

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

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**Exam Roll No: 107**

**TU Registration No: 1-22-44-49-2009**

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UNDERGRADUATE PRACTICUM ASSESSMENT COURSE AT  
FINAL YEAR BACHELOR OF SCIENCE IN AGRICULTURE**

## APPROVAL SHEET

This research report here to, entitled '**Farmer's perception and adaptation measures of vegetable cultivation under climate change and vulnerability context in Nawalparasi district**' prepared and submitted by **Ms. SUSHILA JOSHI** , in fulfillment of requirement of the Undergraduate Practicum Assessment (UPA) for the **Bachelor of Science in Agriculture**, is hereby accepted.

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## ACRONYMS AND ABBREVIATIONS

|                 |   |
|-----------------|---|
| ADB             | Agriculture Development Bank                        |
| ASC             | Agriculture Service Centre                          |
| CBS             | Central Bureau of Statistics                        |
| CC              | Climate Change                                      |
| CO <sub>2</sub> | Carbon dioxide                                      |
| °C              | Degree Celsius                                      |
| DDC             | District Development Committee                      |
| DFO             | District Forest Office                              |
| d.f.            | Degree of freedom                                   |
| DHM             | Department of Hydrology and Meteorology             |
| DWIDP           | Department of Water Induced Disaster Prevention     |
| FAO             | Food and Agriculture Organization of United Nations |
| Fig             | Figure  |
| GDP             | Gross Domestic Product                              |
| GHG             | Green Houses Gas                                    |
| GLDF            | Glacial Lake Outburst Flood                         |
| GoN             | Government of Nepal                                 |
| ha              | Hectare   |

|        |   |
|--------|---|
| HH/hh  | Household   |
| ICIMOD | International Center for Integrated Mountain Development            |
| INGO   | International Non-governmental Organization                         |
| IPCC   | Intergovernmental Panel on Climate Change                           |
| JT/JTA | Junior Technician/Junior Technical Assistant                        |
| LAPA   | Local Adaptation Program of Action to Climate Change                |
| Masl   | Meters above sea level  |
| MDG    | Millennium Development Goal   |
| mm     | Millimeter  |
| MOE    | Ministry of Education   |
| MOFSC  | Ministry of Forest and Soil Conservation                            |
| NAPA   | National Adaptation Program of Action to Climate Change             |
| NARC   | National Agriculture Research Council                               |
| NCVST  | Nepal Climate Vulnerability Study Team                              |
| NGO    | Non-governmental Organization                                       |
| Ppm    | Parts Per Million   |
| %      | Percentage  |
| SAFBIN | Small Scale Farming in Rain-fed area in Bangladesh, India and Nepal |
| SOHAM  | Society of Hydrologist and Meteorologist                            |

|        |  |
|--------|--|
| SPSS   | Statistical Package for Social Science                       |
| Temp   | Temperature  |
| UNDP   | United Nations Development Program                           |
| UNEP   | United Nations Environmental Program                         |
| UNFCCC | United Nations Framework Convention on Climate Change        |
| UNSIDR | United Nations International Strategy for Disaster Reduction |
| VDC    | Village Development Committee                                |
| WFD    | World Food Production  |
| WMO    | World Meteorological Organization                            |
| WWF    | World Wide Fund for Nature                                   |
| Yr     | Year   |

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## ABSTRACT

*A survey research was conducted at Pithauli and Rajahar VDCs of Nawalparasi District, CARITAS-SAFBIN project intervention areas to examine farmer's perception and adaptation measures of vegetable cultivation under climate change and vulnerability context. This study used primary and secondary information to examine the study aim. The household survey, FGD, and KIS were the major primary data collection method applied in the field. This study administered household survey via using pretested structured questionnaire to collect information from 70 households, 5 FGDs and KIS via using semi-structured questionnaire with the respondents. The time series data on climatic parameters, and production and yield of vegetable was collected from DHM and CBS, respectively. Data analysis on minimum temperature, maximum temperature, and annual rainfall were: 18.65°C, 30.50 °C, and 196.89 mm with the deviation in 0.57, 0.44 and 31.91, respectively. Graph showed upward trend of minimum temperature and annual rainfall but negative trend of maximum temperature. However, no any significant correlation has been obtained. Multiple linear regression analysis on predicting relationship of potato yield (dependent variables) with the explanatory variables (age of respondents, gender, khet land and bari land) found that potato yield had significant relationship at 5% level. The value of  $R^2$  (0.071) was also much greater which show good strength of relation between the dependent variable and independent variables. Correlation test between temperature, yield and area of cultivation also predicted positive correlation (0.448). T-test ( $t=4.2$ ) statistics was also significant at 1% level. Similarly, minimum temperature on yield was also positive but estimated  $t$ -value ( $t=1.5$ ) was not significant at 5% level. Unlike it, maximum temperature and annual rainfall effect had negative effect on potato yield. Durbin and Watson Statistics ( $=1.56$ ) gave positive autocorrelation effect in the model. Almost all respondent perceived change in climate in their locality. Respondent experienced erratic rainfall, rise in temperature, decreased monsoon rainfall, decreased winter length, increased frost and dew, increased drought length and frequency associated with decreased in water source in recent years. They also experienced incidence and occurrence of disease and pest. Major adaptation practices autonomously followed by the respondents in vegetable cultivation were use of: hybrid varieties, IPM measures, bio-pesticides, and drip irrigation, supply more manure in the vegetable field, mulching, use of kitchen water, and establishing pond for rainwater harvesting. However, people were unaware of what actually happening to their surroundings.*

**Keywords:** Adaptation, Climate change, Rainwater harvesting, and Erratic rainfall

# **CHAPTER 1: INTRODUCTION**

## **1.1 Background**

Climate change is already being felt and its effects are expected to continue and to increase and rural communities are increasingly vulnerable to climate induced hazards (Gurung and Bhandari 2008). The Intergovernmental Panel on Climate Change suggests that agricultural sector is among the most climate sensitive economic areas (IPCC 2007). Moreover, the smallholder and subsistence farmers of developing countries (in particular, those farming in the marginal regions) are the most vulnerable to livelihood and food insecurity from the effects of climate change (Stern 2006; Heltberg 2009). Climate change adaptation is the major development agenda in many developing countries like Nepal, where majority of the population depends on farming. It is reported that agriculture dependent communities are more affected by the climate change impact. There is a significant risk that many of the trends will accelerate, leading to extreme climatic events and to an increasing risk of abrupt or irreversible climatic shifts (IPCC 2007 and 2013). Global climate change can be expected to threaten food production and its supply, for example through changing patterns of rainfall, increasing incidence of extreme weather and changing distribution of diseases and their vectors (Ibid). Climate change is expected to have serious environmental, economic, and social impacts on South Asia in particular, where rural farmers' livelihood depends on the use of natural resources (ICIMOD 2009). The region is also confronted by issues like poverty, environmental degradation, natural resources depletion, shrinking water resources; desertification and climate change (Schid 2008). Climatic variability in this fragile ecosystem and nature based livelihood system of the rural communities has further threatened the livelihood of the local people.

IPCC (2012) listed three key sectors: food and fiber, land degradation and biodiversity as the most vulnerable to climate change in the South Asian region. The most vulnerable population to climate change and variability have been rural communities with few resources to cope with extreme weather events like landslides, erosion, and drought in low land regions of Nepal. Assessing the potential climate change impacts and economic analysis are urgently needed for the survival of these rural communities.

Due to the fragile ecosystem, which is very sensitive to even slight changes in natural climate, weaker geological situation and complex topography, Nepal is in fourth vulnerable position with regard to climate change (Maplecroft 2011). Findings from the National Adaptation Program of Action (NAPA) showed that Nepal is extremely vulnerable to climate change impacts because it heavily depends on natural resources, particularly water, soils, and forests (MOE 2010). The situation is made worse by poverty, population pressures, land degradation, food insecurity, and deforestation.

Nepal's share in climate change vulnerability is 0.025% of annual greenhouse gas (GHG) emissions (MOE 2009) but climate change impacts made the country highly vulnerable because of increased temperature in high mountain areas than elsewhere (Shrestha et. al. 1999). Glaciers and snowfields will recede and may even disappear, reducing Nepal's dry season water resources. This will affect irrigation and drinking water supply and hydroelectricity will be less reliable. In addition, receding glaciers often leave behind growing glacier lakes that can break through terminal moraines causing catastrophic floods. Global climate change will also likely shift monsoon precipitation patterns in ways that will threaten Nepal's current agricultural practices, infrastructure, bio-diversity, especially in mountain regions where migration of species is physically restricted (Regmi et al. 2009). In order to improve the ability of communities and households to adjust to ongoing and future climate change, we need improved understanding of the risk they are facing. Estimating possible future adaptation is essential to climate change impact and vulnerability assessment. Therefore, assessing the perception on climate change and its impacts on livelihood are urgently needed for the survival of these rural communities.

## **1.2 Statement of problem**

Climate change is threatening the traditional way of agriculture, and so the creation of a sustainable agricultural approach to counter the impact of climate change has been a main priority for the country (Malla 2008). The main challenge for cultivating sustainable agricultural development in Nepal is to turn subsistence farming into commercial farming as well as adapting to the new patterns of farming as a result of increasing temperatures. The overexploitation of natural resources has created a significant problem in sustainable agriculture and helped to

increase the negative effect of climate change on agriculture and life. Most of the agricultural land, in both Terai and hilly region depend on seasonal rain for the proper crop growth in Nepal.

However, as weather patterns have been changing, farmers have had a dilemma. Over-exploitation of natural resources resulted in an environmental degradation which is deeply connected with permanent loss, depletion or pollution of natural resources, adverse weather conditions, changing microclimates and unbalanced situations which affect the inherent chain within the ecosystem. An average temperature rise of 0.06 percent has been recorded in the country. This rise has shown the multidimensional impact of climate change on agriculture. Frequent drought and prolonged rains as well as many fatal floods and landslides are some of the major obstacles being experienced in Nepal in agricultural as well as other sectors of social life. A study conducted by the Nepal Agricultural Research Council (NARC) showed that the change in temperature has had a positive effect on the yield of rice and wheat in all regions but also showed a negative impact on the yield of maize, particularly in the plains land of Nepal, otherwise known as Nepal's bread basket (Malla 2008). There was no prior studies and documentation on vegetables cultivation. In the same issue SAFBIN/Caritas, Nepal was working under the study area. Therefore to acquaint the perception of farmers towards climate change and adaptation measures this research was conducted.

Changes in weather patterns, such as unseasonal heavy rains, hailstones, floods etc. have frequently caused serious damage to crops. Rising annual temperatures, a delayed monsoon season, prolonged or increased annual rainfall as the result of glacial melting, and intense rainfall have all affected many rain-fed communities in Nepal. Extreme climatic conditions increase vulnerability to erosion, landslides, avalanches, flooding, loss of flora and fauna and decreased agricultural production (Nepal and Chipeniuk 2005). Global climate change has caused a change in seasons and rainfall intensity and patterns. These changes will have both a direct and an indirect impact on forests and biodiversity, health, infrastructure development, tourism, livelihoods, water resources, agriculture and the whole ecological chain. The MOE 2014 states "Nepal is also highly affected by climate change since a decade. It has been an urgent necessity to access and document the effects of climate change in different ecological regions and different farming systems as well as to find out the adaptation strategies followed by farmers

which should lead to formulation of policies to mitigate negative impacts of climate change. This knowledge will help in implementing relevant programs to minimize the existing effects and likely impacts in different ecological regions. Indeed, Nepal has to throw all its weight towards finding measures of adaptation in order to reduce the impact of the uncertainties of climate change in an overall way with a focus on agricultural production, crop calendar, water use pattern, agronomical practices, outbreak of insect pest and climate induced disaster to ensure food security.

### **1.3 Objectives**

The general objective of this study was to assess the perception and impacts of climate change on vegetable crops and food security of the communities in the study district. Following are the specific objectives:

- i) Measuring community perceptions on climate change of vegetables by using before and after method
- iii) Mapping climate change adaptation measures taken by the communities along with project level interventions and coordination;
- iii) Estimating relationship of climatic and socio-economic factors affecting on yield of vegetable crops

### **1.4 Rationale of study**

After conduction of the survey, gathering of information and its analysis will give a bird eye view of current situation of impact of climate change in agriculture as well as response of farmers towards change in climate. The study showed how farmers responded towards climate change and the autonomous methods they were practiced. The documentation of these findings and their elaboration in national context give a way out for the problems farmers are facing and will help in national policy formulation. This is considered as pioneering work on collecting information on perception measurements on climate change effect.



Second rationale is there is eye of Nepalese government and its allied agencies. It will be the reference for these concerned agencies. 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. The finding of this study will also help researchers, academicians and practioners for future studies.

Climate change is the most critical global challenge of this century. Effect of climate change encompasses all the vital system supporting world populations. Human health, agriculture, forest, water resources and biodiversity will suffer at different scales depending on local conditions. If the increase in temperature exceeds by 1.5 to 2.5<sup>0</sup>C, there will be the risk of extinction of plant and animal species by 20-30% (IPCC 2007).

Vegetables are the best resource for overcoming micronutrient and deficiencies and provide small holder farmers with high income and jobs per hectares than staple crops ( AVRDC 2006 ). The world production of vegetables has doubled over the past century and value of global trade in vegetable now exceeds than cereals. In Asia, vegetable production grew at an annual average rate of 3.14 % in the 1980s and early 1990s from 144 million mt in 1980 to 218 million mt in 1993 (Ali 2009). Among vegetables, tomatoes are most important horticultural crops world wide and grown over 4 million ha of land area ( FAO 2006 and Brown et al. 2005 ) .

Studies on perception, local knowledge, and adaptive strategies at the household levels as well as lesson learned, can provide the basic concept and methods of assessing climate change impact, vulnerability and adaptation on livelihood of local people. This research seeks to investigate impact of climate change on agriculture and adaptation activities carried out by local people. Based on the case of local people of *Pithauli* and *Rajahar* VDC, this report intends to capture the extent of local peoples' awareness and perception of climatic variability and change and type of adaptation they had made in farming practices in response to the change in climate. This study 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: REVIEW OF LITERATURE

This chapter deals review of the past work done on different aspects of production affected by the climate change in agriculture and vegetable crops inside and outside of country that are relevant to this study.

### 2.1 Climate change and global warming

United Nations Framework Convention on Climate Change (UNFCCC 2002) defines "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere". United Nations framework Conventions on Climate Change (UNFCCC 2001) defines - climate change as *a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period* (Bhusal 2009: pg 3). Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability which may be due to natural internal processes or external force, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC 2006 ).

Global temperature is increasing by  $0.3^{\circ}\text{C}$  to  $0.6^{\circ}\text{C}$  since the last 19<sup>th</sup> century and by  $0.2^{\circ}\text{C}$  to  $0.3^{\circ}\text{C}$  over the last 40 years (1960 2000) (Xiaodong & Baode 2000) with indication of more increase in the global temperature in coming days making earths sustainability more vulnerable.

Referring to IPCC report there has been an unprecedented warming trend during the 20<sup>th</sup> century. The current average global surface temperature of  $15^{\circ}\text{C}$  is nearly  $0.6^{\circ}\text{C}$  higher than it was 100 years ago- most of the increase has been the consequence of human activity. A further increase of  $1.5\text{-}6.0^{\circ}\text{C}$  is projected for the period to 2100. Forth Assessment Report of IPCC (2007) concluded that "most of the observed increase in globally averaged temperatures since the mid 20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations". The average atmospheric  $\text{CO}_2$  concentration has increased from 280 ppm in 1850 to 365 ppm at present, and could exceed 700 ppm by the end of the present century if emissions continue to rise at current rates (IPCC 2007).

Scientists predicted through the global climate models that the average global surface temperature increase from 1.4°C to 5.8°C due to presumed doubling of CO<sub>2</sub> concentration in the atmosphere by the end of the 21<sup>st</sup> century. In the northern hemisphere, precipitation has increased by 0.5% to 1.0% per decade whereas the increase in tropical countries has been 0.2% to 0.3% per decade. The trend of last century has been uneven, but in the period since 1976 the warming trend is roughly three times that of the past 100 years as a whole (WMO 2004 ).

The increases in average global temperature changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere (UNFCCC 2007) clearly indicates the changing trend in climate. Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 to 379 ppm in 2005, and the average global temperature rose by 0.74° C (Ibid) which supports the fact the global increase in the temperature is mainly due to the excess emission of CO<sub>2</sub> from human induced sources.

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

## **2.2 Nepal and climate change vulnerability**

Nepal demonstrates diverse geo-physical and climatic conditions within relatively small areas resulting vast biological diversity, therefore, it is an ideal place to study climate change impacts on natural and socioeconomic spheres. In context of Nepal, a few studies have been carried out on vulnerability and risk assessment of natural hazards. Some of them are (Chhetri & Bhattarai 2001; Dhital, Khanal & Thapa 1993); Dixit 2003; ICIMOD 2002; Khanal, 1999; & Mool,

Bajracharya, and Joshi 2001). However, most of them are based on available information of the past without or in only some extent to climate change and potential future risk of climate change related disasters.

Although Nepal is responsible for only about 0.025% of total annual greenhouse gas emissions of the world (Karki 2007). It is experiencing the increasing trends and the associated effects of global warming. IPCC (2006) reports an increase in mean surface temperature in the range of 0.3°C to 0.8°C over the past 100 years in tropical Asia including Nepal. However, (Shrestha et al. 1999) reported the temperature increase of 0.06°C to 0.12°C per year in most of the middle mountain and Himalayan regions, while the Siwalik and Terai regions shows warming trends of less than 0.03°C/year from 1971-1994.

Nepal's National Assessment Report for the World Summit on Sustainable Development (2002) recognizes the links between climatic circumstances and land degradation, erosion and landslides: "in a nutshell, too much water and too little water is responsible for land degradation in different land uses in Nepal." It also recognizes the increase in landslide risks due to the effects of paddy cultivation and livestock grazing in the hills and mountains. However, the fact that climate change might increase those risks is not discussed, and adaptation to climate change is not mentioned anywhere.

## **2.3 Impact of climate change in Nepal**

The climate is changing in Nepal, like elsewhere in the world. Climate variability is natural. However, the current change is not natural, but due to human activities. The average temperature and the rainfall pattern have changed, which is not variability, that is to say, it is not natural but induced by human activities. IPCC has confirmed global climate change, including in Nepal, and Nepal's reports cited above corroborate climate change in Nepal. Climate change impacts every aspect of nature and human life, and is predicted to continue. This section will highlight the impact of climate change in Nepal on: a) glaciers and water resources, b) agriculture, c) biodiversity and natural resources, and water-induced disasters. Glacier is a much highlighted subject when discussing the impact of climate change in Nepal. Compared to other aspects, several studies have been carried out on glaciers in Nepal. Glacier AX010 in Shorong Himal

retreated by 30 m between 1978 and 1989 (Fujita et al. 2001 ), and most of the glaciers in Khumbu region retreated by 30 to 60 m between 1970 and 1989 (Yamada *et al.*, 1992). Glacial Lake Outburst Flood (GLOF) is the most likely and serious hazard because of the increasing size and number of glacial lakes following a glacier melt. Nepal experienced disasters from GLOFs in 1985: from Dig Cho Glacial Lake, which washed away Namche Hydropower Plant, several hectares of cultivated land, bridges and houses, and caused human and livestock deaths (WWF 2005). In addition to formation and outburst of glacier lakes, there are evidences of disastrous avalanches and icefalls, which could be associated with increasing temperatures.

A massive ice fall in August 2003 blocked the Madi river in Kaski district at its source for several hours, damaged agricultural lands and crops, and killed livestock. The climate change has impact on both quality and quantity of water resources. The discharges of snow-fed rivers have fluctuated in the past. The analysis of the discharge of the Koshi river in eastern Nepal during 1947–1994 showed a decreasing trend during low flow season (Sharma *et al.*, 2000), whereas the discharge of the Kali Gandaki river in western Nepal increased by about 1% annually during 1964–2000 (Shrestha 2004). The discharge of glacier-fed rivers is projected to increase for some time in the future, as glaciers melt and subsequently decrease after the snow and glacier become smaller and smaller (Ibid). The increase and subsequent decrease will have serious impact on hydropower plants, groundwater recharge and agriculture in downstream areas, together with disturbing the local hydrology and aquatic life.

The decrease in reservoir water volume in some hydroelectric power stations in Nepal might have been a result of the observed changes in the precipitation behavior, which resulted in less net water percolation and storage in the ground. Less water is reaching groundwater reservoirs due to erratic rainfall and increase in evaporation despite the increase in total annual precipitation. The water springs in the mid-hills of Nepal have been drying up in the recent past. GoN publicly announced a 45% decrease in spring flows, which are the sources of drinking water for Kathmandu valley. The intensive monsoon does not provide adequate recharge to ground water reservoirs, despite high total precipitation as

most of the precipitation, leaves the site through surface runoff. On the other hand, the decrease in precipitation during the dry season has an adverse impact on groundwater recharge.

## **2.4 Effect of climate change on Nepalese agriculture**

The agriculture sector contributes nearly 33% of Nepal's Gross Domestic Product (GDP) and supports the livelihoods of more than 86% of the population (CBS, 2007). Most of the Nepalese population depends on agriculture for its livelihood, which is based on a rich diversity of species. Of the more than 6,000 vascular plant species found in Nepal, about 550 species and subspecies have food value and some 200 are cultivated (MoFSC 2002). The diversity of livestock (both improved and indigenous breeds) also plays a major role in contributing to the well-being of rural communities. The diversity can be illustrated even for staple cereal crops where in different production zones and conditions rice, wheat, barley, maize, finger millet and buckwheat are all important grain staples.

The GCM projections indicate a potential increase in temperature over Nepal of 0.5-2.0°C with a multimodal mean of 1.4 °C by the 2030s, rising to 3.0-6.3 °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. Existing problems such as soil degradation and increasingly limited water resources are likely to be exacerbated by climate change, increasing the difficulty of achieving food security for the growing population. The recently observed extreme severe weather events between 2006-09 including droughts and floods have significantly affected food production in Nepal (WFP 2009). In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP and UNFCCC 2002).

It is likely that climate change and increasing variability will have both negative and positive impacts on the subsistence farming systems in different production systems. However, the combined effects of increasing CO<sub>2</sub> levels, rising temperatures and changing moisture availability are likely to be complex and are still largely uncertain.

An analysis done by the Nepal Agriculture Research Council (Gautam 2008) using simulation models for major crops such as rice, wheat and maize suggested that rice yields might increase under elevated CO<sub>2</sub> and 4°C increase in the Terai (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 CO<sub>2</sub>, 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 (Malla 2008 and Gautam 2008).

Many farmers reported positive effects from climate change. Farmers of the Mustang and Manang districts have noticed improved apple size in recent years. Other farmers are able to grow cauliflower, cabbage, chili, tomato and cucumber, which used to require greenhouses in order to survive. Local fruits have better sizes and tastes (Dahal 2005). Similarly, a farmer in the Murza VDC in Myagdi reported that the rice cultivation was becoming possible in higher elevation (1,800 m to 2,400 m (Dahal 2006).

A number of negative effects of major concern to farmers have also been described. 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 (Regmi and Adhikary 2007). A drought in the Eastern region of Nepal decreased the rice production by 30% in 2006 and heavy flooding in the Mid-Western and Far-Western region in 2006 and 2008 destroyed crops in many places (Paudel *et al.* 2008). There was also evidence that the vector borne diseases in livestock were increasing, forcing the livestock population to move to higher altitudes (Practical Action 2008).

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. These local landraces have been replaced by short duration modern varieties. Farmers have also described effects on beekeeping and an increase in insect and pest numbers.

The increased unpredictability and intensity of weather events and hazards have been described by farmers as causing significant disruption to rain-fed agriculture, contributing to the loss of local landraces of crops change in timing of fruit tree and coffee flowering, a decline local grass species and reduced size of some fodder trees. Livestock numbers have declined in some areas and this has negatively affected the diet of the population (Regmi et al. 2009).

Agriculture, the mainstay of over 80% of the Nepalese population (CBS 2001), has been affected by both warming and uncertainty of monsoon. The increase in temperature has both negative and positive impact on agriculture. As the climate warms, farmers living in high altitudes, such as Jumla district (2700 masl), can now grow two crops, rice and barley in a year. There is also potential for bringing new land under cultivation in higher elevations. The warming in higher elevations has also created climate conducive to increasing crop intensity. However, thinning snow deposition and retreating snowline have awakened the farmers to the threat of future water scarcity in the region. The prospects of bringing new land under cultivation by clearing the vegetation have also threatened biodiversity conservation in high altitude areas through habitat destruction, degradation, fragmentation and loss. Important habitats will be displaced by croplands. The relationship between crop yield and climate change has yet to be investigated. However, it is worth noting that statistical models predict increase in the yields of C<sub>4</sub> crops and decrease in the yields of C<sub>3</sub> crops with increase in atmospheric CO<sub>2</sub> concentration through potential carbon fertilization effect and warming.

Out of the 2.64 million hectares (ha) of cultivated land in Nepal, only 43% has access to irrigation facilities, of which only 70%, 20% and 10% get irrigation water in monsoon, winter and spring seasons respectively (ADB 2004). The remaining land completely depends on natural precipitation. The crop yield has strong relationship with the amount of precipitation at the right time. The yields of wheat and rice in Kaski district declined over three consecutive years, 2003 to 2005, because of decrease in precipitation (Regmi and Adhikari 2007). But excessive rainfall causes floods and affects crop yields adversely (Gharti Chhetri 2005).



The changed intensity and amount of monsoon rains positively correlate with the increase in water induced disasters like floods and landslides (Ministry of Home, quoted in DWIDP 2006). Extreme precipitation events account for increase in hazards. On August 26-27, 2006, a heavy downpour exceeding 300 mm within twenty-four hours induced massive flooding in Nepalgunj, costing millions of rupees in relief and rescued activities (SOHAM 2006). As the wet season is becoming wetter, water quality is likely to worsen. Human health will be affected adversely in the dry season because of lack of water for sanitation as the dry season becomes drier, where as there is already lack of water for sanitation (Erickson 2006). A plant disease vector, Citrus Psylla, has been recorded above its normal habitat range, which is usually below 1000 masl. Although the vector might have developed new genetic characteristics for cold tolerance, warning in higher altitude could be strong factor. This has increased the probability of occurrence of vector borne plant diseases in higher ecological zones, which were once free of such disease.

## **2.5 Climate change and vegetable production**

Global production of common and traditional vegetables is steadily increasing, and traditional vegetables in particular are attracting the attention of farmers, researcher, policy makers and public. However it is unfortunate that national government and international donors are not yet showing sufficient investment in research and development that this field of horticulture warrants if the UN Sustainable Development Goals are to be achieved in the foreseeable future (Keatinge et al. 2011 UN Sustainable Development Solution Network 2013). If children, nursing mothers, the elderly, teenage girls, the sick, handicapped and other specifically vulnerable groups are more often prone to malnutrition in society, then AVRDC in particular has the duty to ask how our research and development can be specifically tailored to seek quick and sufficient redress of the imposed dietary constraints. We have to give serious thought to the issue that development is appropriate for all people and not just for rich farmers with large land areas of cereals. All these issues must be reflected in future research and development activities and the work of AVRDC must aim to manage the uncertainties of climate change, rapidly mutating pathogens and viruses, the emergence of new insect challenges and how to cope with these without imposing negative environmental consequences. Many factors currently constrain vegetable production, including climate change and extreme climatic events, ever present pests and diseases and adverse policies

towards horticulture. Abiotic stresses may have an increasingly potent effect on vegetable crops, as they are often vulnerable to extreme events of wind and rainfall. Global vegetable such as tomato is quite sensitive to heat damage, water logging, drought and increasing salinity through their individual or combined effects on flowering and fruit setting. Increasing trends in abiotic stresses imposed on horticultural crops may be inferred to be increasing rapidly in East Asia (Keatinge et. al. 2012).

Vegetables are generally sensitive to environmental extremes, and thus high temperatures and limited soil moisture are the major causes of low yields in the tropics and will be further magnified by climate change. Environmental stress is the primary cause of crop losses worldwide, reducing average yields for most major crops by more than 50% (Boyer 1982; Bray et al. 2000). Climatic changes will influence the severity of environmental stress imposed on vegetable crops. Moreover, increasing temperatures, reduced irrigation water availability, flooding, and salinity will be major limiting factors in sustaining and increasing vegetable productivity. Extreme climatic conditions will also negatively impact soil fertility and increase soil erosion. Thus, additional fertilizer application or improved nutrient-use efficiency of crops will be needed to maintain productivity or harness the potential for enhanced crop growth due to increased atmospheric CO<sub>2</sub>. The response of plants to environmental stresses depends on the plant developmental stage and the length and severity of the stress (Bray 2002). High temperature limits the range and production of many crops. High temperatures can cause significant losses in tomato productivity due to reduced fruit set, and smaller and lower quality fruits (Stevens and Rudich 1978). Unpredictable drought is the single most important factor affecting world food security and the catalyst of the great famines of the past (CGIAR 2003). Water availability is expected to be highly sensitive to climate change and severe water stress conditions will affect crop productivity, particularly that of vegetables. In combination with elevated temperatures, decreased precipitation could cause reduction of irrigation water availability and increase in evapotranspiration, leading to severe crop water-stress conditions (IPCC 2001). Vegetables, being succulent products by definition, generally consist of greater than 90% water (AVRDC 1990). Thus, water greatly influences the yield and quality of vegetables; drought conditions drastically reduce vegetable productivity. Vegetable production occurs in both dry and wet seasons in the tropics. However, production is often limited during

the rainy season due to excessive moisture brought about by heavy rain. Most vegetables are highly sensitive to flooding and genetic variation with respect to this character is limited, particularly in tomato. In general, damage to vegetables by flooding is due to the reduction of oxygen in the root zone which inhibits aerobic processes. Flooded tomato plants accumulate endogenous ethylene that causes damage to the plants (Drew 1979).

Potential impacts of climate change on agricultural production will depend not only on climate *per se*, but also on the internal dynamics of agricultural systems, including their ability to adapt to the changes (FAO 2001). Farmers in developing countries of the tropics need tools to adapt and mitigate the adverse effects of climate change on agricultural productivity, and particularly on vegetable production, quality and yield. Current, and new, technologies being developed through plant stress physiology research can potentially contribute to mitigate threats from climate change on vegetable production. However, farmers in developing countries are usually small-holders, have fewer options and must rely heavily on resources available in their farms or within their communities. Thus, technologies that are simple, affordable, and accessible must be used to increase the resilience of farms in less developed countries. AVRDC–The World Vegetable Center has been working to address the effect of environmental stress on vegetable production. Germplasm of the major vegetable crops which are tolerant of high temperatures, flooding and drought has been identified and advanced breeding lines are being developed. Efforts are also underway to identify nitrogen-use efficient germplasm. The quality and efficiency of water management determine the yield and quality of vegetable products. There are several methods of applying irrigation water and the choice depends on the crop, water supply, soil characteristics and topography. Application of irrigation water could be through overhead, surface, drip, or sub-irrigation systems. Various crop management practices such as mulching and the use of shelters and raised beds help to conserve soil moisture, prevent soil degradation, and protect vegetables from heavy rains, high temperatures, and flooding. The use of organic and inorganic mulches is common in high-value vegetable production systems. Vegetables generally are unable to tolerate excessive soil moisture. Tomatoes in particular are considered to be one of the vegetable crops most sensitive to excess water.

## 2.6 Climate Change in Nawalparasi district

Nawalparasi (27°40'00'' to 84°11'15'') Farmers follow traditional agricultural patterns, relying on rainwater and seasons. Temperature has increased from the last 10 years. The annual mean temperature trend was 0.02 to 0.08° C in western over national trend -0.04 to 0.06° C. Similarly, rainfall has decreased from the past four years. The annual mean precipitation trend was -30 to 40 mm in the western over national trend -40 to 40 mm (Practical Action, 2009).

### Loss and Damage in Nawalparasi District: by Flood and Landslides over the past 10 years

| Year      | 2060<br>B.S,2003/04 AD | 2061<br>B.S,2004/05 A.D | 2062<br>B.S,2005/06 A.D | 2063<br>B.S,2006/07 A.D | 2064<br>B.S,2007/08 A.D | 2065<br>B.S,2008/09 A.D | 2066<br>B.S,2009/10 A.D | 2067<br>B.S,2010/11 | 2068<br>B.S,2011/2012 A.D | 2069<br>B.S,2012/13 A.D |
|-----------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|---------------------|---------------------------|-------------------------|
| Land loss | -                      | -                       | -                       | 2144                    | -                       | -                       | -                       | 50                  | -                         | -                       |
| Unit      | -                      | -                       | -                       | Bihga                   | -                       | -                       | -                       | Bigha               | -                         | -                       |
|           |                        |                         |                         |                         |                         |                         |                         |                     |                           |                         |

Source: Disaster Management Section, Ministry of Home Affairs (2013)

## 2.7 Institutional activities on adaptation practices at local level

Adaptation to climate change is a complex, multidimensional, and multi-scale process (Bryant et.al. 2000; Bryan and Behrman 2013). Impact of climate change is an immerging issue and different government and non-government institutions have initiated the climate change adaptation programs and practices. National Adaptation Program of Action to Climate Change (NAPA) Nepal highlighted the adaptation practices and adaptation framework from national to local level (MOE 2010). focused the interdisciplinary approach to implement the program and 80% fund is to be allocated to the local level (MOE 2011). In the LAPA framework, District Development Committee is the main government institution to implement adaptation program by coordinating different government and non-government line agencies at the local level.

## CHAPTER 3: RESEARCH METHODOLOGY

### 3.1 Study site

Two VDCs namely *Rajahar* and *Pithauli* of Nawalparasi district were the study site. Nawalparasi District is located in the Lumbini Zone in the Western Development Region of Nepal (27°40'00'' to 84°11'15''). Its elevation ranges from 91 m to 1936 m. Ecologically, it lies in the Terai region bordering Palpa and Tanahun district in the north, Chitwan, Tanahun and Bihar (India) in the east, Chitwan and Bihar (India) in the south and Rupandehi and Palpa in the west. *Pithauli* VDC is located in 27.65°N and 84.16°E and *Rajahar* is located in 27.74°N and 84.24°E (DDC Nawalparasi 2013).

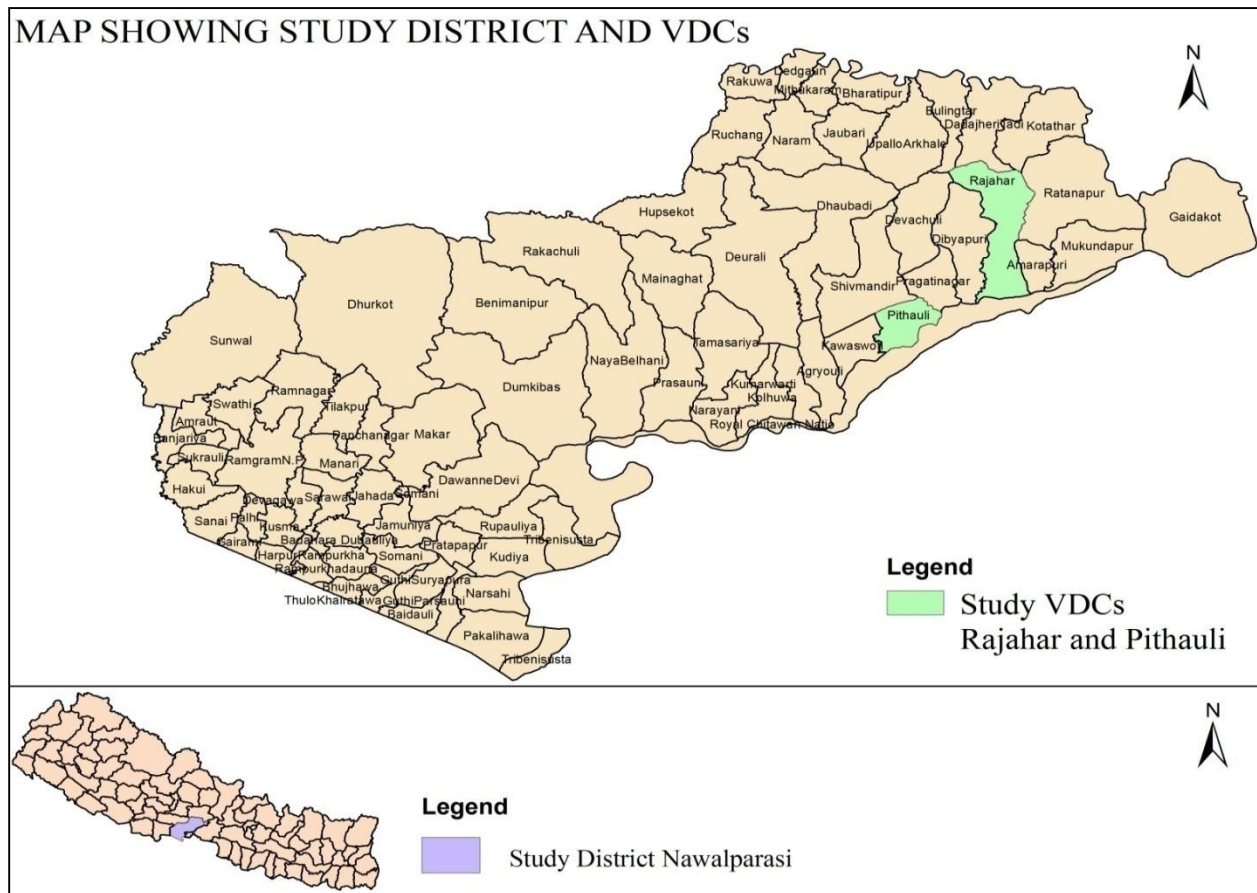


Fig 1: Map of study site (Department of Survey)

**Table 1: Household, population and area of Nawalparasi district/Study site**

| <b>District/VDC</b> | <b>Household</b> | <b>Total population</b> | <b>Male</b> | <b>Female</b> | <b>Total area( sq.km)</b> |
|---------------------|------------------|-------------------------|-------------|---------------|---------------------------|
| Nawalparasi         | 128,793          | 643,508                 | 303,675     | 339,893       | 2132                      |
| <u>Pihauli</u> VDC  | 1,851            | 8,201                   | 3,733       | 4,468         | 15.1                      |
| <u>Rajahar</u> VDC  | 2,426            | 11,119                  | 5,108       | 6,001         | 37.6                      |

Source: CBS (2012)

The logics of selecting these sites were:

These were SAFBIN/Caritas areas where adaptive types of climate change agricultural research was continuing (see photo in appendix 10). The research project was continuing vegetable trials particularly on potato and off-season vegetable. Also research project was continuing trials in rice and wheat. These areas were considered as famous for rain-fed farming. Also the sites were proximate to stations of Department of Hydrological and Meteorology so that these time series data of temperature and precipitation could represent the real effect on vegetable farming.

### **3.2 Types of data use and data collection technique**

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. Study collected twenty-year (1991-2010) data on potato yield, precipitation and temperature data. Web search was conducted to download past researches, proceedings, other published and unpublished research materials of the other organizations.

### 3.3 Primary data collection, sample size, sampling procedure

The researcher made a list on households involved in vegetable production at SAFBIN/Caritas-Nepal working VDC. Study used purposive sampling technique in order to identify how those respondents have perceived climate change parameters impacts in the research project site. In order to ask question to the respondents, researcher prepared a set of questionnaire with the help of research advisor and SAFBIN-CARITAS team (see appendix 1). These questionnaires (open or close ended) were administered for pre-testing at by interviewing four respondents near the same study site with the non-respondents. Then these questionnaires were finalized for HH survey. The primary data were taken by using household survey, focus group discussion and key informant survey.

**Household survey** was conducted for selected 70 household as sample size: 35 from *Pithauli* VDC and 35 from *Rajahar* VDC (See photograph from appendix 10). Household survey of seventy household was conducted with the experienced farmer who had done farming for at least 10 years selected.

**Focus group discussion** was conducted with the respondents of VDCs with the help of semi-structured checklist (see appendix 2). FGD was done to make our survey more effective and for good results, and result triangulation process in comparison to HH survey method. Study conducted three FGD in *Pithauli* VDC at ward no. 2 and two FGDs in *Rajahar* VDCs at ward no.9. Also (see photo in appendix 10)

**Key informant survey** was done to know about the area and to confirm about the changing climate whether it was actually happening or not. For key informant survey, officers from different government organizations like DADO, DFO and DDC, agro vets owners, leader farmers, and staff of Caritas Nepal working district, and JT/JTA of ASC.

### 3.5 Techniques of data tabulation and analysis

Once primary and secondary data collection process finished, data were cleaned and tabulated in Microsoft Excel 2007. These data were also tabulated in Statistical Package of Social Science (SPSS) datasheet. The researcher used to data coding system for easing data analysis. For example: respondent's response of temperature increase, decrease, no change or do not know were coded by 1, 2, 3, and 4, respectively and each code were explained in label and value column under variable view of SPSS datasheet.

Then, 'analyze' option of SPSS Version 16 was used for analyzing frequency counting, average, mean, standard deviation, percentage etc. The descriptive statistics were used to describe the

respondents' socio-economic characters such as sex, age, land holding etc. The relationship of socioeconomic factors on overall yield or relationship of climatic factors on yield was tested by using t-test, f-test, chi-squared test, and correlation as well as regression functions.

**Empirical regression model and its quantitative analysis technique:** Secondary data once collected were analysis by using correlation and regression. In statistics regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent and one or more independent variables. Regression analysis is widely used for prediction and forecasting. It is also used to understand which 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 20 years (1991-2010 AD) for Nawalparasi district collected from Department of Hydrology and Meteorology were taken as independent variables. Researchers considered all vegetable growing seasons and average of temperature and rainfall data of that period was taken into account. Vegetable yield of the same period was assumed as annual yield of the district Nawalparasi. Thus, dependent variable was considered for vegetable 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:

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,  $\Delta Y$  is change in yield of vegetable  $i^{\text{th}}$  year,  $\beta_0$  is the constant term.

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



where,  $y_t$  = yield at year  $t$ ,  $X_i$  = independent variables: temperature ( $X_1$ ),  $X_2$  (rainfall),  $X_3$  (area of cultivation),  $t$  = time (year). “ $\alpha$ ” and “ $\beta$ ” 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 calculated value of  $t$ ,  $f$  exceeds  $t_{0.05}$  (tabulated value of  $t$  at 5% level of significance and  $n-1$  d.f.), 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** was used to explain average annual production, average annual maximum temperature, average annual minimum temperature and average annual rainfall.

## CHAPTER 4: RESULT AND DISCUSSION

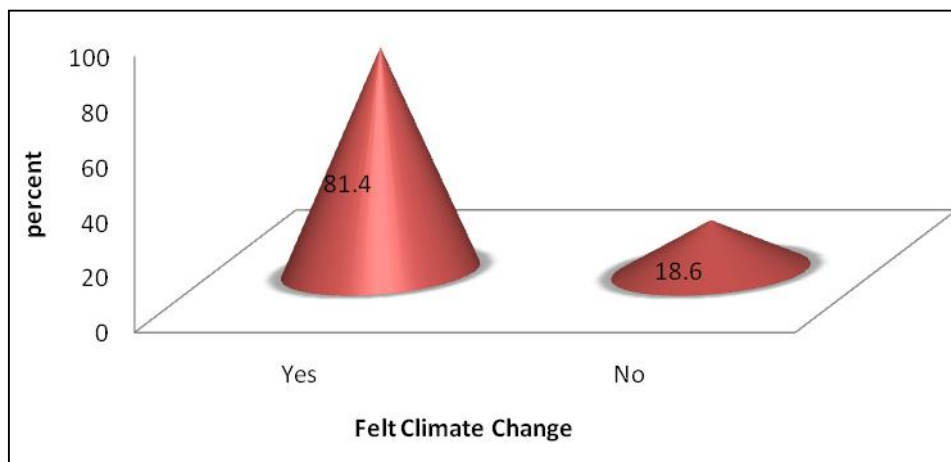
### 4.1 Social-economic characteristics of respondents

Among the 70 household surveyed in *Pithauli* and *Rajahar* VDC of Nawalparasi district, 78.5% were female and 22.5% male. Almost all respondents were farmers having age of: above 60 years (3%), between 30-60 years (81%), and below 30 year (16%). Out of 70 HHs, 32.8% were *Brahmin*, 1.4 % was *Kshetri*, 1.4 % was *Dalit*, 62.4 % were *Janajatis* including *Thonet*, *Mahato*, *Panjyar* and *Khajawar*. Analysis of data in appendix 1 table, landholding of respondent categorized into three ordinal scale: small holders (< 0.5 ha), medium holders (0.5-1 ha) and large holders (>1 ha). As per categories made, 60 % of farmers were small farmers, 32.8 % were medium farmers and 7.2 % were large land holders (see table in appendix 4)

### 4.2 Perception of climate change analysis

#### 4.2.1 Perception of respondents on climate change

The figure 2 depicts perception of respondent about climate change. About 81.4% respondent answered their feelings as 'yes' on question of felt climate change in their locality. However, 18.6% answered as 'don't know' about climate change, meaning that they had no feeling of climate change. Answering 'yes' by majority would be the cause of attachment with the climate change adaptation program run under SAFBIN project from where beneficiaries are taking training, getting climate smart technologies: varieties, trial plot support, and training.

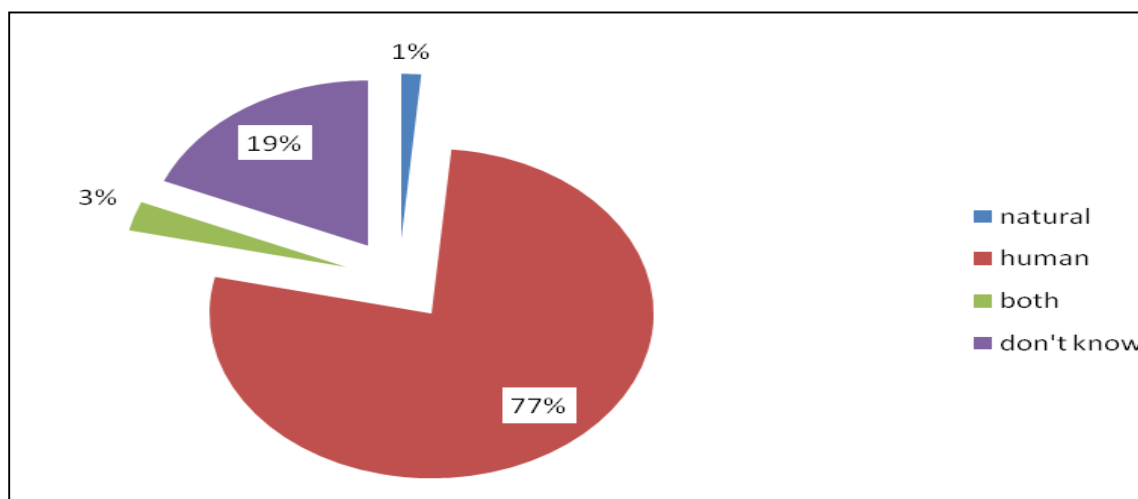


Source: Field survey (2014)

**Fig 2: Perception about (Felt) Climate Change**

#### ***4.2.2 Perception of cause of climate change***

As depicted in fig 3, 77.00% of respondent perceived cause of climate change was human activities and 19% of farmer respondent don't know about cause of climate change. Only 1% said that it was natural. About 3.00% farmers responded cause of climate change was both human activities and natural. It was observed that most of farmers perceived cause of climate change was human activities which is equivalent to climate change 2013: The physical science basis, the science now shown with 95% certainty that human activities is dominant cause of climate change since 20<sup>th</sup> century (IPCC 2013).



Source: Field survey (2014)

**Fig 3: The cause of climate change**

#### ***4.2.3 Perception of respondents in changing weather pattern***

Perception of change in weather parameters was found varied among the respondents which is presented in table 2. As per table, percentage of farmer responded increase in temperature by 98.50%, drought length by 91.50%, drought frequency by 90% and frost and dew amount by 77.30%. Similarly, decrease in monsoon intensity by 67%, monsoon frequency by 90%, hailstorm by 81.30% and flooding by 81.30%. Reports mention on National Adaptation Plan of Action (NAPA) highlighted increased temperature over 10 years. Reports of DHM tend also highlighted decreased trend of rainfall in Nawalparasi district since four years. The respondents

during FGD re-called long duration drought in 2061/62 B.S and faced torrential rainfall in 2064 B.S. Winter rain used to occur during December to February in previous time now delayed and decreased in frequency since past ten-year. There was increased lightening and increased events of hailstorm occurrence. In Nawalparasi, fall of winter dew used to be the source of soil moisture, but now was perceived as hazardous to vegetable crop. Respondents reported burning effect of dews in winter vegetables and fruits in recent years. Increased number of foggy day in winter was suitable environment of late blight disease in tomato, potato, brinjal etc. Also, there was reports of more insect pest (aphid and summer insect attraction in vegetable even in winter season because of increased minimum temperature. Inefficient water usage all over the world and inefficient distribution systems in developing countries further decreased water availability. Water availability is expected to be highly sensitive to climate change and severe water stress conditions will affect crop productivity, particularly that of vegetables.

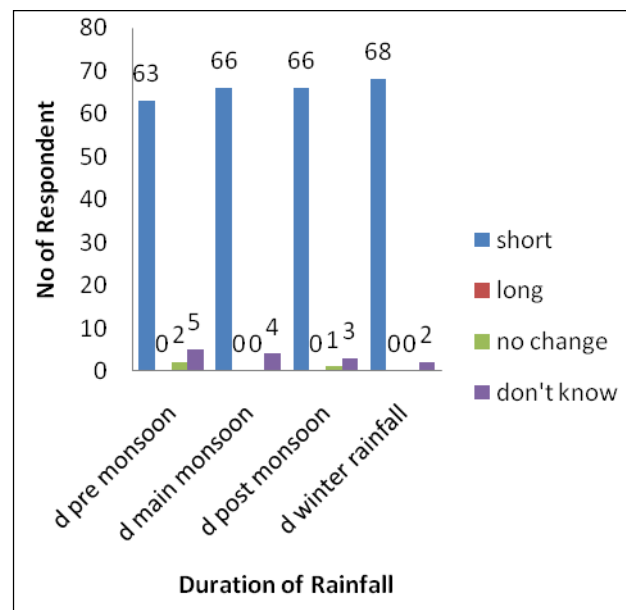
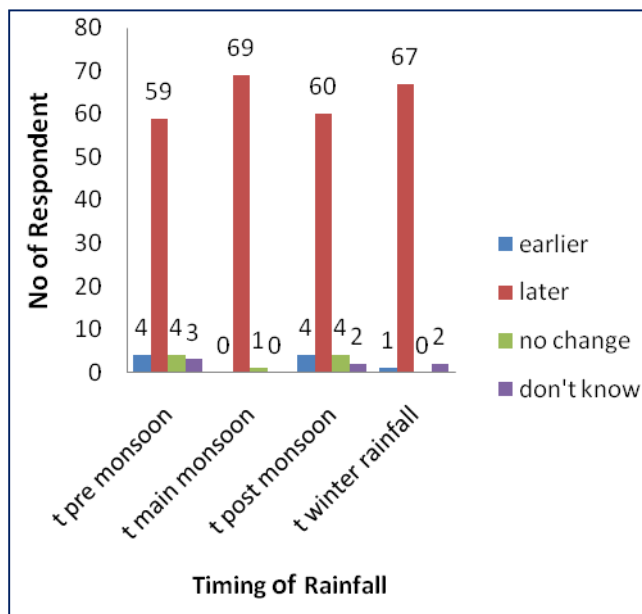
**Table 2: Perception of respondents in changing weather pattern**

| Weather pattern    | Increasing | Decreasing | No change | Don't know |
|--------------------|------------|------------|-----------|------------|
| Temperature level  | 69(98.50)  | 0          | 1(1.50)   | 0          |
| Monsoon intensity  | 21(30.00)  | 47(67.00)  | 1(1.50)   | 1(1.50)    |
| Monsoon frequency  | 5(7.00)    | 63(90.00)  | 1(1.50)   | 1(1.50)    |
| Winter rainfall    | 3(4.20)    | 65(92.80)  | 0         | 2(3.00)    |
| Landslide/Flooding | 11(15.70)  | 57(81.30)  | 2(3.00)   | 0          |
| Drought length     | 64(91.50)  | 6(9.50)    | 0         | 0          |
| Drought frequency  | 63(90.00)  | 5(7.00)    | 1(1.50)   | 1(1.50)    |
| Hailstorm          | 9(12.70)   | 57(81.30)  | 2(3.00)   | 2(3.00)    |
| Frost and dew      | 54(77.30)  | 9(12.70)   | 1(1.50)   | 6(9.50)    |

Source: Field survey (2014)

#### 4.2.4 Perception of respondents in changing timing and duration of rainfall

Fig 4 in left-hand side shows the perception of farmers in changing monsoon time. About 84.2% perceived timing of pre-monsoon became later and timing of main monsoon was also perceived later by 98.5%. Similarly post-monsoon timing and winter rainfall was perceived as later by 85.7% and 95.7%, respectively. Against these perceptions reported, IPCC (2013) documented increasing rainfall trend in monsoon season mainly in Eastern, Western and Far-western region. Post-monsoon in Western Development Region was reported increasing trend. Winter season depicted an increasing rainfall trend all over the country.



Source: Field survey (2014)

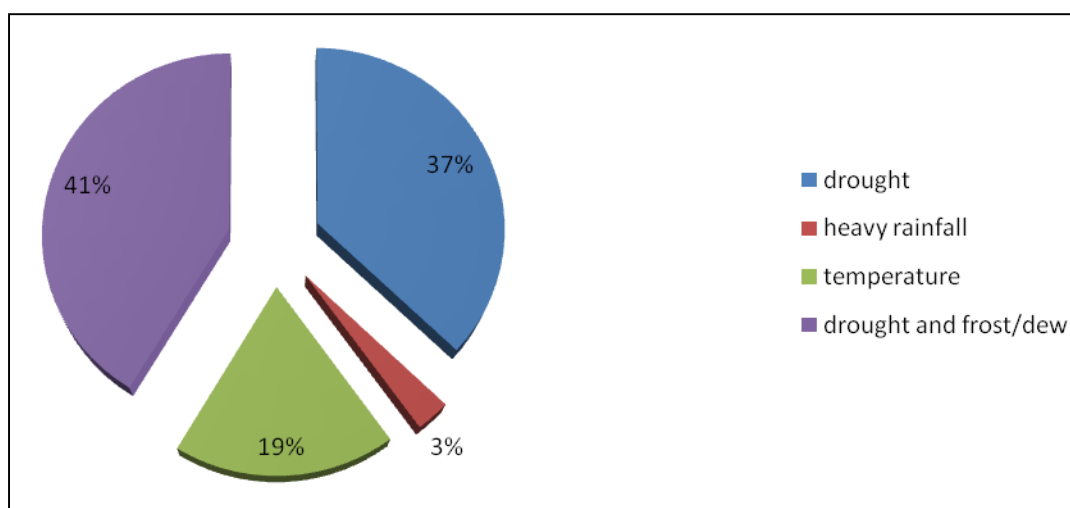
**Fig 4: Perception of respondents in changing timing of rainfall (left) and duration of monsoon rainfall (right)**

Figure 4 (right) shows perception of farmers on 'duration of rainfall'. Duration of pre-monsoon was perceived short by 90% respondents, monsoon by 94.2%, post-monsoon by 94.2% and winter monsoon by 97%. By analogy, it can be inferred that majority of respondents perceived shorter duration of rainfall throughout the seasons of a year. The results was verified with the

NAPA report of delaying onset of pre-monsoon, main monsoon and post-monsoon in the western part than eastern and central part of the country (NAPA, 2011).

#### 4.2.5 Reasons of vegetable failure

Figure 5 showed perception of respondent about main reason for vegetable failure. Winter frost, fog and dew were major reasons potato and tomato crop in winter. About 41% respondents answered drought, frost and dew as major factors of main reason's vegetable failure. About 37% respondent only said long drought as key problem of summer vegetable. In *Pihauli* VDC there was water facility and also *bari-land* for vegetable production. But in *Rajahar* VDC there was not *bari-land*. So, only *khet-land* after harvesting rice was used to grow vegetable even having no water facility. There, the respondents grew potato, tomato, bitter-gourd mainly for home consumption. Yet, they said that there was drought problem. High temperature (19%) and only 3% said heavy rainfall/continuous rainfall were other reasons of vegetable failure.



Source: Field survey (2014)

**Fig 5: Main reasons of vegetable failure**

#### 4.2.6 Change in vegetable performance

Table 3 depicts perception on change in vegetable performance. The yield of potato, cucurbit, and tomato was increased by 82.9%, 71.4%, 61.4%, respectively. This might be due to the hybrid varieties and other improved practices they had been adapting. In contrast to this, according to

book, (Climate change and Agriculture over India), there is sudden decrease in fruit set and due to that, crop growth will increase and expected yield may get reduced. Short photoperiod (i.e. long nights) and cool temperature induce tuber formation in potato. Potato yield is particularly sensitive to high-temp stress because tuber induction (Reynolds and Ewing 1989). There is an interaction between photoperiod and temp; the higher the temperature, the shorter is the photoperiod required for tuberization for any given genotype. High temperature can also adversely affect tuber quality by causing ‘heat sprouting’ which is the premature growth of stolon from immature tubers (Wolfe et.al. 1983; Struik et.al. 1989). Moderately high temperature could significantly reduce tuber yield even when photosynthesis and total biomass production are relatively unaffected.

**Table 3: Change in vegetable performance**

| Performance   | Potato |      |      |      | Cucurbits |      |      |      | Tomato |      |      |     |
|---------------|--------|------|------|------|-----------|------|------|------|--------|------|------|-----|
|               | Inc    | Dec  | NC   | DK   | Inc       | Dec  | NC   | Dk   | Inc    | Dec  | NC   | DK  |
| Yield         | 82.9   | 17.1 | 0    | 0    | 71.4      | 27.2 | 1.4  | 0    | 61.4   | 17.1 | 21.4 | 0   |
| Fruit Size    | 67.1   | 18.6 | 8.6  | 5.7  | 57.2      | 30   | 11.4 | 1.4  | 51.4   | 15.7 | 31.4 | 1.4 |
| Fruit Quality | 54.1   | 12.9 | 11.4 | 21.4 | 40        | 41.4 | 15.7 | 2.9  | 21.4   | 37.1 | 40   | 1.4 |
| Fruit Taste   | 22.9   | 47.1 | 20   | 10   | 20        | 57.1 | 8.6  | 14.3 | 15.7   | 27.1 | 37.1 | 20  |

Source: Field survey (2014)

#### ***4.2.7 Change in vegetable growth in last ten-year***

Table 4, 5, and 6 depict frequency and percentage of farmer’s perception towards change in potato, cucurbit and tomato growth in last 10-year. According to FGD, farmers reported shifting of potato planting date between two-week to 4 week . But potato tuber germination, tuberizing stage and maturity had been felt earlier as shown in table 5. In case of cucurbit particularly bitter-gourd, it was found that seed germination stage, transplanting stage, flowering, flowering period and fruit maturity stage had been earlier. Almost same situation also reported to tomato case. The

farmers didn't know the actual causal factors of shifting of vegetable growth stage but they are autonomously adapting it as new practices. Probably it is the generation change in farming or other operations on-farm or non-farm activities forced them to do.

**Table 4: Change in potato growth in last 10 years**

| Stage of Potato          | Earlier   | Later     | No change | Don't Know |
|--------------------------|-----------|-----------|-----------|------------|
| Potato planting date     | 26(37.10) | 42(60.00) | 2(2.90)   | 0          |
| Potato tuber germination | 52(74.30) | 17(24.30) | 1(1.40)   | 0          |
| Potato tuber stage       | 52(74.30) | 17(24.30) | 1(1.40)   | 0          |
| Potato maturity          | 52(74.30) | 17(24.30) | 1(1.40)   | 0          |

Source: Field Survey (2014)

**Table 5: Change in cucurbit growth in last 10 years**

| Cucurbit stage            | Earlier   | Later     | No change | Don't Know |
|---------------------------|-----------|-----------|-----------|------------|
| Cucurbit seed germination | 56(80.00) | 14(20.00) | 0         | 0          |
| Cucurbit transplanting    | 36(51.40) | 32(42.70) | 2(2.90)   | 0          |
| Cucurbit flowering        | 45(64.30) | 25(35.70) | 0         | 0          |
| Cucurbit flowering period | 43(61.40) | 27(38.60) | 0         | 0          |
| Cucurbit fruit maturity   | 57(81.40) | 12(17.10) | 1(1.40)   | 0          |

Source: Field Survey (2014)



**Table 6: Change in tomato growth in last 10 years**

| Stage of Tomato         | Earlier   | Later     | no change | don't know |
|-------------------------|-----------|-----------|-----------|------------|
| Tomato seed germination | 41(58.60) | 26(37.10) | 2(2.90)   | 1(1.40)    |
| Tomato transplanting    | 36(51.40) | 27(38.60) | 3(4.30)   | 0          |
| Tomato flowering        | 44(62.90) | 26(37.10) | 0         | 0          |
| Tomato flowering period | 43(61.40) | 27(38.60) | 0         | 0          |
| Tomato fruit maturity   | 58(82.90) | 12(17.10) | 0         | 0          |

Source: Field Survey (2014)

### 4.3 Climate change adaptation practices in the study site

#### 4.3.1 Vegetable crop varieties adapted by the respondents

Respondents reported improved and hybrid vegetable varieties adapted in the study areas. These are mentioned in table 7. As per table, major potato varieties were: Cardinal, Lalgulab, Bhutani and etc. Tomato varieties were Srijana, Manisha, Namita and Local ones. Likewise, major bitter guard varieties were Palee and Locals. The study site was Caritas-Nepal intervention area where major vegetable seeds were supported by the project. Other effect they reported that respondents purchased seeds from nearby agro-vet shop and home-grown own seeds (locals variety).

**Table 7: Vegetable crop varieties adapted by the respondents**

| Vegetable                | Varieties  |
|--------------------------|--|
| Potato                   | Cardinal, Lalgulab, Setolau, Lal bandi, Local, Bhutani and TPS |
| Cucurbit- (Bitter-gourd) | Palee and Local  |
| Tomato                   | Srijana, Manisha, Namita and Local                             |

Source: Field survey (2014)

#### ***4.3.2 Key maladies and farmers' adaptation practices***

At the study site, there were some local coping and adaptation strategies adopted in response to observed risks and hazards related to climate and non-climatic factors. Most of the coping activities were found to be event specific based on local knowledge and innovations, because most of the respondents were not aware about actual impacts of climate changes. Though people had been taught about climate change by SAFBIN-Caritas yet they were unaware about impacts of climate change actually. It means there is scope of this project because: The members of Caritas were almost female, although they were trained, but did not practice all concepts at this moment. Project period was also too tenure to solve all kind of complex problems: climatic or non-climatic factors. Second factors would be high pressure of their household work could not emphasize on work sufficiently. Other factors like household income, technology availed etc also affect adaptation. Details of adaptation are included in table 8.

**Table 8: Major adaptation practices of the respondents**

| S.N | Type of effect/Hazard       | Adaptation Practices  |
|-----|-----------------------------|---|
| 1   | Low production              | Use of hybrid varieties(70 HHs)<br>Use of more farm yard manure(70 HHs)   |
| 2   | Inadequate irrigation water | Mulching in winter vegetable (51 HHs)<br>Use of kitchen water(grey water) (16 HHs)<br>Drip irrigation(8 HH)<br>Rainwater harvesting pond construction (3HHs)<br>Installation of shallow tube-well (20HHs) |
| 3   | Water logging condition     | Cutting bunds for rainy season vegetable (35HHs)  |
| 4   | Insect pest attack          | Bio-pesticides(54 HHs)  |

---

|                  |  |
|------------------|--|
|                  | Use pesticides(64 HHs)                           |
|                  | Use of different traps; pheromones traps(40 HHs) |
|                  | IPM(40HHs)                                       |
| 5 Disease        | Bio-pesticides(54 HHs)                           |
|                  | Use pesticides(64 HHs)                           |
|                  | uprooting the diseased plant(70 HHs)             |
| 6 Cold and frost | use of plastic(3 HHs)                            |
|                  | use Dithane M-45(70 HHs)                         |

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Source: Field survey (2014)

From above table, we can see adaptation practices answered by the respondents. However, there was no significant difference in adaptation practices of the respondents in two VDC since both VDC had similar kinds of adaptation supports from SAFBIN-Caritas Nepal.

For low vegetable production of respondents, almost used to hybrid varieties supported from project intervention. Non-members were also using hybrid varieties mainly self-buying from agro-vet shop. Also farmers practiced using more manure from local knowledge which enriched soil fertility For inadequate irrigation facilities about 51 HH had practiced mulching which increase soil moisture. Installation of shallow tube well, rainwater harvesting were other adaptation practices adapted. Also this project had provided drip irrigation to 3 farmers group from where the other members can also used. Similarly kitchen water collection is also alternative to collect water. In *Pithauli* VDC farmers cut bunds for water logging problem but in *Rajahar* VDC there was no water logging problem. The soil absorbed water in *Rajahar* VDC in comparisons to *Pithauli* VDC. For insect pest attack farmers used botanical bio-pesticides ( *Tittedpati* *Artimissia vulgaris*), Neem- *Azadiracta indica*, bokaino- *Melia azadiracta*) made. Other integrated pest management (IPM) approaches were using cow urine, pheromone trap,

cue lure, cow milk, etc. The farmers of both VDC used more manure but fungicides for controlling vegetable diseases.

#### 4.4 Relationship of socio-economic and climatic factors on vegetable crop yield

These relationships were analyzed and results were tested in order to find significance of explained factor by explanatory factors.

##### 4.4.1 Relationship of land holdings on vegetable yield response

Cross-tabulation frequency counting between size of land category with the response of cucurbit yield in table 9 revealed that land category between 10-20 Kaththa (56%) had answered increasing yield responses by 71%, followed by decreasing yield by 28% respondents.

**Table 9: Relationship of respondent holdings with cucurbit yield response cross tabulation**

| Total area in kaththa | cucurbit yield |            |            | Total   |
|-----------------------|----------------|------------|------------|---|
|                       | increasing     | decreasing | no change  |   |
| Below 10              | 13 (19%)       | 6 (9%)     | 1 (1.4%)   | 20 (29%)  |
| 10-20                 | 28 (40%)       | 11 (16%)   | 0          | 39 (56%)  |
| Above 20              | 9 (12.5%)      | 2 (2.5 %)  | 0          | 11 (15%)  |
| Total                 | 50 (71%)       | 19 (28%)   | 1 (1.4%)   | 70 (100%)   |
|                       |                |            |            | Pearson's chi-square = 3.184 Significance level ( $p=0.521$ ) |
|                       | Potato yield   |            | Total      |   |
|                       | increasing     | decreasing |            |   |
| Below 10              | 16 (22.8%)     | 4(5.7%)    | 20 (25.5%) |   |
| 10-20                 | 33 (47%)       | 6 (8.6%)   | 39 (56%)   |   |

|          |           |          |                                  |
|----------|-----------|----------|----------------------------------|
| Above 20 | 9 (12.5%) | 2(2.9%)  | 11 (15.4%)                       |
| Total    | 58 (83%)  | 12 (17%) | 70 (100)                         |
|          |           |          | Pearson's chi-square = 0.208     |
|          |           |          | Significance level ( $p=0.901$ ) |

Note: Figure in parenthesis shows percentage

Source: Own analysis from field survey (2014)

Similarly, cross tabulation count between the size of land category with the response of potato yield is also depicted in table 9. It shows that all kinds of land-holdings felt increased potato yield in the study area because of climate change. Our analogy thus would be increased vegetable yield in the recent years for all kinds of land holders. Significance level of these categories were tested by using Pearson's Chi-square test ( $\chi^2$ ) but were found not significant at 5% level. It means, study found less variability in the response (especially at decreasing yield or no response).

#### ***4.4.2 Relationship of respondent's age, gender, and cultivation area on potato yield response***

Multiple linear regression analysis on predicting relationship of potato yield (dependent variables) with the explanatory variables (age of respondents, gender, khet land and bari land) found that potato yield had significant relationship at 5% level. The value of  $R^2$  (0.071) was also much greater which show good strength of relation between the dependent variable and independent variables ( see appendix 1). This implies that gender, *khet* land and *bari* land played important role in production of vegetable.

Correlation test between temperature, yield and area of cultivation also predicted positive correlation (0.448). Twenty-year's (1991-2010) precipitation data, maximum temperature data, minimum temperature data of Nawalparasi district with annual yield was correlated using Pearson's correlation. Where as maximum temperature and rainfall had no significant correlation as seen in the appendix 1. This indicates minimum temperature of Nawalparasi seem to be favorable to the yield of the potato.

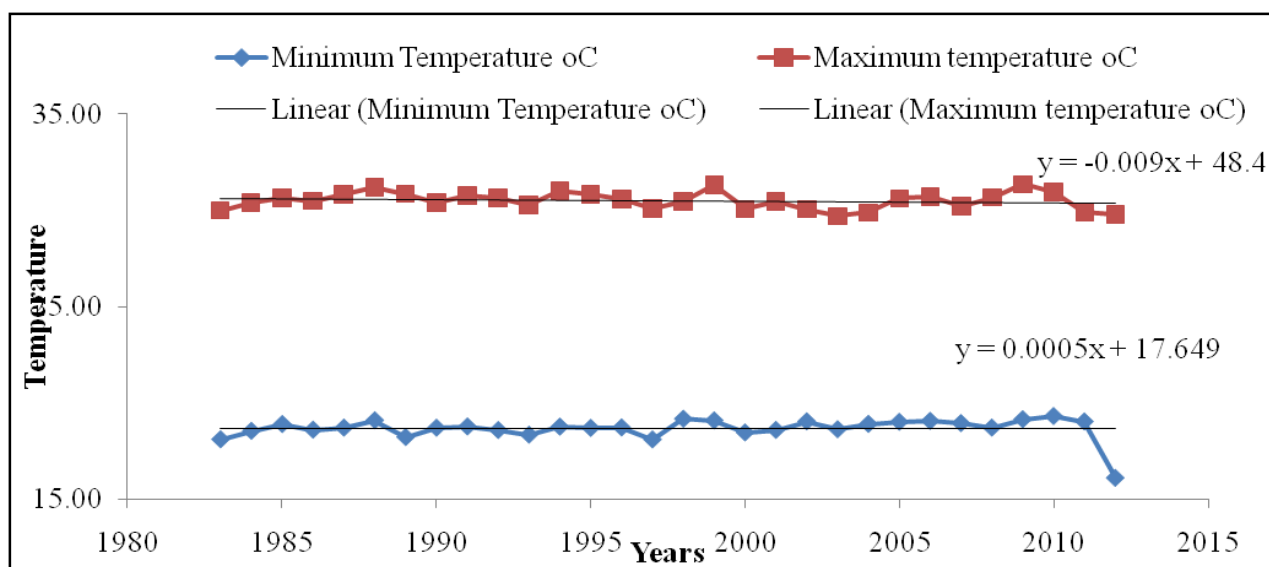
#### ***4.4.3 Trend analysis of potato yield, area and climatic parameters in Nawalparasi***

Results shown in figure table 10, figure 7 and 8 gave temperature and rainfall trend over 20 year duration in Nawalparasi district. From this analysis it was found that potato yield, potato area, mean minimum temperature, mean maximum temperature and mean annual rainfall were 5527.59 mt, 832.37 ha, 18.79°C, 30.54 °C and 201.98 mm, respectively. It showed 6.64 ton productivity of potato per hectare, which is less than national productivity (equivalent 10 tons/ha) (MOAD 2013). The standard deviation results showed skewed pattern of variability in yield, area and rainfall but not much variability in temperature. Trend analysis in figure 7 showed slightly increased positive trend of minimum temperature but somewhere negative trend seen for maximum temperature. Likewise, trend analysis of annual rainfall showed increased trend but down and fall in amount over years. Regression equation over years showed negative relationship for maximum temperature but positive relationship for minimum temperature and rainfall pattern. However, no any significant correlation has been obtained.

**Table 10: Descriptive statistics of non/climatic factors in Nawalparasi district**

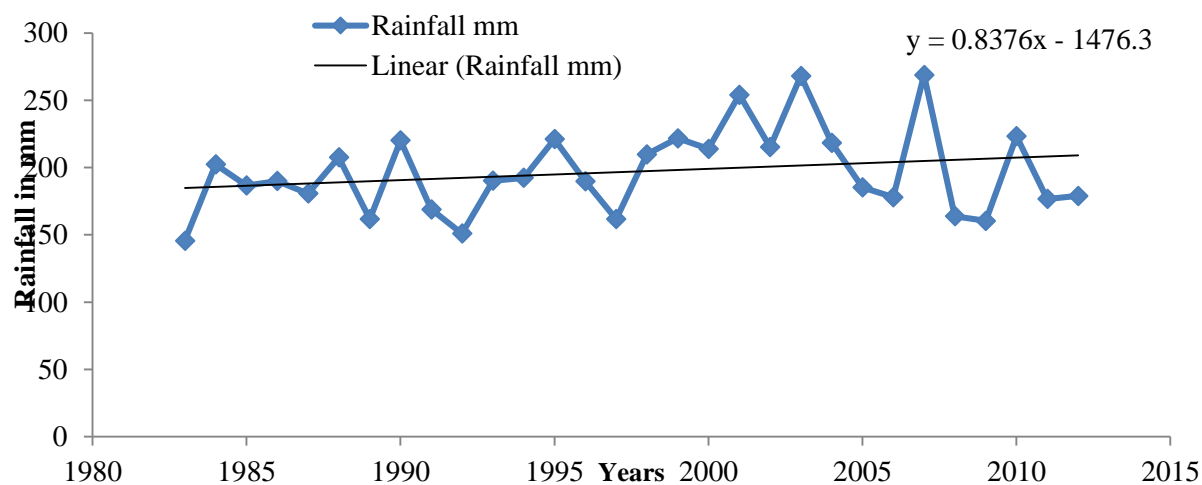
| Descriptive Statistics                 |         |                   |    |
|--|---------|-------------------|----|
|  | Mean    | Std.<br>Deviation | N  |
| Potato yield (mt)                      | 5526.79 | 5660.26           | 19 |
| Area (ha)                              | 832.37  | 250.63            | 19 |
| Annual minimum temperature (°C)        | 18.79   | .314              | 19 |
| Annual average maximum temperature(°C) | 30.54   | .444              | 19 |
| Annual rainfall (mm)                   | 201.98  | 31.59             | 19 |

Source: Own estimate from DHM (2014) and MOAD (2013)



Source: DHM, 2013

**Fig 6: Line graph of maximum and minimum temperature trend**



Source: DHM (2013)

**Fig 7: Line graph showing rainfall (mm) trend of 30 years**

#### **4.4.4 Relationship of temperature, rainfall and area on potato yield**

Multiple regression analysis results shown in table 11 found relationship of potato crop area in Nawalparasi district, annual average minimum temperature ( $^{\circ}\text{C}$ ), average annual maximum

temperature ( $^{\circ}\text{C}$ ), average annual rainfall (in millimeter) of 20 fiscal years (1991/92 to 2010/11 year) to the ultimate annual potato crop yield (in metric tons).

The results depicts that potato area and yield has positive relationship. If potato area increases by 1 unit (hectare), then the yield of potato can increase by 16 unit (mt). T-test ( $t=4.2$ ) statistics was also significant at 1% level. Similarly, minimum temperature on yield was also positive but estimated t-value ( $t=1.5$ ) was not significant at 5% level. Unlike it, maximum temperature and annual rainfall effect had negative effect on potato yield. This relationship respected our literatures and hampered physiological features of potato if maximum temperature and rainfall patterned increase so are detrimental factors for yield increment. R-squared value  $R^2=0.68$ ) means only 68% of the variability was explained by the model. ANOVA table mentions F-statistics = 7.459 which was significant at 5% level, meaning that overall model had characteristics of "goodness of fit". However, results may be divergent in case more data to be incorporated in the model. Durbin and Watson Statistics ( $=1.56$ ) gave positive autocorrelation effect in the model meaning that model had time lagged effect.

**Table 11: Results of multiple regressions among climatic parameters and area on potato yield in Nawalparasi district**

| Model                        | Unstandardized Coefficients   |            | Standardized Coefficients | t      | Sig. |
|------------------------------|-------------------------------|------------|---------------------------|--------|------|
|                              | B                             | Std. Error | Beta                      |        |      |
| (Constant)                   | -4884.256                     | 68154.634  |                           | -.072  | .944 |
| Area                         | 16.477                        | 3.932      | .730                      | 4.190  | .001 |
| Min <sup>m</sup> temperature | 5390.053                      | 3661.950   | .299                      | 1.472  | .163 |
| Max <sup>m</sup> temperature | -3069.372                     | 2386.620   | -.241                     | -1.286 | .219 |
| Annual rainfall              | -53.819                       | 30.636     | -.300                     | -1.757 | .101 |
| $R^2 = 0.681$                | Durbin and Watson Test = 1.56 |            |                           |        |      |



ANOVA<sup>a</sup>

| Model        | Sum of Squares | df | Mean Square  | F     | Sig.              |
|--------------|----------------|----|--------------|-------|-------------------|
| 1 Regression | 392508376.626  | 4  | 98127094.156 | 7.459 | .002 <sup>b</sup> |
| Residual     | 184186014.532  | 14 | 13156143.895 |       |                   |
| Total        | 576694391.158  | 18 |              |       |                   |

a. Dependent Variable: yield

b. Predictors: (Constant), Rainfall, Min\_tempe, Area, Max\_temp

Source: Own analysis from data of DHM and MOAD (2014)

## CHAPTER 5: SUMMARY AND CONCLUSION

### 5.1 Summary

This field research was conducted in *Pithauli* and *Rajahar* VDC of Nawalparasi district based on project intervention areas of Caritas, Nepal with the aim to know vegetable farmer's perception and adaptation measures under climate change and vulnerability context. Seventy HH survey thirty five HH from each VDC was taken with semi structured questionnaire. Pretesting was done before interview survey and only survey was conducted. Household survey, FGD and KIS were major method applied in the field. Data from DHM, CBS and MOAD were collected on climatic parameters and production, respectively and correlated. The field data was entered into Microsoft excel worksheet as well as SPSS worksheet. Then, purposive analysis related to perception analysis, trend analysis and regression analysis undertaken along with relevant descriptive statistics using SPSS.

Regarding to perception analysis results, around 81% respondents answered yes about climate change in their locality related to vegetable production. The cause of climate change perceived by the respondents was human activities followed by no idea on the causal factors. Similar study was also reported in IPCC (2013) with 95% certainty that human activities were the dominant cause of observed warming since the mid 20<sup>th</sup> century. Regarding to response of change on weather factors before ten years and now, respondents answered: temperature level increase (by 99%), change in monsoon intensity decrease (by 67%), monsoon frequency (90%), winter rainfall decreasing (by 93%), flood effect decreasing (by 81%), drought length increase and frequency (by 90%), hailstorm decrease (by 81%), and frost and dew effect increase (by 77%).

Regarding to rainfall pattern in the study area, about 84%, 99%, 86% and 96% answered pre-monsoon, monsoon, post-monsoon timing became late in comparison to usual rainfall pattern in the last decade. Majority of respondents perceived shorter duration of rainfall throughout the seasons of a year. These results were similar to previous studies in other districts of Nepal.

Major climatic factors making vegetables failure or keep always on risk were: cumulative of drought, dew and fog (by 41%) followed by long drought (37%). Even the areas were very near to Narayani river, because of poverty of the respondents, insufficiency irrigation facilities made

great loss on vegetable yield. Farmers shared that 60% respondents planted potato crop later but tuber germination, tuber development and tuber maturity were perceived earlier than usual time. However, cucurbit germination seed germination, transplanting date, flowering, flowering period, and fruit maturity period were reported earlier. Similar physiological changes were also reported for tomato crop. Whatever the losses they felt or faced, performance on yield, fruit size, fruit/tuber quality were perceived increasing but vegetable taste was perceived reducing. The farmers also responded there was occurrence of new pest and disease which was not identified by them. The most infected stages was flowering and fruiting in cucurbits and tomato and tuberization and maturity stage in potato. From these perceptions analysis, we can infer that growing degree days (GDD) of vegetable crops were reducing in the study area but new generation pest were immersed because of warmed micro-climate.

Study also triangulated perceptions by using secondary data analysis of last 30 years for whole district. Mean minimum temperature was slightly growing up, rainfall amount was increasing in trend but pattern (frequency per month, duration of rainfall occurrence) was irregular. The relationships of landholdings with the yield response were analyzed but landholding of the respondents was not significantly different. Relationships of land size, annual mean temperature, annual maximum temperature, and annual rainfall amount had significant relationship on overall yield of potato yield.

In order to safe their crops from changing weather patterns, farmers had used improved seed and hybrid vegetable seeds spontaneously. Other factor of using Hybrid seed would be market force but CARITAS-SAFBIN provided subsidized seed to the targeted respondents. Farmers were using more farm yard manure per unit of land, using IMP approach to manage increased attack of insect and disease pests, and installed swallow tube well substituting dug-wells to reduce groundwater availability in the summer, using mulch, and drip irrigation technologies to adapt these climatic maladies.

## 5.2 Conclusion

Above summary of findings conclude following points:

- Study results showed that vegetable farmers in *Pithauli & Rajahar* VDC had positive response on increased temperature effect on crop production. All monsoons (pre, during and post) and winter rainfall were late, irregular and peculiar in pattern. Farmers perceived increased drought length, hailstorm, and dew effect on overall vegetable production.
- Trend analysis concluded increased mean minimum temperature and maximum temperature in the study area. Rainfall amount was increasing in trend but pattern (frequency per month, duration of rainfall occurrence) was irregular.
- From these perceptions analysis, researcher can conclude that growing degree days (GDD) of vegetable crops were reducing along with shifting farming time later.
- Including other socioeconomic variables, climatic factors had significant effect on overall yield of vegetable crops.
- Multiple linear regression analysis on predicting relationship of potato yield (dependent variables) with the explanatory variables (age of respondents, gender, khet land and bari land) found that potato yield had significant relationship at 5% level.
- Correlation test between temperature, yield and area of cultivation also predicted positive correlation (0.448).
- T-test ( $t=4.2$ ) statistics was also significant at 1% level. Similarly, minimum temperature on yield was also positive but estimated t-value ( $t=1.5$ ) was not significant at 5% level. Unlike it, maximum temperature and annual rainfall effect had negative effect on potato yield.

- The yield of vegetables was found increasing despite reporting of impact of climate change. The causes of yield increment were because of adaptation support from Caritas-SAFBIN program. Major adaptation supports were: training, seed and material supports related to climate smart technique. However, adaptation skills and options supported by the projects were insufficient to address private demand on vegetable cultivation.

### **5.3 Policy recommendations**

The researcher would suggest following recommendations

- The researcher not only collected, tabulated and analyzed climate change response but also identified pros and cons of climate change adaptation response in the study area. In order to response climate change vulnerability at local area, very good initiations have been taken from government sector, donor sector, I/NGO and civil society. One of these organizations is Caritas-SAFBIN is doing adaptive research to response to climate change adaptation program. Present project activities are sensitizing local people and enhancing skills to them. Following points are suggested in order to improve climate change adaptation financing.
- Caritas-SAFBIN is suggested to broaden research boundary by including large number of respondents into research framework to confirm role of socioeconomic and climatic variables inundate climate change. What factors (climatic, socio-economic) are playing decision making on climate change adaptation would be identified by taking large sample size;
- Farmers said "hybrid seed" would be panacea under climate change vulnerability. However, major challenge in the study area were water saving and water utilization technologies, poverty, and soil fertility improvement. Basically, new research/development technique of farming "farming under low water and more water" is suggested to implement. Shifting from rice farming to plastic house-based vegetable farming (in rainy season) would be suitable adaptation example for upland areas.

- Study suggests granting many options of demo trials on vegetable cultivation for low land area Nawalparasi by selecting relatively higher landholders (rich farmers if possible) in close coordination of NARC/IAAS scientists.

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## APPENDICES

### Appendix 1: Structured Questionnaires asked to the respondents

Name of Interviewer: \_\_\_\_\_ Date \_\_\_\_\_ General information

Name of farmer: \_\_\_\_\_ Age: \_\_\_\_\_ years

Address: \_\_\_\_\_

Area of land: \_\_\_\_\_ total ropani \_\_\_\_\_ Bari land \_\_\_\_\_ Khet land

#### 2. Farmer's Perception on Climate change:

2.1 Have you felt about climate change? Yes / No

2.2 Do you know the cause of climate change?

a. it is Natural

b. human-made (caused by pollution emitted by people and industry leading )

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/climate conditions?

| Weather                         | Increased | Decreased | No Change | Don't Know | Remarks |
|---------------------------------|-----------|-----------|-----------|------------|---------|
| Temperature level               |           |           |           |            |         |
| Monsoon Rainfall –intensity     |           |           |           |            |         |
| Monsoon Rainfall- frequency     |           |           |           |            |         |
| Winter-frequency                |           |           |           |            |         |
| Landslide/flooding severity     |           |           |           |            |         |
| Drought-length and Severity     |           |           |           |            |         |
| Drought – Frequency             |           |           |           |            |         |
| Hailstorm-Amount and severity   |           |           |           |            |         |
| Frost & Dew – Amount & Severity |           |           |           |            |         |

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 monsoon(June –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 |

|                              |         |       |           |            |
|------------------------------|---------|-------|-----------|------------|
| Timing of winter rainfall    | Earlier | Later | No change | Don't Know |
| Duration of winter rain fall | Short   | Long  | No change | Don't know |

3.1 Have climate changes had any effect on your vegetable farming over the last 10yrs? 3.2 If yes, have you experienced failure of vegetable in last 10 yrs? Yes/NO if yes, tell reasons for vegetable type failure -----

- a. Drought b. heavy/continuous rainfall c. wind d. frost  
e. temperature f. hailstorm g. drought & frost

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

| Vegetable | Incidence of Pest/disease | Occurrence of new pest in 10 yrs(name of the pest identified) | Which stage of the vegetable pest incidence more? | Name the varieties of crops you are growing |
|-----------|---------------------------|---|---|---|
| Potato    | Increasing/decreasing     | Yes/No  |   |   |
| Cucurbits | Increasing/decreasing     | Yes/No  |   |   |
| Tomato    | Increasing/decreasing     | Yes/No  |   |   |

3.5 Have you noticed any change in vegetable performance in last 10 yrs? Yes/No

| Effect on potato Performance | Increasing | Decreased | No change | Don't know | Effect on Cucurbits Performance | Increasing | Decreased | No change | Don't know | Effect on tomato Performance | Increasing | Decreased | No change | Don't know |
|------------------------------|------------|-----------|-----------|------------|---------------------------------|------------|-----------|-----------|------------|------------------------------|------------|-----------|-----------|------------|
| Yield                        |            |           |           |            | Yield                           |            |           |           |            | Yield                        |            |           |           |            |
| Potato Size                  |            |           |           |            | Size of fruit                   |            |           |           |            | Size of fruit                |            |           |           |            |
| potato quality               |            |           |           |            | Fruit quality                   |            |           |           |            | Fruit quality                |            |           |           |            |
| potato Taste                 |            |           |           |            | fruit Taste                     |            |           |           |            | fruit Taste                  |            |           |           |            |
| Other                        |            |           |           |            | Other                           |            |           |           |            | Other                        |            |           |           |            |

3.6 Please mention following change in vegetable growth in last 10yrs:



| Potato stage              | Earlier | Later | No | Don't | Cucurbit stage           | Earlier | Later | No | Don't | tomato stage             | Earlier | Later | No | Don't |
|---------------------------|---------|-------|----|-------|--------------------------|---------|-------|----|-------|--------------------------|---------|-------|----|-------|
| Planting date             |         |       |    |       | Days of Seed germination |         |       |    |       | Days of Seed germination |         |       |    |       |
| Days of tuber germination |         |       |    |       | Transplanting date       |         |       |    |       | Transplanting date       |         |       |    |       |
| Tubering stage            |         |       |    |       | Flowering                |         |       |    |       | Flowering                |         |       |    |       |
| Tuber maturity period     |         |       |    |       | Flowering Period         |         |       |    |       | Flowering Period         |         |       |    |       |
|                           |         |       |    |       | Fruit maturity Period    |         |       |    |       | Fruit maturity Period    |         |       |    |       |

#### 4. Vulnerability effect in vegetable farming

4.1 Have you faced a climate related crisis in vegetable in last 10 yrs?

Yes/No

4.2 If yes, please tick climatic hazards affected your vegetable farming.

| S.N | Types of effect                                    | Increasing/Long | Decreasing/Short | Reason |
|-----|--|-----------------|------------------|--------|
| a.  | Water logging period during planting               |                 |                  |        |
| b.  | Availability of water source                       |                 |                  |        |
| c.  | Damage of vegetable seedlings                      |                 |                  |        |
| d.  | Losses of winter/potato vegetable by cold-fog      |                 |                  |        |
| e.  | Losses of cucurbits by hailstorms (cum heavy wind) |                 |                  |        |
| f.  | Type of insect pest damage crop                    |                 |                  |        |
| g.  | Type of disease pest damage                        |                 |                  |        |
| h.  | % of total losses in vegetable yield               |                 |                  |        |

#### 5. Climate change/vulnerability context adaptation situation of vegetables

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

| S.N | Types of effect/Hazard                      | Adaptation practices at present context |
|-----|---|---|
| a.  | Low vegetable production                    |   |
| b.  | Low water/insufficient water for irrigation |   |

|    |                                   |  |
|----|-----------------------------------|--|
| c  | More water /water logging problem |  |
| d  | Insect pest attack                |  |
| e  | Disease attack                    |  |
| f. | Loss due to hailstorm             |  |
| g. | Loss due to cold fog/frost        |  |

5.2 What types of adaptation activities are you implementing from Caritas-SAFRIN programme in vegetable?

1. ....
2. ....
3. ....

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

1. ....
2. ....
3. ....

If no or partial acceptance mention area of improvements

1. ....
2. ....
3. ....

5.4 Do you like to continue these practices ? Yes/no

5.5 Have you taught the adaptation techniques learnt from CARITAS to anyone? If yes to whom?

1. Relatives
2. Neighbors
3. Others

## Appendix 2: Checklist for focus group discussion

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

No. of participants : Male..... Female..... Total.....

Age:<20..... 20-50..... >50

Address:\_\_\_\_\_

Area of vegetable farming : total ropani -----Bari land ----- Khet land-----

Q.N 1. Do your group feel about the climate change in your locality?

a) Extremely felt b) Moderate felt c) Fairly felt d) Not felt

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<br>Heavy wind/ Erratic<br>rainfall/hail/insect /disease | Loss of land<br>(kattha) |        | Loss of<br>vegetable<br>(Qnt.) | loss of<br>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 |         |                                   |
| Hailstorm            |         |                                   |
| Prolonged drought    |         |                                   |
| Winter fog/frost     |         |                                   |
| Winter rainfall      |         |                                   |
| Others               |         |                                   |

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<br>organizations (Caritas<br>Nepal or other one) | Suggestions for future<br>support |
|--|---|-----------------------------------|
| Climate change awareness<br>raising  |   |                                   |
| Early warning system   |   |                                   |
| Rain water harvesting  |   |                                   |
| Thi-jar support for drinking<br>water (or kitchen gardening<br>irrigation) |   |                                   |

|   |  |  |
|---|--|--|
| Drip irrigation                                 |  |  |
| Integrated nutrient management                  |  |  |
| Safe-side construction                          |  |  |
| Providing climate-supportive crop varieties     |  |  |
| Rehabilitation of infrastructure                |  |  |
| Farming technique(mulching, earthing, SALT etc) |  |  |

### **Annex 3: Checklist for Key Informant Survey**

#### **Key Informant survey of climate change in vegetable farming of Agro vet, Nawalparasi district**

##### 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 vegetable 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 vegetable 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 ?

#### **Key Informant survey of climate change in vegetable farming for DADO, Nawalparasi District**

##### 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 programs related to climate change in your district?

Yes/No

If yes what type of programs? (Also specify for vegetable farming)

2.4 What type of hazard effect have you seen in this district in vegetable 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 programs?

2.7 Are they implementing these in their farming practice?

**Key Informant survey of climate change for Caritas, Nawalparasi District**

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 programs related to climate change in your district?

Yes/No

If yes what type of programs? (Also specify for vegetable farming?)

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

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

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

2.7 Are they implementing them in their farming practices?

**Key Informant survey of climate change in vegetable farming of leader farmer, Nawalparasi district**

1. General information:

Name: \_\_\_\_\_ Sex: M/F

Age: \_\_\_\_years

Name of the leader farmer : \_\_\_\_\_

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

#### **Appendix 4: Land holding of the respondents**

| Land holdings            | % of household |
|--------------------------|----------------|
| small farmers (<0.5ha)   | 60             |
| medium farmers (0.5-1ha) | 32.8           |
| large farmers (> 1 ha )  | 7.2            |

Source: Field survey, 2014

#### **Appendix 5: Correlation of maximum and minimum temperature along with yield and area of Potato production**

##### **Correlations**

|       |                     | Minimum | maximum | Rainfall | area   | Yield |
|-------|---------------------|---------|---------|----------|--------|-------|
| Yield | Pearson Correlation | .448*   | -.020   | .134     | .750** | 1     |
|       | Sig. (2-tailed)     | .047    | .932    | .574     | .000   |       |
|       | N                   | 20      | 20      | 20       | 20     | 20    |

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

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

#### **Appendix 6: ANOVA**

##### **ANOVA<sup>b</sup>**

| Model |            | Sum of Squares | Df | Mean Square | F     | Sig.              |
|-------|------------|----------------|----|-------------|-------|-------------------|
| 1     | Regression | .702           | 3  | .234        | 1.670 | .182 <sup>a</sup> |
|       | Residual   | 9.241          | 66 | .140        |       |                   |
|       | Total      | 9.943          | 69 |             |       |                   |

a. Predictors: (Constant), Khetland in kattha, Age of the respondent , Area of Bariland kattha

b. Dependent Variable: potato yield

### R Square

| Model | R                 | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------------------|----------|-------------------|----------------------------|
| 1     | .266 <sup>a</sup> | .071     | .028              | .374                       |

### Coefficients

| Model |                         | Unstandardized Coefficients |            | Standardized Coefficients | t     | Sig. |
|-------|-------------------------|-----------------------------|------------|---------------------------|-------|------|
|       |                         | B                           | Std. Error | Beta                      |       |      |
| 1     | (Constant)              | 1.109                       | .219       |                           | 5.065 | .000 |
|       | Age of the respondent   | .002                        | .004       | .057                      | .479  | .633 |
|       | Area of Bariland kattha | .174                        | .087       | .242                      | 2.016 | .048 |
|       | Khetland in kattha      | -.068                       | .069       | -.118                     | -.980 | .331 |

a. Dependent Variable: potato yield

### Appendix 7: Potato production area and yield ( 20 years data )

| Years   | Area | Yield |
|---------|------|-------|
| 1991/92 | 460  | 802   |
| 1992/93 | 500  | 790   |
| 1993/94 | 600  | 1017  |
| 1994/95 | 600  | 1022  |
| 1995/96 | 530  | 445   |
| 1996/97 | 590  | 495   |
| 1997/98 | 610  | 708   |
| 1998/99 | 850  | 950   |
| 1999/00 | 850  | 950   |
| 2000/01 | 950  | 1074  |
| 2001/02 | 875  | 1200  |
| 2002/03 | 875  | 934   |
| 2003/04 | 875  | 11271 |

|         |      |       |
|---------|------|-------|
| 2004/05 | 875  | 11200 |
| 2005/06 | 875  | 13486 |
| 2006/07 | 1025 | 10500 |
| 2007/08 | 1250 | 12384 |
| 2008/09 | 1275 | 12631 |
| 2009/10 | 1100 | 11555 |
| 2010/11 | 1100 | 12545 |

Source: MOA 2010/11

**Appendix 8: Maximum and minimum temperature and rainfall data of Nawalparasi district ( 30 years )**

| 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 9: Vegetable production area and productivity( 10 years data )**

| Year    | Area | Production | Yield | Productivity |
|---------|------|------------|-------|--------------|
| 2003/4  | 4000 | 44135      | 11034 | 11.03        |
| 2004/5  | 4269 | 50472      | 11823 | 11.82        |
| 2005/6  | 4482 | 53525      | 11942 | 11.94        |
| 2006/7  | 4684 | 55773      | 11907 | 11.90        |
| 2007/8  | 4895 | 58115      | 11872 | 11.87        |
| 2008/9  | 5220 | 58230      | 11155 | 11.15        |
| 2009/10 | 4646 | 53201      | 11451 | 11.45        |
| 2010/11 | 7523 | 90670      | 12052 | 12.05        |
| 2011/12 | 4763 | 57570      | 12087 | 12.08        |
| 2012/13 | 4600 | 57806      | 12566 | 12.56        |

Source: MOA 2012/13

## Appendix 10. Photoclips



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



Photo 2: Conducting a household survey at Rajahar VDC



Photo 3: Conducting household survey at Rajahar VDC



Photo 4: FGD at Pithauli VDC

Photo 5: FGD at Rajahar VDC