STUDY ON RICE FARMER'S PERCEPTION AND ADAPTATION MEASURES UNDER CLIMATE CHANGE AND VULNERABILITY CONTEXT IN BARDIYA DISTRICT

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DECLARATION

This is to certify that mini thesis entitled **"Study on Rice Farmer's Perception and Adaptation Measures under Climate Change and Vulnerability Context of Bardiya District in Nepal"** submitted in partial fulfillments of the requirements for the degree of **Bachelor of Science in Agriculture** with major in **Agricultural Economics** of the undergraduate program, Institute of Agriculture and animal science, Lamjung, is a record of original research carried out by **Mr. Hridesh Sharma**, under my supervision, and no part of the research report has been submitted for any other degree.

The assistance and help received during the course of this review have been acknowledged.

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DEDICATED TO
MY BELOVED PARENTS

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ACRONYMS AND ABBREVIATIONS

%	Percentage
@	At the Rate
^{0}C	Degree Celsius
CBS	Central Bureau of Statistics
CC	Climate Change
CO2	Carbon dioxide
DADO	District Agriculture Development Office
DHM	Department of Hydrology and Meteorology
FAO	Food and Agriculture Organizations of United Nations
FGD	Focus Group Discussion
Fig	Figure
GDP	Gross Domestic Product
GHG	Green Houses Gas
GoN	Government of Nepal
ha	Hectare
HH/hh	Household
INGO	International Non-governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature
KIS	Key Informant Survey
LIBIRD	Local Initiatives for Biodiversity, Research and Development
mm	Millimeter
MoAD	Ministry of Agricultural Development
MoEST	Ministry of Environment, Science and Technology
MoPE	Ministry of Population and Environment
NAPA	National Adaptation Plan of Action to Climate Change
NGO	Non-governmental Organization
PA	Practical Action, Nepal
Ppm	Parts Per Million

RARC	Regional Agriculture Research Center
SAFBIN	Small Scale Farming in Rain-fed Area in Bangladesh, India and Nepal
SPSS	Statistical Package for Social Science
Temp	Temperature
UNFCCC	United Nations Framework Convention on Climate Change
VDC	Village Development Committee
Yr	Year

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ABSTRACT

This study was carried out in Kalika and Motipur VDC of the Baridya district during June-September 2014 to investigate the climate change related perceptions of rice farmers and find out the prevailing adaptation practices as well as relationships of climatic factors and social factors on rice production. The study used primary data collected through HH survey, FGD and KIS by using pretested structured questionnaire and semi-structured checklist.

Regarding to perception analysis of 80 households, results revealed that the majority of local farmers experienced the rise in temperature, decrease monsoon rainfall, extend drought length and severity, increase in hailstorn and an increase in the insect pest. Farmers answered shifting pre-monsoon, main-monsoon and post-monsoon time for the shorter period later than usual time in the last decade. Growing degree day of the rice was shorter because of the shifting seed sowing date and transplanting date, flowering period and maturity period of rice were shorter. The key factors like: drought, emergence of insect pest attack, delay on seed bed preparation, decline in soil fertility & less availability of quality seed etc ultimately reduced rice production. Trend analysis of a latest 30-year's period data showed increased maximum, minimum and average temperature by 0.064^{0}C, 0.014^{0}C, and 0.039^{0}C, respectively but decreased trend in annual rainfall by 8.031 mm, decreased pre-monsoon rainfall of 3.96 mm, decreased main monsoon by 3.2 mm, winter rainfall of 1.89 mm. Strange figure was depicted to increased post-monsoon rainfall of 1.89 mm with high annual fluctuation. Regression analysis results showed that maximum temperature and average rainfall had positive (0.63) and negative (-0.296) relationship with the annual rice yield, respectively. The response of farmers over climatic changes on overall rice cultivation, applied climate-smart adaptation practices at Caritas-SAFBIN working areas were: changing seed sowing date use of drought and flood resistant varieties, cutting or build small sized bund and use of more FYM cum chemical fertilizers in their rice farm.

Keywords: Adaptation, climate-smart, perception, rainfall, regression, and trend

CHAPTER1: INTRODUCTION

1.1 Background

Agriculture is the core important sector of national economy in Nepal. It accounts about one third of GDP, employs a two-third of the population, represents 13% of the total foreign trade, and an important component of industry in Nepal. Rice, wheat, maize are the major crops grown by the farmers here in Nepal. The majority (50%) of farmers is small land holding farmers having less than 0.5 ha where almost 80% of farmers remain in rural area (CBS 2012). These small land holding farmer's have strongest bond with the ecosystem, which are very sensitive to climate changes. The poor country like Nepal, with poor farmers are likely to suffer most due to limited resources to cope with and adapt to the effects of climate change (Regmi. et. al. 2010). In addition, poor people are highly vulnerable to climate change impact, but they have the lowest capacity to deal with them (Huq and Ayers 2008).

Climate change, a hot topic of the global concern, it is considered as one of the most serious concerns to sustainable development with adverse impacts on the environment, agriculture, economic activity, natural resources and physical infrastructures (ICAO 2012). The global climate change is caused by GHGs and aerosol content of the atmosphere with anthropogenic and natural forcing. Since 1750, the time of the industrial revolution, carbon dioxide (CO_2) has increased by 31%, methane by 151% and nitrous oxide by 17% (Dahal 2009). In a small country Nepal, however, from 1975 to 2006, the average temperature trend grew by 0.027℃ per decade (Sharma 2009) in spite of the global average trend was 0.017˚C for the similar period (IPCC 2007). This indicates that the average temperature in Nepal is increasing by more than 50 percent compared to the global average. Under different emissions scenario, general circulation models project increase in mean annual temperature in Nepal. It is also projected that by 2060s the temperature will be increased by 1.3 – 3.8℃, and 1.8 -5.8℃ by 2090s with inter model spread of 1.5 – 2 ^{0}C by 2090s under any one emission scenario (UNDP 2007). SEN (2008) projected increase in mean annual rainfall by the end of this century by varying amounts (0-40%) from the base period (1961- 1990) over various parts of Nepal. Exception of projected rainfall decrease was marginally 5 % in Gorkha, Banke and Bardiya.

Climate variability is change in temperature and rainfall, which has resulted in shifts in Agro-ecological zones with prolonged dry spells and higher incidence of insects and disease pest. The sensitivity of food production to climate change is greatest in developing countries due to less advanced technologically 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).

Climate change has made agriculture crop production much more unpredictable. Rice is a major staple crop for Asian countries (Wassmenn et al 2009). Climate change has a huge impact on rice farming. Rising temperature and drought are the major factor for reducing rice farming (Pandey 2012). In rain-fed rice farming area, there is fewer economically active members in the family, less education, smaller farm size and larger proportion of area under drought or submergence-prone fields, limited diversification in the income, and a smaller asset which is a base to be more vulnerable to climate risk (Bhandari et al 2007).

Rice is grown abundantly in the Terai region of Nepal covering the maximum area under rice production. However, growth in production has been low at 1.4 per cent per year over the last two decades. About 70 percent of total rice produced is used for home consumption. Yet, for most subsistence farmers, rice production meets only a part of their annual household food requirements (Ghimire et al. 2013). They are, therefore, particularly vulnerable to external shocks to agriculture.

1.2 Statement of problem

Due to climate change there is a change in the climatic factors such as change in precipitation, temperature, humidity, etc. These factors ultimately cause changes in temperature, landslide, flood, drought, decrease in the level of snow in the mountains, etc., which affect the agriculture. As the nature of agriculture is subsistence and dependent on natural climate. Thus, the impact of climate change on agriculture is highly significant. The impacts are multiplied by the fact that there is a lack of capacity to cope with the adverse impacts of climate change (Practical Action

2010). Although they have been adapting these changes with their own knowledge and skills, the current and future changes in the climate and its impacts will be clearly irresistible to deal with. Moreover, what kinds of adaptation and mitigation strategies are farmers taken and what level of production cost increase/decrease are basic questions of the researcher.

Different studies have been conducted with the broad objective to interpret the climate change in agricultural sectors in Nepal. A district with high biodiversity within a small territory like Bardia has a great scope of micro level study of climate change and adaptation at the local level with a specific aim. There is no prior research on these issues and no documentation is done from the prior studies. It is necessary to assess the impacts of climate change on agriculture and food security conditions and seek the appropriate adaptation strategies to cope these impacts.

1.3 Objective

The general objective of this study was to assess the perception and the impacts of climate change on major food crops and food security of the communities in the study district. Following were the specific objectives, identifying at Caritas-SABIN area:

i) Documenting socioeconomic characteristics of the respondents in relationship to climate change vulnerabilities really happening at the project location;

ii) Mapping community perceptions on climate change factors in the study area,

iii) Determining relationships of socioeconomic factors and climatic factors on the yield, or related explanatory variables, and

iv) Documenting climate change adaptation measures taken by the communities along with project level interventions and coordination.

1.4 Rationale of the study

Documenting climate change related activities in the present study in a primary level adaptation funding are supposed to be used as fundamental resources in the related organization. Motipur and Kalika VDC of Bardiya district are highly vulnerable to drought and low rainfall problems, but the majority of the other VDCs in Bardiya were highly prone to monsoon-flood. In line with these past situations, present study collected response of the farmers and key stakeholders directly or response from published literatures. Hence, this study has mapped climate change vulnerability perceived at local level. It also co-relates the change in temperature and precipitation with the production of the rice. This study facilitates the attention of the researchers, governmental offices, institutes and students would get research idea and implement climate-smart projects and programs.

1.5 Limitations of the study

A country like Nepal with diverse microclimate and geography within the small area has a greater scope of community level study of climate change, where the few studies to document knowledge and adaptation with these changing climatic scenarios. Community and household level studies gather the information about perception, local knowledge and adaptation measures, which provide the basis for development of strategies to fight climate change locally. This study explored the effect of climate change and different adaptation measures practiced by rice growing farmers in the Terai region. The data on rice production of the working VDCs level was not available, so district rice yield data (through crop-cutting survey) was assumed as same as study sites. This study was conducted only at two VDCs, which could not represent even entire Bardiya or Terai region. Thus, the generalization of the study will be suggested for the confined study sites and similar localities only.

CHAPTER 2: LITERATURE REVIEW

This chapter deals review of the past work done on different economic aspects of production of rice inside and outside of the country that are relevant to this study.

UNFCCC, (2001) has defined climate change as a change of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable periods.

According to Intergovernmental Panel for Climate Change (IPCC), it defines climate change as a "change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer." That may be any change in climate over time, whether due to natural variability or because of human activity.

2.1Climate change in global context

A few decades ago, environment, condition was almost static throughout the world, but due to industrial revolution environmental exploitation started in large scale. With the increasing population and increasing demand, the intensive exploitation of the environment occurs. Eventually led to the emission of different harmful gases and polluting the environment. This led to an unwise use to resources. Soon environment scientist advocated saving the environment from exploitation and first historical conference on the human environment (Stockholm 1972) was held to think about the environment issues. Later, integrated concerns into national economic planning and decision-making (Hoksins 2002) on climate change were made.
On 1983, The Brundtland Commission forwarded the concept based on economic growth and defined as "the development which meets the need of the present without compromising the ability of future generations to meet their needs." On 1987, the Commission published a report focusing environment protection, economic growth and social equity. Moreover, on 1992 UN organized "The Earth Summit" in Rio de Generio of Brazil. The primary goal of the summit was to come an understanding of "development" that will support the socioeconomic development as well as prevent the deterioration of the environment. In this Summit, UN convention on climate

change framework for intergovernmental effort to combat climate change was made with 192 member countries. This summit purposed that government should: 1) Gather and share information on greenhouse gas emissions, national policies and best practices, 2) Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; 3) cooperate in preparing for adaptation to the impacts of climate change, and 4) Convention entered into force on 21 March 1994 at the global level.

2.2 Climate change in rice production

Rice productivity and sustainability are threatened by biotic and abiotic stresses, and the effects of these stresses can be further aggravated by a dramatic change in global climate. On a study, producing more with less: exploring farm-based approaches to improve productivity and providing options to farmers in adapting to climate change in Tamilnadu by Gujja. B and T.M. Thiyagarajan have concluded that SRI, SSI, and SWI are showing positive results in farmers' fields. In addition, smart water management and planting practices, farmers in Tamil Nadu have increased rice yields by 30–80% and reduced water use by 30%.

On a report climate, change impact on Agriculture and Costs of Adaptation by International Food Policy Research Institute (IFPRI 2009) forecasts that by 2050 climate change will cause rice prices to increase between 32 to 37%. Moreover, yield loss in rice could be between 10 to 15%.

2.2.1 Rice production and CO_2

The primary effect of rising atmospheric CO_2 (C_a) to plant will respond to increasing resource use efficiency. Increased in amount of C_a causes reduce in stomatal conductance and transpiration and improve water use efficiency, and at the same time C_a stimulates higher rates of photosynthesis and increases light-use efficiency. During long-term exposure to elevated C_a acclimation of photosynthesis can reduces key enzymes of the photosynthetic carbon reduction cycle, and this increases nutrient use efficiency. Other possible effects of increased in amount of C_a observed in the field studies are improved soil–water balance, increased carbon uptake in the shade, greater carbon to nitrogen ratio, and reduced nutrient quality for insect and animal grazers. (Bert G. D. and Miguel A. G-M 1997)

In a study conducted in china with, a regional climate change model (PRECIS) for China, suggested that climate change without carbon dioxide (CO_2) fertilization could reduce the rice, maize and wheat yield by up to 37% in the next 20–80 years (Erda et al 2005). The Intergovernmental Panel on Climate Change's Third Assessment Report also confirmed that CO_2 enrichment under field conditions consistently increases biomass and yields in the range of 5–15%, with CO_2 concentration, elevated to 550 ppm Levels of CO_2 that are elevated to more than 450 ppm will probably cause some deleterious effects on grain quality.

2.2.2 Temperature and rice production

Potential threat to rice production is the increasing temperature. High temperature affects the rice crop at all stages of development, but flowering is affected the most, when it causes spikelet sterility. Higher temperature also increases the respiration of the crop, affect photosynthesis, and shorten the grain-filling period, which ultimately decline the grain yield (Peng et al 2004). A Study conducted by Kumar and Parikh (1996) to see the potential impact of global climate change on Indian agriculture, concluded that grain yield would fall by 25-40 % and rice yield 15-25% if the temperature rises by 4°C. A study conducted by Lal et al (1995) suggested that by the middle of the next century, the surface air temperature over the Indian subcontinent is likely to rise from 1°C during monsoon and 2°C during winter.

During the vegetative phase, rice is relatively more tolerant of high temperatures, but during the reproductive phase, is highly susceptible, particularly at the flowering stage (Jagadish et al 2010). However, a certain degree of overlap of physiological processes (e.g., reduced pollination, number of pollen germinated on the stigma, and increased spikelet sterility) under both high day and night temperatures has been documented (Jagadish et al 2010b).

Rice production is significantly affected by the diurnal temperature change. Day temperatures beyond the critical level can adversely affect photosynthesis, by changing the structural organization of thylakoids and disrupting photosynthetic system II (Zhang et al 2005). In Some empirical studies under field conditions showed that, the high day temperature had no significant negative effects on grain yield (Peng et al 2004, Welch et al 2010).

Rice cultivated under a flooded paddy system is generally not exposed to this level of high-temperature stress. The buffering capacity of standing water, along with efficient transpiration cooling, creates a microclimate with lower temperature, even when ambient air temperature is very high. A comparison of the effect of High Night temperature (HNT) on grain yield under field condition and controlled environment revealed that the increase in the night temperature had a greater negative effect on the rice yield with 1℃ above the critical temperature >22℃ which lead to a 10% reduction in both grain yield and biomass yield (Peng et al 2004 and Welch et al 2010). Peng et al (2004) also reported annual average night time, temperature increased at a rate of 0.04 ºC y^{-1} from 1979 to 2003 at IRRI. The increase in night time temperature was three times greater than the increase in daytime temperature over the same period.

Some tropical and sub-tropical rice growing areas have a high day temperature, which is already close to the optimum levels, with an increase in intensity, and frequency of heat waves coinciding with the sensitive reproductive stage can result in serious damage to rice production. Extreme high day temperature episodes along the Yangtze River in China resulted in an estimated 3 million ha of rice damaged, resulting in a loss of about 5.18 million tons of paddy rice in 2003 (Xia and Qi 2004, Yang et al 2004).

2.2.3 Rice production and flood

Flood is a significant problem for rice farming, especially in the lowlands. However, yield losses are attributed to unpredictable flood events, which can be grouped into three damage mechanisms:

1. Complete submergence: (often referred to as "flash flooding") causing plant mortality after a few days
2. Partial submergence over longer time spans (often referred to as "stagnant flooding") triggers substantial yield losses
3. Water logging in direct-seeded rice creates anaerobic conditions that impair germination (Mohanty et al 2013)

Rice is a semi-aquatic plant, rice is generally intolerant of complete submergence is an important a biotic stress that affects 10-15 million ha of rice fields in South and South-East Asia.

2.3.4 Rice production and drought

Rice farming needs ample water to grow. No rainfall for a week in upland rice growing areas and for about 2 weeks in lowland rice growing area can significantly reduce rice yield. In rain fed drought-prone areas, average yield reduced from 17 to 40% in severe drought years, leading to loss in production and food scarcity. More than 23 million hectares of rain fed rice production areas in south and Southeast Asia are affected by water scarcity. Recurring drought affects nearly 80% of the potential 20 million hectares of rain fed lowland rice in Africa (IRRI 2014).

Drought is the most serious constraint to rice production in unfavourable rice-growing areas and most of the popular farmers' varieties are susceptible to drought stress (Serraj et al 2009). Rice production in rain fed systems, affecting 10 million ha of upland rice and over 13 million ha of rain fed lowland rice in Asia alone (Pandey et al 2007).

The biggest area of drought-prone rain fed lowland rice is located in India (13.3 million ha) and Thailand (8.2 million ha), but drought also regularly occurs in the other major rain fed lowland rice regions: Bangladesh (5.1 million ha), Indonesia (4.0 million ha), Vietnam (2.9 million ha), Myanmar (2.4 million ha), Cambodia (1.6 million ha), and the Philippines (1.3 million ha). Disease and insect pest in rice production: Triggering of pest/disease can also be an indirect impact of climate change. Under climate change scenarios, insect-borne disease, particularly viral disease, may become an important problem. The plant may be more susceptible to pest and disease by altering crop physiology and biochemical changes due to elevated CO_2 and temperature (Rao et al 2010).

2.2.5 Rice weed management effect on climate change

Climate change will increase the weed infestation in the crop production. Rice-weed competition are predicted to increase and will represent a major challenge for sustainable rice production. There may be positive effects of elevated CO_2 levels may have on rice competitiveness with C_4 weeds, but generally abundant number of C_3 species in weed populations of rice in Africa. Higher temperatures and drought will favour C_4 over C_3 plants. Tolerance of rice may also improve against parasitic weeds with increased in CO_2 level, while soil degradation and more frequent droughts or floods (Rodenburg and Meinke 2010) may stimulate invasiveness of such species.

A study conducted to study the impact of climate change on weed in rice and wheat in India concluded that temperature changes might result in an expansion of weeds. Herbicides efficiency might be affected by the raised CO_2 level as CO_2 may increase the tolerance of the weed. The study also concludes that CO_2 favours rhizome growth and tuber growth of perennial weeds that indicates that in the near future, weed will increase the problem in rice and wheat farming.

2.3 Literatures on vulnerability and adaptation

The term vulnerability describes the susceptibility of a group to the impact of hazards. A system is likely to experience harm due to its exposure to hazard to the degree. It is determined by the capacity of a system to anticipate, cope with, resist and recover from the impact of hazards. Exposure to natural hazard of the community is increasing day by day, making it more vulnerable to increasing global change and frequent extreme event (Tuner II 2003).

In context of climate change, O'Brian et al. (2004) classifies vulnerability as 'endpoint' and 'starting point' interpretation of vulnerability. The 'end point' interpretation mainly focuses on climate change mitigation and compensation policy and technical adaptation. While, 'starting point' interpretation focuses on vulnerability of society to climatic hazards, adaptation policy and sustainable development of societies.

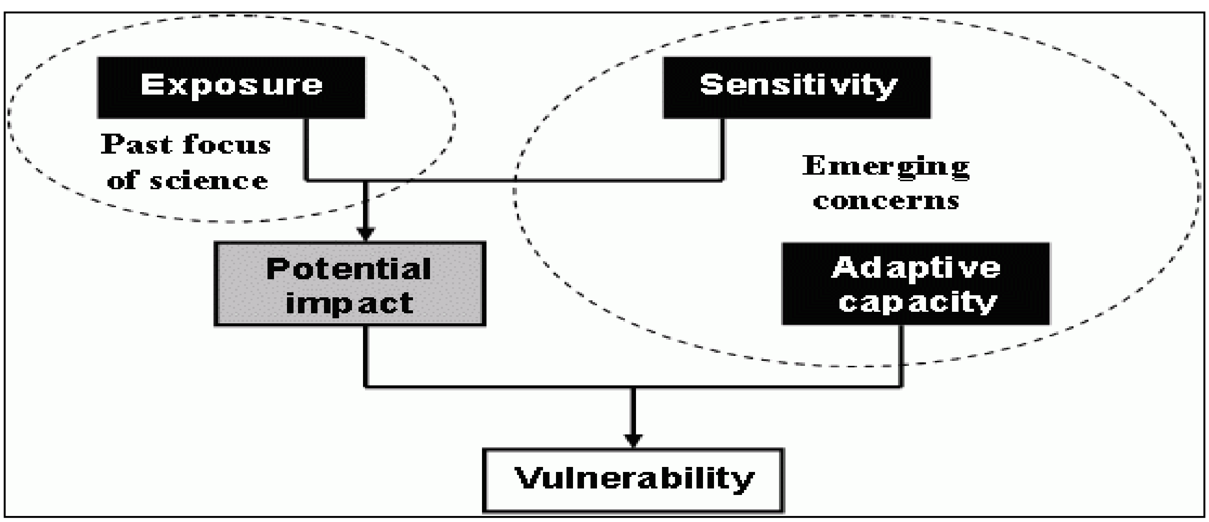
Climate change impacts will be most vulnerable to smallholder farmers. These farmers tend to own fewer livelihood assets, which include land and livestock, have low education; receive lower income and less access to community and government services. They fully depend on rain fed agriculture and occupy land that is more prone to floods, drought and landslides. Many of these farmers have small land holding which is barely able to produce enough for their family. These farmers are more reliant on local natural resources such as water and forest. And they would suffer most from the drying up of local water sources and change in vegetation cover (ADRMA 2011).

On the third assessment report (TAR) of the IPCC defines vulnerability as “the degree to which a system is susceptible to, or unable to cope with, 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.” "In this definition exposure, sensitivity and adaptive capacity are defined as follows: According to IPCC “Exposure is the character, magnitude and rate of climate change and variation” And IUCN defines exposure as the experience of climate change, but in practice the framework includes the impacts of climate change as a measure of exposure. Looking at the determinants of exposure i.e. current climate trends (seasonal), climate induced events, climate projections and community based and scientific data, most of the methodological framework developed by different organizations have made it specific and strategic components.

According to IPCC "Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)." In their framework, IUCN defines sensitivity as impact, but in explaining how to assess sensitivity describe the concept in terms of dependency on resources that are susceptible to impact by climate change (Marshall, et al. 2009).

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Allen Consulting (2005) illustrates 'vulnerability' diagrammatically and demonstrate that exposure to a climate event combined with sensitivity to that event may be interpreted as potential harm.



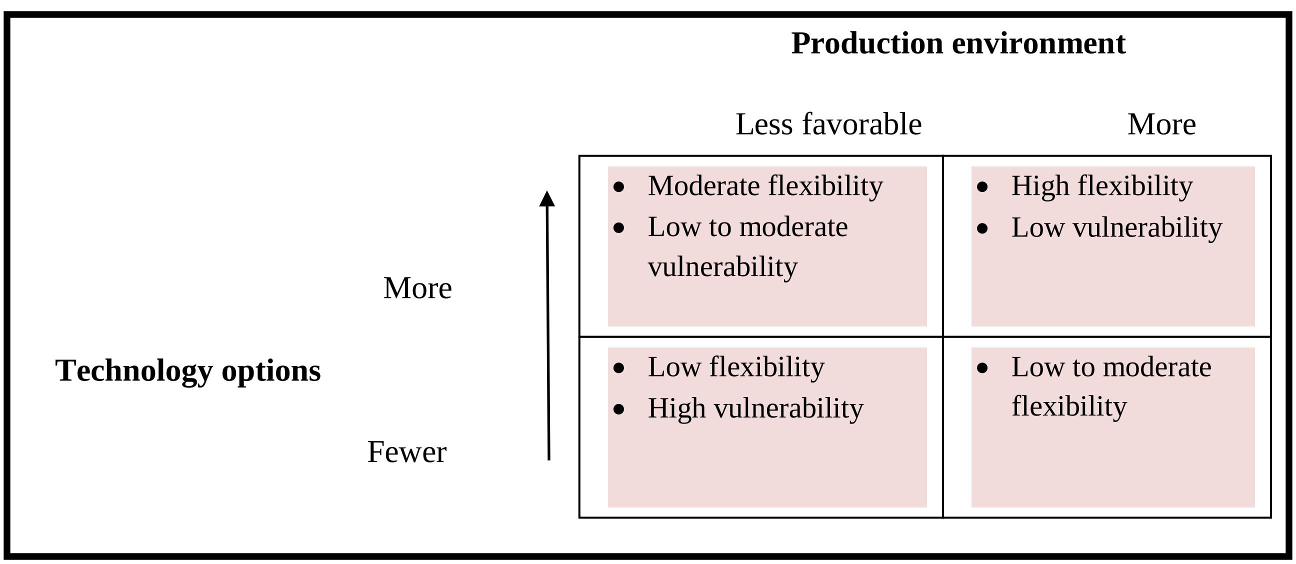
Source: Smith et al. (2010).

Figure 1: A framework for understanding vulnerability

Adaptation refers to outcome of a series of actions undertaken at different spatial scales to cope or adjust in giving new environment created due to stress or hazards or opportunity (Smit and Wandel 2006). Adaptation practices vary depending upon spatial and temporal scale, nature of the sector, actors involved, actions, climatic zone, socioeconomic base or combination of these factors and others (Yohe and Tol 2002). The adaptation programs and policies should be designed as such that they will address cross spectral issues of poverty alleviation, bio-diversity and ecosystem services conservation, reduction of land degradation and soil erosion and increase food security enabling achievement of sustainable development at various scales (FAO 2008). The adaptation measures complementary to develop are desirable (Ribot et al. 1996).

2.3.1 Adaptation of technology and vulnerability

Household vulnerability to climate change largely depends on availability of technological options and the nature of the production environment. Households are most vulnerable if the production environment they operate in is less favorable and technological options are also limited. Moreover, if provision of more technology options is given, then it will help to reduce their vulnerability. (Left section in fig. 2). Whereas if more favorable environment is provided than vulnerability will be low (moving up left to up right) but such changes tend to be more expensive and of a long-term nature (Pandey, S. et al., 2012).



Source: Pandey, et al. (2012)

Figure 2: Technology options and vulnerability

2.4 Literatures related to climate change in Nepal

Every living being need water to live and rice production. In rice, farming almost 47% have irrigation facilities in Nepal. Thus, a larger portion of rice farming in Nepal depends on natural precipitation. However, the precipitation pattern has been noticed to fluctuate for the past 30 years in Nepal (Shrestha et al 2000) causing rice farming more unpredictable. There is no significant trend like the one temperature could be observed in the precipitation. In Nepal there are four distinct seasons; pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and winter (December-February) (GON 2010).

In general, there is decline in pre-monsoon precipitation in far and Midwestern Nepal with only few pockets having decreasing precipitation in western, central and eastern regions. The rest of the part of the country generally increasing trend of pre-monsoon has been noticed. Similarly, decreasing trend in monsoon precipitation in Midwestern and southern Nepal has been noted while other parts of Nepal has increased trend of rainfall. Increase in the post monsoon trend in the most of the Midwestern development region and southern part of western, central and eastern Nepal. Decreasing post-monsoon trend has been noticed in the far-western development. However, the increasing trend of winter monsoon has been noticed in the entire country.

A number of studies report major effects in particular years, such as the droughts of 2008/9 and 2009/10. In recent years, we have seen severe winter droughts. There was one in 2006 combined with extensive summer flooding, and another one in 2009/2010, which is reported to have led to an 11% loss of rice yield, 7% loss in wheat and maize yields leading to a total grain deficit of 400,000 Mt (Poudel 2011). The drought seems to be a major climatic hazard to the agriculture crops followed by the flood and hailstorm is shown in table 1.

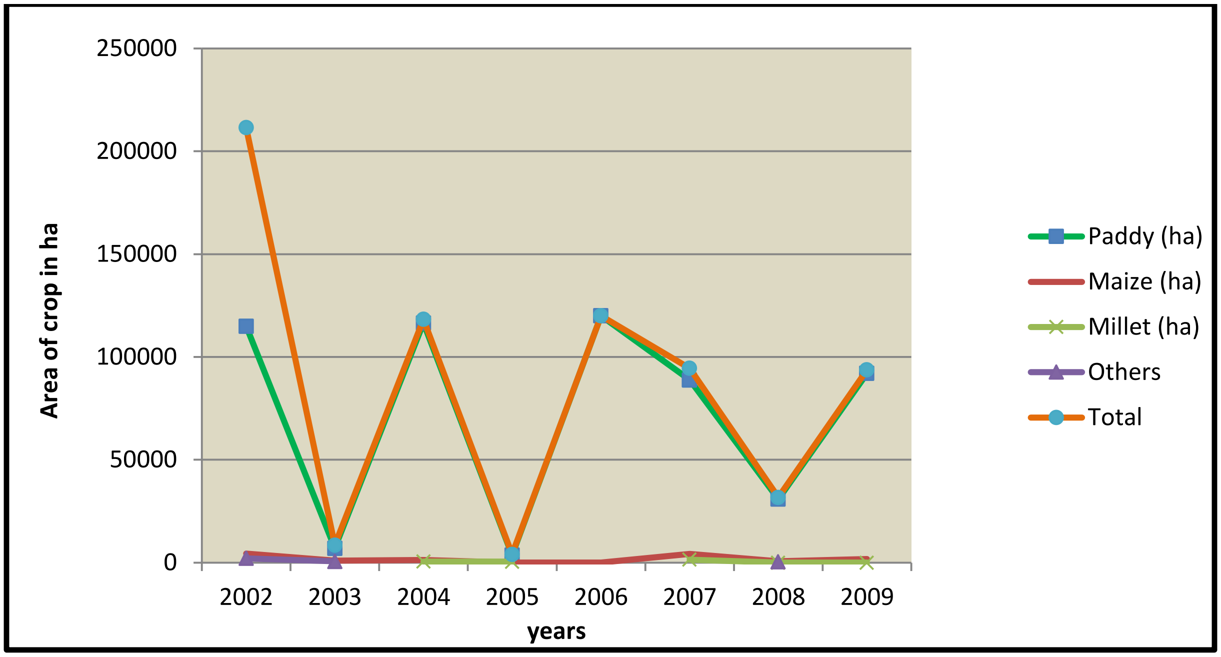
Table1: Loss of agricultural land and crop by climate related extreme events in Nepal (1971-2007)

Events	Loss of Agricultural land and crops (Ha)
Drought	329 332
Flood	196 977
Hail storm	117 518
Rains	54 895
Strong wind	23 239
Cold waves	21 794
Others (snow storm, fire, storm, plague, etc)	83 336
Total	847 648

Source: ISDR global assessment of risks, Nepal report (2009)

Climate change brought various extreme such as flood, drought, hailstorm etc. These extreme events seem to affect paddy crop the most with the fluctuations in the degree of extreme event's occurrence. In 2008, a massive flood on the Koshi River breached of its embankment caused loss of paddy crop as well as the lives of people. Another flooding event in the same year in Kailali and Kanchanpur districts damaged irrigation facilities causing maximum damage to the paddy field.

In 2009, the delayed and weak monsoon caused the delayed in the transplanting of paddy in the most of the part of the country causing the loss in yield of paddy crops.



Source: ABPSD/ MOAD (2010)

Figure 3: Area of crops affected by climate related extreme events in Nepal

Though the trend of paddy production is increasing, but some paddy, producing districts like Dhanusa observed an area and production loss, largely due to localized dry spell. Crop Assessment mission estimated an acreage loss of 32 % and production loss of 56,000 Mt while MoAD reports much lesser loss. Similarly, on 2013 DADO Jumla also estimated paddy loss of 45% due to heavy rainfall and hailstone (DADO Jumla 2013).

2.5 Climate change in Bardiya

Bardiya district Known for grain store lies to the south of the mid western development region of Nepal. The district covers an area of 2,025 km² in which 68.76% is occupied by Terai and 31.27% occupied by Chure hills. Bardiya district is the Tharu land district. According to the census of 2001 the population of Tharu is 201276 (male-101662 and female-99614) and other Magar, Gurung, Tamang and Newar also settled in this district.

2.5.1 Impact of climate change in Bardiya

Impact of climate change different sectors has been noticed. Loss of land races, loss in the production of key crops, change in the cropping pattern, pest and disease are some of the major impact of the climate change in the agriculture sectors. Loss of local land races has been observed with loss of production in the major crops like rice, wheat has been observed. The increasing trend of the insect pest in the agriculture crops has been noticed. Due to fluctuation of timing of rainfall, there changes in the cropping pattern with the incidence of new crops to the locality like maize and vegetable (LIBIRD 2011).

Table 2. Different Categories of Banke/Bardiya district

Categories	**Banke/Bardiya District**
Loss of local landraces	Anadi, Dhunmuniya, Masuli, Shyamjira, Tilki, Barma,Sungapankhi, Deruwa, RTilki, Shyamjira, Sungapankhi, Barma, Kanakjiria, Basmati, Goguwa, Sauthiyari, SuhaGopal, Latera, Rudhani
Loss of production of key crops	Rice, Wheat, Lentil, Chickpea, Mustard, Millet, Maize
Change in cropping patterns due to Extreme events	Only one crop per season
Pest and diseases	Increasing
Input of production	Fertilizers and pesticides Increasing use of chemicals
Emergence of new crops	Vegetables, Maize

Source: LIBIRD (2011)

2.5.2 Climate change and rice production in Bardiya

In a study conducted by SUGAN program (2009) in Banke and Bardiya districts showed change in climatic parameters like temperature and rainfall causing loss in production of major cereal crops like rice, wheat, etc. with an increase in the pest incidence. At another a study by Bandar (2008) in Kaski and Bardiya district, revealed that more households (40%) in the Terai than hills (11.6%) reported a decrease in crop production from 5-25% due to abnormal rainfall. Similarly, 11.1% respondents experienced food insecurity due to crop loss/failure in non-normal rainfall years. The study also revealed that in mid-hills, which receive more than 3000 mm annual rainfall, slight decrease in the total amount of rainfall does not affect the production of rice crop significantly, if distributed normally within the growing season. However, western Terai is a relatively drier area than mid-hills site receiving less than 1500 mm annual rainfall. A slight decrease in the rainfall in this drier area will quickly lead to moisture deficiency for rice crops, largely affecting crop production negatively. It was forwarded that the rice crop of Western Terai is more likely to be affected by a resulting yield reduction for rice crop than that of mid-hills for similar days of dry spells and drought period. Likewise, 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). 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 conducted by Caritas, Nepal 2012 also concluded drought as a limiting factor for rice production and study carried out the different location of Bardiya districts to see the performance of drought tolerant rice varieties; Sukha 1, Sukha 2, Sukha 3 and Radha 4 in moderate drought stress condition revealed that farmers preferred Sukha 3 variety the most because of its several qualitative traits like grain and straw quality, drought tolerance and resistance to insect pest. On the similar context, a study conducted by Rana (2012) in Bardiya district reveled, that grain and biomass yield of rice was decreasing in drought condition. Where in special cases grain and straw yield is increasing, this may be due to use of high yielding varieties, use of more fertilizers that are chemical and supplying water through forced irrigation by using deep borings.

Table 3: Combined Effect of Increase in Temp and $C0_2$ on Rice Productivity in Nepal

Region	Current Rice Yield (kilogram/hectare)	% Deviation in Rice Yield at Various Temperature Levels				
		1ºC	2ºC	3ºC	4ºC	5ºC
Carbon dioxide level (parts per million)	370	420	470	500	560	650
Terai	2,458	16.61	15.43	13.20	9.25	6.51
Mountain	2,105	12.22	12.11	14.75	17.37	17.46
Hill	1,733	17.52	33.21	35.68	37.55	38.93

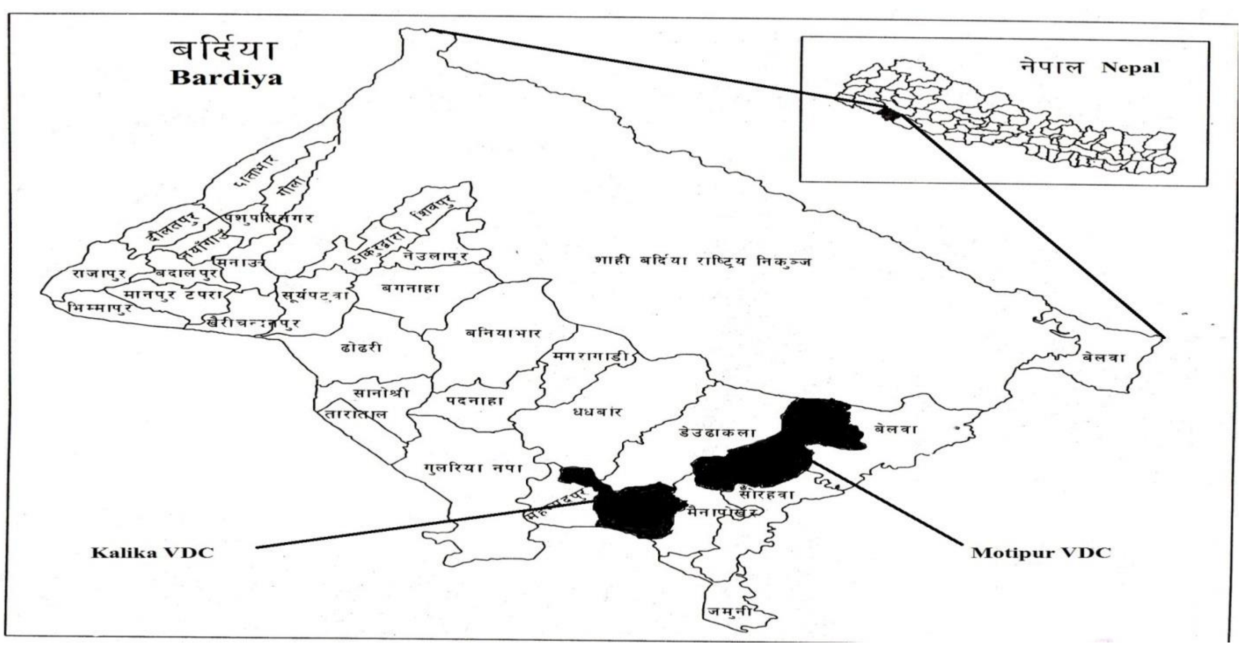
Source: Ahmed and Suphachalasai (2014)

Table 3 depicts that forecasted increase in temperature from (1^0C – 4^0C) with rise in carbon dioxide concentration from (420-560 p.m.) will gradually decrease rice yield in the Terai region while an increase in the yield of rice in mountain and hill region. It also forecasts that in temperature (5^0C) and 650 ppm of Carbon dioxide concentration would increase rice yield by 6.51% in Terai, 17.46% in mountain and 38.93% in the hills. Temperature (5^0C) and carbon dioxide level (650 ppm) could increase rice yield by 6.15% in Terai, 17.46% in mountain and 38.93% in the hills.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Site selection and study duration

The research was conducted in Motipur and Kalika VDCs of Bardiya district during July-September 2014. Bardiya is one of the Terai districts renowned as a granary store of Midwestern Nepal. It is situated at 28º 17"- 28º39" N and 81º 3" - 81º 41" E covers 2,025km^2 total area. Study location of Motipur VDC is 27°42′N 83°08′E and a geographical location of Kalika VDC is 28.20°N 81.44°E. The district is surrounded by the Bank in the East, by Kailali in the West, by Surkhet in the North, and by India in the South. It constitutes 31 VDC and 1 municipality. There are 83176 households occupying 426576 population with the population density of 211 (CBS 213). The Major logic of selecting these study sites were: i) locations were considered as rain-fed region. ii) Locations where Caritas SAFBIN research project, iii) Bardiya is also identified as a vulnerable site for the impacts of climate change by vulnerability assessment conducted by the National Adaptation Programme of Action (NAPA) (MoE 2010). Study sites and whole Bardia district is seen in figure 4



Source:.www.ztopics.com/bardiya

Figure 4: Study locations map

3.2 Research design

Following schematic diagram shown in figure 5 explains whole research design of the present study.

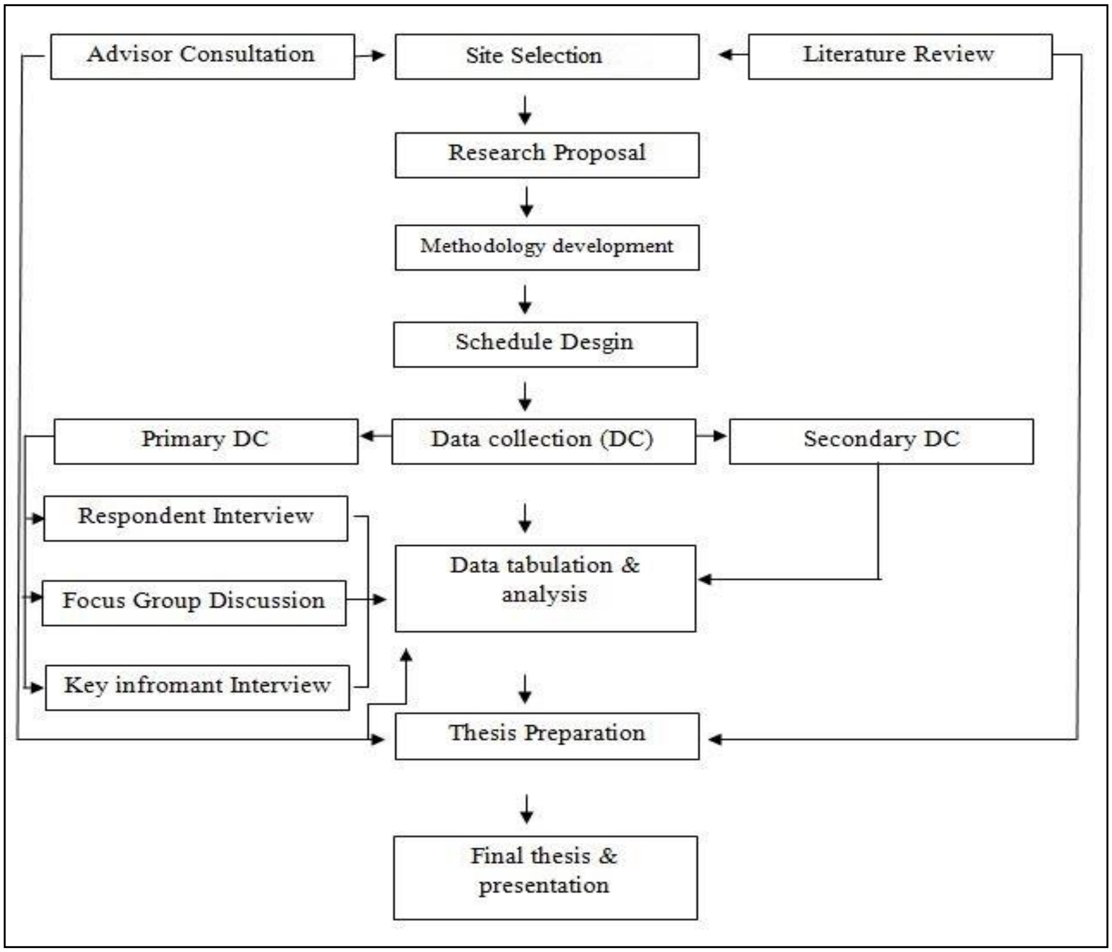


Figure 5: Overview of research design as conducted

3.3 Source of data

The study used primary and secondary data. The primary data were taken by using household survey, focus group discussion and key informant survey. Use of primary data was mainly for perception analysis by using before and after approach**.** Meaning that perception analysis was measured by recalling the effects of climatic factors before ten years and today (this year).

Secondary information and data were collected from Central Bureau of Statistics, District Agriculture Development Office Nawalparasi, Department of Hydrology and Meteorology Babarmahal and past reports of Caritas-SAFBIN project. The study collected twenty-year (1991-

2012) data on rice yield, precipitation and temperature data. Web search was conducted to download past researches, proceedings, other published and unpublished research materials of the other organizations.

3.4. Sampling procedure

Firstly, sample survey was conducted outside of the project area. Altogether 80 respondent's interviews were conducted were 50 respondents sampling was taken from Motipur VDC and 30 respondents selected from Kalika VDC. Fifty percentages of the respondents were from Caritas-SAFBIN members, but rests were non-members. The key informant survey was used for sampling frame. Farmers were selected after key informants survey and a pre-field visit. Our respondents were over 30 years of age and indigenous people were given the first priority in sampling.

3.5. Interview schedule design

Semi-structured questionnaire was prepared consistent with the objectives of study and different variables were included. Pre-testing of the questionnaire was done by interviewing 5 respondents near the study area and some necessary adjustments were made.

3.6. Data collection methods

3.6.1 Primary data collection

For primary data collection, both open and closed question types were used to collect the data.

- **a) Household survey:** Eighty household surveys were done under random basis. Older aged farmers were more preferred while taking the interview by preparing structured questionnaire (see appendix 1.A)
- b) **Focus group discussion** was conducted with the farmers to know the past and present condition of climate, change in the agriculture with the help of prepared semi-structured checklist (see appendix 2). Altogether five focus group discussions by involving 72 members (male 7 and female 65) were conducted.
- c) **A key informant survey** was undertaken with the key person who knew knowledge in a farming area and the changing climatic conditions. Altogether five KIS was taken. Farmer, Agro-vet shops, DADO officer, Caritas Head of SAFBIN programme of Bardiya, RARC Khajura officer were selected for KIS.

3.6.2 Secondary data collection

Secondary information was collected from Central Bureau of Statistics, District Agriculture Development Office, Department of Hydrology and Meteorology, Caritas-SAFBIN project, RARC Khajura. Some additional information was obtained from associated organizations and professionals.

3.7 Data tabulation and analysis

The information collected from the field was entered in the data sheet in excel by coding the data and analyzed. SPPS was used for descriptive tools like frequency counting, average, mean, standard deviation, percentage, etc. The descriptive statistics were used to describe the respondents' socioeconomic characters such as sex, age, land holding etc. After secondary data collection, analysis was done by using correlation and regression. Regression analysis is widely used for prediction and forecasting. It is also used to understand among the independent variables are related to the dependent variable, and to explore the forms of these relationships. Monthly temperature and monthly rainfall data of nearby station for the periods of 27 years (1985-2012 AD) for Bardiya district was collected from Department of Hydrology and Meteorology were taken as independent variables. For analysis six months from June to November was, consider as growing seasons and average of temperature and rainfall data of that period was taken into account. The paddy yield of the same period was assumed as annual yield of the Bardiya district. Thus, paddy yield was considered as dependent variable and its independent variables were climatic (temperature) and non-climatic (area of cultivation).

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

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

$$\Delta Y=\beta_0 +\beta_1\Delta R + \beta_2\Delta T_{max} + \beta_3\Delta T_{min} \text{----------------------} (1)$$

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

$\beta_{1,}$ $\beta_{2,}$ and β_3 are coefficient of respective climate variable rainfall (R), maximum temp & minimum temp, respectively. Classical regression model (CRM) of the above question can be written as Y_t = $\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + u_i$ ----------------- (2)

Where, y_t = yield at year t, Xi = independent variables: temperature (X_1), X_2 (rainfall), X_3 (area of cultivation), t = time (year). "α" and "β" are the constants and slope coefficients estimated by the principle of ordinary least square (OLS) estimator (Gujrati, Porter and Gunasekar 2013).

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 the calculated value of t, if 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 a sample and mean of parent population is significant at the 5 % level, if it exceeds $t_{0.01}$ the difference is said to be significant at the 1 % level. Chi-square (X^2) test was tested to measure the normality of the model. In addition, measuring the relationship of various responses is 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 accepted 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.

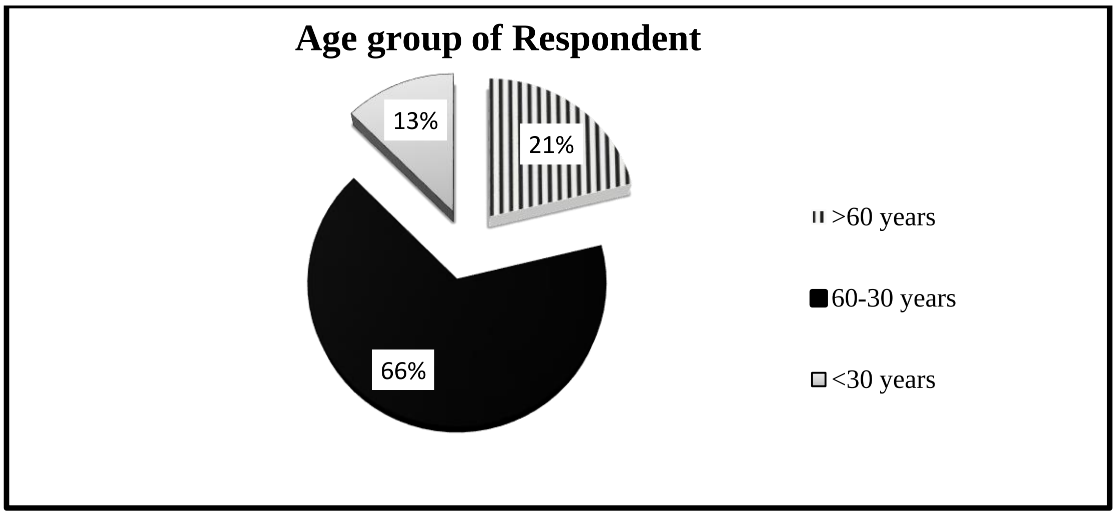
Trend analysis was used to explain average annual production, average annual maximum temperature, average annual minimum temperature and average annual rainfall.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Socioeconomic status of the respondents

Household survey was conducted in two VDCs (Motipur and Kalika) of Bardiya district with 80 household respondents. A household survey reveals that the majority of the respondent were female. Out of 80 respondents, 62.5% were female and 37.5% were male.

On the figure. 6, we can see 21% of the farmers were above 60 years, 66% were between 60-30 years and 13% were under thirty years. Tharu people dominated community. In our HH survey, 57.8% were Tharu followed by Dalit 17% , Chettri 13% and Bharmin 12.2%.



Source: Field survey (2014)

Figure 6: Age group of respondent

Landholding of the respondent was categorized into three groups as small farmer < 0.5ha, medium farmer 0.5-1 ha and > 1 ha are the large farmers. From the analysis, it was found that most of the farmers were small holders i.e. <0.5 ha. The average landholding size was 19.1 Kattha per household.

Table 5: Landholding size of households

S.N	Land holding farmers	% of households
1	Large (>1 ha)	15
2	Medium (0.5-1 ha)	38.8
3	Small (<0.5 ha)	46.2

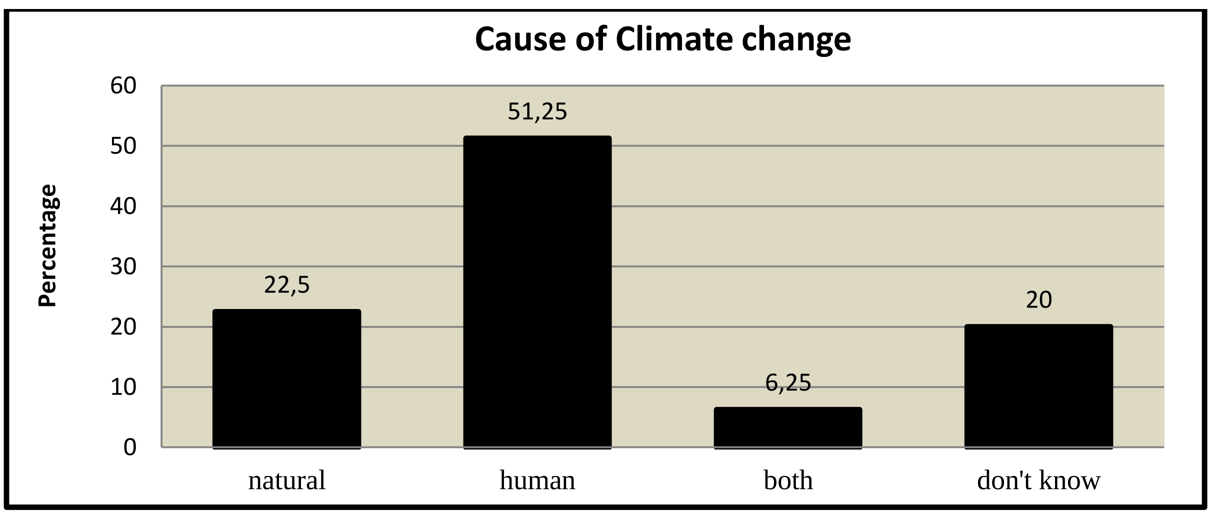
Source: Field survey (2014)

The major crops grown are paddy, wheat, lentil, chickpea, maize and vegetables. Rice and maize are rainy season crop while wheat, lentil, chickpea were grown in the winter season. Paddy crop is the principal crop in the area, whereas average rice productivity was 3.1.

4.2 Perception analysis of the respondents of climate change parameters

4.2.1 Cause of climate change

The majority of the respondent perceived that the major cause of climate change was human activities. Human activities were the major cause of climate change was perceived by 51.25 % of the respondent while 22.5 % perceived that the causes of climate change was natural (may be good) forces, few 6.25% perceived climate change was due to both human activities and natural forces and 20% did not know the actual reasons for the climate change.



Source: Field survey (2014)

Figure 7: Cause of climate change

4.2.2 Perception on weather conditions

All the respondents felt the change in climatic parameters. The study revealed that the entire respondent experienced the increase in the level temperature in their locality. The majority of the respondent (97.5%) experienced that there is a decrease in the monsoon frequency with the majority 96.25 % and 90% perceived that there is an increase in the drought length and drought frequency. Similarly, 53.75% experienced the increase in the hailstone, 31.25% experienced the decrease and 15 % experienced no change in the hailstone occurrence. In the same way majority 38.75% experienced the decrease in humidity, 28.75% experienced there was no change in the humidity, 11.255 experienced the increase while 25% did not know about the humidity. The majority of the respondent experienced the no change in the wind speed, 27.50% experienced the decrease, 25% experienced the increase and 3.75% did not know about the wind speed.

Table 6: Perception on weather condition (%)

Type of weather	Increase	Decrease	No change	Don't know
Temperature	100.00	0.00	0.00	0.00
Monsoon frequency	1.25	97.50	1.25	0.00
Drought length	96.25	1.25	2.50	0.00
Drought frequency	90.00	3.75	6.25	0.00
Hailstone	53.75	31.25	15.00	0.00
Humidity	11.25	38.75	28.75	25.00
Wind	25.00	27.50	46.25	3.75

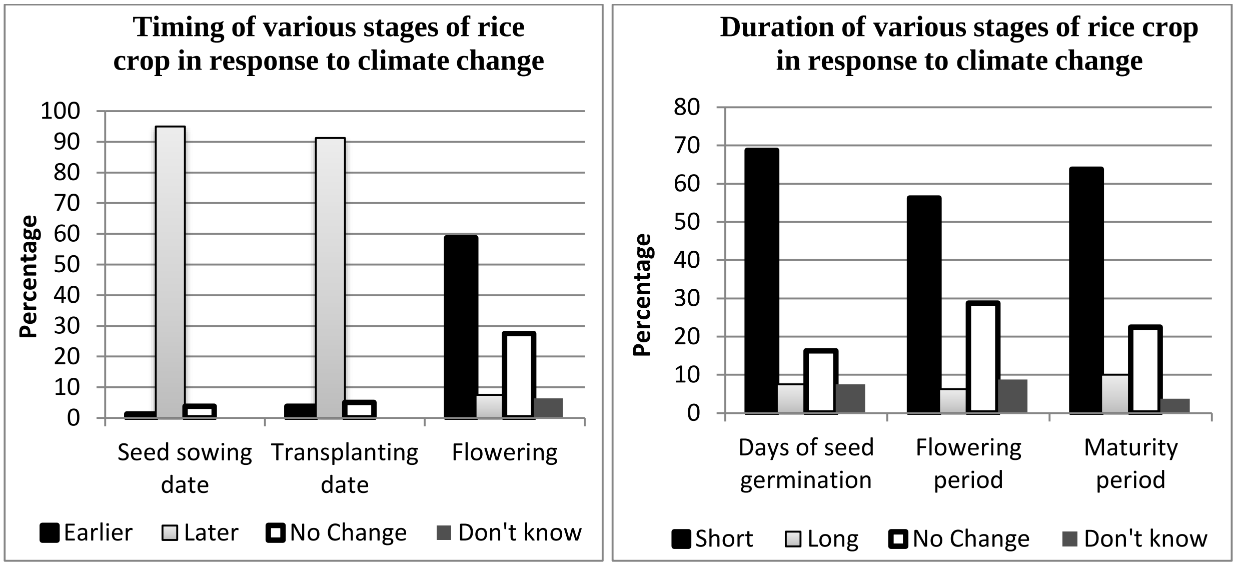
Source: Field survey (2014)

The entire respondent experienced that the timing of pre monsoon, main monsoon and post monsoon was later than usual it used to be a decade ago. Similarly the entire respondent experienced that the duration of pre monsoon, main monsoon and post monsoon is shorter than usual it used to be a decade ago**.**

4.2.3 Perception on rice stages

Due to delayed on monsoon, the rice seed sowing date & transplanting date had shifted later than usual date of seed sowing and transplanting experienced by 95 % and 91.25%, respectively.

68.75% of the respondent perceived shorter days of seed germination, 58.75% experienced earlier rice flowering, 56.25% and 63.75%) felt shorter than usual flowering & maturity period.

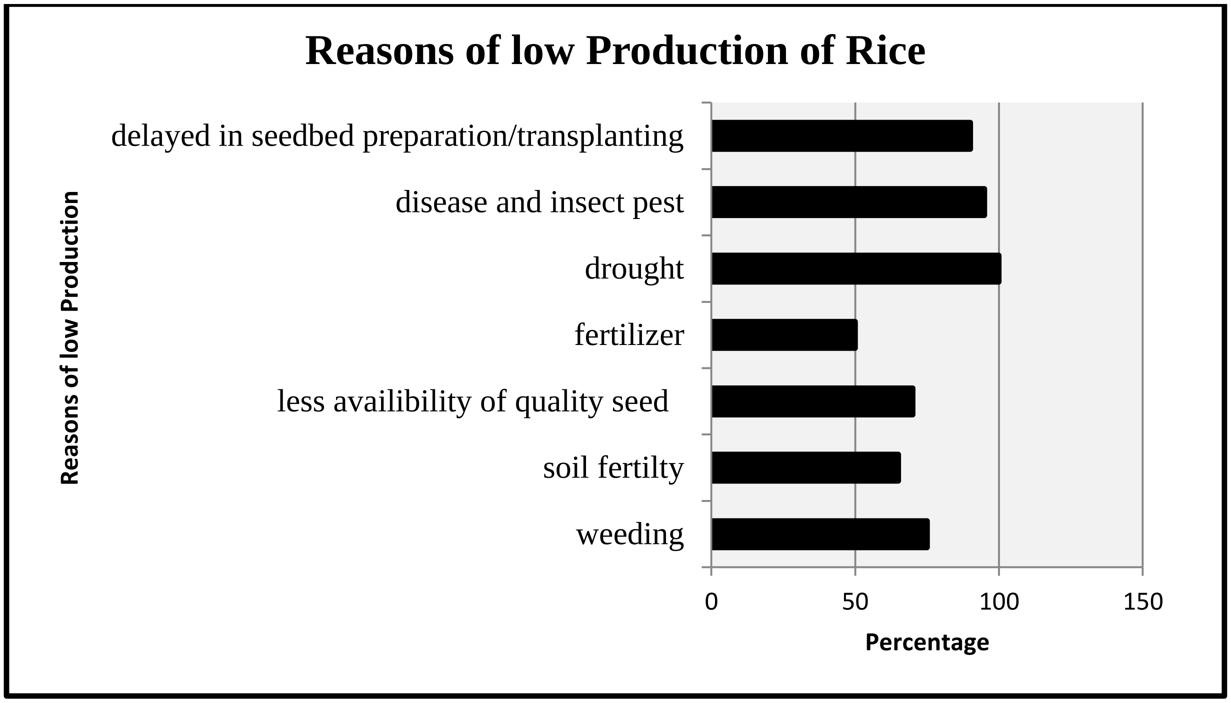


Source: Field survey (2014)

Figure 8: Climate change response of respondent's on various stages of rice crop

4.2.4 Reasons of low rice production

Perception analysis revealed that drought was the major problem of the rice farming, where the majority of the respondent experienced drought as major factor, followed by 93% experienced disease and insect pest attack Using old seedling (due to delays in transplanting) as well as delayed in seedbed preparation were other limiting factors experienced by 90% of the respondent. Similarly, fertilizer and less availability of quality seed were also the factors of limiting the rice production experienced by 50% and 73% of the respondent, respectively.



Source: Field survey (2014)

Figure 9: Reasons of Low Production of Rice

4.2.5 Perception of climatic hazards timeline in Motipur and Kalika VDCs

The tool, FGD, conducted to identify the major hazard occurred in Motipur and Kalika VDC within 10 years associated with rice farming, identified following timeline of climatic hazard

Table 7: Timeline of climate change hazards at Motipur VDC, Bardiya

Date (BS)	Disaster	Effects
2065	Drought	Lose up to 50% in paddy resulting difficulties to cultivate
2066	Drought	Decrease the yield of paddy crop by 10-15%
2067	Drought	Decrease the yield of paddy crop by 10-15%
2069	Drought	Loss of paddy crop up to 10 %
2069	Insect	Attack of armyworm that reduced 30-40% yield

Source: FGD (2014).

Table 8: Timeline of climate change hazards at Kalika VDC, Bardiya

Date (BS)	Disaster	Effects
2062	Flood	Damage the paddy crop and also affected the livelihood of people
2064	Wind	Effected the paddy crop by causing the lodging effect
2066	Drought	Decrease the yield of Paddy crop by 10-15%
2067	Drought	Decrease the yield of Paddy crop by 10-15%
2069	Insect	Infestation of Army worm increased and caused 30-40% failure in paddy crop

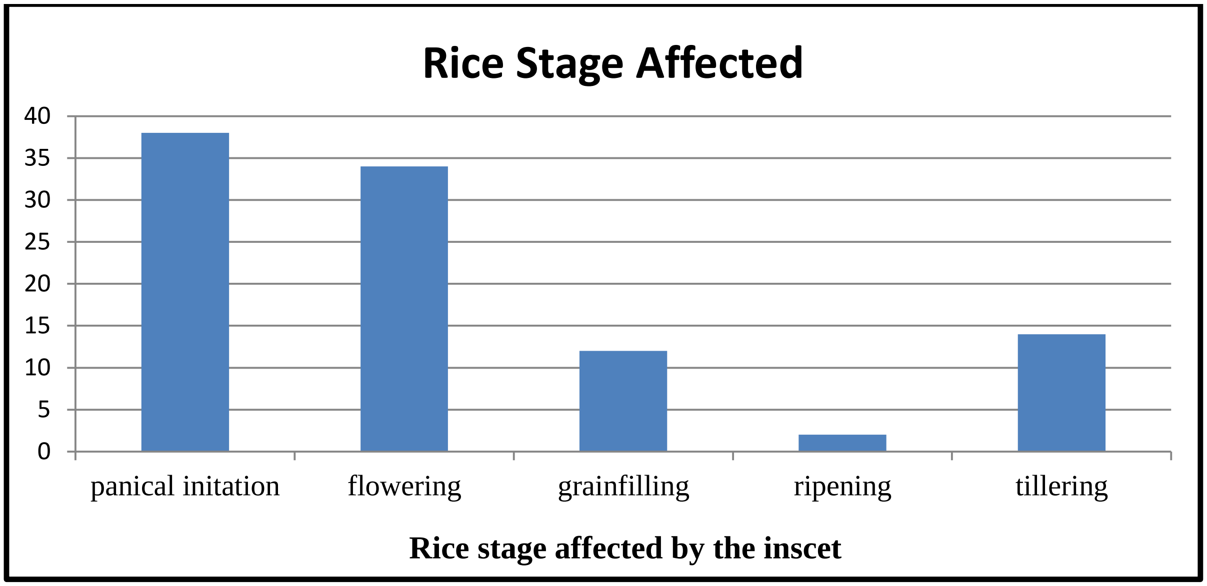
Source: FGD (2014)

4.2.6 Caritas vs Non-Caritas-group perception on climate change

The difference in the Caritas-SAFBIN group and non-group was clear. Members were active to respond the answer having deep knowledge on climate change effect because Caritas-SAFBIN has been doing variety trail with farmers. With the view to cope with increase drought in the different area in Bardiya district, varietal trial of rice like: *Sukha 1*, *Sukha 2, Sukha 3* and *Radha 4* are under study, where, *Sukha 3* varieties were most preferred by the farmers against their local variety *Radha 4* (Caritas annual report 2012). In addition, due to this almost all the Caritas farmers adapted the drought tolerant varieties. After the adaptation of drought varieties, Caritas farmers confirmed that their food sufficiency was improved for 2-3 months. Members at Kalika VDC confirmed using debris/wastage burn in the field in order to manage pest was stopped now. Some farmers reported that they had stopped using a light trap to kill the insect pest because while using the light trap by few farmers, light trap will attract the insects from all around the surrounding and dense population will be created by light trap rather kill those insects.

4.2.7 Respondents perception on insect pest attack on rice farming

According to the majority, the farmers (38%), they experienced that panicle initiation stage was most affected by the insects. About 36% of the farmers' experienced flowering stages were the next stage that was affected by the insect. Similarly, 14% of the farmers experienced that tillering stage was the most affected stage. While other experienced grain filling and ripening stage were also other stage the insects affects. According to FGD, farmers reported that rice stem borer, armyworm was the major insects in the Motipur VDC. While farmers reported that rice stem borer, rice stink bug and armyworm were the major insects in the Kalika VDC.



Source: Own drawing from field survey (2014)

Figure 10: Rice stage affected by the insects

4.3 Role of social-economic and climatic factors on rice yield

4.3.1 Relation of age, gender and khet land on rice production

In the linear regression analysis using SPSS of independent varying age, gender, *khet land* on dependent variable rice production was found to be highly significant which is much less than 0.05 (See appendix 4.A). The value of R^2 (0.956) was also much greater which showed strength of the relation between the dependent variable and independent variables (see appendix 4.B). This implied that gender, *khet land* played important role in production of rice, but relates to the age of the respondents of the rice production had a weak relationship (see appendix 4.C).

4.3.2 Correlation between rice productivity and climatic parameters

For the correlation analysis 27-year's rice production of Bardiya district was taken from CBS while climatic parameters; maximum temperature of the growing season, a minimum temperature of the growing season, rainfall of the growing season of twenty-seven (1985-2012) years was done from DHM of Ranijaruwa Nursery of Bardiya district. In this correlation analysis, maximum temperature has a significant relation with the productivity of the of Bardiya district (N=27, $p<0.05$) and strong relation was found between them (R^2=0. 630). However, no significant relation was found between rice productivity and minimum temperature of the growing season (see appendix 5).

4.4 Trend analysis of climatic factors

4.4.1 Maximum and minimum temperature trend

In the trend analysis of the temperature of Bardiya district minimum temperature and maximum temperature of the Ranijaruwa Nursery station was taken from DHM. The average annual minimum temperature and average annual maximum temperature were obtained using the average of all months using SPSS. Mean maximum and minimum temperature was 32.98 ℃ and 22.52℃.

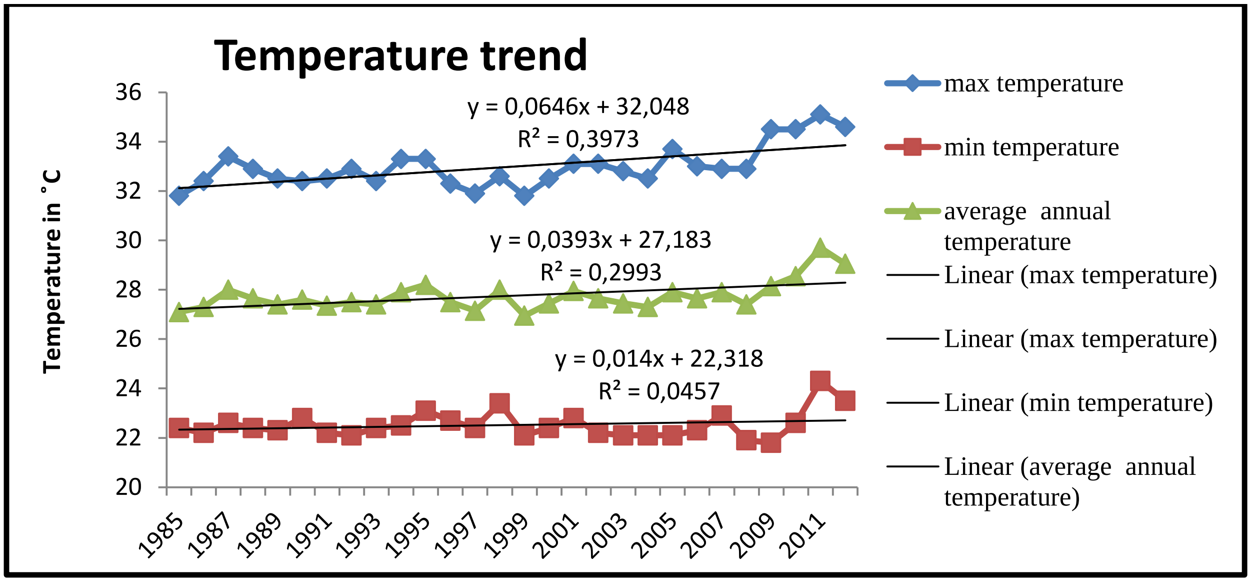
Table 9: Showing the trend of maximum temperature and minimum temperature

Temperature	Yearly		
	t max	t min	t. Average
Mean (℃)	32.98	22.52	27.75
Standard Deviation	0.843588	0.539106	0.59128369
Maximum temperature (℃)	34.6	24.3	29.7
Minimum temperature (℃)	31.8	21.8	26.95
Correlation with time	0.630	0.214	0.547
Trend (℃ / year)	0.064	0.014	0.299

Source: Own estimates from DHM (2014)

The highly significant relation was obtained between time with maximum temperature and the average temperature while no significant relation was obtained with the minimum temperature. There was increasing trend of maximum temperature, minimum temperature and average.

On the trend analysis of the temperature of Bardiya district twenty eight years (1985-2012), minimum temperature and maximum temperature of the Rani Jaruwa nursery station was taken from the DHM. The average annual minimum temperature and average annual maximum temperature were obtained using the average of all months using SPSS. Mean maximum temperature obtained is 32.98 ℃ where as mean minimum temperature obtained is 22.52℃. The highly significant relation was obtained between time with maximum temperature and the average temperature while no significant relation was obtained with the minimum temperature. The analysis found the increasing trend was of maximum temperature (0.064), minimum temperature (0.014) and average temperature (0.299) of the Bardiya district.



Source: Own drawing from DHM (2014)

Figure 12: Temperature trend of Bardiya district

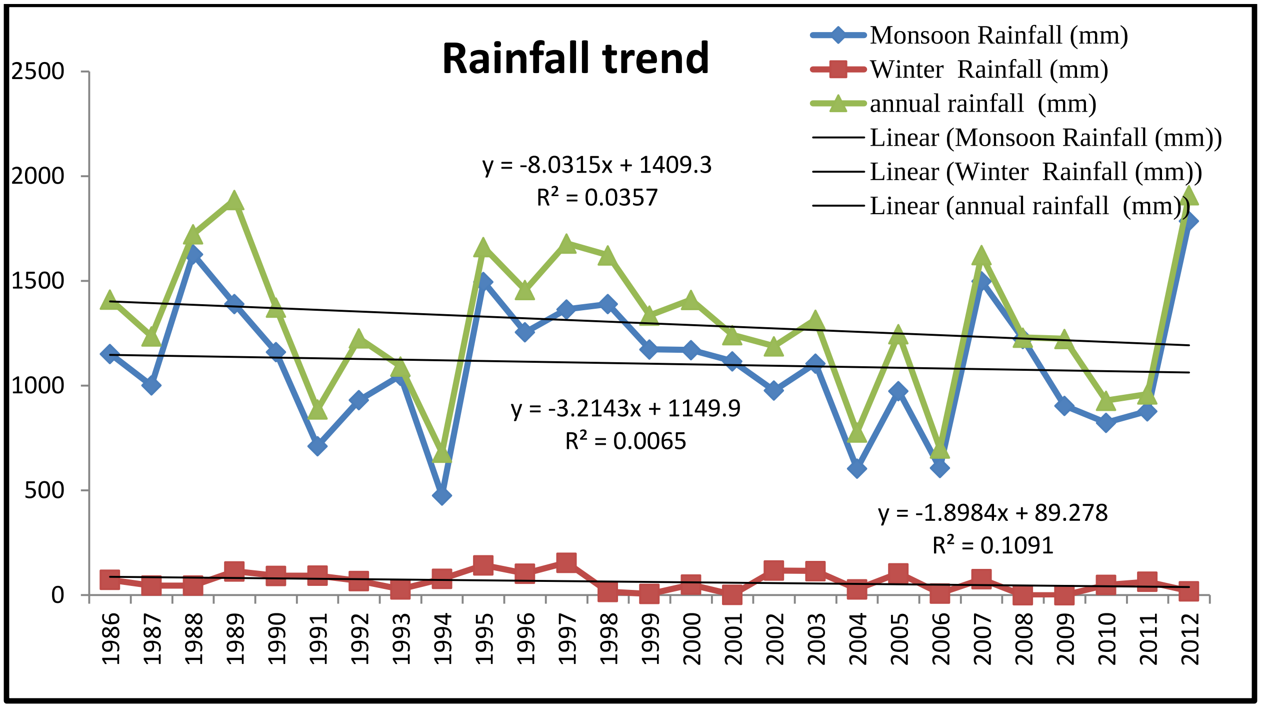
4.4.2 Rainfall tends

About 27-year rainfall of the Rainjaruwa nursery was taken from DHM to analyse the rainfall trend of the Bardiya district. From this analysis, we found that highest mean was 1104.88 mm of main monsoon rainfall and the least mean was 38.34 mm of the post monsoon rainfall. While annual rainfall was 1296.84 mm. High deviations in the main monsoon and annual rainfall was found 317.57 mm and 337.35 mm, respectively, but the lowest deviation was 45.61 mm, which was found in the winter monsoon. The maximum rainfall was noted to fall in the main monsoon that was 1785 mm while lowest maximum rainfall noted was 154.8 mm of the winter rainfall. Post monsoon and winter monsoon noted to have zero rainfall in the various years. There was a highly significant correlation was found between time and main monsoon while no significant correlation was found with others. The trend of the pre monsoon (-3.21), main monsoon (3.21), winter monsoon (-1.89) and the annual rainfall (-8.03) was found the decreasing while increasing trend was found in the post monsoon rainfall (1.041). The farmers Table 8 also perceived this evidence in a decrease in rainfall. While these evidences were in a decrease in rainfall trend was concluded in the NAPA report also.

Table 10: Showing trend of Rainfall of Bardiya

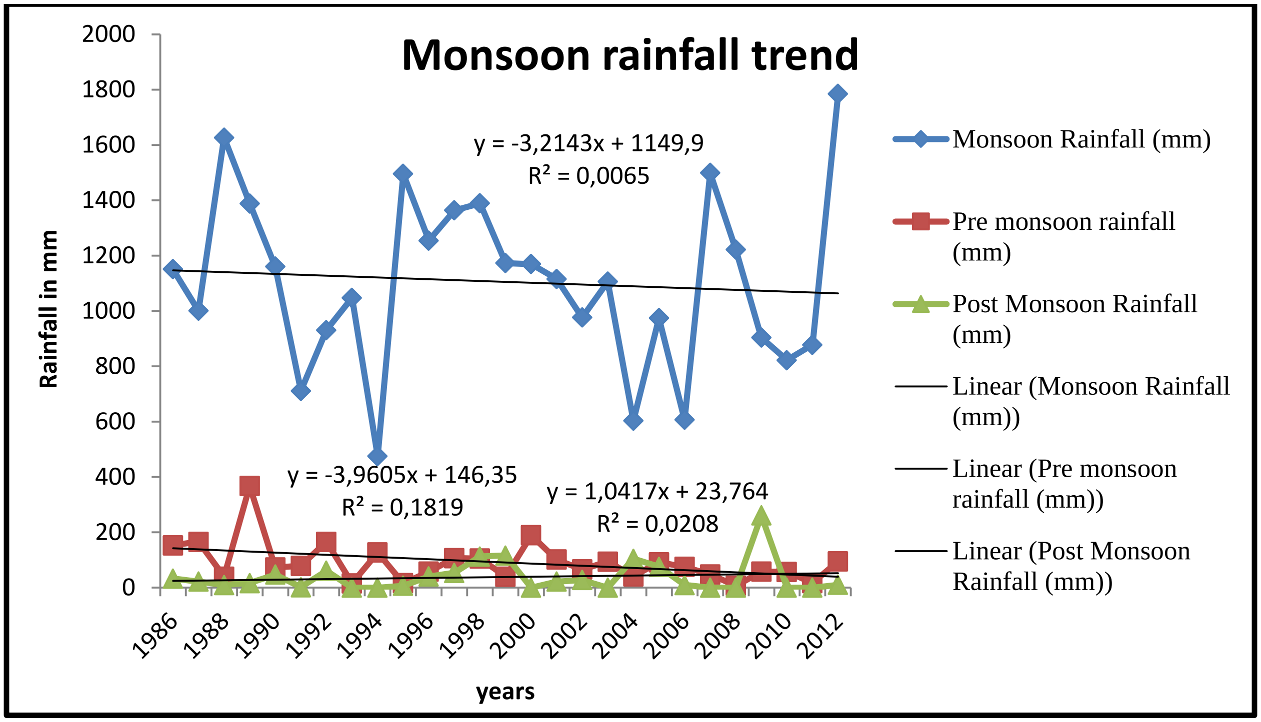
	Pre monsoon	Main monsoon	Post monsoon	Winter monsoon	Annual rainfall
Mean (mm)	90.9	1104.88	38.34	62.7	1296.84
Standard deviation	73.6965	317.5747	57.35573	45.61823	337.3511
Maximum rainfall	367.5	1785	261.5	154.8	1909.6
Minimum rainfall	7	603.4	0	0	777
Correlation with time	-0.427	-0.08	0.144	-0.33	-0.189
Trend (mm/year)	-3.9605	-3.2143	1.0417	-1.8984	-8.0315

Source: Own estimates from DHM (2014)



Source: Own drawing from DHM (2014)

Figure 13. Rainfall trend of the Bardiya district



Source: Own drawings from DHM (2014)

Figure 14: Monsoon rainfall trend of the Bardiya district

4.5 Climate change adaptation practices of the respondents

4.5.1 Change in the rice varieties

According to the farmers, local landraces of many crops were lost in the study area. The farmer also reported that they had lost the long duration rice varieties. The majority of the farmers in the both VDC grew Radha 4 and Sabitri but who were supported under Caritas-SAFBIN used to Sukha rice variety. Nonmembers of SAFBIN were cultivating same varieties, buying from nearby Agra-vet shops or from Indian shops, but the DADO facilitated very few farmers. Rice variety like, 6444, Supreme Sone, Super Moti used to buy from India. From the table 10 we can see farmers were inclined towards the hybrid and improved varieties. Farmers also reported of replacing rice seeds every three years.

Table 11: Varietal adaptation in Motipur VDC

S.N	Previously varieties	Current varieties
1	Janaki, Sarjubhawan, Makarkaddhu, Hawamansuli, Sabitri, Radha-4, Karangi, 6451, 6444, Derawa, Champain, Hardinatha, Moti, Bindeshawori, Saurab ,Gorakhanath, Suhawat	Sabitri, Radha 4, Sukha 1, Sukha 2, Sukha 3, Ramdhan, Karangi, Sambamasuli, 6444, Loknath, Champaion, Goraknath, SupremeSona, Samba, SarjuBhawan, Bindeshawori, SuperMoti, Hardinath-1, Saurab

Source: Field survey (2014)

Table 12: Varietal adaptation in Kalika VDC

S. N	Previously varieties	Current varieties
1	SarjuBhawan, Bhadiya, SarjuBhawan, Gopal,Madanchand, SambaMansuli, Suhawat Bikash,Suwapankhi,Sabitri,Deharadhun, Janaki, Diruwa, JiraMansuli	Radha-4, Prithivi, Survi, Suka rice-1, Sukha rice-2, Sukha rice-3, 6444, janaki, SambaMansuli, Super moti, SupremeSona

Source: Field survey (2014)

Rice growing farmers at the local level had different problems under climate change scenarios. Farmers are adapting different local practices to escape these problems. Rice growing farmers under the loss of productivity scenario have adopted climate smart varieties like *Sukha1, Sukha 2 and Sukha 3* to escape drought in the area. Most of the farmers (96%) used *Sukha* varieties of rice were the Caritas farmers.

4.5.2 Other adaptation practices of the rice growers

Details of adaptation practices are depicted in table 13. Farmers also adopted the change in the sowing date because of untimely rainfall and lack of irrigation facilities. While farmers also started to use more FYM/compost and chemical fertilizer to increase the production. Respondents experienced the increase in the disease and pest attack on the rice farm. A few farmers recently adapted strong insecticides and fungicides to control the insect and disease pests. Alternative of chemical control, IPM practices was adapted in Kalika VDC. Some farmers also practiced hand removal (roughing) infected rice plant in order to disturb disease spreading.

Farmers having planning rice in the low land area (water-logging condition) used to cut bunds. Both VDCs had no irrigation facilities. To escape more water requirements of rice, farmers started transplanting paddy seedlings after the onset of monsoon. Very few farmers used electric motor for drawing groundwater in order to prepare wet-method of seedbed. The farmer also experienced rice seed storage loss by the damage of store grain pest. Farmer lets the rice properly dry after cutting the rice in the paddy field. Then, threshing and again drying if not properly dried.

Caritas-SAFBIN supported farmers adopted a few options to escape climate change impact are listed in table 13.

Table 13: Adaptation practices by the rice-growing farmers

Types of problems	**Adaptation practices**
Loss of productivity	Change in sowing date Adaptation of climate smart varieties Use of more FYM/compost & chemical fertilizer
Disease and pest attack	Spraying chemical fungicides, pesticides, etc. IPM practices Hand removing if seen in small amount
Water logging condition	Cutting bunds, build a low height bund
Water scarcity (during seed bed preparation)	Using a motor pump for extracting groundwater through STW (only by richer farmers) Sowing after rainfall
Weed infestation	Hand weeding
Loss of rice seed by store grain, pest	Proper drying
Drought	Drought tolerant varieties

Source: Field survey (2014)

CHAPTER 5: SUMMARY AND CONCLUSION

5.1 Summary

Rice is a major staple crop in Nepal, cultivated dominantly in rainy season and partially in spring season. Past studies in other countries reported climate change had an effect on rice cultivation (Karna 2014). However, such studies was not performed in Bardiya. Thus, present study was carried out in Kalika and Motipur VDC of Bardiya district during July-September 2014 with the objectives of a) documenting special differences on climate change vulnerabilities really happening at the project location b) measure community perceptions of climate change before and after project intervention c) mapping climate change adaptation measures taken by the communities along with project level interventions and coordination.

Altogether eighty HH survey was chosen and organized interview schedule with the help of pre-tested structured questionnaire. Five FGDs with the involvement of 72 participants and 5 KIS also conducted to collect other data and information by using semi-structured questionnaires. Climatic parameters and paddy production of Baridya district was collected from DHM, CBS and MOAD, respectively. The collected primary and secondary data were entered into Microsoft excel worksheet as well as SPSS worksheet. Then, perception analysis, trend analysis and regression analysis were undertaken by using SPSS version 16.

Regarding to perception, analysis, all respondents answered well perception of climate change in their locality, by answering causes induced by the human activities (51.25%) followed by natural forces (22%). On the response of change on the weather factors of 10 years by respondents, 100% respondents answered increasing temperature level, 98% experienced a decrease in monsoon frequency, 96% experienced an increase in drought length, 90% experienced increase in drought frequency, 54% experienced increase in hailstone, 38.75% experienced decreased in the humidity, and 46% experienced no change in wind speed. Likewise, all the respondents answered shifting later of all timing of pre-monsoon, main monsoon and post-monsoon rainfall Because of rainfall effect, the rice seed sowing date & transplanting date had been shifting later than usual date, as answered by 95 % and 91% respondents. Rising temperature effect made a shorter seed germination date (by 69%), early rice flowering (by 59%), and shorter maturity period (by 64%) respondent perceived. A similar result was also reported by Practical Action adaptation research report (2010), where local communities have perceived deviation on the dates of precipitation with an increase in the drought duration and increase in the temperature level. People reported early germination of local paddy seed and early harvesting than that before.

Regarding the reasons of low rice production, farmers experienced drought as a major factor, followed by an attack of insect pest and delay in transplanting time. On the study, farmers reported continued losses ranging from 10-50% in the production due to drought or delay in pre-monsoon rainfall. However, since Caritas-SAFBIN launched, farmers experienced high rice productivity because of the adaptation of *Sukha* varieties in spite of problem of increased effect of insect pest damage (about 10-50%).

Results after analyzing secondary data gave increased mean annual temperature, maximum temperature and minimum temperatures by 0.039^0C, 0.064^0C and 0.014^0C, respectively but decreased mean rainfall by 8.031mm. Pre-monsoon rainfall, main monsoon rainfall and winter monsoon rainfall were decreasing in trend by 3.96 mm, 3.2mm and 1.89 mm. However, post-monsoon rainfall was increased by 1.89 mm. Results of analyzing relationships of age, gender, lowland (*khetland*) with the rice yield showed a strong relationship of age, gender, *khetland* with rice yield. The relationship of rainfall data, temperature data and paddy production data were analysed. Highly significant and positive (0.063) relationship was found among paddy yield in relation to maximum temperature and rainfall (-0.296).

Rain-fed rice farming was practiced in the study site, where there were no facilities of irrigation. Farmers were fully dependent on natural rainfall, which increases the level of uncertainty. Thus, these are prone to drought. Adaptation with the changing climatic condition of the research site seems to be poor.

5.2 Conclusion

Above results supported researcher to conclude following points:

- The majority of responses of respondents on climatic factors revealed that interconnection of various factors with climatic factors have adverse effect on rice production.
- Although rate is low but fluction of rainfall was concluded. Farmers' experience also gave abundant edidence of shifting pre-monsoo, monsoon and post-monsoon rainfall pattern. Direct impact was shifted rice-planting calendar. Late rice planting but early or usual rice-harvesting concluded reducing rice growing degree day of main season rice.
- Trend analysis as well as regression analysis confirmed researcher to conclude increased trend of mean temperature and reducing rainfall pattern have a positive relationship on rice yield. However, autonomous practices of farmers as well as Caritas-SAFBIN supported activities prioritize climate change adaptation as first best policy.
- Although, Caritas-SAFBIN or other organizations are doing adaptive research at field level, study concludes weaker level of implementation of adaptation related programme in the study area.

5.3 Policy Recommendations

- Study suggests Caritas-SAFBIN Management Team to replicate the findings of the this research in the working districts of similar climate, crop, and clients.
- As the study was completed by taking few VDC's samples, limited key informant interview, and FGD, the researchers suggest Caritas-SAFBIN to check the current results and findings by conducting advanced research in the large sampling frame. Research priority would be including many socioeconomic and climatic variables and mapping their relationship on the final decision of climate change adaptation. Further research is the important to document the impacts, vulnerability and adaptation of the study area that might help in policy making and prioritizing adaptation process for wider areas' of rice growers.
- In order to supplement the current level of adaptation supports to the respondents, the study recommends more coverage and more adaptation activities. Examples would be climate change-smart groundwater extraction technologies and rapid extension of technology diffusions along with climate change mitigation programmes in a coordinated way.

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APPENDICES

Appendix 1 (A): Pre-tested questionnaire for household survey

Name of Interviewer:______________________ Date of interview:_________

1. General information

Name of farmer: _________________________ Age: _____years

Address:_______________________

Area of land:_____________ Bari land _____________ *Khet land* _____________

Area of rice cultivation:_______________________ Rice production:____________________

Rice variety:____

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 d. Don't Know

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? Yes/No

Type of weather	Increased	Decreased	No Change	Don't Know

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	Like scale Indicators			
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 1st – 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 yrs? 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 yr? Yes/no

3.4 From where do you get seed of rice:

a) Own b) Governmental agencies__________ c) Agro-vet

d) From India e) Other _____________

3.5 Have you noticed any change in rice 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

3.6 Have you experienced problems and emergence of new weeds ? Yes/No

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

4. Vulnerability effect in rice crop farming

4.1 Have you faced a climate related crisis in rice farming in current 10 yrs? Yes/no
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 what are the adaptation activities/strategies followed by your household to adopt the climate change impacts?

a. change in sowing date ( )

b. change in varieties of rice: Previous variety…………………………………………….

New variety…………………………………………………...

c. diversified farming instead of growing rice ( )

d.(i) Application of more chemical fertilizers ( )

(ii) Application of more FYM/Compost ( )

(iii) Application of herbicide and pesticide ( )

e. change in seed sowing method ( )

f. adopting different IPM practices ( )

5.2 Type of Effect/Hazard

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		

5.3 Are you willing to give up farming and migrate for remittance and wage labor on adaptation practices/strategies? Yes/No

5.4 What type of storage technique are you following__________________________________

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

……………………………………………………………………………………………………

……………………………………………………………………………………………………

5.6How do you feel that adaptation techniques are better performing in your farm? Yes/No

If yes, …………………………………………………………………………………………………

If no or partial acceptance mention area of improvements……………

5.7 How do you feel that adaptation support increasing food self-sufficiency of your house? Yes/No. If yes, please said number of month food support.……………..

If no or partial acceptance mention area of improvement…………..

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

5.9 Have you taught the adaptation techniques learnt from Caritas-SAFBIN to anyone? If yes, with whom? 1) Relatives , 2) Neighbours 3) others

Appendix 1 (B): Checklist for focus group discussion

Name of group/community participants:…………………………………………………

Date of FGD……………………………………………………………………………….

Name of participants…………………………………………………………………………

Address.………………………………………………………………………………………

Area of Rice farming: total ropani…………Upland rice………… low land rice ………..

Q.N 1. Does your group feel 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 is the major hazard happened in your locality within 10 yrs? Construct a timeline of economic losses of climate-induce hazard.

Year	Types of hazards Heavy wind/ Erratic rainfall/hail/insect /disease	Loss of land (katta)		Loss of rice (Qnt.)	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		
Landslide / land loss		

5. In your opinion, what kind of adaptation related supports are getting from Caritas-Nepal? (If another organization supporting adaptation activity, 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 2 (A): Monthly Rainfall (Ranijaruwa Nursery)

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1985	DNA	DNA	DNA	DNA	DNA	96.4	518.8	531.7	447.8	194.7	0	7.2
1986	2.8	36.2	2.1	42.8	82.6	216.5	372.1	335.4	227.4	26.8	6.4	34.4
1987	13.4	7	0	30.4	122.6	56.4	552	245.4	147.3	22.2	0	25.5
1988	0	20	30.2	56.2	79.8	341.1	638.2	573	74.6	10	0	25.6
1989	59.8	15	0	0	40	297.8	433	322.6	335.5	14	2.7	39
1990	0	75.2	55	2	310.5	217	473	299	171.4	46.4	1	17.2
1991	5.2	38.6	16.4	16.6	39.6	112.6	159.4	339.7	99.8	0	2	49.2
1992	15.7	13.8	0	2.4	77	162.3	203.7	314.7	250.2	60.1	1.4	38
1993	16.2	12.1	49	18.8	98	101.4	288.6	551.4	106.2	0	0	0
1994	26.8	51	0	0	15.9	43	211.6	194.4	26.2	0	0	0
1995	80.5	61.9	6.8	0	120.4	221.8	413.9	685.8	173.8	7.2	0	0
1996	20.4	82.6	0	12	4.1	213.5	646.5	261.4	133.3	40.6	0	0
1997	56	0	3.2	30.6	24	98.6	636.8	551.4	76.8	43.2	10.8	98.8
1998	0	16	61.3	10	35.5	139.1	484	513	253	78	34.5	0
1999	1.5	0	0	0	105	213.9	372.8	477.9	108.6	116	0	4.4
2000	22.8	27.7	9	30.7	0	433	373.8	99.2	263.5	0	0	0
2001	2	0	2	0	187.5	338.4	433.8	261	83	22	0	0
2002	52.5	58.5	0	0	101.5	141.9	248	477.5	109	28	0	6.5
2003	44	71	19	10.5	36.5	0	388.4	241.6	476	0	0	0
2004	28	0	0	25	69	107.5	268.7	127.5	99.7	104.6	0	0

2005	83.4	21.2	17	6	18	77.8	369.4	361.6	165.3	75.5	0	0
2006	0	0	32.8	8	51	0	0	429.6	177	10	0	8
2007	0	76	46	8	21	28	725.8	276	469	0	0	0
2008	0	0	0	0	48	339.5	453.2	309.5	120	0	0	0
2009	0	0	0	7	0	0	329.8	449.8	124	261.5	0	0
2010	0	32	0	0	58	0	344	478.5	0	0	0	17
2011	0	64	0	13	44	178	270.9	232	197	0	0	0
2012	0	18.5	0	17	0	DNA	DNA	503.5	113	10.5	0	0
2013	0	103.5	0	56.6	39	629.5	649.5	300	206	0	0	4.5

Appendix 2 (B): Maximum Temperature (Ranijaruwa Nursery)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	DNA	DNA	DNA	DNA	DNA	36.6	31.7	32.8	32	30.1	27.7	23.2
1986	23	25	31.4	34.8	33.4	36.2	32.4	33.6	32.5	31.6	27.8	24
1987	22	DNA	DNA	DNA	39.2	38.9	33.4	33.3	33.4	31.7	29.6	25.6
1988	24.9	27.3	30.3	36	38	36.8	34.1	32.5	33.4	32.2	28.4	25.4
1989	21.2	24.1	30.3	36.3	38	34.8	33.2	34	32.9	32.1	28	22.2
1990	22.5	23.5	29.4	35.4	35.2	35.7	32.5	33.6	33.1	31	28.4	24.1
1991	21.6	26.2	30.8	36	38.8	36.8	34.7	33	32.4	31.6	26.6	23.3
1992	21.3	23.2	30.7	37.9	37.3	38	34.5	33.1	33.1	31	28.1	23.5
1993	19.9	26.7	28.7	35.2	37.8	36.7	33.6	32.9	31.7	31.8	27.7	24.8
1994	23.1	24.3	32.6	36	39.7	38.9	34.9	33.3	33.3	31.3	28	24.1
1995	20.7	25.6	30.2	37.1	39	38.1	34.5	33.8	32.6	32.4	28.3	24.1
1996	21.2	24.9	30.9	36.4	39.7	36.7	33.3	32.8	33	30.2	27.8	23.9
1997	21.7	24.1	29.8	33.7	38	37.3	33.5	32.2	32.4	29.3	27.1	20.2
1998	19	24.5	28	34.8	38.5	36.9	33.1	31.9	33	32	28.8	23.7
1999	19.8	25	31.4	38.2	36.8	35.3	31.8	32.2	32	31.4	28.6	24.4
2000	20.1	23.2	30	36	36.9	33.7	32.5	35.6	32.6	32.4	28.1	24.2
2001	19.9	27.1	31.6	36.5	36	34	33.7	34.8	33.8	32.5	29.3	23.8
2002	22.9	25.9	31.3	35.2	36.9	36.6	34.4	33.3	32.7	32.2	29.2	24
2003	18.2	24.8	29.6	37.2	37.9	36.5	34.5	33.2	32	32.2	28.5	23.1
2004	20.1	25.1	32.2	36.6	37.1	35.7	33.3	33.7	33	31.9	27.6	23.4
2005	18.9	25.8	31.6	35.8	37.6	39.7	33.6	33.2	34.8	31.9	28.9	25.5
2006	23	28.2	31.5	35.3	36.5	35.9	33.1	34.1	33.9	32.2	28.8	22
2007	22.4	25.1	28	33.7	35.7	37.1	33	33.4	31.8	32.2	29.9	24.5
2008	24.8	23.9	31.7	37	38.1	35.9	32.6	33.3	34.2	32.3	29.6	24.7
2009	24.9	28.9	32.5	37.2	37.2	39.6	35.7	34.1	36.7	32.5	28.6	26

2010	20.8	25.7	32.2	37.7	40.5	38.2	35.5	34.6	34.3	34	30.4	25.9
2011	23.5	26.1	31.1	36.8	36.5	35.5	34.6	36.8	36.3	34.3	33	DNA
2012	22.1	26.9	31.8	38.5	43.2	DNA	DNA	35.1	34.4	37.5	31.4	20.7

Appendix 2 (C): Minimum Temperature (Ranijaruwa Nursery)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	DNA	DNA	DNA	DNA	DNA	27.2	25.8	26.2	DNA	DNA	DNA	9.3
1986	7.1	9.4	13	16.9	20.6	24.3	25.4	25.9	24.6	19.2	13.8	9.8
1987	9	10.3	13.7	17.2	20.8	25.9	25.5	25.7	25.5	19.9	12.9	8.8
1988	8	10	13.7	18.2	24.3	25.3	26.4	26.2	25.2	19.2	12	9.9
1989	7	8.5	12.7	15.9	23.8	24.5	26.2	25.8	25.3	19.6	12.5	9.1
1990	9	10.9	14.8	19	23.4	26.8	25.9	26.1	25.4	19	13.4	9.2
1991	6.8	10.4	14.6	19.4	23.7	26.2	26.8	26.2	24.6	18	11.6	8.5
1992	7.6	8.8	12.2	17.6	22	24.4	25.5	25.9	24.6	19.3	13.4	8.4
1993	7.8	12	11.9	16.2	23.2	25.3	25.9	25.9	24.7	19	13.5	8.4
1994	7.5	9.4	14.6	15.9	22.5	26.8	26.5	26.2	24.3	18.4	12.7	8.3
1995	7.3	9.9	13.6	17.9	22.9	27.7	26.5	26	25.1	20.1	13.7	9.1
1996	8.2	10.1	15.6	18.5	23.3	26.4	26.3	25.5	24.9	20.2	13.1	7.1
1997	6.6	7.6	13.6	19.2	21.4	25.3	26.3	26.2	25	17.6	14	9.8
1998	7.2	10.1	13.5	19.6	25	25.6	25.8	25.1	25.4	22.1	16.3	9.7
1999	8	10.2	12.5	18.9	22.9	23.4	26	25.3	24.8	20	12.7	9.1
2000	7.8	8.5	12.4	18.5	23	24.8	25.2	24	25	20.3	15	7.8
2001	6.9	9.1	11.7	17	21.9	24.5	26.5	26.3	25.3	20.2	13.9	10.5
2002	8.1	10.2	12.9	18.5	23	25.2	26.5	25.5	24.2	19.3	12.7	9.4
2003	7.5	8.3	12.7	17.6	19.6	24	25.9	25.9	24.7	18.8	13.3	9
2004	8.2	10	15	20.8	23	23.3	26.1	26	25.1	20.1	12.5	9.5
2005	7.7	11.7	15.6	19	19.5	26.1	25.3	25.5	25.2	18.5	12.5	7.4
2006	7	12	12.8	17.6	22.8	23.9	25.3	24.4	24.4	21.4	14.4	7.4
2007	7.5	12.3	14.8	18.8	25.9	25.3	25.4	26.2	25.2	20.8	14.7	9
2008	7.7	7.8	13.7	17.3	20.3	24.9	25.2	24.9	22.3	19	15.3	12.6
2009	8.9	9.1	11.5	16.9	23.6	23.1	25.3	26.2	24.6	18.6	13	9.2
2010	8	10.8	15.2	20.4	20.7	20.2	25.7	26	25	23.1	16	10.1
2011	9.4	9.9	18.8	18.4	28.4	26.4	25.4	27.5	27.1	21.4	17.8	DNA
2012	13.1	15.2	19.2	23.2	21.6	DNA	DNA	25.9	23.8	25.1	19.5	12.6

Appendix 2 (D): Rice production of Bardiya district

Years	Total area (Hacters)	Production (M.Ton)	Productivity
1985/86	26900	59180	2.20
1986/87	25800	58890	2.28
1987/88	33150	69760	2.10
1988/89	33150	76180	2.30
1989/90	29050	72450	2.49
1990/91	32150	80400	2.50
1991/92	27370	64980	2.37
1992/93	29050	56650	1.95
1993/94	30320	86500	2.85
1994/95	29250	74150	2.54
1995/96	31320	77830	2.48
1996/97	31500	79800	2.53
1997/98	31500	75590	2.40
1998/99	32180	85280	2.65
1999/00	34875	95650	2.74
2000/01	34878	105227	3.02
2001/02	36996	115670	3.12
2002/03	35000	105420	3.01
2003/04	36630	114280	3.12
2004/05	36630	114280	3.12
2005/06	36600	118680	3.24
2006/07	36640	106256	2.90
2007/08	38000	120850	3.18
2008/09	38500	123200	3.20
2009/10	39500	126800	3.21
2010/11	42550	148925	3.50
2011/12	45500	188825	4.15
2012/13	45000	159575	3.55

Appendix 3 (A): Demography of Kalika VDC

Ward No	Household	Total population	Male	Female
1	261	1,566	788	788
2	280	1,287	607	680
3	340	1,474	666	808
4	1,191	4,557	2,257	2,300
5	322	1,510	692	818
6	118	479	206	273
7	183	792	353	439

8	325	1,411	632	779
9	111	477	215	262

Source: CBS 2013

Appendix 3 (B): Demogarphy of Motipur VDC

Ward	Household	Total population	Male	Female
1	263	1,318	627	691
2	453	2,614	1,233	1,381
3	199	1,004	507	497
4	214	1,170	521	649
5	290	1,423	683	740
6	587	2,731	1,272	1,459
7	1,050	5,961	2,784	3,177
8	903	3,774	1,758	2,016
9	219	1,091	518	573

Source: CBS 2013

Appendix 4(A): Regression analysis for the total rice production with age of respondent and *khet land* (ANOVA)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9313.604	2	4656.802	707.745	.000[b]
	Residual	506.643	77	6.580		
	Total	9820.247	79			

a. Dependent Variable: total rice production in kg

b. Predictors: (Constant), age of the respondent , khet in kattha

Appendix 4 (B): Regression analysis for the total rice production with age of respondent and *khet land* (R-Square)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974[a]	.948	.947	2.5651

a. Predictors: (Constant), age of the respondent , khet in kattha

b. Dependent Variable: total rice production in kg

Appendix 4 (C): Coefficients of regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.611	1.003		1.606	.112
1 Khet land (in kattha)	.927	.025	.974	37.599	.000
age of the respondent	-.006	.020	-.008	-.313	.755

a. Dependent Variable: total rice production in kg

Appendix 5: Analysis of correlation of rice productivity with climatic factors

	max temp jun-july	max temp aug-sep	max temp oct-nov	max-temp-growing season	Mini temp of jun-july	Mini temp of aug-sep	Mini temp of oct-nov	min-temp-growing season	rainfall-growing season
Pearson Correlation	.021	.665**	.770**	.630**	-.393*	.201	.554**	.304	-.296
Sig. (2-tailed)	.918	.000	.000	.000	.042	.315	.003	.123	.134
N	27	27	27	27	27	27	27	27	27

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

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

Appendix 6: Glimpse of research

Photo 1: CARITAS/Nepal intervention site (Kalika VDC)

Photo 2: Conducting FGD at Kalika VDC

Photo 3: Conducting FGD at Motipur VDC

Photo 4: Household survey at Kalika VDC

Photo 5: Household survey at Motipur VDC