

FINAL RESEARCH REPORT

**Identification of Public Health Problems  
Resulting from Climate Change and  
Preparation of Guidelines for its  
Prevention in Nepal**

2011

Conducted By



Nepal Health Research Council (NHRC)

Supported By



World Health Organization (WHO)

## **RESEARCH REPORT**

# **Identification of Public Health Problems Resulting from Climate Change and Preparation of Guidelines for its Prevention in Nepal**

### **Study Team Members**

Mr. Meghnath Dhimal, Principal Investigator

Dr. G. P Bhandari, Co- Investigator

Dr. Bandana Pradhan, Team Member

Mr. Sarju Kumar Baidya, Team Member

Mr. Dhurba Raj Ghimire, Team Member

Mr. Er. Birendra Man Shakya, Team Member

Mr. Hari Datt Joshi, Research Assistant

Mr. Bikram Dhimal, Research Assistant

### **Research Advisor**

Prof. Dr. Chop Lal Bhusal

## **Acknowledgement**

I extend my sincere thanks to all the research team members who were involved in this research study. I would like to thank Mr. Meghnath Dhimal, Principal Investigator of this study who developed the idea, concepts, proposal and implemented it effectively to generate the results. My sincere thank goes to Dr. Gajananda Prakash Bhandari, Co-principal Investigator of this study, Nepal Health Research Council and team members Dr. Bandana Pradhan, Institute of Medicine, Mr Dhruba Raj Ghimire, Statistical Officer Department of Health Services, Mr. Birendra Man Shakya, Chief, Water Quality Monitoring and Improvement Section, Department of Water Supply and Sewerage, Ministry of Physical Planning and Works, Mr. Sarju Kumar Baidya, Senior Meteorologist, Department of Hydrology and Meteorology, Ministry of Environment for their contribution in conducting research by providing data and valuable suggestions, guidance to accomplish the study on time. I am grateful to Mr. Nam Raj Khatri, National Operational Officer of WHO Country Office Nepal for providing his technical input on this study.

I extend my sincere thanks to all the staffs of district health offices, other government offices, NGOs, INGOs and all other individuals who co-operated during our data collection period. I would also like to thanks Mr. Bikram Dhimal and Mr. Hari Datt Joshi for their hard work in preparing this report and assisting in overall research activities.

At last but not the least, I am very thankful to World Health Organization (WHO) country office Nepal for the financial and technical support to complete this research study. My sincere thanks go to Dr. Shanker Pratap Singh, Member Secretary, Nepal Health Research Council for his valuable support and all other staffs of NHRC especially Mr. Nirbhay Kumar Sharma and Mr. Subodh Kumar Karna for their administrative support to accomplish this research activity on time.

**Prof. Dr. Chop Lal Bhusal**

**Executive Chairman**

## ACRONYMS

<b>ADB</b>	Asian Development Bank
<b>AEPC</b>	Alternative Energy Promotion Center
<b>AHW</b>	Auxiliary Health Worker
<b>ARI</b>	Acute Respiratory Infection
<b>COPD</b>	Chronic Obstructive Pulmonary Disease
<b>DALY</b>	Disability Adjusted Life Years
<b>DHF</b>	Dengue Hemorrhagic Fever
<b>DHO</b>	District Health Office
<b>DOHS</b>	Department of Health Services
<b>DPHO</b>	District Public Health Office
<b>DUDBC</b>	Department of Urban Development and Building Construction
<b>DWSS</b>	Department of Water Supply and Sewerage
<b>INGO</b>	International Non-governmental Organization
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>HIMS</b>	Health Information and Management System
<b>MoE</b>	Ministry of Environment
<b>MoHP</b>	Ministry of Health and Population
<b>MoPPW</b>	Ministry of Physical Planning and Works
<b>NAPA</b>	National Adaptation Programme of Action

<b>NGO</b>	Non-governmental Organization
<b>NHRC</b>	Nepal Health Research Council
<b>NHT</b>	Nepal Humanitarian Transition
<b>UV</b>	Ultraviolet Radiation
<b>VDC</b>	Village Development Committee
<b>WHO</b>	World Health Organization

## **Executive Summary**

The varying effect of climate change has its impact on the economic, social and cultural development of the country. Displacement of the people from multiple extreme climatic conditions has urged the emergency of developing the best adaptation and mitigation measures to minimize the effects of climate change to the development of nation. Health is another specific sector that has the direct impact resulting from climate change. The study was carried out to identify the public health problems resulting from climate change and also the preparation of guidelines to prevent the public health problems from climate change in the context of Nepal. The objectives of study were to review policies of Government of Nepal in agriculture, water, sanitation, shelter, transport and energy with respect to climate change and human health and recommend for good practices, to explore of the effect of climate change in health in different climatic regions especially on vector borne disease and water borne disease, assessment of relationship of vector borne diseases particularly of malaria and diarrhea with climatic data of different region of the country and development of certain guidelines to protect human health from climate change.

An exploratory descriptive study was carried out and retrospective data analysis was made collecting climatic data and health facility data of malaria and diarrheal diseases from HMIS and DHM. Time series analysis is made to show the relationship between the climatic events (temperature, rainfall) with the occurrence of diarrhea and malaria. Qualitative information was gathered through Focus Group Discussion and In-depth interview with the health workers and local community to explore the effects of climate change on the health of the people. Ten districts were selected for the study out of which time series analysis was made in six districts (two districts each from terai, hill and mountain were analyzed in average having the similar geographical distribution) covering the three ecological regions because of limited data in other study districts. Regression analysis in terai region shows that with rise of minimum temperature diarrheal and malaria disease seems to be increasing whereas diarrhoeal disease seems to be decreasing in rise of rainfall. Similarly in hilly region with rise in the maximum temperature malaria cases decreases and increase with rise of minimum temperature. Increase in rainfall also shows the increase in diarrheal numbers. Himalayan

region time series analysis shows that rise in minimum temperature trend of malaria cases also increases and diarrheal disease also increases with rising rainfall. Policies of Government were reviewed and key points were identified that have addressed directly or indirectly to climate change and public health issues. Nepal Government do not have specific policies on climate change and health but newly formed plan such as Nepal Health section Implementation Plan 2010-2015 have address issues related to climate change and health in its five years periodic programs of health of sector and three years interim approach paper 2010-2013 has also tried make the development work climate resilient. Negegy subsidy policies have some important provisions which have other Government policies such National Urbanization Policy, Urban water supply policy, rural water supply policy. Energy subsidy policy, national health policies have some important provisions which directly or indirectly address the issues related to climate change and health. The qualitative data collected from the health professionals and community people shows that impact related to climate change are emerging and vary from east to west and south to north because of micro-climatic variation within the country. Some part of Nepal have draught and some problem have draught, terai have lesser increasing temperature with extreme cold in winter while as temperature pattern is increasing much faster in higher altitudes with decreasing colder days with snow fall and increasing days with higher temperatures. Health professions and community people have perceived that prevalence of diarrheal disease increasing in mountain region though severity of diarrhea has decrease because of massive community level interventions on time which are attributed to poor quality of water contaminated with coli form, poor sanitation and hygiene. The indigenous malaria cases are not reported from mountain region but many imported cases are reported and nuisance of mosquitoes is increasing in mountain regions of Nepal compelling the people to use bed nets for sleeping. The people perceived that prevalence of other water borne diseases such as typhoid, cholera and dysentery, skin diseases have also increased also increased in mountain region. Similarly in hilly region, both imported and indigenous cases of malaria are reported and population density and altitudinal distribution of mosquitoes increasing, mosquitoes are found throughout the world in lower parts of the hill, due to uneven distribution of rainfall pattern and changes in timing of monsoon, extreme events like landslides and floods are

increasing causing loss of lives and properties. The prevalence of water borne diseases such as diarrhea, typhoid, dysentery, enteric fever, viral fever, skin diseases has increased which are also associated with poor quality and quantity of available water and low sanitation coverage and hygiene. In terai region malaria cases are decreasing due to massive intervention programs in highly affected VDCs but cases are seen from higher altitude and new places of district demanding the expansion of malaria control program within the district also. In terai increasing frequency of flood and landslide in upstream and higher altitudes has affected the lives and properties and cases of water borne diseases increasing. The monthly data of long time could not be called both from HMIs and individual health facility. However, time series analysis shows that some climatic data and cases of malaria and diarrheas are significantly correlated. In order to confirm the attribution of climate change, the recording and reporting system of climate sensitive diseases should be strengthened at health facility level, entomological study should be carried from where indigenous malaria cases are reported and in other suspected new places too. The water supply and sanitation coverage need to increase and should ensure the quality of supplied drinking water implementing water quality surveillance.

As this study is primarily based on secondary data and qualitative data collected from the field, detailed prospective study is required to discern the attribution of climate change on these diseases. There is dire need of prospective studies on altitudinal distribution of vector borne diseases and their vectors, their susceptibility to insecticides in the context of climate change. Similarly, study on diarrhea and its attributing factors, forecasting the season of diarrhea and preparing early warning system are important aspects for managing diarrheal cases in the context of climate change. Public health are the most sensitive and important indicator of the nation development and thus to safeguard it comprehensive policy and programs also should be brought forth.



## Table of Contents

<b>ACKNOWLEDGEMENT</b> .....	<b>III</b>
<b>ACRONYMS</b> .....	<b>IV</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>VI</b>
<b>CHAPTER 1</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>1</b>
<b>1.1 BACKGROUND</b> .....	<b>1</b>
<b>1.2 OBJECTIVES</b> .....	<b>3</b>
<b>1.3 RATIONALE OF RESEARCH STUDY</b> .....	<b>3</b>
<b>1.4 LIMITATIONS OF THE STUDY</b> .....	<b>4</b>
<b>1.5 REVIEWED NATIONAL AND INTERNATIONAL JOURNAL ARTICLES</b> .....	<b>5</b>
<b>CHAPTER 2</b> .....	<b>14</b>
<b>METHODOLOGY</b> .....	<b>14</b>
<b>2.1 FORMATION OF STUDY TEAM</b> .....	<b>14</b>
<b>2.2 LITERATURE REVIEWS</b> .....	<b>14</b>
<i>2.2.1 National and International Journal Articles</i> .....	<b>14</b>
<i>2.2.2 Review of Government of Nepal Policies</i> .....	<b>14</b>
<b>2.3 SITE SELECTION FOR FIELD STUDY AND ITS JUSTIFICATION</b> .....	<b>15</b>
<b>2.4 STUDY DESIGN</b> .....	<b>15</b>
<b>2.5 STUDY TYPE:</b> .....	<b>15</b>
<b>2.6 DATA COLLECTION TOOLS AND TECHNIQUES:</b> .....	<b>15</b>
<b>2.7 DATA ENTRY AND ANALYSIS:</b> .....	<b>16</b>
<b>2.8 GUIDELINE PREPARATION:</b> .....	<b>16</b>
<b>CHAPTER 3</b> .....	<b>17</b>
<b>FINDINGS</b> .....	<b>17</b>
<b>3.1 REVIEW OF GOVERNMENT POLICIES</b> .....	<b>17</b>
<b>3.2 RESEARCH FINDINGS FROM QUALITATIVE STUDY</b> .....	<b>22</b>
<i>3.2.1 Focus Group Discussion with District Public Health Office Staffs- Dhangadi, Kailali</i> .....	<b>22</b>
<i>3.2.2 Focus Group Discussion with community people: Dhangadi, Kailali</i> .....	<b>23</b>
<i>3.2.3 Focus Group Discussion with NGO and other government line agencies in Kailali districts</i> .....	<b>24</b>
<i>3.2.4 Focus Group Discussion with District Public Health Office Staffs - Doti</i> .....	<b>25</b>
<i>3.2.5 Focus Group Discussion with community people, governmental and non government line agencies in Doti, District</i> .....	<b>25</b>
<i>3.2.6 Focus Group Discussion with District Public Health Office Staffs in Bajhang</i> .....	<b>26</b>

3.2.7 Focus Group Discussion with community people, governmental and non government line agencies .....	26
3.2.8 In-depth interview with District Health Officer from Morang.....	27
3.2.9 Focus Group Discussion with District Health staff and other agencies at Dhankuta .....	31
3.2.10 Interaction Meeting with District Public Health Office Staffs and Other line agencies in Sankhasuwa, District .....	32
3.2.11 In-depth Interview with District Health Staff from Central Region.....	34
3.2.12 Summary of Qualitative findings .....	37
<b>3.3 FINDINGS FROM TIME SERIES ANALYSIS.....</b>	<b>40</b>
3.3.1 Trend analysis from terai region: Chitwan and Morang district.....	40
3.3.2 Trend analysis from hill region: Dhankuta and Nuwakot district .....	43
3.3.3 Trend analysis from mountain region: Sankhuwasabha and Rasuwa district.....	46
<b>CHAPTER 4.....</b>	<b>52</b>
DISCUSSION .....	52
<b>CHAPTER 5.....</b>	<b>55</b>
CONCLUSION AND RECOMMENDATION .....	55
<b>REFERENCES.....</b>	<b>58</b>
<b>ANNEX 1 .....</b>	<b>63</b>
<b>ANNEX 2 .....</b>	<b>64</b>
<b>ANNEX 3 .....</b>	<b>65</b>
<b>ANNEX 4 .....</b>	<b>66</b>

## List of Table

Table 1: Public health adaptation measure in relation to health impacts of climate change .....	7
Table 2 Essential services of public health, with climate change examples.....	11
Table 3: Analogue and predictive model for health and climate study .....	12
Table 4 The reflection of climate and health issue on the government policies.....	17
Table 5 Regression analysis of climatic factors with diarrhea and malaria of Terai Region .....	43
Table 6: Regression analysis of climatic factors with diarrhea and malaria of Hill Region .....	45
Table 7: Regression analysis of climatic factors with diarrhea and malaria of mountain region.....	48

## List of Figure

Figure 1: Yearly distribution of diarrhea and malaria disease in terai region .....	40
Figure 2 Yearly distribution of malaria and temperature trend analysis .....	41
Figure 3: Trend analysis of malaria with max and min temperature.....	41
Figure 4 Trend analysis of diarrhea and total rainfall.....	42
Figure 5: Trend Analysis of disease pattern .....	43
Figure 6: Trend Analysis of climatic data .....	44
Figure 7: Trend analysis of malaria and temperature .....	44
Figure 8: Trend analysis of diarrhea and total rainfall .....	45
Figure 9: Trend Analysis of Disease pattern .....	46
Figure 10: Trend Analysis of Climatic Conditions .....	47
Figure 11: Trend analysis of malaria and temperature pattern.....	47
Figure 12: Trend Analysis of Diarrhoea and Rainfall .....	48

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Climate change is a current global concern, which is near unanimous scientific consensus. Human activities have been defined as the responsible factors for rising atmospheric concentration of greenhouse gases. The average global temperature is projected to increase between 1.4 and 5.8 °C by the end of this century (IPCC, 2001). These facts suggest that climate is changing, and is widely showing varying impacts on human health. The trends of mortality and morbidity are in increasing order due to heatstroke, cold, drought or storms and other environmental disaster. The major climatic vulnerability and relative risk has been listed out mostly in developing country rather than developed country (IPCC, 2001). Hypothermia, hyperthermia, death, injuries, psychological stress has well-thought out the direct health impact of climate change-extreme weather and climate induced disaster. And chronic effect of climate change on human may have indirect health impact like, cardio-respiratory disorder, malnutrition, vector borne diseases, diarrheal diseases and psychological diseases (Jonathan et al, 2005). There is broad consensus that climate changes can affect human health. The IPCC fourth assessment report concludes that climate change currently contributes to the global burden of disease and premature deaths. At this early stage the effects are small, but are projected to progressively increase in all countries and regions (IPCC 2007).

Nepal is one of the most climate sensitive Himalayan countries, though it has negligible emission of greenhouse gases that are climate susceptible. The prevalence of respiratory disorder, diarrheal disease and other vector borne diseases are increasing in Nepal. The reasons behind it are poor sanitation, hygiene and air pollutants exceeding the national ambient air quality standards and poor quality of water (Dhimal et.al, 2009). More than 3.4 million people do not have enough food to eat and some 28,000 children under five die each year from easily preventable illnesses. Women, children and underprivileged population, mainly in the Mid- and Far-Western hill and mountain regions are likely to be

suffered from food deficit than remaining part of country (NHT, 2010). The sufferings of food- insecurity or decline in agricultural food production are due to floods, droughts and irregular precipitation, which are the end consequences of climate change (Malla, 2008). The health impacts of climate change in the context of Nepal are noticeable. However, studies on health impacts of climate change in Nepal are limited. This study aims to explore the effects of climate change on diarrhoeal and vector borne diseases using qualitative information from health professionals and community people and analyzing past data of diarrheal diseases and malaria.

Scientists have showed that climate change has direct influenced on incidence of diarrheal diseases. An approximate effect of climate change on diarrheal diseases for developing countries is available from global burden of diseases assessment which are based on two available time series analysis. The analysis using available daily data from Lima, Peru showed that pediatric hospitalizations for diarrhea increased by 8% for every 1 degree Celsius increase in temperature (average across all seasons) (Checkley et.al 2000). The analysis of monthly data from Fiji showed that diarrhea notifications increased by approximately 3% per 1 degree Celsius increase in temperature. WHO suggest that in developing countries, diarrhea incidence will increase by approximately 5% per increase in 1 degree Celsius temperature (Campbell et.al 2007). However, such studies are not available in the context of Nepal.

The study conducted in African highland showed that, an elevated region that once was free from malaria because mosquitoes could not live in colder temperatures are now endemic to malaria because of increasing temperature. When temperature increase just a little bit, the mosquitoes larvae mature faster, they take more blood meals, and inside the mosquitoes, the parasites develop faster and chance of local transmission of malaria cases if imported cases are introduced. However; such studies are not conducted in Nepal. In order to explore this situation in the context of Nepal and formulate the specific research plan for future, this study focusing on diarrhea and malaria is carried out.

## **1.2 Objectives**

The general objective of this study was to identify the public health problems resulting from climate change and preparation of guidelines for its prevention in Nepal.

The specific objectives are as follows

- To explore the effect of climate change in health in different climatological regions especially on vector borne and water borne diseases
- To assess the relationship between climatic factors and health effect specially malaria and diarrhea in different climatological region of Nepal
- To review the policies of Government of Nepal regarding agriculture, water, sanitation, shelter, transport and energy with respect to climate change and human health and
- To develop guidelines for good practices to protect human health from climate change

## **1.3 Rationale of research study**

There are challenges and opportunities for the identification of climate sensitive diseases to human health in Nepal. The human population has adjusted in the different altitudinal microclimatic variation and developed social adaptive practice to be safe from hazards. The opportunity is to achieve the profound knowledge in health related research due to climate change. The research on the present social environment may be helpful for generating the knowledge and ideal practice to cope with adverse situation, though there is tremendous amount of challenge. The prevalence of diseases and other threats to human health depend largely on local climate. Climatic parameter like extreme temperature and precipitation can lead directly to loss of life as well as it can increase air, water, and land pollution. The vectors of diseases such as malaria, dengue and other few insects have been found at high elevated land which were previously not recorded in that area. The vector borne disease like malaria, dengue fever, yellow fever, and encephalitis may be increased in additional place where its causative agent did not exist before. The water borne diseases such as cholera and diarrhea outbreak has appeared frequently in

every year. The dengue outbreak in central Nepal and cholera outbreak in mid-western and far western Nepal may be the current examples. The vector borne diseases like dengue, Japanese encephalitis and malaria, that were prevalent only in terai region are now being seen in mid hilly region as well which is the most alarming situation for the Nepalese health system (Dhimal et al.,2009). And main cause for it may be the source of drinking water which is also drying out in every new coming year. The ultimate effect of it may loss in sanitation practice, which is a causative source for health hazards. These effects may be raised due to change in pattern of seasonal precipitation. There are very few numbers of researches conducted on impact of climate change on the public health in Nepal. The information on human health and climate change could not be representative for national scenario and are also in fragmented form. There is need for their compilation and collection of primary information from related field (such as vector borne disease, water pollution and sanitation related diseases,) at local level. This information and knowledge can be useful for preparation of guidelines for prevention of health impacts from climate change, and fulfill information gap between local government and policy level. While developing National Adaptation Plan of Action (NAPA), transect walk survey was conducted in Koshi, Gandaki and Karnali river basins and has collected few information regarding public health impacts of climate change. In order to fulfill above mentioned statement and further study the health impacts of climate change in different climatologically diverse zones, Nepal Health Research Council conducted research entitled “Identification of public health problem results from climate change and preparation of guidelines for its prevention in Nepal” with the support of WHO Country Office, Nepal.

#### **1.4 Limitations of the Study**

The data were not collected from the community level. The data were collected from the district headquarter level only. Water quality analysis was not carried out to assess its status and the source of water availability was also not observed. Study is based only on the qualitative information and the retrospective data analysis. Vector survey was also not conducted. Health facility as well as climate data that were available was not complete

and could not make retrospective analysis even of ten years time duration. Study could not assess the scenario up to the grass root level health facility. Grassroot level health facility data in relation to altitudinal variation was not incorporated. Study could not cover all the development region of the country. Socio-economic and demographic data are not incorporated in the study. There may be plenty of confounding variables that were not assessed in the study. Because of these limitations, this study just gives the snapshots of existing situation of climate change and health in Nepal and will provide the basis for future studies as well as program planning.

### **1.5 Reviewed National and International Journal Articles**

The major reviewed articles on climate change and diarrheal and vector borne diseases is summarized below.

The climatic vulnerability to people living in small islands and coastal areas of Indonesia is due to the rise in sea level where there is high expansion of the vector-borne diseases, particularly malaria and dengue, and the increased water borne disease like diarrhea. A huge number of populations are suffering from the protein energy malnutrition (Menne, Ebi KL & eds, 2005). And some adaptation practices-community health promotion, relocating populations, surveillance, prevention, and preparation for communicable disease control and health workforce training have been developed (Wirawan, 2010).

Roland has concluded that the incidence of many vector-borne diseases is associated with extreme weather events and annual changes in weather conditions. The factors responsible for the emergence/reemergence of vector-borne diseases are complex and mutually influence each other. The incidence and spread of parasites and arboviruses are affected by insecticide and drug resistance, deforestation, irrigation systems and dams, changes in public health policy, demographic changes, and societal changes (Roland, 2004).

Literature review study of Medline, biological abstract and environmental abstract and analysis of MIMS was carried out to examine the impact of climate change on medications and human health. This study shows that climate change associated with



medication related health impacts through determination of storage conditions, increased heat stress from medication induced heat intolerance and by influencing pharmacokinetics. In addition UV radiation from stratospheric ozone depletion may increase the significance of medications that can lead to an increased sensitivity to the damaging effects of UV radiation. (Beggs, 2000).

The effects of climate change is negative to human health and the impact is likely to be most on low-income countries where capacity to adapt is weakest, but also on the most vulnerable groups in developed countries. World Health Organization has developed adaptation strategies, including (1) the variation of appropriateness and effectiveness of adaptation options by region and across demographic groups; (2) how to exploit opportunities, as well as to reduce risks; (3) the cost of adaptation and the potential to exacerbate climate change (e.g., extensive use of air conditioning); (4) the need for adaptation to multiple factors, including climate change; (5) the systemic nature of climate impacts that means that many sectors will need to be involved to reduce public-health impacts; and (6) maladaptation—i.e., policies that increase vulnerability to climate change can result in serious negative effects. In addition, simultaneous-equal importance should be provided in the mitigation practice, in which climate change is mitigated by reducing the use of fossil fuels and increasing the use of a number of renewable energy technologies should improve health in the near term by reducing exposure to air pollution (Howard et al, 2008); (Menne, Ebi, & eds. 2005); (Samuel, & Joel 1999); & (Haines et al, 2006).

Haines et al., (2006) has reviewed international article and concluded that climate changes caused annually over 150,000 deaths and five million disability-adjusted life-years (DALY), because of infectious diseases, diarrheal disease and others, mainly in developing countries than developed. They developed adaptation measure through reviewing the reliable evidence based information which is outlined below.

**Table 1: Public health adaptation measure in relation to health impacts of climate change**

Health Outcome	Public health	Surveillance
Mortality and morbidity due to heat waves	Public health education Health warning system. Emergency preparedness.	Enhance health surveillance of routine data for early detection of heat wave effects (e.g. monitoring from funeral homes, calls to NHS direct).
Floods	Public health education, boil water notices. Emergency preparedness. Checklist for post-flood activities.	Surveillance for flood effects, with long-term follow-up. Coordinated national surveillance for flood deaths, injuries and illnesses.
Air quality Vector-borne diseases	Warnings for high pollution days. Public health education	Daily air pollution measurements. Monitoring of vectors, and reservoir hosts, integrated surveillance for human and animal diseases.
Food borne disease	Maintenance and strengthening of food hygiene measures.	Integrated surveillance for human and animal diseases.
Water-borne diseases	Risk assessment for extreme rainfall events. Risk assessment of health effects of algal blooms.	Increased microbiological monitoring of public water supplies and private wells, and enhanced surveillance during and following heavy rainfall events.

Source: Haines et al, 2006.

Transmission of infectious disease is determined by many factors, including extrinsic social, economic, climatic, and ecological conditions, and intrinsic human immunity, as major cause for it is sensitive to climate. Proliferation of salmonella and cholera bacteria

is more rapid at higher temperatures, salmonella in animal gut and food, cholera in water. Short-term climatic variations have found positive association with occurrence of infectious diseases like malaria outbreaks and dengue fever outbreaks in south Asia and South America (Venezuela and Columbia) (McMichael et al, 2006).

Scientific committee has predicted that by 2030 there will be 10% more diarrheal diseases and serious impact on health of young children below five years. If global temperatures increase by 2 to 3°C, as expected, it is estimated that the population at risk for malaria will increase by 3 to 5%, which means that millions of additional people would probably become infected with malaria each year. The technical committee on global climate change has recommended the researcher for required additional research on the ecology and epidemiology of infectious diseases that will probably be affected by climate change. One of the goals of research on climate change should be the development of early warning systems to help populations prepare for impending epidemics (Shuman et al, 2010).

Deforestation and climatic volatility are particularly potent combinations for creating conducive environment to disease emergence and spreading. The ranges of infectious diseases and vectors are changing in altitude, and resurgence among humans, wildlife, livestock, crops, forests and marine life have been found however, snail's population; the intermediate hosts for schistosomiasis, has revealed reduction in some regions of the United States, which may be due to high temperature. Winter mortality has been expected to decline in the Northern Hemisphere from respiratory disease because of reducing combustion of wood. And recorded extreme weather events have been believed to create conducive environment for additional cluster of insect, rodent-and water-borne diseases in additional part of country, where, it was not expected previously (Epstein, 2001).

Scientific committee of India has concluded, climate change has become a major issue for public health because of unpredicted environmental calamities which are directly influenced by it. National health profile of India has reported the heat events have been increasing in the last decade, mainly in Andhra Pradesh, Orissa, and Kashmir. In Andhra Pradesh more than 1421 death occurred by heat wave in 2003, which is an all-time high in the history of Andhra Pradesh. A lack of water and poor water quality can compromise hygiene and health. This increases the risk of diarrhea, which kills approximately 1.8 million people every year, as well as trachoma (an eye infection that can lead to blindness) and other illnesses. Both floods and droughts increase the risk of diarrheal diseases, and more than 577,000 disability-adjusted life years were lost due to malaria and dengue. Malnutrition causes millions of deaths each year, from both a lack of sufficient nutrients to sustain life and a resulting vulnerability to infectious diseases such as malaria, diarrhea, and respiratory illnesses. There is historical evidence of associations between climatic conditions and vector-borne diseases (Majra & Gur, 2009).

Variations in environmental conditions, especially climatic parameters, affect the dengue viruses and their principal mosquito vector, *Aedes aegypti*. A numerical model to simulate the response of *Aedes aegypti* was observed to see the climatic variations from 1958 to 1995 and to examine how modeled *Aedes aegypti* populations may be related to dengue and DHF cases worldwide. The model is driven by precipitation, temperature, relative humidity and solar radiation (input) to describe the effects of global-scale climatic conditions on *Aedes aegypti* abundances (output). The finding showed variations in climate can induce large variations in Modeled *Aedes aegypti* populations at the global scale. These climate-induced variations in Modeled *Aedes aegypti* populations was strongly correlated to reported historical dengue/DHF cases, especially in Central America and Southeast Asia. In Honduras, Nicaragua and Thailand, disease incidence and the Modeled mosquito densities were found to be significantly correlated (P, 0.05 for each) (Hopp & Foley, 2003, PATZ & OLSON, 2006).

Indian government has developed the adaptation strategies to face the public health impact of climate change. The government decided the traditional knowledge needs to be

integrated with the upcoming modern technology based solutions in order to arrive to a solution for adaptation strategies. While developing/building capacity of community for their livelihood enhancement/security, it should be ensured that it is ecologically sound. The governmental and non governmental organizations as well as responsible stakeholder with intellectual responsible body need to be considered, who is responsible? Who is affected? Who should act? What is to be done? (WHO & ADB, 2009).

Children are particularly vulnerable to the health risks of climate change because of their potentially greater exposures to changing temperature and precipitation patterns. Clinicians need to insist that disaster preparedness and response planning take into account the special needs of children. And health policy makers realized the critical roles to clinicians to play in avoiding, preparing for, and effectively responding to the health risks of current and future climate change. Therefore, American Academy of Pediatrics published the following policy statement with technical report to make pediatricians aware of climate change. 1) Educate themselves about the links between child health and climate change. 2) Educate families about lifestyle changes that may mitigate climate change. 3) Advocate for comprehensive local and national policies addressing climate change. 4) Educate elected officials and others who are in the health risks. 5) Initiatives that promote to reduce greenhouse gas emissions and develop the practice to encourage environmental sustainability both personally and professionally. 6) Build and support coalitions to develop comprehensive approaches to mitigate and adapt to climate change. 7) Strengthen public health infrastructure, disease surveillance and reporting, and disaster preparedness. 8) Work to ensure that concepts related to the pediatric health implications of climate change are part of pediatric training and curricula (Kristie, Ebi & Paulson, 2010).

It has been considered that the potential health effects of climate change have been extensively increasing, therefore, well-established principles point to a vigorous, proactive public health approach to climate change has required. One such principle is prevention, which is categorized as primary, secondary and tertiary based on the essential

public health services as in given table, developed by the American Public Health Association in 1994 (Howard et al, 2008) & (Longstreth, 1999).

**Table 2 Essential services of public health, with climate change examples**

Service	Climate Change Example
Monitor health status to identify and solve community health problems	Tracking of diseases and trends related to climate change
Diagnose and investigate health problems and health hazards in the community.	Investigation of infectious water-, food-, and vector-borne disease outbreaks
Inform, educate, and empower people about health issues.	Informing the public and policymakers about health impacts of climate change
Mobilize community partnerships and action to identify and solve health problems.	Public health partnerships with industry, other professional groups, faith community, and others, to craft and implement solutions
Develop policies and plans that support individual and community health efforts.	Municipal heat-wave preparedness plans
Enforce laws and regulations that protect health and ensure safety.	(Little role for public health)
Link people to needed personal health services and ensure the provision of health care when otherwise unavailable.	Health care service provision following disasters
Ensure competent public and personal health care workforce.	Training of health care providers on health aspects of climate change

Evaluate effectiveness, accessibility, and quality of personal and population-based health services.	Program assessment of preparedness efforts such as heat-wave plans
Research for new insights and innovative solutions to health problems.	Research on health effects of climate change, including innovative techniques such as modeling, and research on optimal adaptation strategies

Source: Howard et al, 2008.

The above researches have concluded that research into the health impacts of climate change is still at an early stage elsewhere. McMichael et al., (2000), have developed analogue and predictive model for the quantitative estimation of health impacts of future climatic change. A brief description of analogue and predictive model has listed as shown in table.

**Table 3: Analogue and predictive model for health and climate study**

Analogue studies	Empirical/statistical	Analogue of a warming trend. E.g. increased malaria in highland region correlated with a local trend in warming. Analogue of extreme events. E.g. assessment of the mortality impact of a heat wave. Description of basic or recurrent climate/health relationships. E.g. interannual variation in malaria correlated with minimum seasonal temperature using time series data.
Predictive models	Empirical-statistical models	Extrapolation of simple climate/disease relationship using univariate regression, e.g. daily temperature and mortality. Extrapolation of climate/vector/disease

		relationship using mapping and statistical methods for use with spatially correlated data. E.g. mapping tick abundance with climate and other variables.
	Process-based or biological models	Models derived from accepted theory can be applied universally. E.g. forecasting changes in areas suitable for vector-borne disease transmission using a vectorial capacity model.
	Integrated assessment models	Multidisciplinary process-based and/or empirical-statistical models linked together horizontally or vertically. E.g. impact of climate change on food supply and risk of hunger.

Source: (McMichael and Kovats, 2000; World Health Organization, 2003)



## **CHAPTER 2**

### **METHODOLOGY**

#### **2.1 Formation of Study Team**

The multidisciplinary team consisting of environmental health expert, public health expert, epidemiologist, meteorologist, environmental engineer and statistician were formed. The interdisciplinary team held series of meeting to develop the concepts and collected the relevant data.

#### **2.2 Literature Reviews**

The literature reviews included the review of national and international journals articles, as well as review of government policies on water, sanitation, health, agriculture and energy sectors.

##### **2.2.1 National and International Journal Articles**

The relevant literature on climate change and public health was assessed through international and national journal (Medline) and other concern organization's websites such as World Health Organization (WHO), Intergovernmental Panel on Climate Change (IPCC), and relevant national concerned bodies. We collected more than fifteen published international article on health impact of climate change. While reviewing the articles, we were specific on vector borne and diarrheal diseases. More than ninety percent were review articles and few articles were original article which had incorporated time series analysis of climatic data and the health effects over a long period of time.

##### **2.2.2 Review of Government of Nepal Policies**

We collected the published Nepal government policies, acts/rule, guideline, standards and permissible limit through related ministry, department, and autonomous bodies of government. Then, experts of related field and research assistants have systematically reviewed these policies with respect to climate change and public health. The reviewed government's documents include materials related to agriculture, water, sanitation, shelter, health, environment and transport and energy sector.

### **2.3 Site Selection for Field study and its Justification**

Three major cross-sections including Eastern, Central and Far-Western Development region of Nepal was selected for the study. From each cross-section, three districts representing from terai, hill and mountain were selected. The selected districts include Morang, Dhankuta and Sankhuwasabha from eastern development region, Chitwan, Dhading, Nuwakot and Rasuwa from central development region and Kailali, Doti, and Bajhang from Far-Western development region of Nepal. The district represents all the ecological regions of Nepal and major administrative zones of Nepal.

### **2.4 Study Design**

Both the qualitative and quantitative methods were used in this study. The health facility data of diarrheal and vector borne diseases were collected from each health facility of last five to ten years depending on availability of data using standard format and were analyzed using time series retrospective analysis. The climatic data were collected from Department of Hydrology and Meteorology, Ministry of Environment, Government of Nepal. For exploring the health effects resulting from climate change, in-depth interview with key informants and focus group discussion were conducted with community people, health worker, female community health volunteers and teacher and generated data were analyzed using qualitative methods. The qualitative data analysis protocol was adapted for systematic analysis as prescribed by Catherine et al 2000.

### **2.5 Study type:**

This study was descriptive study.

### **2.6 Data collection tools and techniques:**

Key informants interview guideline and Focal Group Discussion guideline were used for collection of qualitative data. Standard format was used to compile secondary data of diarrheal and vector borne diseases. The diarrhea and malaria monthly data were collected both from health facility and HMIS, section, Management Division, DOHS. The research participants of this study includes District Health/Public Health Officers, Malaria Inspectors, Diarrhoeal

Diseases program officers, paramedics, districts water supply and sanitation supply engineer, NGO/ INGOs representative working in the district, community leaders, community people, female community health volunteers etc., The research participants were purposively selected for the study based on convenient and expert judgment.

### **2.7 Data entry and analysis:**

The climatic data temperature and precipitation as well as diseases data were entered in excel sheet systematically and were analyzed in SPSS 13 version. Two districts from each region were averaged for the time series analysis having same geographical orientation. Monthly data of all districts could not be collected and analysis was done only of six districts.

### **2.8 Guideline preparation:**

Guidelines are prepared based on the finding of present study as well as other national and international relevant reference study.

## CHAPTER 3

### FINDINGS

#### 3.1 Review of Government Policies

There were not any specific policy on climate and health in Nepal. However, attempt has been made to review the provisions in policies of different sectors such as energy, water, sanitation, agriculture which has implication for climate change and health directly and indirectly. The table 4 reflects the major findings of policies reviewed.

Table 4 The reflection of climate and health issue on the government policies

S N	Policies	Health aspects	Climate change aspects
1	Renewable Energy Subsidy Policy 2066 B.S (2009 A.D)	Policy is supportive for reduction of respiratory disorder like acute respiratory infection, acute lower respiratory infection, COPD and pulmonary tuberculosis.  Minimizing vector borne diseases and diarrheal diseases.  But there is no any provision in subsidy policy for disposal of waste product due to solar power plant, thermal power plant, and others.	Minimize the indoor air pollution in rural part of country.  Provision of subsidy may reduce the green house gases emission.

2	National Agro-diversity policy 2063 B.S (2006 A.D)	<p>Misutilization of biotechnical system in agriculture may reduce the agro-diversity, as result the problem of malnutrition and related health problem may rise.</p> <p>Biotechnology may encourage farmer to misconsumption of chemicals like pesticide and chemical fertilizer, though there is well provision of organic fertilizer and development of natural pest.</p>	Overutilization of pesticide and chemical fertilizer on soil and additional change on species may alter natural ecology and microclimate.
3	National agricultural policy 2061 B.S (2004 A.D)	<p>Overutilization of pesticide and chemical fertilizer on soil and agricultural products may affect human health through biomagnifications and bioaccumulation. There is lack of mitigation strategy on policy in the misuse of Chemical fertilizer and pesticide in agricultural land that will create conducive situation for respiratory disorder, skin diseases, vector borne diseases, and water borne diseases.</p>	Misuse of chemical fertilizer and pesticide can alter microclimate of soil, air and water. Later this issue may become global climate concern with gradual cumulative effects.
5	Commercial Agricultural promotional policy 2064 B.S (2007 A.D)	<p>Depletion of species diversity with retardation of medicinal plants and herbs may bring various health hazards like malnutrition, respiratory disorders etc.</p> <p>Rapid commercialization of agriculture system may need to use more and more chemical like heavy metal, hydrocarbon, and other compounds for operating instruments emitting these compounds. The emitted hydro compound and heavy metal may be hazardous for public health.</p>	Subsidy may be exciting the farmer to import instrument, like tractor, thrasher refrigerator harvester and other equipments which may emit more green house gases
6	National Tea Policy 2057 B.S	Continuous unscientific addition of pesticide and chemical fertilizer on agricultural land of tea farming can	Application of advance instrument, pesticide, chemical fertilizer in the tea

	(2000 A.D)	degrade aquatic ecosystem, agricultural biodiversity can cause loss of indigenous crops. This ultimately result in both acute and chronic human health hazards like gastro-intestinal disorders, cancers, skin diseases through biomagnifications and other respiratory disorder and, other vector borne disease, though government has committed for good provision of health facility to communities around tea farming area	estate that may produce intolerable pollution like green gases, land pollution and air pollution.
7	National coffee policy 2060 B.S (2003 A.D)	There is good provision in policy for providing health facility to local people involve in coffee farming.  The problem of malnutrition will rise if higher priority is given only to the coffee farming.	There is high chance for land degradation, water pollution and increase in air pollution due to unskilled human resource and unscientific practice for cultivation, purification, distribution of coffee.
8	National milk policy 2064 B.S (2007 A.D)	Development of the services on animal health and diseases control.  Occupational health hazards such as zoonotic diseases may occur.	Policy has emphasized to promote industry for manufacturing of medicine, dairy institute, and rural road construction. This type of activities may play a vital role in climate change.
9	National seed germination policy 2056 B.S (1999 A.D)	Promotion of tissue culture may lead to the extinction of biodiversity, can modify species thus increasing the chance of malnutrition.	Policy is focused on developing climate change resistance seed through biotechnology thus enhancing the better offseason crop production.
10	National Fertilizer policy 2058 B.S (2001 A.D)	Misutilization of chemical fertilizer and pesticides may be Carcinogenic.	Emission of GHGs from chemical fertilizer

11	National Irrigation policy, 2067 B.S (2010 A.D)	Malnutrition can be minimized through sustainable agricultural production practice.	High extraction of groundwater and trans-basin system may create the problem of desertification, alternation in freshwater ecosystem.
12	Rural Energy Policy, 2063 B.S (2006 A.D)	Eco-health approach can exist in nature if alternative energy practice is well developed. It reduces respiratory disorder and other relevant diseases.  Vector borne diseases may appear due to dam construction for hydropower	Reduction in the emission of green house gases and indoor air pollution.  Microclimate may change and local agricultural practice may alter locally available food resources.
13	Biotechnology Policy 2063 B.S (2006 A.D)	Improper utilization of biotechnological process may be supportive for communicable diseases, vector borne and nutrition deficiency diseases.	Technology like embryo transfer, gene transformation may reduce the genetic biodiversity; it may also reduce tolerating capacity of species to environment.
14	National Shelter Policy 1996 B.S (1942 A.D)	Policy has encouraged the establishment of housing and land development companies through the joint participation of Nepal government with private sector companies. Unmanaged shelter construction can create climate change that will be conducive for climate sensitive diseases.	Construction of apartment for fulfilling the increasing shelter demand in urban area without conducting environmental impact assessment may cause environmental degradation
15	Urban sanitation and drinking water policy- 2066 B.S ( 2009 A.D)	Long time extraction of groundwater may degrade groundwater reservoirs, causing various health hazards like arsenicosis, gastro-intestinal and skin diseases.	Regular extraction of groundwater to fulfill demand of drinking water may create the problem of land subsistence and change in local climate.

16	National Urban policy 2064 B.S (2007 A.D)	The promotion of industrial infrastructure can produce high concentration of waste and gases in urban areas. There is no any well specific provision for control and management of urban waste, which has become a serious cumulative health hazard in big cities of Nepal. Unsustainable sewerage production and heat emission by concrete building in urbanized area may increase the adverse health impact like vector and water borne disease because of favorable breeding environment for vectors and other infectious agent.	There is lack of mitigation practice for minimizing greenhouse gases producing industry in urban area. Absence of well advanced technology promotion in industrial area, it may create hydrocarbon pollution as well as acid rain hence disturb the hydrological cycle. Therefore there is need of active implementation of alternative practice.
17	Rural Water Supply and Sanitation National Policy 2061 B.S (2004 A.D)	Public awareness, health education and sanitation activities will be conducted together with water supplying and sanitation programme  Reduce water borne diseases and its victims in the nation	Can contribute to reduce the health impacts of climate change on diarrheal diseases.

Nepal Government has prepared the National Adaptation Programme of Action (NAPA) for protecting the vulnerable sectors from climate change. The identified adaptation programs on public health are as follows (GON 2010).

- reducing public health impacts of climate change through evidence based research and piloting,
- empowering communities through public education for responding adverse effects of climate change on public health,
- investigating diseases outbreak and emergency response,
- Scaling up program on vector borne, water and food borne diseases and disasters



- strengthening early forecasting/ warning and surveillance system on climate change and public health.

The identified adaptation projects on other thematic areas in NAPA other than that in Public Health are also equally important to public health because health is the cross-cutting issue and has co-benefits from the works of other sector like water and sanitation, nutrition, disaster response, protection of aromatic plants, urban environment improvement. For example, rainwater harvesting identified by the water and energy group as a community –based adaptation option also increase domestic water supply and improve sanitation, early warning system identified by the climate induced disasters reduce human injury and deaths, agricultural diversification that increase food availability as well as livelihood options, all contribute to ensuring nutrition and well –being.

At national level water supply coverage is 80.4 percent and water sanitation coverage is only 43 percent. There is variation in sanitation and water supply coverage in different study districts with more than 70 percent of population having water supply coverage but only less than 50 percent have water sanitation coverage in average. Like of climatic and diseases data, It could not it could not be found the monthly and yearly data of water supply and sanitation coverage of districts and could not be included in time series analysis.

### **3.2 Findings from Qualitative Study**

#### **3.2.1 Focus Group Discussion with District Public Health Office Staffs- Dhangadi, Kailali**

With the discussion and consultation with the district health staff, it was identified that the climate change has become a major environmental factor for diseases transmission. In case of Kailali district, Skin Diseases, Acute Respiratory Infection (ARI) including other infectious diseases like Malaria and Diarrhea are among top ten diseases. They also feel that the vector and water borne diseases are also increasing. The number of mosquitoes is rising every year. Mosquitoes did not use to trouble in autumn but now they are found even in the month of September/October. It means there is perennial distribution of mosquitoes.

*"Earlier the number of mosquitoes used to get reduced by the end of September or the beginning of October. But these days they are observed even in the month of Mangsir (December) and Poush (January). It seems the effect of climate change is in rise and the expert and researcher could put this more accurately. While comparing the present changing scenario with the respect to the past years we feel that the effect of climate change is happening. However it needs to be scientifically proven. Government needs to form a unit at the local agency to conduct study and research on the effects of climate change and other environmental parameter at the local level and navigate the findings to the national level"*

**- Acting District Health Officer, Kailali.**

The risk for the outbreak of diarrheal diseases has rampantly gone up from few previous years and is more difficult for the health institutions to control. Cases of diarrheal disease have mostly been affected by flood, landslide and water sanitation facilities. The local newspaper has also reported the increase in the number of diarrheal cases in the flood hit area of western part of the district last year. In the same year some of the VDCs in the hilly part of the district were also affected by landslide. There was big loss of property and human lives in *Pangdone* VDC among those. It was heard that there was high scarcity of drinking water as well as river water in those VDCs during that period. Source of drinking water that is mainly formed by river and stone spout has dried out during dry season and underground water level has also decreased in certain part of the district.

### **3.2.2 Focus Group Discussion with community people: Dhangadi, Kailali**

According to community people malaria has gone down because of increasing awareness and anti-malarial vaccine, however number of mosquitoes has increased. Prevalence of diarrhea is mostly seen among low income generating people, where there is lack of sanitation facilities and drinking water, and in flood affected area.

*"It is felt that the temperature has also gone up these days. One cannot stand out for long in April/May due to extreme heat. The household surrounding gets heated from early morning and temperature is also rising day by day. Perhaps health post is seeing more skin diseases which can be related to the increased temperature as well to the lack of safe water. And the problem of uterine prolapse is also high. About 40 to 50 percent of women suffer from this. I don't know what its reason is. But I feel it may be the indirect consequence of climate change"*

**A female community health volunteer of Kailali**

### **3.2.3 Focus Group Discussion with NGO and other government line agencies in Kailali districts**

No any activities have been conducted within district for climate change adaptation by governmental and non- governmental line agencies. Every organization stressed that there is lack of skilled human resource as well as sufficient fund to conduct program in this issue. None of them are actively functional to run the project concerning on climatic change adaptation and mitigation, however district alternative energy promotion unit has launched, climate adaptive activity like cooking stove-*laghu bidhyut* within certain villages and Care Nepal assist the affected population on emergency period like post flood.

*"Our unit has been conducting programs focusing on mitigation rather than adaptation to cope up the effect of climate change such as use of improved stove "ghatta" and other alternative energy sources. Our unit is also spreading the awareness on adequate tree plantation in every "ghatta" with the intention of saving jungles. We came up with this thought because we need to cut a tree every year to run "ghatta". If we go on cutting a tree every year without replacing it with new plantation there will be lower possibilities of protecting trees which could result in flood, landslides and eventually the loss of lives and property".*

**-Officer of District Alternative Energy Promotion Unit Kailali, District**

### **3.2.4 Focus Group Discussion with District Public Health Office Staffs - Doti**

Diarrhea, ARI, acute gastritis, skin diseases are listed as health hazards most prone to people within the district. Diarrheal cases are increasing compared to last year. However the severity due to diarrhea has decreased though the incidence of the disease has been increased due to timely management of cases.

*We cannot say that all the health related states/events and the epidemic of the disease is related to climate change. For instance diarrhea could result due to stale food, poor sanitation and lack of awareness which combine to give virus, bacteria and parasites favorable environment for transmitting disease but climate change could have big role in vector distribution. Therefore, it is difficult to give statement without evidence. Behind any epidemic there could be various environmental factors hidden. But we need to identify the real fact. So, NHRC needs to form research unit in every DHO in which environment health research should also get priority. In this way research activities needs to be organized. –District Public Health Officer, Doti*

### **3.2.5 Focus Group Discussion with community people, governmental and non government line agencies in Doti, District**

The pattern of rainfall and snowfall has changed with respect to time. High altitudinal mountain areas are now changing into bare rock, which used to be covered with sufficient snow and glacier in previous years. Sources of water in most of the places have dried up. The incidence of natural calamities is high in districts of northern region and the risk of flood and landslide is also very high. Agriculture is also affected in last 1-2 years among other areas. Agricultural products are decreasing which poses threat on the availability of food stuffs. Problem of food is being sharper day by day. Radhachaur a species of Paddies is not being cultivated nowadays. Such problems are rising day by day. Probably, these are the effects of climate change. There is an urgent need of adaptation programs to cope with above condition. Plantation programs need to be expanded up to school level. We need to evolve a society for declaring open defecation area. There needs to be coordination among INGO and NGO working in related areas to conduct programs on climate change in community level

### **3.2.6 Focus Group Discussion with District Public Health Office Staffs in Bajhang**

The diarrheal disease is major burden of district. Epidemic of diarrhea was seen in the previous year when there was high morbidity and mortality but this year the number of diarrheal cases has been reduced because of major priority area of interventions given to diarrhea however the problem of diarrhea is still the same. There is increasing lack of adequate water for drinking and other domestic purposes and also the hygiene and sanitation are poor which could lead to the chance of acquiring many infectious diseases.

*"Bajhang is considered as a low risk area for Malaria. P. falciparum is zero here. Central level target is set to collect 300 slides for malarial examinations and yearly 8 to 10 cases of p. vivax is seen in the district. Few cases of clinical malaria are seen. There is relatively low knowledge among health workers on malaria and also the disease surveillance is low. Mosquito's distributions are also increasing these days. The mosquitoes were only found in Dadeldhura district and in recent years it has been found in highland of Darchula. Now the occurrences of mosquitoes are shifting to higher altitudes and also seen in Bajhang in almost every VDC which were not the favorable environment for the mosquito to survive. Due to the increase in the number of mosquitoes nowadays almost all the people of this district use bed nets while sleeping" - Malaria Inspector, Bajhang District*

### **3.2.7 Focus Group Discussion with community people, governmental and non government line agencies**

Bajhang district has been facing problems of natural calamities in recent time. The fertile land is losing its productivity to some extent, resulting in food productions for less than 6 months. The frequent landslide has become common in every year. The density of forest is very thin within whole district and is changing into bare hills. Before ten years there was frequent occurrence of landslide in *Thalara* and *Chhanna* VDCs. Therefore government should be initiating the policy of one person one tree plantation but after the establishment of Khaptad National Park, the rate of landslides occurrence have declined. It rains timely and constantly. Snowfall used to occur throughout the autumn in Bajhang headquarters and high glacier in Saipal Mountain by the first

week of Magh, but now it is rare. It's extremely cold in winter and intolerable hot in summer bringing temperature extremes.

*We have toilet facilities in school which did not have before, however due to the lack of water there is no good hygiene around the toilet and school premises. There was sufficient source of water near around school site almost in all season but now sources are drying out except in rainy season. It takes around one hour to bring water for drinking purpose from source to school. Many school children even don't come to school because of lack of water in toilet that may be indirect effect of climate change. The problem is seen high among girls than boys and this even compels them to leave the school. Primary School Teacher of Bajhang, District*

### **3.2.8 In-depth interview with District Health Officer from Morang**

The extent of winter season is going colder and summer season hotter. Prevalence of diseases is heightening due to the change in climatic pattern. Trend of vector borne diseases shows increasing trend in higher altitude. Malaria cases in Morang district are decreasing but kalazar cases are increasing and also the probability of outbreak of vector borne diseases is high mainly due to recurring floods, heat stroke etc. Most of researches have been found to be quoting that the increased temperature may be significant factor for disease prevalence. But there is lack of sufficient environmental health research in Nepal for further clear operational expansion of the relationship between the increased prevalence of diseases and change in temperature. Though average temperature is increasing somehow in these days every year but temperature is not the sole reason for happening of each disease incidence. Also, there are some limitation in slide collection and examination of malaria in our health system.

Incidence of water borne diseases like typhoid, cholera and dysentery is in increasing trend even though more than sixty percent of the household population use toilet with adequate water resources. On the other side, poor community people perceive open defecation as easier as and less harmful than suffocated latrines.

Noise pollution and air pollution is in increasing order every year and associated diseases related to respiratory infection is also found to be alarming. Roads are unsafe which increase chance of

physical injury, acute respiratory infection, tuberculosis, asthma and chronic obstructive pulmonary disorders. This may be due to increase in air pollution concentration.

There is no line agencies, NGOs, INGOs to conduct the programs related to climate change. District health office has not ever conducted the program related to climate change. Although, there is sufficient budget in the environment sector but that is not being utilized in productive activity coordinating with health sector.

### A case study

I am seventy five years old. I have not heard about the term climate change till now. I have felt temperature is increasing every year. Rainfall duration has reduced and has been occurring in erratic form. In general all of the people do not have access to the water. I have enough land here nearby but no production at all due to inadequate water for irrigation. The agricultural production has significantly decreased due to low rainfall and other climatic unfavorable condition. In addition land broker have plotted the productive land into concrete land and they are insensitive for future. People will not get food to survive in near future by increased and unplanned urbanization and other changed climatic factors. There is shortage of food in some community. People who do not have access to agricultural do not have enough food crops to feed themselves. Municipality also does not focus on these problems because of weak governance.

Local people

Age: 75 years

Address: Itahari-3 Sunsari



### **A case study from Morang District**

Rainy season is not usual and natural. Erratic rainfall has been occurring. Kalazar is increasing more in summer season. It has thus reduced the immunity power of child and the old people. Diseases like ARI, diarrhea, Asthma, COPD has been increasing mostly among children and old people. Skin diseases are also the burden to the community. Rota viral infection rate has increased. Climate change may be the causal factor for increase in such mentioned health problems like diarrhea. There is drastic change in the food eating habit of the community; distribution of the mosquito and related diseases like kala-azar, malaria is increased. People's income generation activities have also decreased due to the extreme changes in the climatic events. The working capacity of the people has decreased due to severe heat and cold. On this ground there is drastic reduction in the agriculture; therefore people cannot afford the healthy diet.

In addition to it, water quality in this district is not fine and thus the probability of water borne disease epidemic is a highly challenging issue. Only less than 50% of the people are aware about climate change, study about its impact on health has not been conducted by any NGO/INGO. Air pollution has been increasing every day which is the main issue at present. The road is not safe and is narrow with increasing number of vehicle every year. There is somehow visible result seen in hygiene and sanitation and people are aware about the health hazards due to the open defecations.

Mitigation and Adaptation should be promoted like one person one plant concept. Plantation should be secure. Household should be made airy and well ventilated. Flood and landslide control should be addressed through bio-engineering and other alternative approach. Income generation activities in poor community should be promoted and pollution reduction technology should be developed. People prone to floods and landslide should have the access to the safer place and first-aid should be immediate given. Evacuation place should be identified.

Sanitation practice should be promoted in flood affected region to prevent the possible outbreak of the disease. Health's check up and medical diagnosis/distribution should be made on time through trained and skilled health workers.

**Medical Superintendent**

**Koshi Zonal Hospital, Biratnagar**

### **3.2. 9 Focus Group Discussion with District Health staff and other agencies at Dhankuta**

Climate change is showing a significant impact on public health. After analyzing the qualitative information of Dhankuta, it is observed that the seasonal occurrence of disease has shifted earlier than the general occurrence sequence. Lower altitudinal diseases are shifting towards higher altitude in these days. The number of mosquito has dramatically increased with comparison to previous year even in winter season. Some years back dengue, kalazar, JE were only found to be in border and terai region of the country but these days with change in the climatic events their occurrence has been shifting towards hilly region. The favorable environment for mosquito breeding is developing in hilly and mountainous region.

#### **A case study from Dhankuta District**

I am health assistant and working in malaria as well as diarrheal diseases section for many years. Mosquitoes are arising everywhere and its distribution is also rampant in higher altitude as well. Mosquitoes are increasing rapidly in almost 25 V.D.Cs of the districts. District health office Dhankuta has recorded five Malaria positive cases in this year. Out of five cases, four cases were indigenous and one has travel history from terai region. With this very panic scenario there is higher probability of malaria outbreak in our district. This also shows that we are in danger stage. I feel that morphology of the mosquito found in hilly area is similar to those found in the terai region. But, entomological study are not carried out to confirm the vector of diseases.

In terms of water borne disease, the severity of diarrhea has somehow decreased due to the greater focus on it from NGOs and public health offices but we cannot be safe from diarrhea. Typhoid is at peak among all other diseases. Its incidence is high with respect to diarrhea along with ARI cases at large number. Water source are scarce so that there is decrease in sufficiency and along with it there is poor quality of water distribution. However, water quality surveillance system has not in place.

**Health Assistant**

**District Health Office (DHO), Dhankuta**

There is higher probability of disease outbreak. Cholera, diarrhea has also the same scenario as related to malaria occurrence. Mental disorders related to meningitis due to the extreme heat are also rising every year.

### **3. 2.10 Interaction Meeting with District Public Health Office Staffs and Other line agencies in Sankhasuwa, District**

There has been vast difference in the weather pattern since few decades. Temperature is increasing and rainfall has been dramatically declined. Some years back snowfalls used to be seen from nearby places of khadbari but in these days it is hard to see snowcapped mountain in summer. Some years back, the environment was clean without any pollution but these days air pollution is increasing. Unmanaged transports and unplanned urbanization is the main reason behind it.

#### **A case study from Sankhuwasabha**

I know everything about the health status of this district. I have been staying here since 23 years back. If we analyze last 10 years data on vector borne disease, there is no malarial parasite. Few reported cases that are seen are imported from the people residing in terai and India.

Reported cases of malaria are not seen as outbreak because they are all imported and are being treated. District hospital has recorded their travel history in every case. Yes, climate change can have an impact to the human health. The working capacity of the people is decreasing, clean food and fresh air is not available now. Diarrhea is the major problem here because there is no water supply and water is not adequate at all. Water source is found almost everywhere but are not adequate to fulfill the need of human because some are dried out and others are at very long distance from human settlement so supply cannot be fulfilled.

**Public Health Officer**

Every family members of this district suffer from air pollution due to increased dust pollution. In addition massive building construction is the major factor for increasing pollution as well. So, development is also another hindrance for environmental sustainability. Environmental burden of health ailments such as skin diseases, diarrhea and pneumonia are major health problem though the severity of cases is reduced in comparison to previous years. Red Cross is only one organization that works in disaster related problem and health issues in this district. There is continuous program running in public health sector so climate change should also be included in the regular public health programs.

### **3.2.11 In-depth Interview with District Health Staff from Central Region**

Directly and indirectly, change in climate has huge impact on health. Untimely rainfall and unseasonal climatic variation has grossly affected the agriculture production. This will in long run may create food deficit and decrease in food production ultimately resulting in conditions such as malnutrition and other deficiency disorders. Vector borne diseases are alarming. The distribution of vector borne diseases is not only the reason of climate change but also transportation and other physical development activities as confounding factor for the distribution of other diseases. Water borne diseases are decreasing in order with respect to previous year. There is no any physio-chemical and biological contamination in drinking water and the quality of water in district is drinkable.

#### **A case study from Chitwan**

People are not fully adapting to the changing environment. Physical and mental sickness is alarming due to it. Increasing temperature creating favorable environment for vector breeding has challenged public health sector. Dengue outbreak occurred last year in Chitwan district. Favorable climate is the precursor for the vectors to complete their life cycle and produce diseases and the cases of dengue has dramatically increased since last year which were very few in numbers some years back. More than 400 cases of DHF have been recorded. Though the mortality was very less, morbidity was extremely high. We are expecting that the dengue outbreak may occur once again this year. Hospital staffs are often susceptible to mosquitoes bite and we even found two dengue positive cases among doctors who were senior consultants. Chitwan is malaria endemic district. Cerebral malaria is also endemic here which were few in number some years back. Rotaviral diarrhea is also found. Water availability is adequate and is of good quality so water borne diseases are not a big burden here. Relatively burden of vector borne diseases are higher than water borne.

**Pathologist**

**Bhartpur Central Hospital, Chitwan**

### **A case study from Dhading District**

I am working in health system of government for three years as a doctor. In this district, the patient flow is certainly increasing in district hospital and in medicals/private hospitals as well. Dhading is malaria endemic district though it is not high risk district but nowadays the prevalence of malaria is on increasing trend. Positive malaria is also arising along with large number of clinical malaria. Filariasis is one of the greatest burdens in the district. The vectors of filariasis were found earlier than the vectors of malaria. Mosquitoes are shifting to higher hills and Himalayas of Dhading. I heard that malaria is even reported from Himalayan region so there may be some sort of climate change impact in vector distribution that has been affecting health.

Enteric fever is major problem as well. Though diarrheal numbers are decreasing and its burden is low at present, we cannot avoid that we are free from diarrheal diseases. Due to geographical variation and extreme landscape, many people even do not have access to adequate water. Quite improvement in hygiene and sanitation of local community is seen in the district. People are aware and focused to maintain health and most of them use toilets.

Skin diseases may be slightly increasing but we cannot totally relate it to climate change. Diagnosis system/ intervention were weak in previous years so skin ailments were not seen but these days its occurrence is observed because of active case detection.

**Medical Superintendent  
Dhading District Hospital**

Climate change is happening and it is a matter of world wide concern. Climate change related disaster and other consequences have negative impact on health. Temperature is somehow increasing and erratic form of rainfall is occurring. There is no reduction in the total amount of rainfall but unseasonable and erratic type of rainfall is happening and associated health problems have been observed in Dhading and Nuwakot district. The favorable environment for arthropods/ parasites breeding has been created due to environmental changes.

### **A case study from Nuwakot District**

I have been working in this district since 1992. Temperature is obviously increasing and winter season is going cooler. Mosquitoes are seen largely before starting of the summer season and there is seasonal variation in occurrence of mosquitoes. Vector borne disease must be increasing but in our health system there are lots of problem, so we have not exact scientific reporting on slide collection and examination.

Numbers of diarrheal cases are in decreasing trend somehow than previous years. During fiscal year 051/052 there was huge problem to manage the diarrheal patient due to their large masses on hospital but these days their numbers are decreasing in OPD. The income generation capacity and educational status has improved than earlier time, this may be main reason for reduction in number of diarrheal cases. In addition, improvement on curative health system is another factor that minimizes the diarrheal diseases but typhoid cases are increasing than previous years. There is probability of Typhoid outbreak in Nuwakot district.

Water resources are decreasing and few are even drying out and obviously there is increasing need and demand of water to the people. Demand cannot be fulfilled from natural resource and supply water is also contaminated. Due to fungal infection, water borne illness may increase in district.

Pollution level is increasing and its effect is increasing every year. If we analyze the 10 years trend in food production, the quality of green vegetable and its taste has been lost and we cannot consume fresh vegetables. Use of pesticides/fertilizers has affected the productivity and health of the farmers and soil quality too has deteriorated. Such activity and natural change has brought direct and indirect effect to our ecosystem. Thus climate change has happened but its impact has not been assessed yet scientifically in term of its magnitude.

**Senior AHW**

**Nuwakot, District Health Office**

The snowfall pattern in Rasuwa district has changed with respect to previous years. Though it is a mountain district, the glacial covered land areas are now changed into rangeland. Water sources in most of the places are slowly decreasing. Agricultural production is in declining trend that may pose threat to the availability of food stuffs in following years. There is maximum

#### **A case study from Rasuwa District**

I am working here from two years ago. Rasuwa is malaria free district. All the change and hazards are not only due to climatic factor so there is no clear distinction between the health impacts due to the climate change. Vector borne disease is not seen in district. But in lowland area mosquitoes are seen. We can truly predict that mosquitoes are shifting towards higher altitude. Among the top ten diseases ARI, diarrhea and typhoid hit the list. The trend of diarrheal diseases is highly increasing. Last year we nearly had to encounter the outbreak of hepatitis C. Last year a research team had collected 49 water samples for analysis of water quality and research report has shown *coliform* positive in all cases. There is high chance of outbreak of water borne disease but Rasuwa being a mountainous district located at more than 2000m height from sea level, the breeding capacity of microorganism become negligible. Literacy rate, economy poor sanitation etc are the responsible factors for the outbreak of water borne diseases. People immediately do not visit health institution and the severity of the disease has shown a sign of alertness.

**Senior Public Health Officer**

**Rasuwa, District Health Office**

probability that the previously growing plants species may shift their altitudinal location. Diarrhea is major burden of district. Rasuwa is considered as a low risk area for Malaria. *Plasmodium falciparum* is zero here.

#### **3.2.12 Summary of Qualitative findings**

It is found that the impact related to climate change on public health vary from east to west as well as south to north and quite difficult to generalize in term of administrative region or ecological region because of the fact that Nepal has great micro climatic variation and our socioeconomic status is not also evenly distributed. However, the perception of health professionals and community people about climate change impact on public health is broadly grouped in following table.



**Table 5: Perception of the health professions and community people towards climate change and public health in Nepal**

Region	Mountain	Hill	Terai
Public Health Issues	<ul style="list-style-type: none"> <li>• Incidence of Diarrheal diseases has been increased and epidemic has occurred in past years in few districts.</li> <li>• The perceived factors are increasing shortage of water for drinking and domestic purposes, poor hygiene and sanitation</li> <li>• The region do not have indigenous malaria cases but imported cases are reported</li> <li>• The population density of mosquitoes is increasing and distribution of mosquitoes increasing in higher altitudes too but entomological study to confirm the diseases vector is not carried out.</li> <li>• It is notability known whether the prevalent mosquitoes diseases or not and local people have no knowledge of malaria and its transmission cycle</li> <li>• School have constructed toilets but no water available which has increased the absenteeism of adolescent girls in schools and have impact on their study as well as psychology.</li> <li>• Coliform Contamination in drinking water sources</li> <li>• Increasing the temperature trend and decreasing the</li> </ul>	<ul style="list-style-type: none"> <li>• Timing of rainfall and snowfall has changed compared to past and sudden intense rainfall after a prolonged draught has caused frequent flood and landslide in latter days.</li> <li>• Food production has declined in latter days due to change in rainfall pattern and seasons</li> <li>• Though severity and mortality of diarrheal diseases has gone down drastically, incidence rate of diarrhea cases has increased over the years which might be because of better case detection rate and deterioration of water quality and sanitation as well as habit of open defecation</li> <li>• Seasonal occurrence of diseases has shifted earlier resulting diseases outbreak before pre-monsoon.</li> <li>• The diseases which were prevailing in the lower altitudes in the past have shifted in higher altitudes such as Dengue, Typhoid, Enteric fever, viral fever, Cholera, Meningitis etc.</li> <li>• Complaints of Depression and hypertension, mental problems, Psychological Stress has increased</li> </ul>	<ul style="list-style-type: none"> <li>• Despite the intervention programs are in place by Government, I/NHOs, skin diseases, ARI, malaria and diarrhoeal diseases are still in top ten positions.</li> <li>• Cases of rotaviral diarrhoe is increasing over the year's perennial distribution of mosquitoes and reporting the malaria cases from higher altitudes of the districts.</li> <li>• Cases of kalazar are increasing in endemic districts of eastern terai</li> <li>• Cases of diarrheal diseases has increased because of frequent floods, landslides in higher altitudes, and poor quality of water supply and sanitation</li> <li>• Total number of malaria cases has drastically increased over the years because of massive intervention</li> </ul>

	<p>amount and time of rainfall</p> <ul style="list-style-type: none"> <li>• Water sources dry up</li> </ul>	<p>among the people</p> <ul style="list-style-type: none"> <li>• Incidence of skin diseases has increased</li> <li>• Drying out of stone spouts, river streams and other sources of water for long seasons.</li> <li>• Shortage of water and poor quality of supplied water and absence of drinking water quality surveillance mechanism in place</li> <li>• Prevalence of both indigenous and imported malaria cases</li> <li>• Agriculture production has declined and problem of food scarcity and impact on nutritional status of marginalized people</li> <li>• Perennial distribution of mosquitoes in lower range and shifting in higher altitudes gradually</li> </ul>	<p>programs in place, however, population density of mosquitoes is increasing</p> <ul style="list-style-type: none"> <li>• Depletion of ground water table</li> <li>• Air pollution level is increasing</li> <li>• Cases of typhoid, cholera, dysentery and diarrhea have increased over the years because of poor quality water, open defecation and other factors.</li> </ul>
<p>Adopted measures for mitigating health impacts</p>	<ul style="list-style-type: none"> <li>• Use of bed nets while sleeping for protecting from mosquitoes bites</li> </ul>	<ul style="list-style-type: none"> <li>• Initiation of campaign for declaring open defecation zones and toilet construction in in each schools in few districts</li> <li>• Promotion of rainwater harvesting technologies for collecting rain water</li> </ul>	<ul style="list-style-type: none"> <li>• Post flood management programs by Government and I/NGOs</li> <li>• Distribution of Insecticide treated bet Nets in high malaria endemic VDCs of affected districts</li> <li>• Promtion of alternative energy such as Lagu-bidhut and Ghataa.</li> </ul>

### 3.3 Findings from Time Series Analysis

#### 3.3.1 Trend analysis from terai region: Chitwan and Morang district

##### 3.3.1.1 Yearly distribution of diarrhea and malaria disease

Fig 1 shows the trend analysis of diarrhea and malaria disease for the year 2003 to 2009. The trendline of diarrhoea shows decreasing trend from the year 2003 till 2009 and significant reduction of it was observed in 2007. This is the analysis done using the data of Chitwan and Morang district of terai regions.

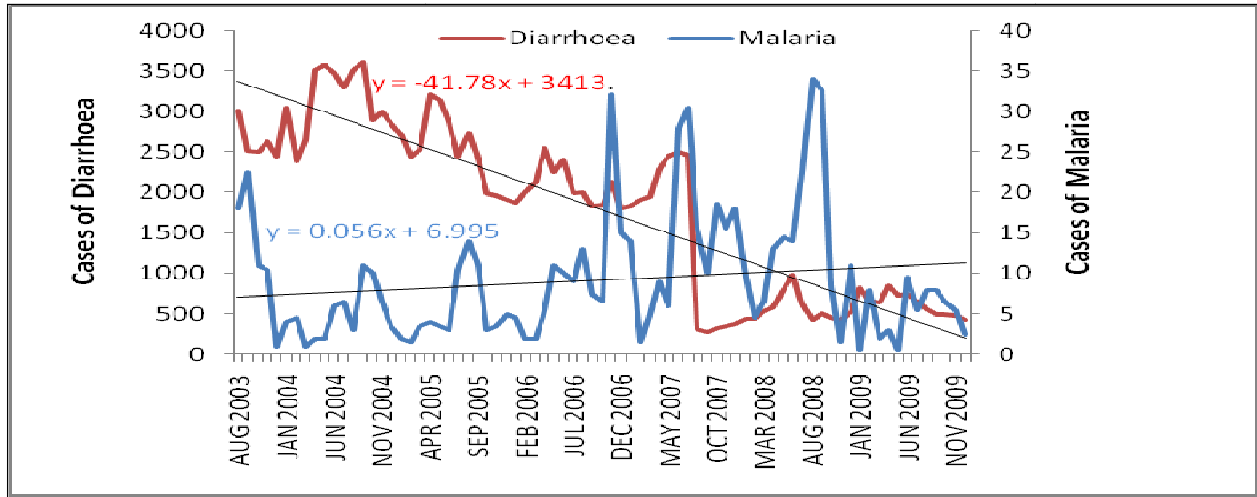
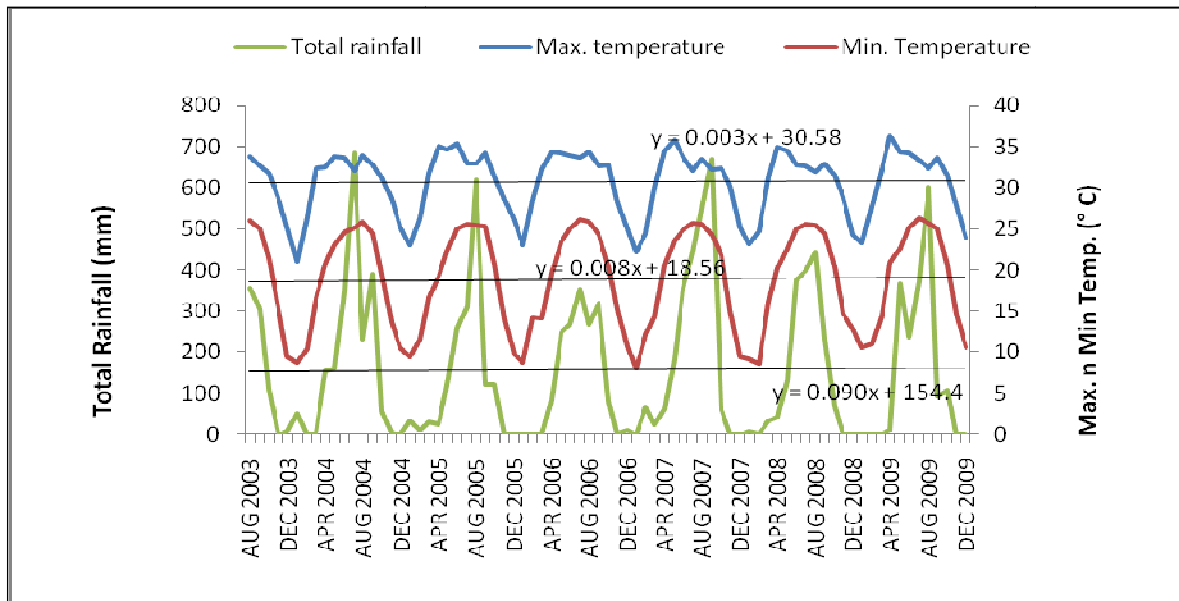


Figure 1: Yearly distribution of diarrhea and malaria disease in terai region

The trendline equation shows that every year monthly cases of diarrhea is decreasing by 41 in number. The total number of malaria cases is in fluctuating nature from the year 2003 till 2006 and the number of cases seems to be irregular but number is increased in total than previous years. The trendline equation shows every year the total malaria cases is increasing by 0.056 in number per month keeping other things constant.

##### 3.3.1.2 Yearly distribution of rainfall and temperature trend analysis

Fig no. 2 shows the pattern of climatic conditions of the study districts from the year 2003 till 2009. Overall trend shows that the total rainfall and temperature both minimum and maximum seems to be in fluctuating nature ( increasing and decreasing).

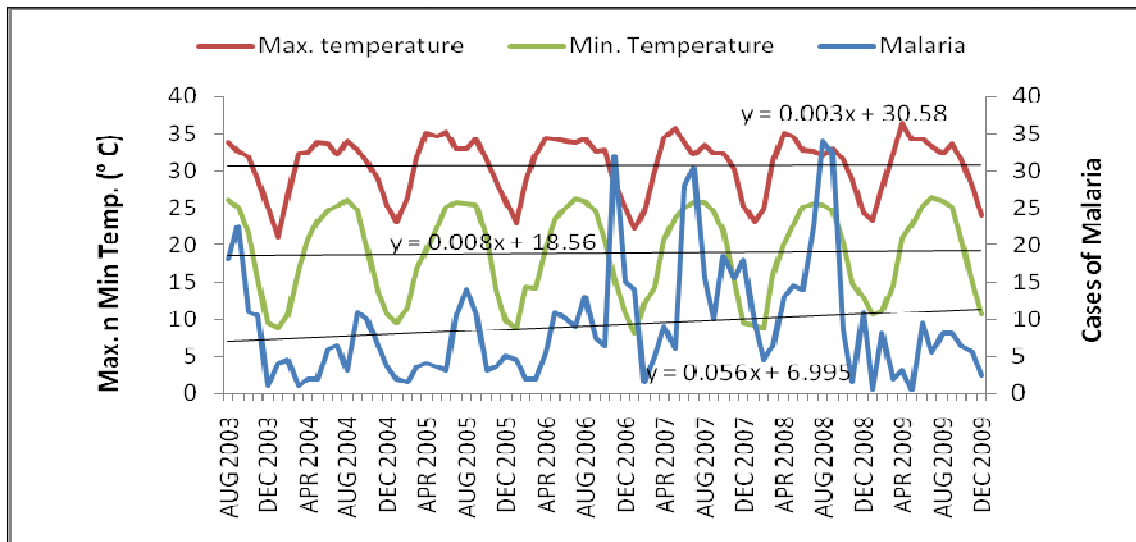


**Figure 2 Yearly distribution of malaria and temperature trend analysis**

As shown by the trendline equation (in average) that total rainfall is increasing by 0.090 mm and average min temperature by 0.008°C and maximum temperature by 0.003°C per month.

**3.3.1.3 Trend analysis of malaria with max and min temperature**

Fig 3 shows the trend analysis of the malaria with min and max temperature since the year 2003 till 2009.

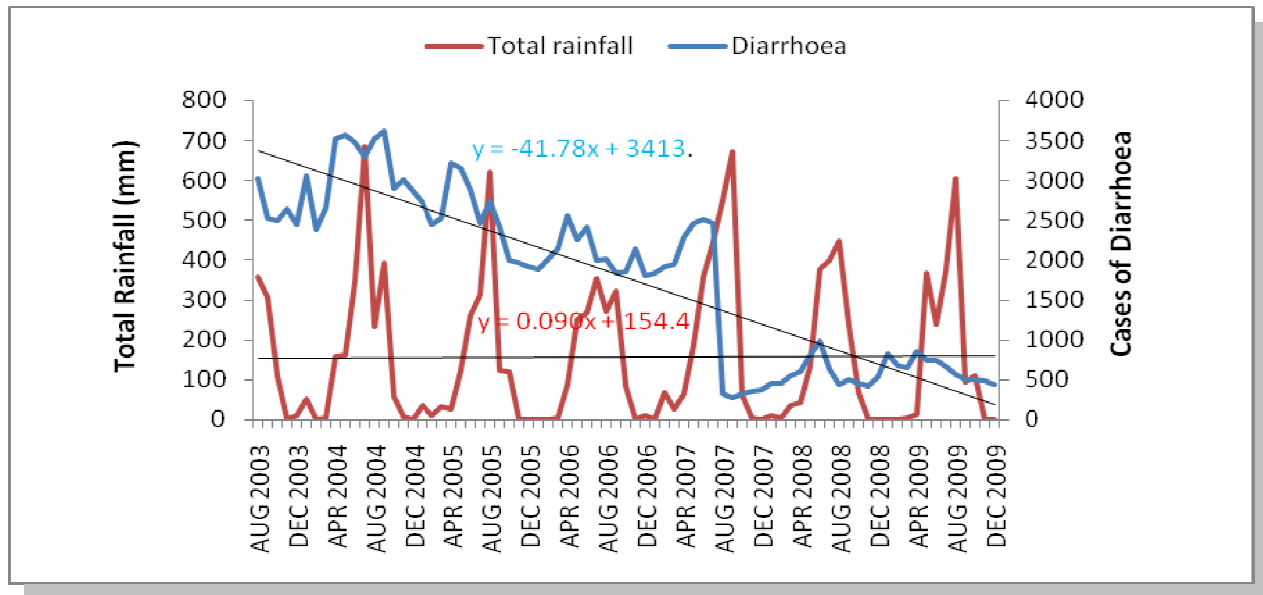


**Figure 3: Trend analysis of malaria with max and min temperature**

The temperature both maximum and minimum and number of cases of malaria seem to be fluctuating however, between the year 2006-2008 the number of malaria cases are large in number and since then the number seems to be reduced till 2009.

### 3.3.1.4 Trend analysis of diarrhea and total rainfall

Fig 4 shows the trend of diarrhoea and total rainfall pattern since the year 2003 till 2009.



**Figure 4 Trend analysis of diarrhea and total rainfall**

Diarrheal disease seems to be decreasing but the total rainfall seems to be in fluctuating pattern. The trendline equation shows that every year the total cases of diarrhoea is decreasing by 41 in number.

### 3.3.1.5 Regression analysis of climatic factors with diarrhea and malaria from Terai Region

Regression analysis of malaria and diarrhea with respect to climatic factors shows the pattern in occurrence of diarrhea and malaria. When the maximum temperature is increased by 1 °C, the number of malaria cases decreased by 1.12 number per month ( $p < 0.05$ ) as shown by the table. If the temperature increase more than optimum then it may hinder the occurrence of malaria, When minimum temperature increases by 1°C than the total number of malaria also increases by 1.17 in number per month and is statistically significant as mentioned in the table.

**Table 6 Regression analysis of climatic factors with diarrhea and malaria of Terai Region**

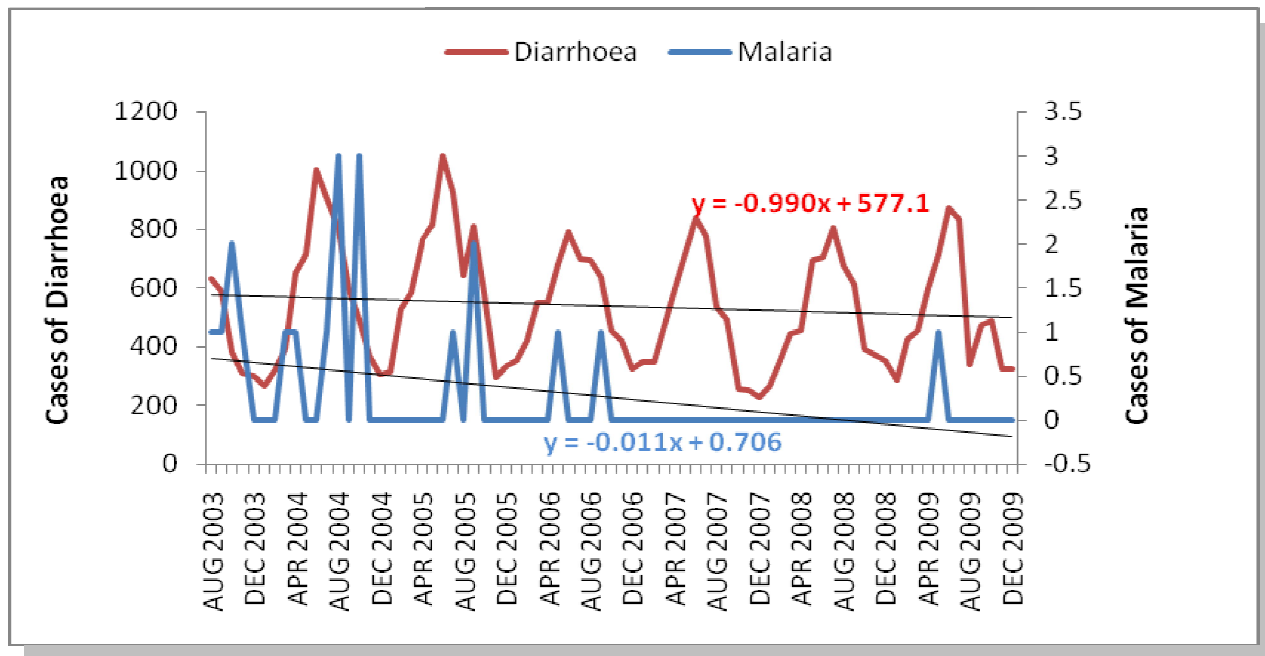
Malaria				
<i>Factor</i>	$\beta$	$\beta(SE)$	<i>T</i>	<i>P</i>
Rho (AR)	0.50	0.10	4.86	0.00
Max. temp	-1.12	0.51	-2.19	0.03
Min. temp.	1.17	0.42	2.79	0.01
Total rain fall	0.00	0.01	-0.69	0.49
Constant	22.25			

Diarrhoea				
<i>Factor</i>	$\beta$	$\beta(SE)$	<i>T</i>	<i>P</i>
Rho (AR)	0.95	0.04	25.96	0.00
Max. temp	-34.16	25.74	-1.33	0.19
Min. temp.	43.80	21.63	2.03	0.05
Total rain fall	-0.25	0.30	-0.83	0.41
Constant	2015.58			

In case of diarrhea rise in 1 °C max temp 34.16 number of diarrheal cases were found to be decreased ( $p>0.05$ ). Increase in 1°C min. temperature 43.80 number of diarrheal cases were found to be increased which is statistically significant. No relation has been found in the occurrence of malaria, whereas in case of diarrhea increase in rainfall shows decrease in diarrheal cases ( $p<0.05$ ). This shows that increase in minimum temperature is positively correlated with malaria cases as it prolongs the occurrence of mosquitoes in winter too.

**3.3.2 Trend analysis from hill region: Dhankuta and Nuwakot district**



**Figure 5: Trend Analysis of disease pattern**

The figure shows the trend analysis of diarrhoea and malaria disease since the year 2003 till 2009. Both malaria and diarrhoea seems to be in decreasing trend from the year 2003 till 2009 and the trendline equation also shows the same. Every month 0.99 number of diarrhoeal cases and 0.011 number of malaria cases seems to be decreasing.

### 3.3.2.1 Trend analysis of climatic data

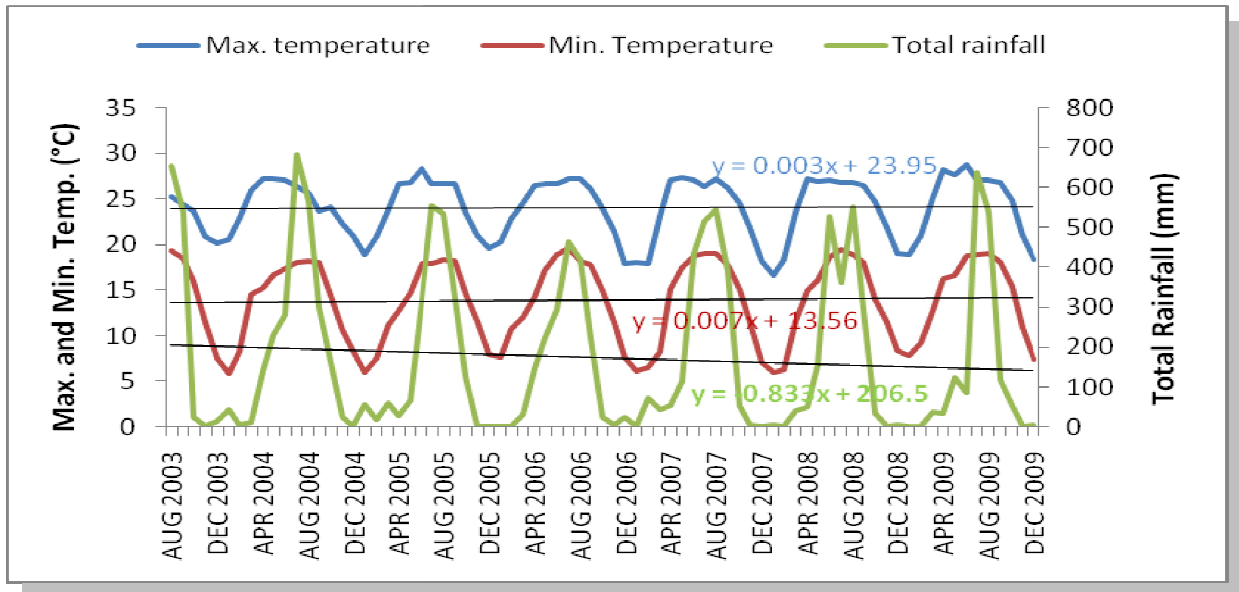


Figure 6: Trend Analysis of climatic data

Max and min temperature along with rainfall seems to be in increasing trend as shown in the figure along with trendline equation. The pattern is fluctuating for both the climatic conditions.

### 3.3.2.2 Trend analysis of malaria and temperature

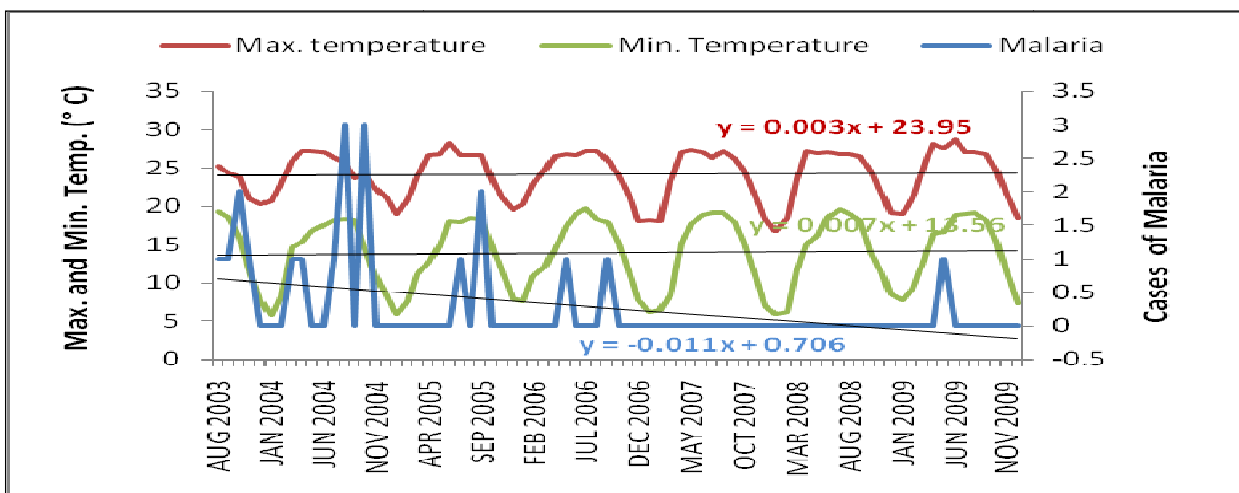


Figure 7: Trend analysis of malaria and temperature

The figure shows the pattern and trend analysis of climatic factors for the occurrence of disease. Max and min temperature seems to be irregular and similar fluctuating pattern every year while malaria seems to be in decreasing trend and similar pattern is shown by the trendline equation as well.

### 3.3.2.3 Trend analysis of diarrhea and total rainfall

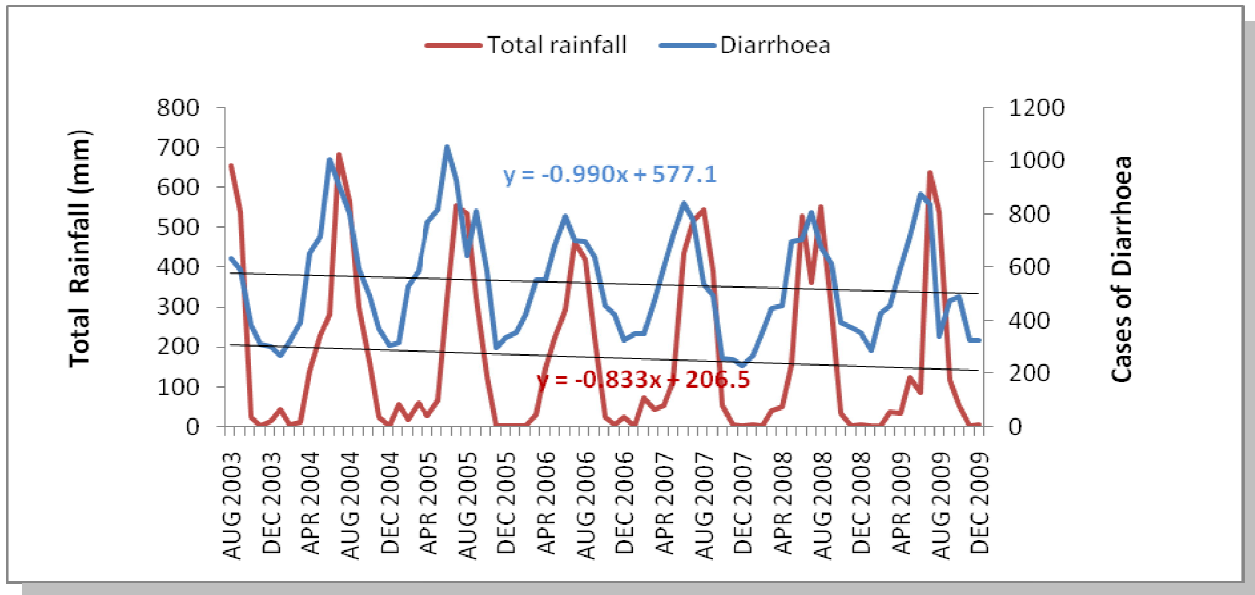


Figure 8: Trend analysis of diarrhea and total rainfall

Rainfall and diarrhoeal disease trend is shown by the figure. The trend seems to be of irregular nature with both the amount of rainfall and cases of diarrhoea decreasing in its volume and in number respectively.

### 3.3.2.4 Regression analysis of climatic factors with diarrhea and malaria of Hill Region

Table 7: Regression analysis of climatic factors with diarrhea and malaria of Hill Region

<b>Malaria</b>				
Factor	$\beta$	$\beta(SE)$	T	P
Rho (AR)	0.03	0.12	0.28	0.77
Max. temp	-0.07	0.05	-1.22	0.22
Min. temp.	0.07	0.05	1.54	0.12
Total rain fall	0.01	0.01	0.17	0.86
Constant	0.83			
<b>Diarrhea</b>				
Factor	$\beta$	$\beta(SE)$	T	P
Rho (AR)	0.49	0.11	4.47	0.00

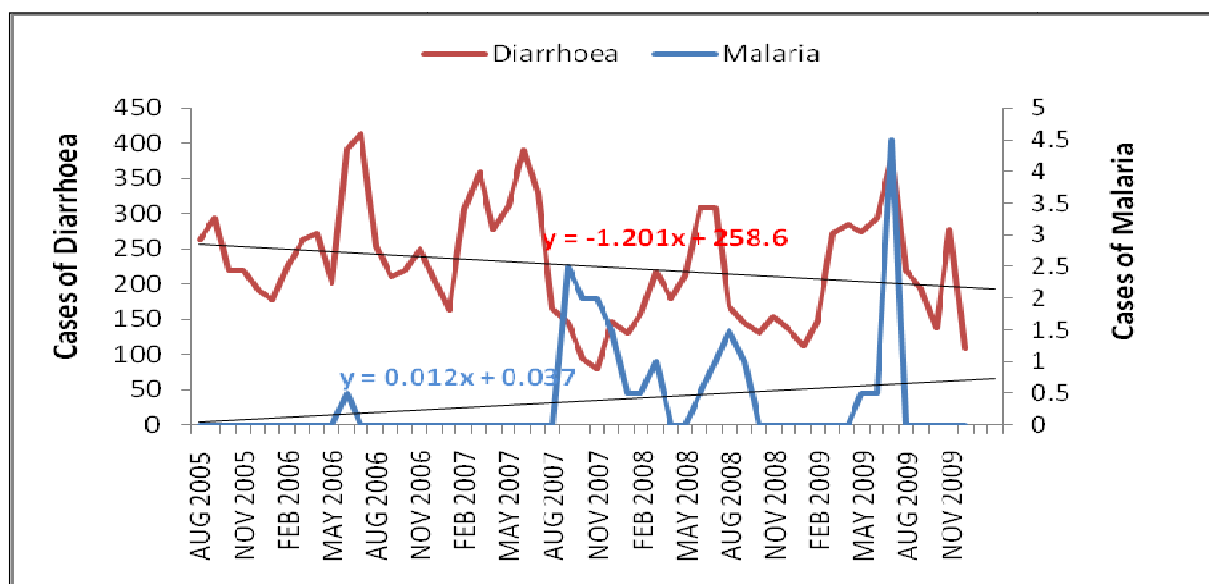


Max. temp	30.36	12.36	2.46	0.02
Min. temp.	4.98	10.35	0.48	0.63
Total rain fall	0.22	0.10	2.15	0.03
Constant	-299.82			

Table shows the regression analysis of climatic factors for the occurrence of diarrhea. With every increase in 1<sup>0</sup>C of maximum and minimum temperature the number of diarrheal cases increase by 30.36 (p<0.05) and 4.98 (p>0.05) respectively. Rainfall increase also shows the increase in diarrheal occurrence which is statistically significant (p<0.05). With every rise of 1<sup>0</sup> C of maximum temperature malaria cases decreases by 0.07 and increase by 0.07 when minimum temperature rise by 1<sup>0</sup>C.

### 3.3.3 Trend analysis from mountain region: Sankhuwasabha and Rasuwa district

#### 3.3.3.1 Trend analysis of disease pattern



**Figure 9: Trend Analysis of Disease pattern**

The figure shows the total number of diarrheal disease and malaria disease trend analysis since 2003-2009. The trendline equation shows that the number of diarrheal disease is decreasing by 1.2 in number but the number of malaria cases is increasing by 0.012 number cases per month.

### 3.3.3.2 Trend Analysis of Climatic Conditions

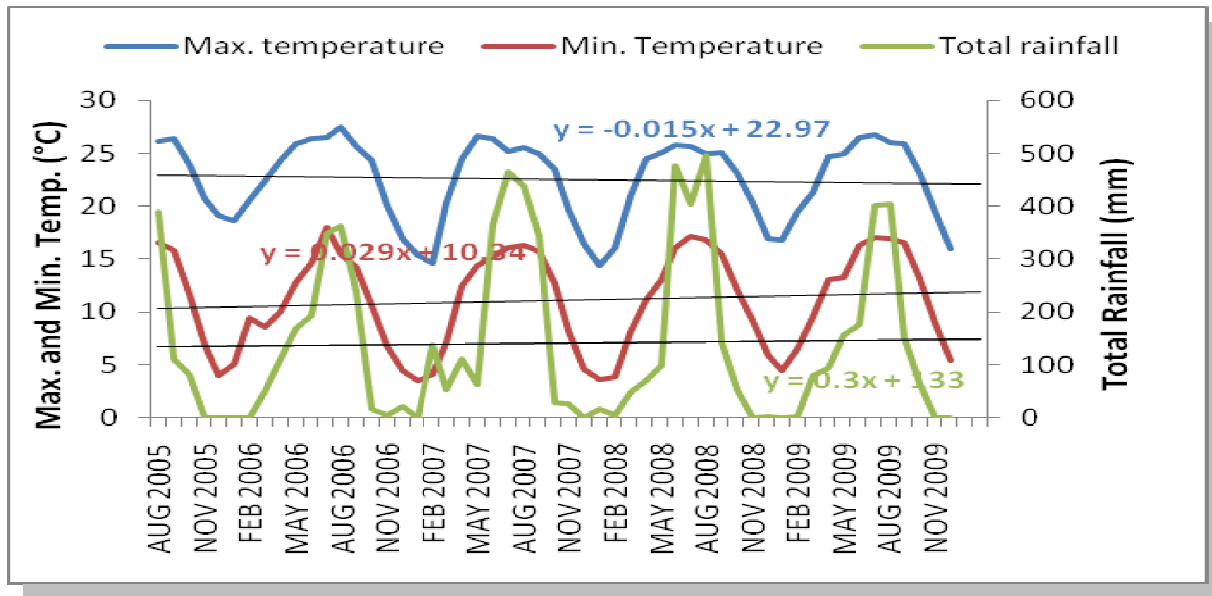


Figure 10: Trend Analysis of Climatic Conditions

The figure shows the trend analysis of max and min temperature as well as total rainfall. The trendline analysis is made of each indicator. Maximum temperature and minimum temperature is decreasing and increasing by  $0.015^{\circ}\text{C}$  and  $0.029^{\circ}\text{C}$  respectively and total rainfall is also in fluctuating pattern with trendline showing increase of  $0.3$  mm rainfall monthly.

### 3.3.3.3 Trend analysis of malaria and temperature pattern

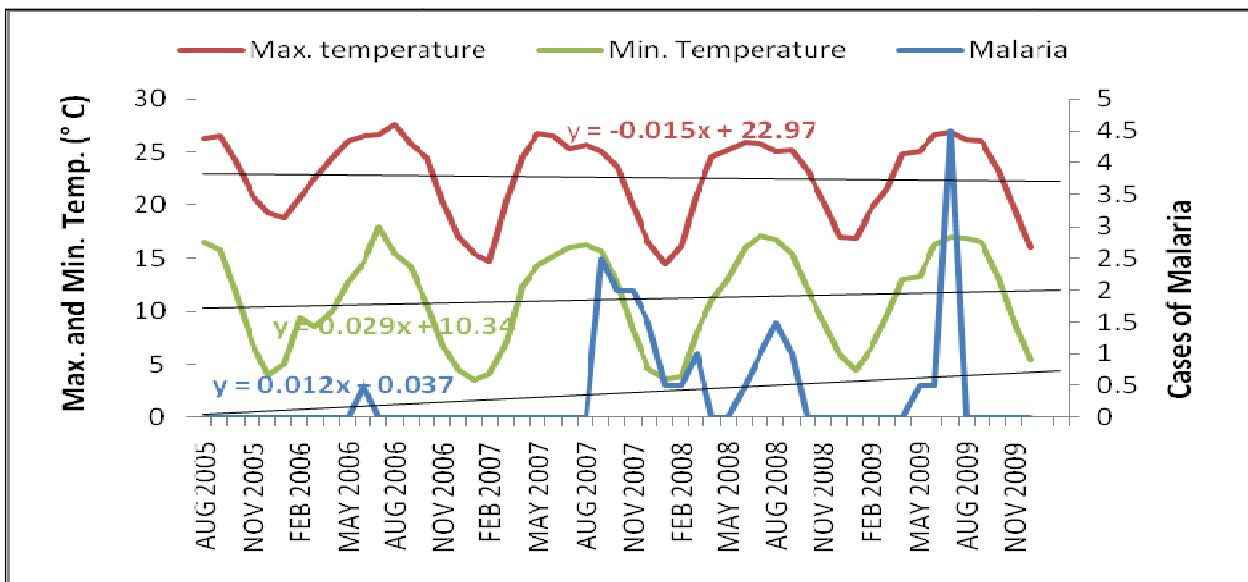


Figure 11: Trend analysis of malaria and temperature pattern

The figure shows the yearly trend of max and min temperature with malaria. Maximum and minimum temperature seems to be of similar fluctuating pattern. The number of malaria cases seems to be few in number from the year 2003 to 2007 and the number is rising and is of fluctuating type.

### 3.3.3.4 Trend Analysis of Diarrhea and Rainfall

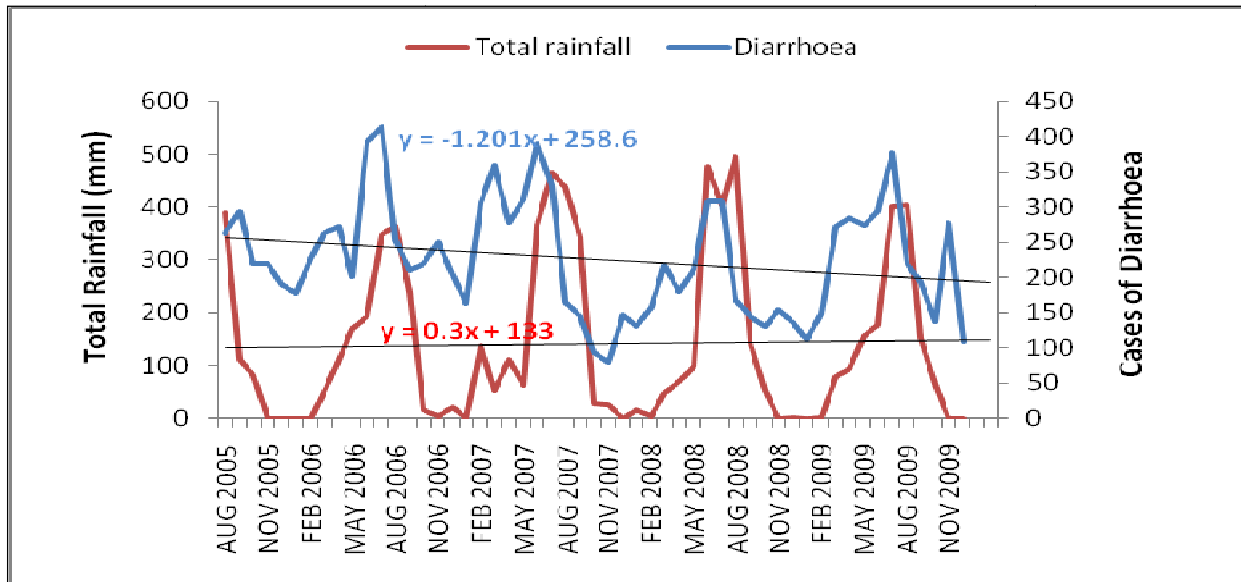


Figure 12: Trend Analysis of Diarrhoea and Rainfall

Figure 12 shows the trend analysis of the total rainfall and the number of diarrhoeal disease. Though the figure shows fluctuating nature, the trendline equation shows that the diarrhoeal disease is decreasing by 1.2 cases every month and rainfall is increasing by 0.3 mm every month since the year 2003 till 2009.

### 3.3.3.5 Regression analysis of climatic factors with diarrhea and malaria of mountain region

Table 8: Regression analysis of climatic factors with diarrhea and malaria of mountain region

Malaria				
<i>Factor</i>	$\beta$	$\beta(SE)$	<i>T</i>	<i>P</i>
Rho (AR)	0.27	0.14	1.95	0.06
Max. temp	-0.06	0.10	-0.57	0.57
Min. temp.	0.05	0.10	0.53	0.60
Total rain fall	0.00	0.00	0.87	0.39
Constant	0.96			

Diarrhea

<i>Factor</i>	<i>β</i>	<i>β(SE)</i>	<i>T</i>	<i>P</i>
Rho (AR)	0.44	0.13	3.25	0.00
Max. temp	8.39	8.97	0.94	0.35
Min. temp.	-2.31	8.64	-0.27	0.79
Total rain fall	0.14	0.10	1.36	0.18
Constant	42.10			

In mountain region the regression analysis shows no significant relation with the occurrence of malaria and diarrhea with respect to the climatic conditions. Increase in 1<sup>0</sup>C max temperature shows that the malaria cases decline by 0.06 number of cases and with same increase in min temperature cases rise by 0.05 in number per month (p<0.05). Rainfall has no relation with the occurrence of malaria.

Cases of diarrhea increase by 8.39 in number per month for every rise in max temperature by 1<sup>0</sup>C. With the rise of minimum temperature by 1<sup>0</sup>C the number of diarrheal cases decreases by 2.31 in number monthly. With increase in total rainfall the number of diarrheal cases increases but is not statistically significant.

### 3.4 Guideline Preparation

**Table No: 9 Guidelines for the prevention of public health problems from climate change**

<b>Issues related to climate change</b>	<b>Recommended Guidelines</b>
Drying out of water sources	Water harvesting strategy should be developed at rural as well as urban settings.
	Protection of watersheds and conservation of forest is needed.
	Ensuring community participation for protection and conservation of water sources at local level
Conducive environment for vector breeding and appearance of mosquitoes in higher altitude areas	Ensure the entomological surveillance in new places where mosquitoes are appeared and vector borne diseases are reported. Conduct research study on altitudinal distribution of disease vectors in Nepal.

	Develop the evidence based vector borne diseases control program in hilly and mountain regions of Nepal.
	Mobilize the entomologists and vector control officers to identify and control the disease vectors in vector borne diseases endemic areas.
Water quality and quantity	Ensure the quality of supplied drinking water enforcing water quality surveillance at all level
	Ensure the monitoring of quality and quantity of supplied water, establishing inter - sectoral coordination team.
Deforestation	Prohibition of rampant deforestation and promote afforestation.
	Promote rainwater harvesting system when constructing new houses and integrate it with National Building Code.
Water borne disease	Emphasize on proper reporting and recording system of water borne and vector borne diseases both from public and private sectors.
	Stratify the areas as per the burden of water borne diseases and mobilize the resources to address those diseases
	Determine the etiological factors of water borne diseases outbreak and develop the early warning system accordingly.
Extreme climatic events ( Heat, Flood, landslide)	Tree plantation to reduce excessive heat and strategy to develop surface reflectivity need to be developed.
	Emergency preparedness and early response mechanism should be developed and made well functional at all levels.
	Health workers should be oriented on rapid response of extreme climatic events readily prepared to address

	the disaster.
	Physical infrastructure should be built as per the National Building code to resist disaster
	Safety measures to protect from extreme events like heat, cold and unfavorable conditions need to be promoted in early phase. Skin protective measures clothes and extreme stress coping mechanism need to be formulated.
Weak Program Implementation	With increasing climate induced health problem, vector borne disease program need to be strengthen at every level of health facility.
	Training to the health worker about the impact of climate change in health need to be given.
	Orient the health professionals on impacts of climate change on health.
	Ensure public private partnership to cope with impact of climate change on health.
	Integrate climate change issue in broader development plans of Nepal.
	Publication of IEC/BCC materials.
Loss in agricultural productivity	In order to ensure the sustainability of agricultural production in perspective of climate change, Government should orient and motivate the farmers to adopt drought and flood tolerant crops.
	Promote kitchen garden, organic farming etc in order to meet the increasing demand of food.
Human resource development	Develop Human resources through education and training to work in the field of environmental health.

## **CHAPTER 4**

### **DISCUSSION**

There are several mechanisms by which climate change can affect human health (Haines, et al, 2006). The potential health hazards of climate change have become more severe in recent years due to increase of morbidity and mortality (McMichael et al, 2000). Insufficient water supply and lack in sanitation standard has projected as major cause for water borne disease (Roland et al., 2004). The diarrheal cases are in increasing order in most of the developing countries worldwide, where there is lack of inadequate water supply and poor sanitation and hygiene practices (Epstein, 2001). Qualitative information revealed through various discussions and expert information that water borne diseases, mainly diarrhea is still a crisis and of increasing trend. People perceive the need of intervention and further need of more programs to address the water borne infections. Sanitation practice, environmental surroundings, availability of water and its usage are the factor that determines the extent of occurrence of diarrheal disease and correlated situation has been observed in South Asia and South America (Venezuela and Columbia) (McMichael et al, 2006). Occurrence of diarrhea through time series regression analysis shows fluctuating trend in current study. With increase in rainfall and other climatic conditions the occurrence of diarrhea seems to be changing. With respect to the time series analysis though the significance and association between the disease and climate are less correlated and is of varying trend but still the burden of disease with respect to diarrhea is colossal. The analyzed data are of the governmental health facility but the diarrheal patients may visit the private medicals so the cases are in still submerged conditions. The water resources are drying out and rainfall is erratic with unseasonal hydrological cycle throughout the world (Longstreth et al., 1999). Local people perception from lower terrain region to high mountains reveals that the source of drinking water are drying out, mainly decrease in ground water, surface water and stone spout. In most of the villages in hill and mountains the probability of the water borne diseases may be likely due to poor sanitation and hygiene though the transmission of infectious disease is determined by many factors including socio-economic, lack of awareness and ecological conditions and intrinsic human immunity (Emily et al., 2010).

In addition, the proliferation of salmonella and cholera is more rapid at higher temperature with contaminated water supply and in animal gut and stale food. These factors are mainly modified by short term and long term in climatic variation. (McMichael et al, 2006).

The number of mosquitoes all over the tropical and temperate climatic zone has considerably increased and has been shifting towards higher altitude. Favorable environment for mosquitoes is developing in hilly and even in mountain region of Nepal. In a previous study the Dengue, Kalazar, JE were reported from the border and terai region of the country but these days the occurrences of cases are also recorded from hill districts as well, this may be the reflection of climate change (Gautam et al., 2009). The present study has also revealed that mosquito's distributions are shifting to higher altitudes. Health workers perceived from Bajhang (Far-western) that mosquitoes were only found in Dadeldhura (hill) district but in later year it was found in high altitude of Darchula (mid-hill and Himalaya). Now the occurrences of mosquitoes are also seen in Bajhang (mid-hill and Himalaya) in almost every VDCs and every member in family used bed nets while sleeping. The number of mosquito has dramatically increased in higher altitude because of the favorable environment. The main factor for survival of vector in higher altitudinal region is due to increase in global temperature (Jonathan et al., 2005). But malaria cases in Morang district have been reported as decreasing with respect to previous years but kalazar cases are increasing and also the probability of outbreak of vector borne diseases is high. With increase in the maximum temperature the number of malaria cases is decreasing every month since 2003 till 2007 but with increase in the minimum temperature the number of malaria seems to be in increasing trend as shown by the time series regression analysis. Though, climatic factors may be the main reason for the occurrence of malaria, increased intervention and program like distribution of bed nets, insecticides spraying and other measures applied may be the factors for decrease in malaria with increased temperature. Disease control program of governmental and nongovernmental organizations may be major reason for achieving Millennium Development Goal though climatic factors plays significant role in the occurrence of the disease.

People living in high altitude reported that the snowfall pattern in mountain range in Nepal has changed in past few decades. The glacially coverage land area has now changed to rangeland and



its ultimate effect on livelihood of indigenous communities has been noted. It is estimated, maximum extent of seasonally frozen ground in non-permafrost areas has decreased by 7% in the Northern Hemisphere from 1901 to 2002, with decrease of up to 15% in spring. As climate warms through out the 21<sup>st</sup> century, glacier and ice caps are projected to lose mass owing to a dominance of summer melting over winter precipitation and there has been reported the some extinction in species (Schneeberger et al., 2003). The flowering cycle in some plant species has reported shifting of flowering and fruiting period such as that of like rhododendron, peach, pear, apple and *kaphal*. Some species of cultivated plants are not growing properly nowadays, like Paddies "*Radhachaur*" reported from hill district, far-western which was main agricultural plant in far-western part of hill in the previous years. It may be due to shifting in hydrological cycle, rainfall pattern and increase in temperature. The potential impact of climate change on food security is major concern around nation. The average annual agriculture production both in quality and quantity has been reported in reducing picture in every next year. Poor nutritional status has created a conducive environment for disease infection in many poor communities in Nepal (Malla, 2008). Food security situation of the country has been a great challenge for the policy makers and planners due to loss in productivity, which is determined by different factors, such as climatic and other environmental variables (Dahal et al., 2010).

Communities perceived that lots of properties were lost due to various disasters. They also perceived that climatic changes may be the significant factor for the occurrences of unrestrained disasters every year. As per the data available from disaster management section, there seems to be high variation of property loss by different disasters such as flood, landslide, earthquake, thunderbolt, fire, hailstone, wind storm, epidemic etc. From 2001 to 2007, total death due to disaster toll 2318 and 439 were missing, 1318 people were injured during calamities. And total 4,90,984 families were affected by the disaster. More than 86,650 houses were destroyed and there was significant loss of animals and land. Total estimated loss during disaster was Rs.138,275,909,888 (GON, 2007). This information showed that there is somewhat increase in trend of loss in magnitude of life and properties. Various types of health impacts have reflected throughout the world ranging from immediate effects of physical injury, morbidity and mortality by different type of natural disaster (Haines et al., 2006).

## **CHAPTER 5**

### **CONCLUSION and RECOMMENDATION**

Climate change has a relation to the occurrence of the disease. People living on Himalayan range and at low land area are more vulnerable to extreme climatic conditions. The effects of climate change pose a huge public health challenge to all nations at present. The occurrence of disease and the changing trend in the prevalence of climate sensitive diseases is certainly a result of climate change. Regression analysis in terai region shows that with rise of minimum temperature diarrheal and malaria disease seems to be increasing whereas diarrhoeal disease seems to be decreasing in rise of rainfall. Similarly in hilly region with rise in the maximum temperature malaria cases decreases and increase with rise of minimum temperature. Increase in rainfall also shows the increase in diarrheal numbers. Himalayan region time series analysis shows that increase in minimum temperature trend of malaria cases also increases and diarrheal disease also increases with increasing rainfall. Different policies of line agencies and of the government were reviewed. Each policy has directly or indirectly addressed the issues related to climate change and its health consequences. Policies have strongly mentioned the provision to deal with the health hazards and the consequences related to climatic events. If the policies can be followed accordingly in more comprehensive way then in some way the matters of health impacts resulting from climate change can be addressed.

According to the altitudinal variation, there is shifting of malaria and other vector borne diseases from Terai to Himalayan region. Climate change is happening and is obviously a major concern in the entire sector that influences health. Some sort of fluctuation in the disease pattern is occurring. Water borne disease has decreased since few years because of many multiple interventions from government sector and others partners but we cannot overshadow the extreme climatic conditions that are the major factors for inducing disease.

Water resources all over the places are drying out every year and the scarcity of water resources has definitely affected the sanitation practice of the people. Most of the water supply has been contaminated and its quality has been degraded. Lack of water resources has facilitated the

occurrence of diarrhea, typhoid etc. Temperature has increased over the years that have reduced the working capacity of the people with excessive heat and the agricultural productivity has been reduced due to erratic and unseasonal rainfall. Lack of water resources has facilitated the occurrence of diarrhea, typhoid etc. Increased temperature has reduced the working capacity of the people with excessive heat and the agricultural productivity has been reduced due to erratic and unseasonal rainfall. On overall, the prevalence of vector borne diseases has reduced in terai regions due to massive intervention programs but indigenous cases are reported from higher altitudes including hilly regions but mountain regions are still free from indigenous cases of malaria and other vector borne diseases. Distribution of mosquitoes has been seen in higher altitudes and has compelled the people to use bed nets for sleeping even in mountain regions. However, detail entomological study has not been carried out to confirm the diseases vectors. Diarrheal diseases and skin diseases have been found problem in all ecological regions of Nepal and found associated with poor quality and quantity of water and poor sanitation and hygiene. Those diseases which were mainly reported in lower parts of Nepal have been increasingly reported from upper parts to such as cholera, typhoid, Rota viral diarrhea and viral fever etc. Based on the findings of the study following recommendations are made

In order to confirm the attribution of climate change, the recording and reporting system of climate sensitive diseases should be strengthened at health facility level, entomological study should be carried from where indigenous malaria cases are reported and in other suspected new places too. The water supply and sanitation coverage need to increase and should ensure the quality of supplied drinking water implementing water quality surveillance.

- As this study is primarily based on secondary data and qualitative data collected from the field, detail prospective study is required to discern the attribution of climate change on vector –borne and diarrheal diseases in Nepal.
- There is dire need of prospective studies on altitudinal distribution of vector borne diseases and their vectors, their susceptibility to insecticides in the context of climate change.

- Similarly, study on diarrhea and its attributing factors, forecasting the season of diarrhea and preparing early warning system are important aspect for managing diarrheal outbreak in the context of climate change.
- Public health are the most sensitive and important indicator of the nation development and thus to safeguard it comprehensive policy and programs also should be brought forth based on emerging evidences from local and international context.

## References

- Asian Development Bank. *Climate change adaptation in Himalchal pardesh*. Asian Development Bank, India. 2009. Viewed 15 July 2010 & available at: [www.preventionweb.net/.../11775\\_UNISDRBriefingAdaptationtoClimateCh.pdf](http://www.preventionweb.net/.../11775_UNISDRBriefingAdaptationtoClimateCh.pdf).
- Beggs, PJ 2000, Impacts of climate and climate change on medications and human health. *Australian New Zealand Journal of Public Health*, vol.24, pp. 630-2.
- Campbell-Lendrum D, Woodruff R. Climate change: quantifying the health impact at national and local levels. Editors, Prüss-Üstün A, Corvalán C. World Health Organization, Geneva, 2007. (WHO Environmental Burden of Disease Series No. 14)
- Catherine P, Sue Z, Nicholas M 2000, *Qualitative research in health care: Analyzing qualitative data*. BMJ; 320; 114-116. [doi:10.1136/bmj.320.7227.114].
- Checkley, W. et al., (2000). Effects of El Nino and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children. *Lancet*, 355(9202): 442-450.
- Dahal H, Khanal DR. 2010, *Food security and climate change adaptation framework: issues and challenges*. Nepal Agriculture Research council.: Khumaltar, Nepal.
- Dhimal M, Bhattarai L & Bhusal, CL 2009, *Situational analysis of environmental health in Nepal*. Kathmandu; Nepal health research council.
- Dhimal M, Bhusal CL 2009, *Impacts of climate change on human health and adaptation strategies for Nepal*. J Nepal Health Res Counc Oct; 7(15):140-141
- Dhimal M, Thaukur AK, Maskey S, Banerjee MK, Bhattarai L, Maskey MK 2009, *Environmental Conditions Associated with vector of dengue and Corrective actions for its prevention in Nepal*. Kathmandu, Nepal, World Health Organization and Nepal Health Research Council.
- Dixit A, Gyawali D, Pokherel A, Khan F et al., 2009, Climate change induced uncertainties and Nepal's development predicaments. Kathmandu, Nepal: Institute for Social and Environmental Transition-Nepal (ISET-N).
- Emily KS, 2010, Global Climate Change and Infectious Diseases, *New England Journal of Medicine*, mar 25, vol.362, pp.1061-63.
- Epstein, PR 2001, Climate change and emerging infectious diseases. *Microbes and Infection*, vol. 3 pp. 747–754.

Gautam I, Dhimal M, Shretha SR, Tamrakar AS. 2009. *First Record of Aedes Aegypti (L.) Vector of Dengue Virus from Kathmandu, Nepal. Journal of Natural History Museum.* Vol.24 pp. 156-64.

Government of Nepal, 1996. *National shelter policy 1996 BS.* Singhadurbar, Kathmandu: Ministry of Physical Planning and Development.

Government of Nepal, 1999. *National seed germination policy 2056 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2000. *National Tea Policy 2057 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2001. *National Fertilizer policy 2058 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2003. *National coffee policy 2060 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2004. *National agricultural policy 2061 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2006. *National milk policy 2064 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2006. *Biotechnology policy 2063 BS.* Singhadurbar, Kathmandu: Ministry of Environment, Science and Technology.

Government of Nepal, 2006. *National Agro-diversity policy 2063 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2006. *Rural Energy policy, 2063 BS.* Singhadurbar, Kathmandu: Ministry of Environment, Science and Technology.

Government of Nepal, 2007, *Commercial Agricultural promotional policy 2064 BS.* Singhadurbar, Kathmandu: Ministry of Agriculture.

Government of Nepal, 2007, *Loss of Lives and properties By Type of Disasters.* Ministry of Home Affairs, Disaster management section; Singdarbar Kathmandu Nepal.

Government of Nepal, 2007. *National Urban policy 2064 BS.* Singhadurbar, Kathmandu: Ministry of Physical Planning and Development.

Government of Nepal, 2009. *Subsidy Policy for Renewable Energy, 2066 BS.* Singhadurbar, Kathmandu: Ministry of Environment; Alternative Energy Promotion Centre.

Government of Nepal, 2009. *Urban sanitation and drinking water policy 2066 BS*. Singhadurbar, Kathmandu: Ministry of Physical Planning and Development.

Government of Nepal, 2010, *Climate change vulnerability mapping for Nepal*. Singhadurbar, Kathmandu; Ministry of Environment

Government of Nepal, 2010, *National adaptation programme of action to climate change*. Singhadurbar, Kathmandu; Ministry of Environment.

Government of Nepal, 2010. *National irrigation policy, 2010 A.D.* Singhadurbar, Kathmandu: Ministry of Irrigation.

Haines, A, Kovats, RS, Campbell-Lendrum, D & Corvalan, C 2006, Climate change and human health: impacts, vulnerability, and mitigation. *Lancet*, vol.367 pp.2101–09.

Haines, A, Kovats, RS, Campbell-Lendrum, D & Corvalan, C 2006, Climate change and human health: Impacts, vulnerability and public health, *Public Health*, vol.120, pp.585–596.

Hopp, MJ & Foley, JA 2003, Worldwide fluctuations in dengue fever cases related to climate variability. *Climate Research*, Vol.25, pp. 85–94.

Howard, F, Jeremy, H, George, L, Josephine, M, & Michael McGeehin 2008, Climate Change: The Public Health Response. *American Journal of Public Health*, vol.98, pp.435–445.

IPCC, 2001, *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report 1–1000*, Cambridge Univ. Press, Cambridge, United Kingdom.

IPCC, 2001, *The Scientific Basis: Contribution of Working Group I to the Third Assessment Report 1–944*, Cambridge Univ. Press, Cambridge, United Kingdom.

Jonathan AP, Diarmid, CL, Tracey, H & Jonathan, AF 2005, Impact of regional climate change on human health. *NATURE*, vol.438, pp. 310-317.

Kristie, LE & Jerome, A 2010. Paulson. Climate Change and Child Health in the United States. *Current Problem in Pediatric Adolescent Health Care*, vol. 40 pp.2-18.

Longstreth, J 1999, Public health consequences of global climate change in the United States—some regions may suffer disproportionately. *Environmental Health Perspective*, vol.107, pp.169–179.

Majra, JP & Gur, A 2009, Climate change and health: Why should India be concerned?. *Indian Journal Occupation Environment Medicine*, vol.13, pp.11-6.

Malla, G, 2008, Climate change and its impact on Nepalese agriculture. *The Journal of Agriculture and Environment*, vol. 9, pp.1-7.

Marasini, SP 2009, *Country paper on Disaster Risk Reduction Management in Nepal*, Disaster Management Section, Ministry of Home Affairs, Kathmandu, Nepal.

Maskey MK, Dhimal M, Bhattarai L. 2009. *Review of Emerging Health Risks due to Climate Change and Develop an Inventory of Good Practice and Adaptation Measures to Reduce the Adverse Health Implications of Climate Change in the context of Different Ecological Conditions in Nepal*. Kathmandu; World Health Organization.

McMichael AJ & Kovats RS, 2000, *Strategies for assessing health impacts of global environmental change*. In: Westra L (ed) *Implementing ecological integrity: restoring regional and global environmental and human health*, Dordrecht, Kluwer Academic Publishers, forthcoming, Geneva.

McMichael AJ, Kovats RS, Menne B, Corvalan C & Bertollini R, 2000, *Climate change and human health: Impact and adaptation*. World Health Organization, Geneva.

McMichael, AJ, Woodruff, RE & Hales, S 2006, Climate change and human health: present and future risks, *Lancet*; vol.367, pp.859–69.

Menne B, Ebi KL, eds. *Climate change and adaptation strategies for human health* Hessen, GmbH & Co. KG, Germany, 2005. Viewed on 20 July 2010 & available at: [drr.ucepa.org/.../Haines,%20Kovats.2006.Climate%20Change%20and%20Human%20Health.pdf](http://drr.ucepa.org/.../Haines,%20Kovats.2006.Climate%20Change%20and%20Human%20Health.pdf).

NTH, 2010, *Nepal Humanitarian Transition Appeal 2010*. Viewed on, 20 June 2010 & Available at: <http://ochaonline.un.org/humanitarianappeal/webpage.asp?Page=1849>.

PATZ, JA, & OLSON, SH 2006, Climate change and health: global to local influences on disease risk. *Annals of Tropical Medicine & Parasitology*, Vol. 100, pp. 535–549.

Roland, Z 2004, Global climate change and the emergence/re-emergence of infectious diseases. *International Journal of Medical Microbiology*, vol.293, pp.16-26.

Samuel F, Joel BS, Richard SJT 1999, Weathering climate change: some simple rules to guide adaptation decisions. *Ecological Economics* vol.30, pp.67–78.

Singh, R.B. et al., (2001). The influence of climate variation and change on diarrheal disease in the Pacific Islands. *Environ Health Perspect*, 109(2): 155-9



Wirawan MA, 2010. Public Health Responses to Climate Change Health Impacts in Indonesia, *Asia Pacific Journal Public Health*, vol.22, pp.25.

World Health Organization, 2009, *Adaptation to Climate Change by Reducing Disaster Risks: Country Practices and Lessons*. World Health organization, Geneva. Viewed 15 July 2010 [www.adb.org/documents/books/cca-himachal.../cca-himachal-pradesh-3.pdf](http://www.adb.org/documents/books/cca-himachal.../cca-himachal-pradesh-3.pdf)

## ANNEX 1

### **Focus Group Discussion Guidelines**

Introduction of the participants/facilitator

Major public health problems of the districts

Patterns of occurrence of diseases

Occurrence of diseases pattern in these days with comparison to previous year (possible reasons)

Prevalence of diarrhea (Increasing/decreasing trend and possible reason behind it)

Distribution of Mosquitoes and prevalence of malaria in the district

Is its prevalence increasing at present than previous year?

How far is the source of water for the domestic purposes?

What is the source of water for the domestic purposes?

Is the availability of water adequate?

What is the danger of floods, and landslide? How its occurrence here?

Are climate change awareness program ever conducted in the district?

## ANNEX 2

### **In-Depth Interview Guidelines**

Perception on health impact of climate change

The present situation of water and vector borne disease in this district

Diarrheal trend and other water borne diseases and reason behind it

Source of drinking water

The situation of Hygiene and sanitation in this district

The outbreak probability of vector borne and water borne diseases

Climate change program conducted ever

Activity for community awareness requiring for climate change

Recommendation for management of climate sensitive diseases

## ANNEX 3

**Table No: 10 National water and sanitation coverage**

Region	Total Population	Water Supply Coverage		Sanitation Coverage	
		Population	Percentage	Population	Percentage
EDR	6,374,298	4,871,651	76.4	2,692,909	42.2
CDR	9,859,227	8,017,531	81.3	4,543,201	46.1
WDR	5,468,946	4,624,967	84.6	2,927,999	53.5
MWDR	3,646,321	2,782,076	76.3	1,120,285	30.7
FWDR	2,694,765	2,245,110	83.3	784,647	29.1
Mountain	1,987,700	1,542,782	77.6	668,549	33.6
Hill	12,292,169	9,827,087	79.9	6,501,912	52.9
Terai	13,763,788	11,171,466	81.2	4,899,480	35.6
<b>National</b>	<b>28,043,657</b>	<b>22,541,335</b>	<b>80.4</b>	<b>12069941</b>	<b>43</b>

Source: NMIP Water and Sanitation Survey 2010

**Table No: 11 Water supply and sanitation coverage by districts**

District	Total Population	Water Supply Coverage		Sanitation Coverage	
		Population	Percentage	Population	Percentage
Morang	1,019,083	873,966	85.8	473,812	46.5
Dhankuta	194,274	148,464	76.4	94,504	48.6
Sankhuwasabha	184,845	148,375	80.3	98,692	53.4
Chitwan	583,656	496,399	85	484,908	83.1
Dhading	405,045	280,494	69.3	208,301	51.4
Nuwakot	340,579	265,379	77.9	106,082	31.1
Rasuwa	53,494	47,845	89.4	22,410	41.9
Kailali	791,596	701,592	88.6	310,333	39.2
Doti	249,064	199,152	80	58,054	23.3
Bajhang	198,588	115,638	58.2	27,868	14

Source: NMIP Water and Sanitation Survey 2010

## ANNEX 4

### Photographs



*In-depth interview with Hospital staffs of Sunsari districts*



*In-depth interview with Engineer of District Water Supply Office of Sunsari district*



*Focus Group Discussion among staffs of District Health Office, Dhankuta*



*In-depth interview with Public Health Officer of Sankhuwasabha district*