability in a warming world: country case study-Nepal. UNDP, Kathmandu, Nepal; 46-67.
- Hsu, P.-C., T. Li, and B. Wang, 2011: Trends in global monsoon area and precipitation in the past 30 years. *Geophysical research Letters*, 38.
- Hsu, P.-C., T. Li, H. Murakami, and A. Kitoh, 2013: Future Change of the Global monsoon revealed from 19-CMIP5 models. *Journal of Geophysical Research: Atmospheres*, 118.
- ICAO. 2012. climate change: adaptation. International civil aviation organization, a united nations specialized agency. <http://www.icao.int/environmental-protection/pages/adaptation.aspx>.
- IPCC 1998. The regional impacts of climate change: An assessment of vulnerability. Special report of IPCC working group II [Watson, R.T.; M.C. Zinyowera, R.H. Moss R.H. and D.J. Dokken (eds.)], Cambridge University Press, Cambridge.
- 2001b. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of WG II to TAR of the Intergovernmental Panel on Climate Change [McCarthy, M.C., O.F.
- 2001. Climate change 2007: synthesis report. Contribution of working groups I, II and III to the fourth assessment report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland; 104.
- IRRI. 2006. An information summary for supporters of international rice research. International Rice Research Institute, Philippines.; 21-32.
- Jarvis, A., A. Lane, and R. Hijmans. 2007. In press. The effect of climate change on crop wild relatives. *Agriculture, Ecosystems and Environment* 21:109-116.
- Aydinalp, C. and M. S. Cresser. 2008. The effects of global climate change on agriculture. *American-Eurasian J. Agric. & Environ. Sci.* 3 (5): 672-676.
- Jarvis, D. I. and A. HD. Brown. 2008. A global perspective of the richness and evenness of traditional crop genetic diversity maintained by farming communities. *Proceedings of the National Academy of Sciences*. Available at: www.pnas.org/cgi/doi/10.1073/pnas.0800607105.
- Joshi GR (ed.) H. Sultana, Iqbal M.M., 2009. Planting window as an adaptation option to offset the likely impacts of climate change with emphasis on Rainfed areas. *Earth and Environmental Science*. 6:93-96
- Kotschi, J. 2006. Coping with Climate Change and the Role of Agrobiodiversity. In: Conference on International Agricultural Research for Development, 11-13 October, 2006, University of Bonn, Tropentag.

- Lobell, D.B. and C. B. Field. 2007. Global scale climate–crop yield relationships and the impacts of recent warming *Environmental Research Letters* 2 014002. doi: 10.1088/1748-9326/2/1/014002.
- Malla, G. 2008. Climate change and its impact on Nepalese agriculture. *The Journal of Agriculture and Environment* 9:19-23.
- Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington DC, USA. pp. 21-26.
- MoAC. 2007. Selected indicators of Nepalese agriculture and population. Ministry of Agriculture and Co-operatives. Agri-Business Promotion and Statistics Division, Kathmandu, Nepal.
- NCVST. 2009. Vulnerability through the eyes of vulnerable: climate change induced uncertainties and Nepal's development predicaments. Institute for Social and Environmental Transition-Nepal. Nepal Climate Vulnerability Study Team (NCVST). Kathmandu, Nepal, 34-42.
- Pachauri, R.K., 1992. Global warming: impacts and implications for South Asia. *In: The regions and global warming: impacts and response strategies* [Schmandt, J. and J. Clarkson (eds.)], Oxford University Press, New York.
- Pradhan, R.B., 1997: Vulnerability and adaptation assessment of agriculture sector to climate change in Nepal. *In: Proceedings of the workshop on climate change in Nepal*, 25 June 1997 Kathmandu, US Country Study program, Department of Hydrology and Meteorology of Nepal.
- Raut. A. 2006. Climate change Impacts on Nepal. A bulletin on change and development. Special issue on Nepal 60:34-46.
- Regmi BR, A. Morcrette, A Paudyal, R Bastakoti, S Pradhan . 2010. Participatory tools and techniques for assessing climate change impacts and exploring adaptation options. Livelihood and forestry program, Nepal.
- Regmi, B. R and A. Adhikari. 2007. Climate risk and vulnerability in Nepal. Country case study- Nepal. Human Development Report 2007/2008. Fighting climate change: Human solidarity in a divided world. Human Development Report Office Occasional Paper UNDP.
- Regmi, B. R., L. Thapa, G. B. Sharma & S. Khadka, 2008. Climate Change Risk, Vulnerability and Adaptation Strategies at Community Level, LI-BIRD.
- Shrestha U. B, S. Gautam., K. S. Bawa. 2012. Widespread climate change in the Himalayas and associated changes in local ecosystems. *PLoS ONE* 7(5):e36741
- Slade, M.E. 1982. Trends in Natural-Resource Commodity Prices: An Analysis of the Time Domain. *Journal of Environmental Economics and Management* 9 (2); 122–137.

- Tiwari, M. 2002. Profiles of vulnerable groups in Nepal. FAO, Rome.;22-25.
- UNFCCC 2007.Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Available online at http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/txt/pub_07_impacts.pdf
- Wang, B., and Q.Ding,2006:Changes in global monsoon precipitation over the past 56 years. *Geophysical Research Letters*,33,L06711.
- Wang, B., J. Liu, H.-J.Kin, P. J. Webster, and S.-Y. Yim, 2012b: Recent change of the global monsoon precipitation (1979-2008). *Climate Dynamics*,39,1123-1135.
- 、
- WFP. 2009. The cost of coping. A collision of crises and the impact of sustained food security deterioration in Nepal. United Nations World Food Proqramme, Kathmandu, Nepal; 34-39.
- WWF. 2006. Climate change impacts in the Amazon-review of scientific literature. World Wide Fund for Nature. Presentation at the 8th UN conference of the parties to the Biodiversity Convention. New York, USA.

APPENDICES

Appendix 1: Household Survey Questionnaire

Name of Interviewer:_____

Date of interview:-----

1.General information

Name of farmer: _____

Age: _____years

Address:_____

Area of land:_____ total ropani _____ Bari land _____Khet land

Major source of income _____

Major Agricultural commodities:

Food Sufficiency:< 3 months ☐ 3-6 months ☐ 6-9months ☐ 9-12 months ☐

2. Farmer's Perception on Climate change:

2.1 Have you felt climate change in your locality? Yes / No

2.2 Do you know the cause of climate change?

a. It is natural

b. Human-made (it is caused by pollution emitted by people and industry leading)

c. Both

2.3 Have you experienced any change/deviation in weather parameters over the past 10yrs?

Yes/no

2.4 Have you noticed changes in the following weather conditions since a decade?

Type of weather	Increased	Decreased	No Change	Don't Know	Remarks
Temperature level					

Monsoon rainfall –intensity					
Monsoon rainfall- frequency					
Wind					
Drought-length N Severity					
Drought – Frequency					
Hailstone (Amount n severity)					
Humidity					

2.5 Have you noticed changes in timing of Rainfall(Monsoon) ? (tick)

Weather pattern				
Timing of pre monsoon (before June)	Earlier	Later	No change	Don't Know
Duration of pre monsoon	Short	Long	No change	Don't know
Timing Of Main rainfall(June 1 st – august 30)	Earlier	Later	No change	Don't Know
Duration of main monsoon	Short	Long	No change	Don't know
Timing of Post-monsoon(1-30 sept)	Earlier	Later	No change	Don't Know
Duration of post monsoon	Short	Long	No change	Don't know

3. Effect of Climate changes on rice

3.1 Have climate changes had any effect on your rice farming over the last 10yrs?

Yes/No

3.2 Have you experienced failure of rice in last 10 years?

Yes/No

Reasons for rice failure: a. Drought b. heavy/continuous rainfall c. wind d. others

3.3 Have you experienced changing problems of pest and diseases in the last 10yrs? Yes/No

a. Increase severity – Yes/No

b. In which stage there of rice is affected more? _____

c. Is there occurrence of new pest/disease in last 10 year? Yes/no

If yes, mention the new pest and disease name.....

3.4 Have you experience problems and emergence of new weeds? Yes/no

If yes, mention the name of weeds.....

3.5 Have you noticed any change in wheat performance in last 10yrs ?

Yes/No

Effect on crop Performance	Increased	Decreased	No change
Crop Yield			
Crop Biomass Yield			
Grain Size			
Grain quality			
Crop Taste			
Other			

3.5 Have you noticed any change in rice crop growth activities now in comparison to last ten years?

Stage				
Seed sowing Date	Earlier	Later	No change	Don't know
Days of Seed germination	Short	Long	No change	Don't know
Transplanting Date	Earlier	Later	No change	Don't know

Flowering	Earlier	Later	No change	Don't know
Flowering Period	Short	long	No change	Don't know
Maturity Period	Short	long	No change	Don't know
Rice yield	Increase	Decrease	No change	No care

4. Vulnerability effect in rice crop farming

4.1 Have you faced a climate related crisis in rice farming in current 10 years? Yes/no
4.2 If yes, please response type of climatic hazards:

S. N	Types of effect	Increasing/Long	Decreasing/Short	Reason
A	Losses in productivity of the rice variety			
B	Water logging period during seedbed preparation			
C	Water logging period after transplanting			
D	Delayed in transplanting period			
E	Increase time to reach water source			
F	Damage of rice seedlings			
G	Damage by flooding/land slide			
H	Early transplanting period			
I	Early harvesting			
J	Losses of spring rice by drought			
K	Damage by winter rainfall /post-monsoon fall			
L	Losses of standing crop by water /wind			
M	Insect pest damage			
N	Disease and weed pest damage			

O	Losses of rice seed by store grain pest			
P	% of losses in rice yield			

5. Climate change/vulnerability context adaptation situation of rice

5.1 Please tell me the major adaptation practices to the particular climatic hazards

S.N	Types of effect/Hazard	Adaptation practices implemented	Other suggestions for adaptation
A	Water logging period during seedbed preparation		
B	Water logging period after transplanting		
C	Delayed in transplanting period		
D	Increase time to reach water source		
E	Damage of rice seedlings		
F	Damage by flooding/land slide		
f.	Losses of spring rice by drought		
g.	Damage by winter rainfall /post-monsoon fall		
H	Losses of standing crop by water /wind		
I	Insect pest damage		
J	Disease and weed pest damage		
K	Losses of rice seed by store grain pest		

5.2 Will you please tell me the method of storage that you are practicing;

5.3 What types of adaptation activities are you implementing from Caritas-SAFRIN programme in rice crop?

1.

2.

3.

5.4 How do you feel that adaptation techniques are better performing in your farm? No/yes

If yes,

1.....

2.

3.....

5.5 How do you feel that adaptation support increasing food self-sufficiency of your house? No/yes.

If yes, please say number of month food support

5.6 If no or partial acceptance mention area of improvements

1.

2.

3.

5.7 Do you like to continue these practices forever? Yes/no

Thank you

Appendix2: Checklist for Focus Group Discussion (FGD)

Name of Group/community Participants: ----- Date of FGD taken-----

Name of participants: -----

Address: _____

Area of vegetable farming: total ropani ----- Upland rice ----- low land rice -----

Q.N.1. Do your group feels about the climate change in rice farming in your locality?

a) Extremely felt b) Moderate feel c) Fairly feel d) No feel

Q.N.2) Does your community discuss on climate change related issues? Yes () No ()

Q.N.3) What are the major hazard happened in your locality within 10 yrs? Construct timeline of economic losses of climate-induce hazard.

Year	Types of hazards Heavy wind/ Erratic rainfall/hail/insect /disease	Loss of land (kattha)		Loss of rice (Qtl.)	loss of people (No)	Others
		Cultivable	others			
2061						
2062						
2063						
2064						
2065						
2066						
2067						
2068						
2069						
2070						
2071						

Q.N.4. Please share effect of hazard and respective adaptation strategies of your group

Hazards	Effects	Adaptation strategies implemented
Pre-monsoon rainfall		
Water logging		
Erratic monsoon		
Prolonged drought		
Drought		
Post monsoon fall		
Land slide / land loss		

Q.N.5. In your opinion, what kind of adaptation related supports are getting from Caritas-Nepal?
(if other organization supporting adaptation activities please mention)

Support strategy/techniques	Supported by organizations (Caritas Nepal or other one)	Suggestions for future support
Climate change awareness raising training to the group		
Early warning system		
River/stream control		
Integrated nutrient management		
IPM		
Safe-side construction		
Providing climate-supportive crop varieties		
Rehabilitation of infrastructure		
Other farming technique		
Crop insurance		

Appendix 3: Key Informant survey of climate change for Caritas, Nawalparasi

1. General information:

Name: _____ Sex: M/F Age: ____ years

Organization: _____

2. Key informant perception on climate change:

2.1 Have you felt about climate change? Yes/No

If yes, what are the cause of climate change? _____

2.2 Have you experienced any change/deviation in whether pattern in this district?

2.3 Does Caritas have programmes related to climate change in your district? Yes/No

If yes what type of programmes? (Also specify for rice farming)

2.4 What type of hazard effect have you seen in this district in rice farming ?

2.5 What type of adoption activities/ strategies are given by Caritas for rice farming to adopt climate change impact ?

2.6 What type of farmer's are benefited from this programmes?

2.7 Are they implementing them in their farming practice Yes/No

Appendix 4: Key Informant survey of climate change for Agro vet ,Nawalparasi

1.General information:

Name: _____

Sex: M/F

Age: ____years

Name of Agro Vet : _____

2. Key informant perception on climate change

2.1 Have you felt about climate change?

Yes/No

If yes, what are the cause of climate change?_____

2.2 Have you experienced any change/deviation in whether pattern in this district?

2.3 What type of hazard effect have you seen in this district in rice farming?

2.4 Are farmers purchasing chemical fertilizer from this Agro Vet? Yes/No

If yes, what are they?

Is it increasing or decreasing?

2.4 Mention rice varieties is preferred most by farmer's in this locality?

2.5 From where are you bringing these seed?

2.6 Is there any failure of rice varieties given by you or any other agro vet?

Yes/No

If Yes which varieties?

2.7 What are the major diseases and pest does the farmer report frequently?

2.8 Are farmers purchasing insecticides and pesticides?

Yes/No

If yes, what are they ?

Is it increasing or decreasing ?

Appendix 5: Key Informant survey of climate change for DADO, Nawalparasi

1. General information:

Name: _____

Sex: M/F

Age: ____years

Occupation: _____

2. Key informant perception on climate change:

2.1 Have you felt about climate change?

Yes/No

If yes, what are the cause of climate change? _____

2.2 Have you experienced any change/deviation in whether pattern in your district?

2.3 Does DADO have programmes related to climate change in your district?

Yes/No

If yes what type of programmes? (Also specify for rice farming)

2.4 What type of hazard effect have you seen in this district in rice farming?

2.5 What type of adoption activities/ strategies supported by DADO in order to mitigate /adopt climate change impact?

2.6 What type of farmer's are benefited from this programmes?

2.7 Are they implementing these in their farming practice?

Appendix 6: Key Informant survey of climate change for leader farmer, Nawalparasi

1. General information:

Name: _____ Sex: M/F Age: ____ years

Name of Agro Vet : _____

2. Key informant perception on climate change:

2.1 Have you felt about climate change? Yes/No

If yes, what are the cause of climate change? _____

2.2 Have you experienced any change/deviation in whether pattern in this district? Yes/No

If yes what are they?

2.3 What type of hazard effect have you seen in this district in rice farming?

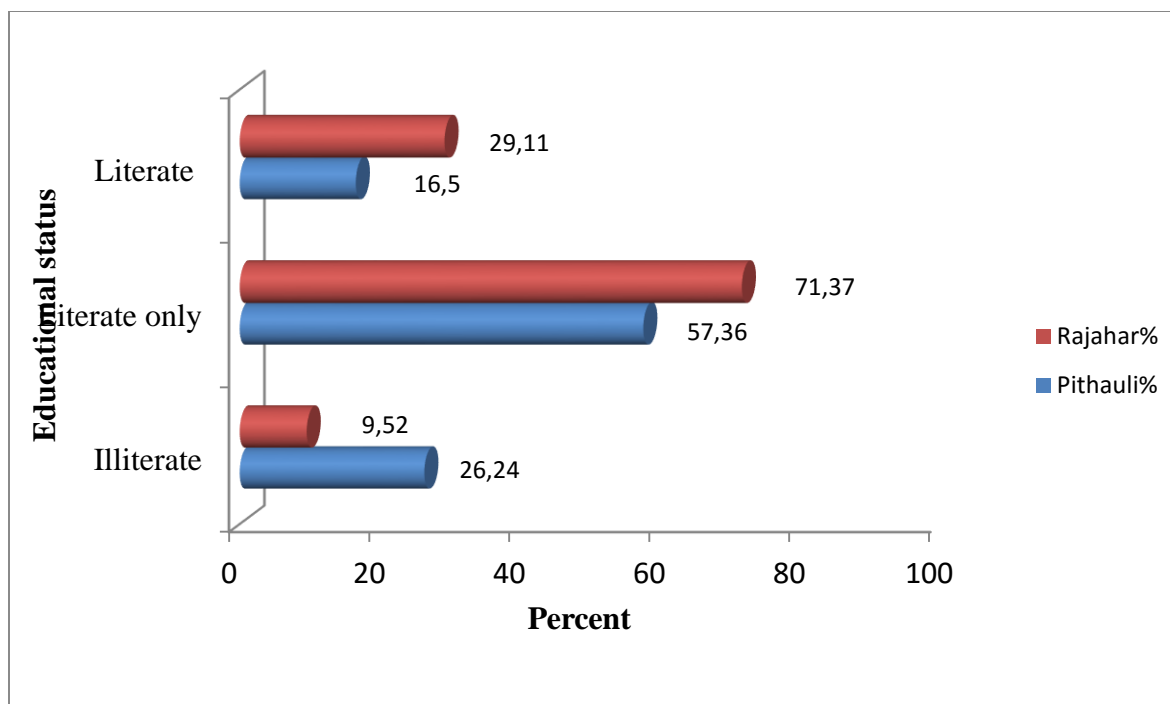
2.4 What are the adoption practices/strategies are you following to cope with climate change hazards in rice farming? (*Loss of productivity, flooding, disease, pest, drought*)

2.5 Are you implementing these practices in your farming?

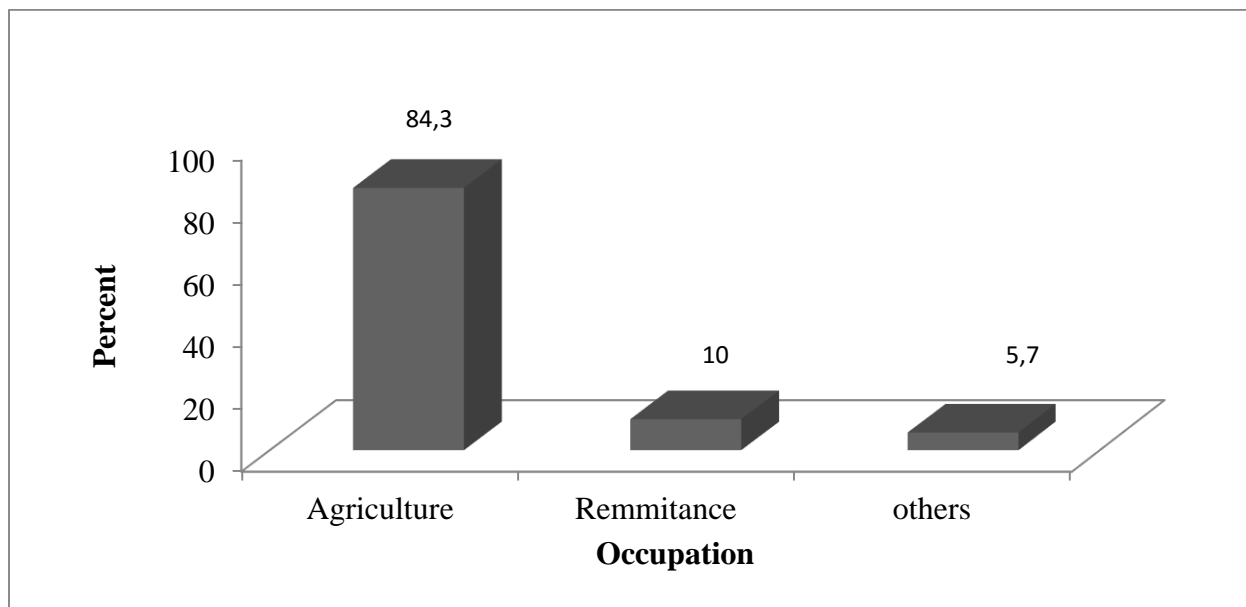
2.6 Are you getting any support from any organization to cope with climate change hazard in rice farming ? Yes/No

If Yes, mention their name and there support programme?

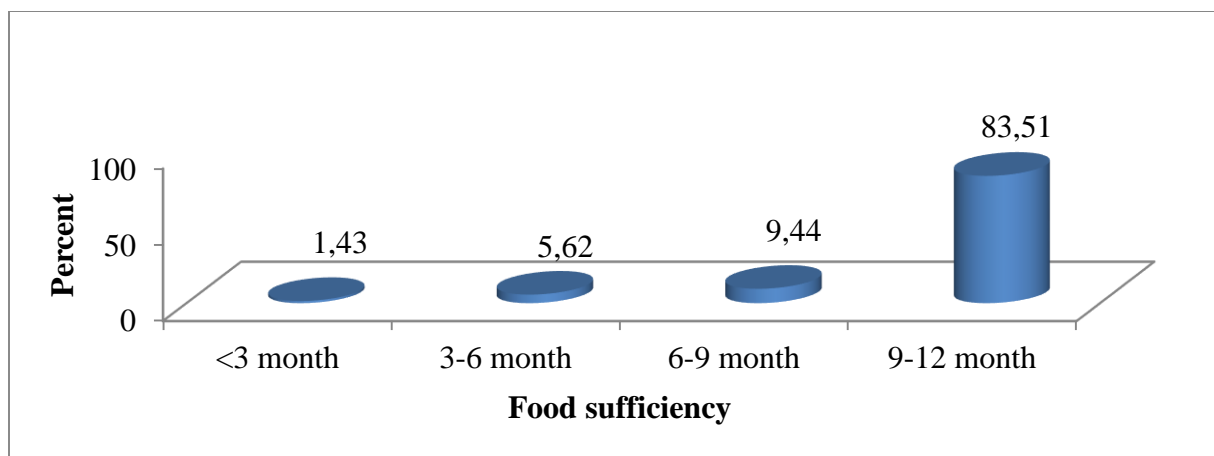
Appendix7: Educational status of the farmers of Nawalparasi district



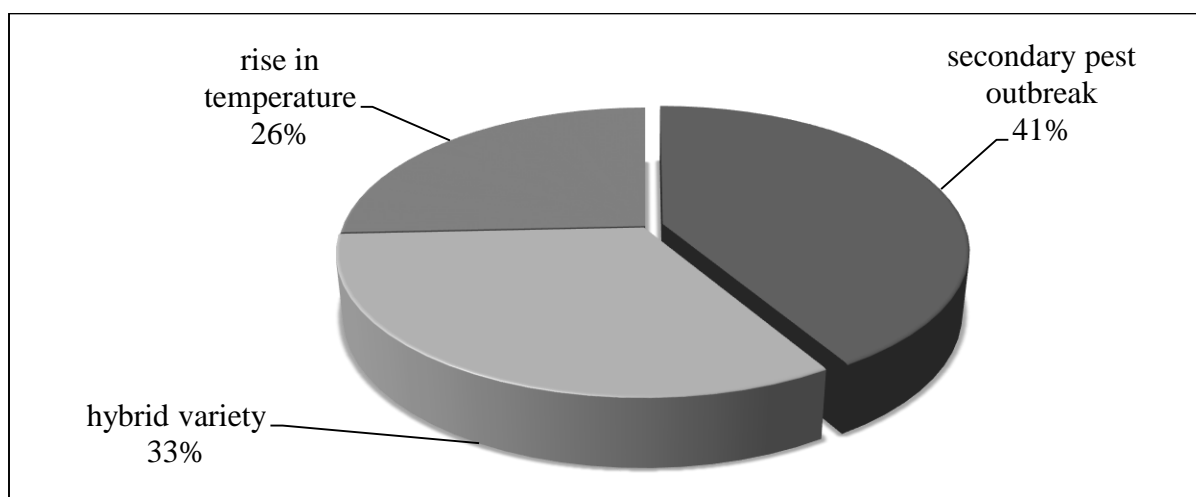
Appendix 8: Means of livelihood of the people of Nawalparasi district



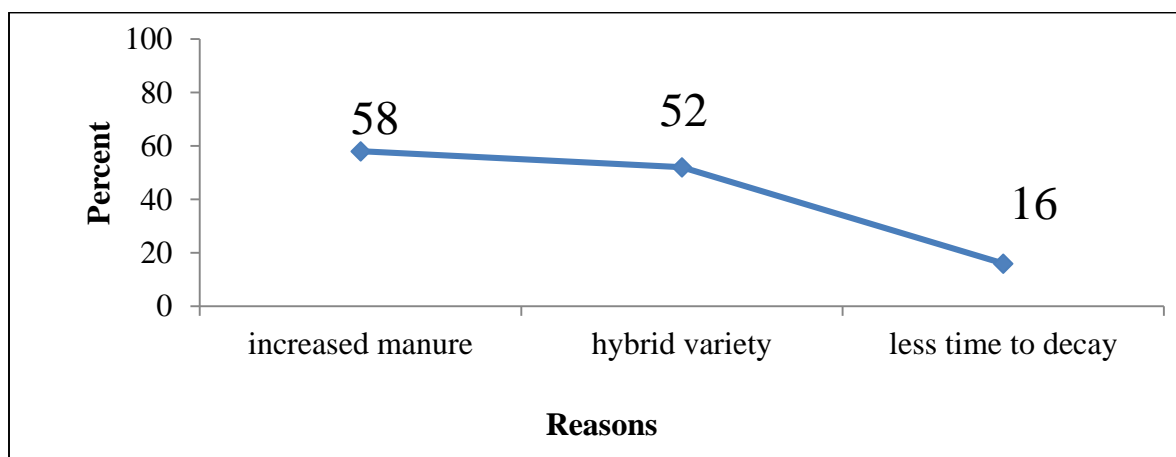
Appendix9: Food sufficiency of the farmers of Nawalparasi district



Appendix 10: Reasons of increasing insect pest damage



Appendix 11: Reasons of increasing disease and weed



Appendix 12: ANOVA table

Analysis of variance (ANOVA^a)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	49363249151.52	4	12340812287.88	13.846	.000 ^b
1 Residual	23173577742.35	26	891291451.63		
Total	72536826893.87	30			

a. Dependent Variable: Rice yield in mt

b. Predictors: (Constant), Rainfall (mm) six month average), ricearea, Max tem (June-Nov) average, Min tem (June-Nov) average

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
	.825 ^a	.68	.63	29854.51	1.13

a. Predictors: (Constant), Rainfall (mm) six month average), rice area, Max tem (June-Nov) average, Min tem (June-Nov) average

b. Dependent Variable: Rice yield in mt

Appendix 13: Average annual production of Nawalparasi district

Year	Production Area
	Nawalparasi(Mton)
1976	127154
1977	107040
1978	126920
1979	76150
1980	129660
1981	99370
1982	92790
1983	130100
1984	138760
1985	145450
1986	123630
1987	158410
1988	158850
1989	173560
1990	159250
1991	103710
1992	94640
1993	148050
1994	128740
1995	178060
1996	188000
1997	180270
1998	189680
1999	201040
2000	204906
2001	198800
2002	208430
2003	213100
2004	177368
2005	168253
2007	217500
2008	253750
2009	241875
2010	278850

Source: MOA 2010/11

Appendix 14: Temperature and rainfall records over last 30 years (1983-2012) in Dumkauli
 Meteorological Station, Nawalparasi

Year	Minimum Temperature °C	Maximum temperature °C	Rainfall mm
1983	18.09	30.00	145.68
1984	18.53	30.39	202.33
1985	18.88	30.63	186.64
1986	18.59	30.49	190.05
1987	18.70	30.82	180.68
1988	19.08	31.21	207.62
1989	18.21	30.85	161.71
1990	18.69	30.39	220.20
1991	18.76	30.76	168.93
1992	18.58	30.63	150.99
1993	18.33	30.27	190.22
1994	18.75	31.03	192.39
1995	18.68	30.83	221.16
1996	18.71	30.58	189.86
1997	18.08	30.11	161.73
1998	19.16	30.47	209.83
1999	19.08	31.33	221.78
2000	18.45	30.07	213.84
2001	18.58	30.47	254.08
2002	19.03	30.06	215.23
2003	18.62	29.71	268.13
2004	18.89	29.88	218.44
2005	19.00	30.63	185.22
2006	19.05	30.69	177.98
2007	18.93	30.23	268.82
2008	18.70	30.68	163.85
2009	19.13	31.36	160.37
2010	19.30	30.97	223.33
2011	19.02	29.93	176.68
2012	16.09	29.78	178.99

Source: DHM 2012

Appendix 15: Glimpse of survey research, 2014



1. Researcher observing survey



2. Researcher conducting household survey at Nawalparasi district



3. Research team along with the farmers of the surveyed area of Pithauli



4. Researcher conducting Focus Group Discussion at



5. Rice field (rice+duck) of the farmers at



6. Rice stems borer and its management practices