Protecting Health from Climate Change

VULNERABILITY AND ADAPTATION ASSESSMENT OF THE HEALTH IMPACTS OF CLIMATE VARIABILITY AND CHANGE IN NEPAL

Table of Contents

EXECUTIVE SUMMARY

The global change in climate occurs due to the accumulation of greenhouse gases in the atmosphere arising from the combustion of fossil fuels. There is near unanimous scientific consensus that greenhouse gas emissions generated by human activity will change Earth's climate. The recent (globally averaged) warming by 0.5 C is partly attributable to such anthropogenic emissions.

The spectrum of health effects of climate change includes direct physical effects from climate extremes such as flash floods and storms, (injuries, drowning) and indirect effects via environmental, ecological and social pathways. The health effects that occur through these pathways are basically water and food borne diarrheal diseases, vector borne diseases, malnutrition and many more. Health is considered one of the sectors being highly vulnerable to climate change. There is strong evidence of impacts of climate variability on health outcomes in Nepal. Hence, it became a global concern to address the issue of health effect of climate change and concern of Nepal as well.

The potential health impacts can be reduced through a combination of strengthening key health system functions and improved management of risks presented by a changing climate and it is important to describe the current capacity to manage the risk of climate sensitive health outcomes focusing on vector borne diseases, water borne diseases, child mortality, diarrhoea and malnutrition.

The aim of this consideration is to conduct a vulnerability and adaptation assessment of the health impacts of climate variability and change in Nepal. This report is structured according to the WHO report “Protecting health from climate change”.

Firstly, the public health policies and program that address climate sensitive health outcomes were assessed. Nepal developed policy level provision regarding to adaptation policy called National Adaptation Programme of Action to climate change (NAPA). The Nepal Health Sector Plan has envisioned strengthening health system of Nepal to cope with the health effect of climate change. Nepal is implementing its Health Sector Strategy that also includes a chapter on climate change and health.

Secondly, Current risks of climate-sensitive health outcomes including the most vulnerable populations and regions were assessed. Based on the existing studies, the potential vulnerable population groups of Nepal are identified, such as children and women, squatter settlement and slum dwellers, rag pickers, street children and child workers, elderly population etc. A sensitive index was calculated to figure out the geographical regions with different level of risk which showed a highest score to the Western Mountain – the Mustang district, indicating very sensitive or risk to climate change. The index analysis depicts that highest exposure index value is found in most districts of the Mid- and Far-Western Hills and Mountain regions, signifying greater vulnerability to climate change health impacts. Adaptive

capacity index was also calculated and the lowest adaptive index score is to the Central Hill and Eastern Tarai cluster regions, meaning low vulnerability. It means the Tarai districts are relatively more vulnerable to health outcomes.

Thirdly, a relationship between climate conditions and health outcomes were established. This is to show the trend analysis to decipher any probable relationship between climate and disease occurrence throughout Nepal. The trend of malaria cases and maximum temperature showed that, with minimum change in temperature, the number of cases increased. Similar trend was observed when cases were compared against minimum temperature. The diarrhoeal cases also changed with changing maximum temperature level.

Further, interactions between environmental and socioeconomic determinants of health were also assessed. Regarding the environmental burden of diseases, the likely affected environmental indicators identified were forest, water, soil and air, and ultimately the human health. It has been observed that the feature of the Monsoon rainfall pattern has changed, for instance the intensity of rainfall pattern has increased but the total volume of precipitation has decreased. It is noted that it has affected the ecosystem such as loss of biodiversity, threatening to food security through adverse impacts on winter and spring crops, shifting of hydrograph cycle including drying up of water resources, increasing flash floods, possible droughts, and glacial lake outbursts. Similarly, while exploring the socio-economic determinants of health, it was found that the wealth quintile in the Mountain Region was relatively high vulnerable as this region has high percentage of lowest wealth quintile, followed it by the Mid-Western Hill and Far-Western Hill. The spatial mapping of poverty indexes by district showed improving situation in socio-economic status of the districts of eastern and southern part of Nepal between 2006 and 2011.

Similarly, the child mortality rate was assessed at national level as a climate sensitive health outcome at regional and national level, which was relatively higher in the Mountain Region than in the Tarai and Hill regions. It is highest in the Far-Western Region, among the five development regions.

Moreover, the occurrences of extreme weather events pose grave threat on human health and it has indirect but substantial effect on well-being and health of people. Every disaster has serious implications for human health.

The current capacity of the health system needs to be assessed so as properly to manage the risks of climate-sensitive health outcomes. Since knowledge on climate change impacts and climate related health outcomes is generally limited in the health sector, capacity building is considered one of the immediate priorities in the design of adaptation framework.

There is however a general lack of knowledge and understanding on the causal-effect relationship of climate variables with health impacts since health outcomes are the functions of both climate and non-climate factors. Since health is the primary goal of sustainable development and includes physical, social and psychological well-being, it is crucial that the health impacts of climate change be understood and properly addressed.

A time series modelling was conducted to assess the association between the climate variables and health outcome which showed that the daily cremation counts in Kathmandu, versus temperature showed a negative association between cold temperatures and mortality that strengthened with increasing lag time over 2-21 days, and a more acute positive association between mortality and hot temperatures after a lag of 0-7 days.

A model of the observed spatial patterns of malaria in relation to average climate at district scale suggested that malaria risk is strongly associated with long term average temperature in Nepal. Observed spatial patterns of malaria were also consistent with the results of a theoretical model.

Projections of temperature increase for the year 2050 suggested that, other things being equal, the spatial distribution of malaria risk would expand northwards as a result of climate change. Comparable results were obtained using the empirical model and the theoretical model.

The impacts of climate change on public health are becoming more apparent in Nepal. However, still public health system are implementing activities according to their annual work plan without much linking and considering the climate change.

While the failure to understand the link between the growing health problems and climate change among the concerned health professions, medical experts and implementing partners has failed to deliver effective results from the health programmes, the issue of public health agenda is left behind in the government and donor funded climate change adaptation and mitigation programmes.

Advocate for the strengthening of primary health care (including primary prevention) services to support capacity of local communities to become resilient to climate-related health risks. Waterborne diseases are a major public health problem in Nepal. Therefore, changes in climate will increase their incidence. Health professionals need to be trained on climate change and its impacts on human health to deal with future adversity and provide technical support for building capacity to assess and monitor vulnerability to climate change-related health risks.

The government in association with NGOs/research organizations working on climate change and health issues may initiate training programmes for health professionals. Increase public awareness and action on prevention of climate change-sensitive diseases. Support the assessment of the effectiveness of health emergency management measures in reducing the impact of extreme events on health with the development of appropriate evaluation methods and pilot studies.

1 INTRODUCTION

The global change in climate occurs due to the accumulation of greenhouse gases in the atmosphere arising from the combustion of fossil fuels.[1] There is near unanimous scientific consensus that greenhouse gas emissions generated by human activity will change Earth's climate. The recent (globally averaged) warming by 0.5 C is partly attributable to such anthropogenic emissions.[2]

The report from the United Nations' Intergovernmental Panel on Climate Change (IPCC) provided evidence on the effect of human release of greenhouse gases from fossil fuels and deforestation on the global climate change.[3] The IPCC estimate that since the mid-19th century there has been an increase in average temperature of 0.6 C, most of this increase occurring at the end of 20th century. In addition, it provides evidence of changes in the patterns of precipitation, aridification, and humidity.[3]

The World Health Organization estimates that the warming and precipitation trends due to anthropogenic climate change of the past 30 years already claim many lives. Many prevalent human diseases are linked to climate fluctuations, from cardiovascular mortality and respiratory illnesses due to heat waves, to altered transmission of infectious diseases and malnutrition from crop failures. Uncertainty remains in attributing the expansion or resurgence of diseases to climate change, owing to lack of long-term, high-quality data sets as well as the large influence of socio-economic factors and changes in immunity and drug resistance.[4] Further, Climate change will affect human health in many ways - mostly adversely.[2]

Nepal Government Responses to Climate Change

Nepal signed the United Nations Framework Convention on Climate Change (UNFCC) in 1992 during the UN conference on Environment and Development in Rio de Janeiro, Brazil. Nepal also adopted the Kyoto Protocol on 1997 to implement the convention effectively. The protocol has entered in to force in Nepal in 2005.

The Sustainable Development Agenda for Nepal[5] and the Millennium Development Goals initiatives have also addressed the issue of climate change to a certain extent. Between 1996 and 2006, the then Ministry of Population and Environment was the designated focal point to implement the provisions of the UNFCC. Between 2007 and 2009, in the process of implementing the Convention, Nepal has:

i) Prepared the action plan related to capacity building under the National Capacity Needs Self Assessment Project in order to implement the Rio Conventions (Climate Change, Desertification and Biological Diversity);

ii) Issued CDM project-approval processes and procedures to benefit from the provisions of the Kyoto Protocol;

iii) Started preparing the National Adaptation Programme of Action (NAPA);

iv) Started preparing the Second National Communication (SNC); and

v) Implemented a project on strengthening capacity for managing climate change and the environment.

The Government of Nepal issued the “Kalapatthar Declaration” prior to the 15th Session of the conference of the Parties (COP-15) to the UNFCC, held in Copenhagen in 2009. The South Asian Regional Climate Change Conference “from Kathmandu to Copenhagen” was held and a Memorandum of Understanding was signed by 14 donors and development partners to support Nepal on climate change activities. A status paper for COP 15 was also prepared. In July 2009, a 25-member Climate Change Council, including eight experts, was constituted under the Chairmanship of Right Honourable Prime Minister. Similarly, the Right Honourable Prime Minister, during COP 15, stressed the need for addressing the impact of climate change in the mountains, and that decisions and negotiations of the Convention must consider this issue very seriously. From this, climate change appeared in 2009 as a national development issue.

The Interim Constitution of Nepal (2007) and Three-Year Interim Plan (2008-2010) have also addressed the issue of environmental management and climate change. The Government of Nepal established the Climate Change Management Division in the Ministry of Environment (MoE) in 2010. The MoE prepared the National Adaptation Programme of Action, which was endorsed by the Government in 2010. Local Adaptation Plans of Action (LAPAs) are being prepared to implement adaptation programmes. A multi-stakeholder Climate Change Initiatives Coordination Committee (MCCICC) has been formed to coordinate climate change activities and implement collaborative programmes with representation from relevant ministries and institutions, international and national nongovernment organizations, academia, private sector, and donors. The National Planning Commission has initiated climate-resilient planning tools in the fiscal year 2010-11 to make the country’s economy and infrastructure climate-resilient. It is evident that institutional, collaborative and programmatic activities have been expanded to address the issue of climate change in recent years. Efforts to mobilise funds to implement the programmes on climate change are under way[6].

The NAPA process is a vehicle for the Least Developed Countries Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to prioritize urgent and immediate adaptation actions. Known as the "expanded" NAPA process, the NAPA formulation process in Nepal (2008-2010) was also used as a launching pad for the development of a multi-stakeholder framework on climate change action, ensuring that the NAPA-related stakeholder processes are institutionalized and backed up by a dedicated knowledge management and learning support. The overall structure of the NAPA has three components: preparation and dissemination of a NAPA document; development and maintenance of a climate change knowledge management and learning platform for Nepal; and, development of a multi-stakeholder framework of action on climate change in Nepal[6].

The Government of Nepal is managing concurrent initiatives on climate change that are supported by different development partners. These include the National Adaptation Programme of Action (NAPA), Reducing Emissions from Deforestation in Developing Countries (REDD) , the Pilot Programme for Climate Resilience (PPCR), the Strengthening Capacity for Managing Climate Change and the Environment, and the Second National Communication[7]. The Ministry of Environment (MoE) is the focal point of the Government on climate change, with the Ministry of Forests and Soil Conservation (MoFSC) leading on the Reducing Emissions from Deforestation in Developing Countries (REDD) programme. The Ministry of Finance (MoF) has the responsibility to coordinate foreign aid flows and the National Planning Commission (NPC) leads in policy formulation and coordination on development planning.

Response to climate change in Nepal has been growing in recent years with an effort to cope with the changing situation and build resilience capacity into adaptation to climate change. In climate induced vulnerability context, Nepal developed policy level provision regarding to adaptation policy called National Adaptation Programme of Action to climate change (NAPA).

In Nepal, the NAPA was developed with the three components: Preparation and dissemination of NAPA document, development and maintenance of Nepal Climate Change Knowledge Management Centre (NCCKMC) and development of Multi-Stakeholder Climate Change Initiative Coordination Committee (MCCICC)

In the NAPA of Nepal, nine integrated projects have been identified as the urgent and immediate national adaptation priority. They are:

1. Promoting Community-based Adaptation through Integrated Management of Agriculture, Water, Forest and Biodiversity Sector
2. Building and Enhancing Adaptive Capacity of Vulnerable Communities Through Improved System and Access to Services Related to Agriculture Development
3. Community-Based Disaster Management for Facilitating Climate Adaptation
4. GLOF Monitoring and Disaster Risk Reduction and forest and Ecosystem Management for Supporting Climate-Led Adaptation Innovations
5. Adapting to Climate Challenges in Public Health and ecosystem Management for Climate Adaptation

6. Empowering Vulnerable Communities through Sustainable Management of Water Resource and Clean Energy Support and promoting Climate Smart Urban Settlement

Nepal is no exception to the influence that climate change can inflict on health. Being one of the least developed countries of the world, Nepal may be one of the least contributors to changing climate but the negative impact of climate change is going to be one of the highest in this region. This is why it is high time that focus must be laden to the issue of climate change and health in Nepal.[8]

RATIONALE

The Earth's average surface temperature has risen by about 0.74 degrees Celsius in the past 100 years and it could even rise by up to 5 degree Celsius by 2080 if the emission of such gases are not decisively reduced[9]. It is now universally acknowledged that the climate change we are witnessing will continue for a long time.

Many countries have already planned a strategic direction in terms of adaptation plan for climate change and its effect on human health and few are in the process of development.

Clearly Nepal is facing climate change-induced consequences in many spheres of society and development. Nepal is also in the process of developing national level strategy to reduce the effect of climate change in human health.

Hence, in the verge of limited information related to climate change and health in Nepal, it is difficult to draw clear conclusions **to develop national level strategy** for future adaptation measures for Nepal.

2 OBJECTIVE AND PROCESS OF THE ASSESSMENT

2.1 Objective

The overall objective is to conduct a vulnerability and adaptation assessment of the health impacts of climate change in Nepal.

The specific objectives were:

- To conduct Vulnerability & Adaptation Assessment based on the framework outlined in Pan American Health Organization WHO (2012) to develop Nepal's Country Strategy for protecting human health from the adverse effect of climate change through specific:
  - Analysis of public health policies and program to address climate sensitive health outcomes in Nepal
  - Assessment of human health risks of current climate variability and recent climate change in Nepal
  - Analysis of trends in climate change-related exposures in Nepal
  - Assessment of current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions in Nepal
  - Assessment of interactions between environmental and socioeconomic determinants of health in Nepal
  - Assessment of current capacity of health and other sectors to manage the risks of climate-sensitive health outcomes in Nepal

2.2 Process of the assessment

This report is based on the process and structure presented in a WHO report "Protecting health from climate change: Vulnerability and Adaptation Assessment"[10] which makes the stakeholders to understand clear picture of relationship between climate change and health in Nepal and compare it with other country and region specific information.

2.2.1 Approach

Initially the Ministry of Health and Population formed a technical committee for the development of national level strategy and guide the technical team as a working group to generate evidence for the formulation of strategies.

Then a group of consultant as a technical team with different specialty related to climate and health was formed with the support of WHO which included epidemiologist as a lead consultant, health system expert, meteorologist, environmental expert, disaster risk expert as a consultant team member.

A workshop was held in Kathmandu in August 2013 to strengthen capacity of the technical committee, technical team and other stakeholders from relevant ministry by an External Expert on Climate Change and health.

In December 2013, a consultative meeting was held between the climate change expert and consultants.

Again in February 2014, a capacity strengthening meeting for the technical team consultants was organized by WHO.

Many other regular meetings were also held to finalize individual report and compilation.

2.2.2 Methods

The first process started by the technical team was the desk review of all the reports and articles (published & unpublished) by each of the consultants on their relevant areas of expertise. Then a series of meetings were organized to share the initial documents prepared with scope and objective of this documentation.

2.2.2.1 Scope of the Assessment

2.2.2.1.1 Geographical:

Nepal is administratively divided into five regions with 75 districts and has three ecological zones (Mountain, Hill and Terai). Therefore, the geographical scope for this assessment was limited to 15 eco-developmental regions considering the five developmental regions and three ecological zones. Later two eco-developmental regions of the far western region were merged due to its less population size and finally 13 eco-developmental regions were consider for assessment as 13 clusters. The clusters were similar to the domain used as an unit by the widely accepted Demographic and Health Survey 2011[11] of Nepal.[11] The clusters are as follows:

- Eastern Mountain (Taplejung, Sankhuwashaba, Solukhumbu), Central Mountain (Dolakha, Sindhupalchok, Rasuwa), Western Mountain (Mustang, Manang), Mid-western Mountain (Dolpa, Jumla, Mugu, Kalikot, Humla), Far-western Mountain (Bajura, Bajhang, Darchula)
- Eastern Hill (Ilam, Panchthar, Terhathum, Dhankuta, Bhojpur, Khotang, Udaypur, Okhaldhunga), Central Hill (Ramechhap, Sindhuli, Kavre, Makwanpur, Bhaktapur, Lalitpur, Kathmandu, Nuwakot, Dhading), Western Hill (Gorkha, Lamjung, Tanahun, Kaski, Syangja, Palpa, Parbat,Gulmi, Arghakhanchi, Baglung, Mayagdi), Mid-western Hill (Pyuthan, Rolpa, Rukum, Salyan, Jajarkot, Surkhet, Dailekh), Far-western Hill (Achham, Doti, Dadeldhura, Baitadi)
- Eastern Terai (Jhapa, Morang, Sunsari,Saptari, Siraha), Central Terai (Dhanusa, Mahottari, Sarlahi, Rautahat, Bara, Parsa, Chitwan), Western Terai (Nawalparasi,

Rupandehi, Kapilbastu), Mid-western Terai (Dang, Banke, Bardiya), Far-western Terai (Kailali, Kanchanpur)

2.2.2.1.2 Health Outcome:

The health outcomes that were directly the consequences of the adverse of the climate change were analyzed and are as follows:

1. Diarrheal disease
2. Malaria
3. Acute Respiratory Tract Infection (ARI)
4. Malnutrition

Diarrheal diseases and Malaria were assessed for all age group, while ARI and Malnutrition were assessed only for children under five years of age due the program and reporting system in Nepal.

2.2.2.1.3 Climate Data

Climate data were categorized for the purpose of assessment as follows:

1. Maximum Temperature
2. Minimum Temperature
3. Total rainfall
4. Extreme Events

The monthly meteorological data was requested and retrieved from Department of Hydrology and Meteorology for the period of 10 years from 2001 to 2010 and analyzed accordingly. Further, the cluster wise data on daily maximum temperature, minimum temperature and total rainfall was retrieved by down scaling the global meteorological data which has been explained in detail in the respective chapter itself. The data on extreme events were accessed through desk review.

2.2.2.1.4 Data Availability & Statistical Analysis

Initially, the team members proposed to analyze the data for the period of at least ten years for all clusters. Therefore, all the information was retrieved from 2001 to 2010 as far as possible. However, the quantitative data related to health outcome was not possible to get for the entire 10 year period due to a different system of storage. Hence, it was analyzed partly from 2004 to 2008.

The health policy and program data were reviewed from the published and unpublished documents relating the climate change health outcomes for the period of 10 years from 2001 to 2010 and analyzed accordingly.

Similarly, extreme weather events information was mostly qualitative in nature and obtained through desk review.

A Distributed Lag Non-linear modeling (DLNM) was performed to study the relationship between climate change and its health outcome.

2.2.2.1.5 Vulnerability and Adaptation

Vulnerability is defined as "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes and vulnerability is a function of character, magnitude and rate of climate variation to which a system is exposed its sensitivity and adaptive capacity"[3]. Thus according to this definition, vulnerability has three components, viz exposure, sensitivity and adaptive capacity. These three components are described as follows:

Vulnerability = *f* (exposure, sensitivity, adaptive capacity)

Where,

- *f = function*
- *Exposure* can be interpreted as the direct danger (i.e., the stressor), and the nature and extent of changes to a region's climate variables (e.g., temperature, precipitation, extreme weather events).
- *Sensitivity* describes the human–environmental conditions that can worsen the hazard, ameliorate the hazard, or trigger an impact.
- *Adaptive capacity* represents the potential to implement adaptation measures that help avert potential impacts

Two components, viz exposure and sensitivity together represent the potential impact, while adaptive capacity is the extent to which these impacts can be averted. Thus vulnerability is the potential impact (I)minus adaptive capacity (AC). This leads to the following mathematical equation for vulnerability:

$V = f(I - AC)$

3 VULNERABILITY AND ADAPTATION ASSESSMENT

3.1 Public health policies and program to address climate sensitive health outcomes

Nepal is implementing its Health Sector Strategy as a Sector Wide Approach (SWAP). The successful implementation of NHSP-1 led to the development of NHSP-2 (2010-2015), which has its goal in improving the health and nutritional status of the Nepali population, especially the poor and excluded. The following three key objectives are set out in the Results Framework:

- to increase access to and utilization of quality essential health care services;
- to reduce cultural and economic barriers to accessing health care services and harmful cultural practices in partnership with non-state actors;

- to improve the health system to achieve universal coverage of essential health services.

NHSP - 2 (MoHP) has mentioned that it will establish a knowledge network with academia and practitioners on climate change and climate change public health response team. The NHSSP 2010-2015 was developed in 2010 with a broad vision "to enhance sustainable development of the health sector for better health and well-being of all Nepalese, especially of the poor, women and children, thereby contributing to poverty alleviation and socio-economic development." The NHSP- 2 comprises three goals: to reduce newborn, child and maternal morbidity and mortality with increased reproductive health; to reduce morbidity and mortality of HIV/AIDS, Malaria, Tuberculosis, and other communicable diseases; and to reduce the burden of non-communicable diseases and other health problems.

Consistent with these goals, the health strategy has identified strategic areas such as health service delivery; health care financing; human resource for health; health information system; and health system governance. Several elements consistent with climate change issues and response can be found among a set of policy directions identified in the NHSP

- Implement pro-poor health financing systems such as free drug policy and health insurance schemes.
- Strengthen and invest in health information system and health research for evidence based policy-making, planning, monitoring performance and evaluation.
- Prevent and control communicable and selected chronic and non-communicable diseases, and strengthen disease surveillance systems for effective response to emerging and remerging diseases.
- Strengthen public health interventions to deal with cross-cutting challenges, especially gender, hygiene and sanitation, school health, environmental health risks, mental health, injury, occupational health, disaster through timely response, effective collaboration and coordination with other sectors.

Similarly, the overarching national objective of the heath sector in the Tenth Plan was to reduce the magnitude of poverty substantially and make it sustainable by developing and mobilizing human resources.

In order to achieve this objective the plan aimed to i) improve the quality of health services and extend the services to poor people living in remote areas and ii) manage the rising population and extend the access of reproductive health and family planning services to rural areas in consideration of maternal health services.

The Three Year Interim Plan developed in 2007 also envisions establishing appropriate conditions of quality health services delivery, accessible to all, with a particular focus on low income groups and contributing to the improve health of Nepalese population.

3.1.1 Public Health System and Structure

Ministry of Health & Population is mandated with the development of policies, plan; monitoring & supervision of the activities implemented through different tiers of the health system including Department of Health Services, Regional Health Directorate, District Public Health Offices and regulating the activities related to health sector in Nepal.

The Department of Health Services is responsible for the implementation of preventive and curative health services throughout the country planned and budgeted by the MoHP and is one of the three departments under the Ministry of Health.

Under the Department of Health Services (DoHS) there are 5 Regional Health Directorates, each located at the headquarters of each of the five development regions of Nepal. In 62 of the 75 districts, there is a District Health Office (DHO) with a District Hospital and a District Public Health Office (DPHO) under its umbrella. At the district level, each Ministry has offices that manage the planning and implementation for their respective sector.

The DHO co-ordinates health development activities in the district through the District Development Committee (DDC) and is responsible for all health-related activities in the district including the organization and management of district hospitals, primary health care centers (PHCC), health posts (HP) and sub-health posts (SHPs).

There is one Primary Health Care Center (PHCC) at each of the 205 electoral constituencies and approximately 100,000 population, one health post (HP) for 3-5 Village Development Committees (VDCs) and one sub-health post (SHP) for each VDC. The SHPs are the first facility-based contact point for basic health services and serve as the referral centre for volunteer health workers, such as Female Community Health Volunteers (FCHVs). About 48,850 FCHVs, several thousand mothers' group (MGs) Village Health Workers (VHWs) and Maternal and Child Health Workers (MCHWs) are working in SHPs. There is one FCHV in each ward for VDC. The SHPs serves as venue for 20 community-based health activities and as a referral point for patients to HPs and PHCs, and district, zonal and regional hospitals, and finally to the specialty tertiary care centers in Kathmandu. The referral system was designed to ensure that the majority of population has access to public health care facilities and affordable treatment. There is one health committee in each VDC.

3.1.2 Health Institutional Structure Relevant to Climate Change Response

The Ministry of Health is the apex institution with extensive network of health care centers and facilities across the country. Several divisions and centers established under the umbrella of MOHP being more or less relevant to climate change include:

- EDCD(Malaria and Dengue and disaster management and NEOC at MOHP);
- National Health Training Center(Capacity Building of Health Service Providers);
- National Health Education Information and Communication Centre(NHEICC) for IEC/BCC)
- Sub health post to tertiary hospital; and
- National Infectious Disease Hospital

Six Thematic Working Group (TWG) are formed, each led by different ministries; Agriculture and Food Security; Forests and Bio-diversity; Water Resources and Energy; Climate Induced Disasters; Urban Settlement and Infrastructure and Public Health. Each Task Force formed “Reference Groups” for wider consultation on a regular basis.

Nepal is implementing its Health Sector Strategy as a Sector Wide Approach (SWAP) by linking annual work plan with strategy to the medium term economic expenditure framework (MTEF). The latest strategy includes a chapter on climate change and health.

A number of progresses under this strategy are relevant in terms of planning for and adapting to climate change. For instance, policies and programmes like the National Drinking Water Quality Standards (2006); early warning epidemic system in 28 districts; devolution of health services to local management community in the districts’ and village council to ensure community oversight; community health insurance schemes are likely to help address the aspects of climate change.

The EDCD is of particular relevance as far as vector-borne disease is concerned. The EDCD has an ambitious goal of elimination of malaria incidents by 2026. The EDCD has its extensive network down to the VDC level (village malaria workers), which facilitates information flow between VDC and the EDCD and distribution of treated nets and appropriate anti-malaria drugs. As a result the number of malaria incidents has decreased over the last decade.

The adaptation strategy has focused largely on awareness raising and public health initiatives at the community level. The urgent and immediate need is to carry out research and studies to understand the scale and epidemiology of health problems caused by climate change and formulation of evidenced based adaptation strategies. Adaptation priorities on the health sector also include increasing access to information and knowledge on impacts of climate change on human health particularly with regard to emergencies and outbreak of diarrhoea including piloting and implementation support.

The activity components adapting to climate challenges in public health includes:

1. Reducing public health impacts of climate change through evidenced based research and piloting.
2. Empowering communities through public education for responding adverse effects of climate change in public health.
3. Investing disease outbreak and emergency response.

4. Scaling up programs on vector borne, water and food borne disease.
5. Strengthening forecasting /early warning and surveillance system on climate change and health

Nevertheless it needs to allocate more resources to develop physical infrastructure and increase people's access to services due to lack of local bodies; inadequate financing, technology and human resource and lack of public awareness on climate related disasters and limited reach of early warning system

3.2 Current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions

Generally, the vulnerability of a population to a health risk depends on local environment, availability of local resources, effectiveness of governance and public institutions, quality of public health infrastructure and access to relevant local information on extreme weather threats. Spatial distribution of these factors is usually not uniform, affecting the population to vulnerable at varying degrees. The differences are based on topography, demography, socioeconomic factors and so on. The communities having low capacity to adapt to climate variability and change are much vulnerable and susceptible to it than those having high adaptive capacity. To effectively achieve the targeted adaptation strategies, it is essential to understand the existing features of those factors across the country. It then will help us to assess variability of risks or find vulnerable populations by cluster region.

First, Nepal's topography can broadly be divided into three physiographic regions (Figure 2). Its three-fourths area is made up of mountains and hills, which are topographically rugged, geologically fragile and mostly inaccessible by roads, where almost 50 percent of population lives (Table 3). But however the hills in particular offer favourable climatic condition for human habitat. The Tarai on the other hand is a plain that shares 23 percent of total area, but accommodates over 50 percent of the total population.

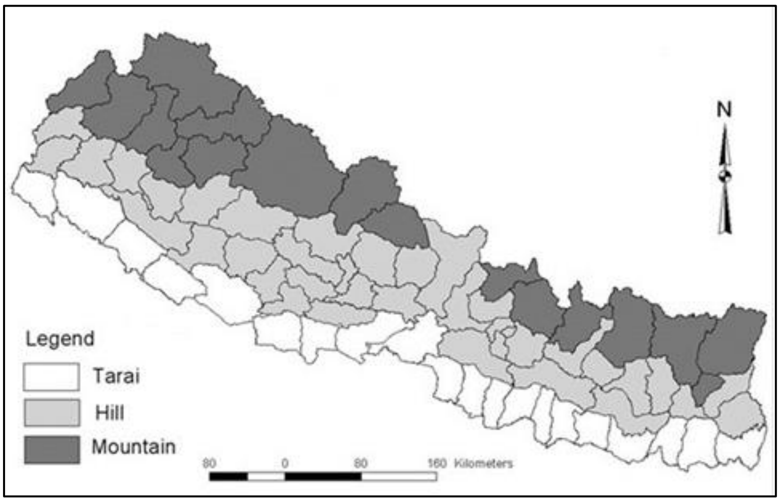


Figure 1: Physiographic regions of Nepal

Table 1: Spatial extent of physiographic regions and their features

Physiographic region	Area		No. of districts	Population features (2011)			
	Km²	%		In million	%	Growth rate % per annum	Density persons/km²
Mountain	51,817	35.2	16	1.80	6.74	0.62	35
Hill	61,345	41.7	39	11.48	43.11	1.13	187
Tarai	34,019	23.1	20	13.35	50.15	1.75	392
Total	**147,181**	**100**	**75**	**26.62**	**100**	**1.40**	**181**

Source: CBS (2013)

Secondly, the Government of Nepal (MLD 1997) has defined 22 mountain and hill districts as remote or marginal districts in terms of relative absence of given infrastructure and backwardness (Figure 3). This covers 66 thousands km² and represents almost 45 percent of the total area. The marginal regions are characterised by ruggedness of terrain with slope above 30° and poor to worst conditions in socioeconomic infrastructure measured in terms of settlement pattern (mostly dispersed), road density, literacy rate, and poverty index (Pradhan 2007).

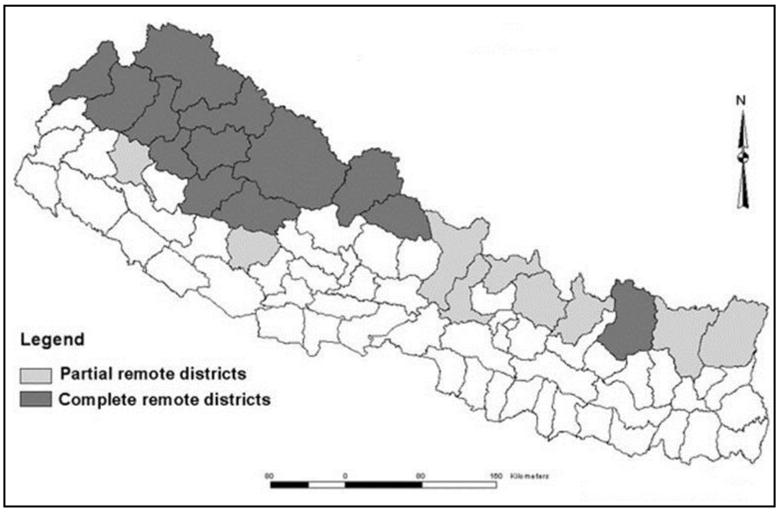


Figure 2: Remote regions of Nepal

Thirdly, the population size of Nepal has grown rapidly over the past decades. Likewise the municipal or urban population has grown very rapidly over the past years. The country's growth rates of population have however a declining trend. But the proportion of population living in the urban areas has increased rapidly over the past years (Table 4). Life expectancy at birth is also increasing for both male and female.

Table 2: Growths of population by decade, Nepal[11]

Indicators	1971	1981	1991	2001	2011
Population (millions)	11.6	15.0	18.5	23.2	26.6
Inter-censuses growth rate (%)	2.1	2.6	2.1	2.2	1.4
Density (number of persons/km^2)	79	102	126	157	181
Percentage of urban population	4.0	6.4	9.2	13.9	17.0
Life expectancy at birth (years) of sex					
Male	42.0	50.9	55.0	60.1	65.6
Female	40.0	48.1	53.5	60.7	68.2

Along with the population, the density has also increased in the country from 157 persons per km² in 2001 to 181 persons per km² in 2011. The density of population varies greatly over the 15 cluster regions. The Eastern Tarai has the largest population density (>525 p/km²), while the Western Mountain has the lowest population density (<4 p/km²), but it shows highest decrease at -23 point percent in the density during 2001-2011 decade (Annex I). During the same decade, two other mountain clusters (Eastern and Central) and the Eastern Hill, too have shown declined in the population density. All the rest 11 clusters have shown an increase in the density at varying percent points, but the three clusters, viz. Mid Western Mountain, Central Hill and Far Western Tarai have shown a relatively largest increase in population density. Figures 3 and 4 depict population density by district and changing scenario in the density between 2001 and 2011.

Table 3: Change in population density (persons per square km) between 2001 and 2011

Regions	2001	2011	Change (%)
EM	38.5	37.6	-2.4
CM	88.4	82.5	-7.2
WM	4.2	3.4	-22.9
MWM	14.5	18.2	20.5
FWM	50.2	58.4	14.1
EH	152.9	149.0	-2.6
CH	300.1	375.4	20.1
WH	152.5	153.5	0.6
MWH	107.4	123.1	12.7
FWH	118.2	127.5	7.3
ET	453.9	525.3	13.6
CT	421.7	504.7	16.4
WT	333.3	398.4	16.3
MWT	168.2	201.0	16.3
FWT	205.3	253.2	18.9
Total	**157.0**	**181.0**	**15.3**

Source: CBS, 2003; 2013

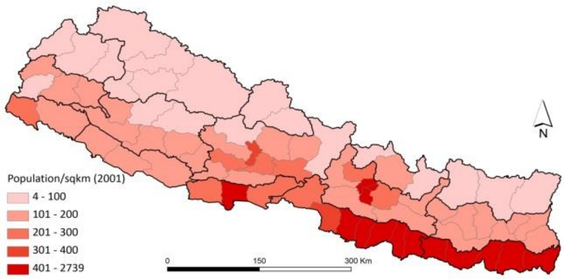


Figure 3: Population density, 2001

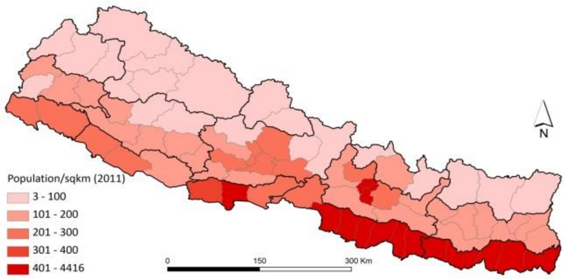


Figure 4: Population density, 2011

3.2.1 Potential vulnerable populations of Nepal

Based on the existing studies, the potential vulnerable population groups of Nepal are identified, such as: (i) children and women (especially pregnant), (ii) squatter settlement and slum dwellers (large cities), (iii) dwellers of flood plain, river banks and steep hill slope, (iv) internally displaced persons, (v) rag pickers, street children and child workers, (vi) commercial sex workers, (vii) prisoners, (viii) refugees, (ix) elderly population, and (x) infant population (<1 year of age). The population size of these groups may vary due to geographical locations, population characteristics, settlement types, occupation types, and socio-cultural, economic and political situations. According to the NDHS study (2011)[11], the infant and under-5 years of age populations, representing the vulnerable group share 2.8 percent and 13.6 percent of the total population respectively. Likewise, the expected pregnancies women population shares 3.7 percent and elderly population (>65 years of age) shares 4.4 percent.

Risk Assessment

Risk assessment is a method to assess potential vulnerable population. This method is a process of determining the probability and magnitude of harm to human life and welfare or environment potentially caused by the release of hazardous chemical, physical or biological pollutants. The estimation of potentially vulnerable populations by district in terms of climate sensitive diseases in Nepal is shown in Table 6.

Table 4: Potential vulnerable population in terms of climate sensitive diseases in Nepal

<table>
<tr><th>Diseases</th><th>No. of districts</th><th>Potential risk population (%)</th><th>Remarks</th></tr>
<tr><td>Malaria</td><td>65</td><td>91.6</td><td rowspan="2">All but mountain districts</td></tr>
<tr><td>Lymphatic filariasis</td><td>60</td><td>87.0</td></tr>
<tr><td>Japanese encephalitis</td><td>24</td><td>53.9</td><td rowspan="2">All Tarai + its adjoining districts</td></tr>
<tr><td>Kala-azar</td><td>12</td><td>29.7</td></tr>
<tr><td>Water and food borne</td><td>75</td><td>100</td><td rowspan="2">All district</td></tr>
<tr><td>Non-communicable</td><td>75</td><td>100</td></tr>
</table>

Source: DOHS (2013)

3.2.2 Distribution of Risk Populations

The quantitative assessment of vulnerability has been estimated using a 'vulnerability index' at the geographic scale of districts and clusters. The data have been gathered at district level. For interpretation, district level status has been used wherever relevant. So, district is the main statistical spatial unit. There are 75 districts and each district is further divided into Ilakas or sub-districts, the politico-electoral units, the number ranging 9 to 20, which are formed comprising a number of Village Development Committees (VDC) and in some cases Municipalities.

Second, indicators have been selected for each of the three components of vulnerability, (sensitivity, exposure and adaptive capacity) based on the available data and existing research studies and reports.

3.2.2.1 Vulnerability Assessment Indicators

Table 5 depicts indicators for the vulnerability assessment.

Table 5: Indicators for vulnerability assessment

Particulars	Indicators/indices
A. **Sensitivity**	
Demography	1. Density
	2. Under 5 children
	3. Elderly population
	4. Gender
Ecology	5. Forest coverage
	6. Protected area
B**. Exposure/Risk**	
Meteorology	1. Temperature
	2. Precipitation
Climate induced disasters	3. Landslides
	4. Floods
	5. GLOFs
Drought	6. Occurrence
	7. Drying-up of water sources
Diseases	8. Diarrhoeal disease
	9. ARI
	10. Malaria
C**. Adaptation**	
Socio-economic	1. Wealth quintile
	2. Gender empowerment
	3. Human Poverty
	4. Literacy
	5. Nutrition
	6. Food balance
Infrastructure	7. Road access
	8. Communication access
	9. Drinking water access
	10. Sanitation coverage
	11. Education coverage
Technology	12. TV/radio
	13. Telephone/mobile
	14. Cycle/motor cycle
Health services	15. Health service access
	16. Health human resources
Government responses	17. Health service systems
	18. Awareness programs
	19. Policy measures

The following method has been used:

Step 1: Data standardization or normalization of the indicators using functional relationship

The methodology used in UNDP's Human Development Index (HDI) (UNDP, 2006) has been followed to normalize the indicators. All the values of the indicators are normalized so that they all lie between 0 and 1. Before doing this, it is important to identify the functional relationship between the indicators and vulnerability. Two types of functional relationship of indicators to vulnerability are possible: (i) direct relation and (ii) inverse relation. The following equations are used to describe their relationships:

Equation 1: direct functional relation

$$Yij = \frac{Max\{Xij\} - Xij}{Max\{Xij\} - Min\{Xij\}} \quad \ldots\ldots\ldots\ldots\ldots\ldots$$

Equation 2: inverse functional relation

$$Yij = \frac{Xij - Max\{Xij\}}{Max\{Xij\} - Min\{Xij\}} \ldots\ldots\ldots\ldots\ldots\ldots$$

Where,

Yi,j = standardized indicator/sub indices/index of type i of region j; Xi,j = not standardized indicator/sub indices/index of type i of region j; X_i^{MAX} = maximum value of the indicators/ sub indices/index of region j, and X_i^{MIN} is the minimum value of the indicator/sub indices/ index of region j.

Step 2: Methods of construction of vulnerability index

After computing the normalized scores, the index is constructed by weighting.

Assigning Average of Scores

Equal weights are given to each indicator and simple average of all the normalized scores to construct the vulnerability index by using the equation 3, such as:

Equation 3: assigning average score

$$VI = \frac{\sum_j Xij + \sum_j Yij}{K}$$

Step 3: Operational definitions and indices

Socioeconomic Status

The wealth index is one of the composite indexes, which has been created by following three steps[11]:

- In the first step, a subset of common indicators is used to create wealth scores for households. Categorical variables were used and transformed into separate dichotomous (0-1) indicators.

These indicators and those that are continuous were then examined using a principal component analysis to produce a common factor score for each household.

- In the second step, separate factor scores are produced for households between urban and rural areas using area-specific indicators
- The third step combines the separate area-specific factor scores to produce a nationally applicable combined wealth index by adjusting area-specific scores through a regression on the common factor scores.

This three-step procedure permits greater adaptability of the wealth index in both urban and rural areas. The resulting combined wealth index has a mean of zero and a standard deviation of one. After computing the index, national-level wealth quintiles (from lowest to highest) were obtained by assigning the household score to each household member, ranking each person in the population by his or her score, and then divided the ranking into five equal categories, each comprising 20 percent of the population.

Source of Drinking Water (DWSS 2011)

- Improved source is considered as water drawn from piped into dwelling/yard/plot, publictap/standpipe, tube well or borehole, protected well, protected spring, rain water, bottled water
- Non-improved source is considered as water taken from unprotected well, unprotected spring, tanker truck/cart with drum, surface water

Solid Fuel

Solid fuels used for domestic cooking purpose are wood, straw/shrubs/grass, agricultural crop,animal dung, coal, lignite and charcoal.

Food Production

The major food production in each district has been converted into kilocalories per capita per day and used as an indicator of the availability of food. Major food production of rice, maize, wheat, millet, barley, and potatoes has been taken as total production.

Data Sources

The study used the following data sources:

- NDHS (Nepal Demographic Health Survey) for the years: 2001, 2006, 2011
- Nepal Living Standard Survey (NLSS): 1996, 2004 and 2011
- HMIS (Health Management Information System) data from DOHS (Department of Health Services of the years 2001-2013
- Department of Hydrology and Meteorology (DHM) for climate data
- Central Bureau of Statistics (CBS) for demography data, 2001, 2006, 2011
- National Planning Commission (NPC) and World Food Programme (WFP) – food security, 2006 and 2011
- Ministry of Science and Technology and Environment (MOSTE)

Besides, all relevant reports and published documents such as food security atlas, health reports, water and sanitation reports, poverty report, and others available have been collected.

As per the requirements for the text, maps, tables, graphs, and cross tabulations were prepared. District level data has been considered for the analysis. Values were estimated by taking average value of the districts of the regional cluster for the missing districts in the NDHS report, such as four in 2001 and three in 2011.

3.2.2.2 Sensitivity

Figure 6 depicts sensitive index score over districts. The index shows a highest score to the Western Mountain – the Mustang district (over 0.81 point), indicating very sensitive or risk. The districts with higher and high sensitive scores are scattered across the country.

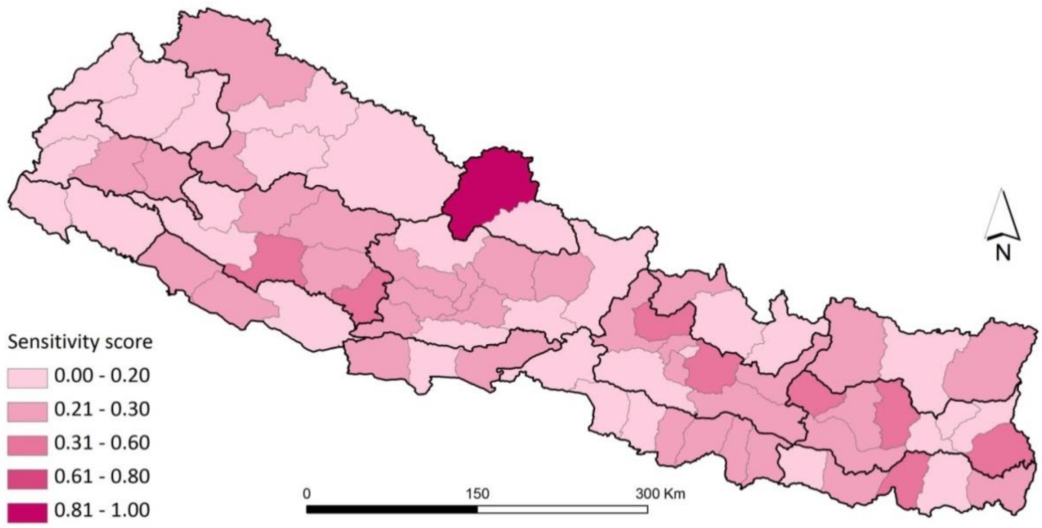


Figure 5: Distribution of composite sensitive index by district, Nepal

By cluster region, the Western Mountain has the highest mean sensitive score (0.56 point) with huge standard deviation value, indicating very vulnerable. This is followed by Central Hill and Eastern Tarai (at 0.25 mean score). Two cluster regions, viz. Far-Western Mountain and Far-Western Tarai have lowest mean score of 0.16 (Table 7).

Table 6: Distribution of composite sensitive index score by Cluster region, Nepal

Cluster region	Mean	SD	Cluster region	Mean	SD
ME	0.22	0.06	HMW	0.22	0.12
MC	0.19	0.02	HFW	0.20	0.03
MW	0.56	0.62	TE	0.25	0.19
MMW	0.20	0.05	TC	0.20	0.05
MFW	0.16	0.04	TW	0.18	0.08
HE	0.22	0.10	TMW	0.20	0.06
HC	0.25	0.09	TFW	0.16	0.00
HW	0.20	0.05	**Country**	**0.23**	**0.10**

Source: National reports (2000-2013)

3.2.2.3 Exposure

The distribution of exposure index scores over districts is shown in Figure 6. The index analysis depicts that highest exposure index value is found in most districts of the Mid- and Far-Western Hills and Mountain regions, signifying greater vulnerability to climate change health impacts.

Table 8 reveals that, with mean score of 0.74, the Far-Western Mountain is the most vulnerable

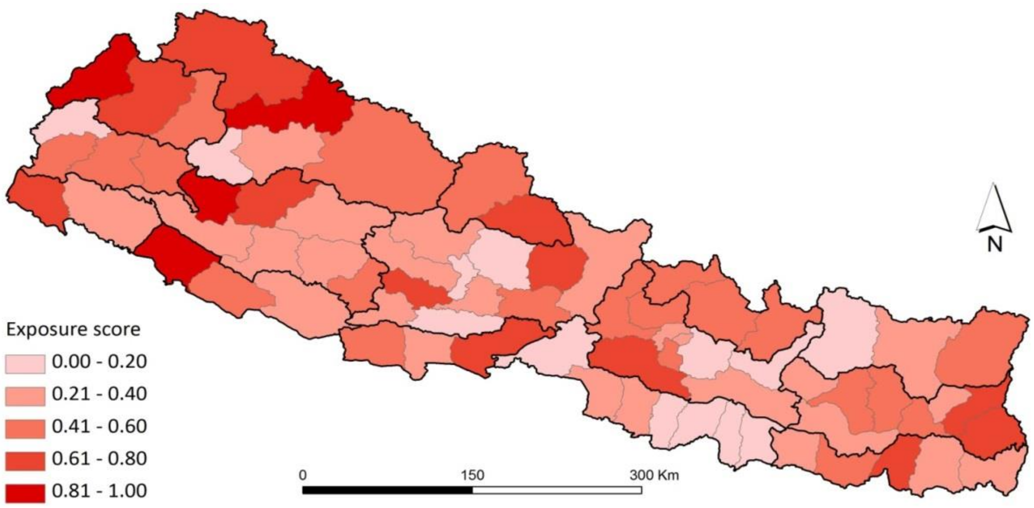


Figure 6: Distribution of composite exposure index by district, Nepal

in terms of exposure. This is followed by the Western Mountain (at mean score of 0.63). In terms of exposure index, the Central Tarai is the least vulnerable.

Table 7: Distribution of composite exposure index score by Cluster region, Nepal

Cluster region	Mean	SD	Cluster region	Mean	SD
ME	0.33	0.20	HMW	0.43	0.24
MC	0.47	0.07	HFW	0.43	0.20
MW	0.63	0.16	TE	0.43	0.21
MMW	0.52	0.32	TC	0.17	0.11
MFW	0.74	0.19	TW	0.49	0.14
HE	0.45	0.17	TMW	0.56	0.32

HC	0.37	0.19	TFW	0.47	0.32
HW	0.34	0.18	Country	**0.46**	**0.20**

Source: National reports (2000-2013)

3.2.2.4 Adaptive Capacity

Figure 8 depicts adaptive capacity index values over the districts. Relatively highest and higher adaptation index scores are found in the most districts of the Mid- and Far-Western Hills and Mountains, indicating low or poor adaptive capacity, i.e. more vulnerable and vice versa.

As shown in Table 9, the Mid-Western Mountain has the largest mean adaptive index score, meaning the lowest adaptability or highest vulnerability. Next to it is the Far-Western Mountain (at mean score of 0.55). The lowest adaptive index score is to the Central Hill and Eastern Tarai cluster regions, meaning low vulnerability.

Table 8: Distribution of composite adaptive index score by Cluster region, Nepal

Cluster region	Mean	SD	Cluster region	Mean	SD
ME	0.36	0.08	HMW	0.50	0.13
MC	0.48	0.09	HFW	0.49	0.10
MW	0.35	0.06	TE	0.23	0.09
MMW	0.76	0.19	TC	0.33	0.09
MFW	0.55	0.12	TW	0.25	0.11
HE	0.29	0.08	TMW	0.28	0.06
HC	0.23	0.17	TFW	0.26	0.04
HW	0.26	0.08	**Country**	**0.37**	**0.10**

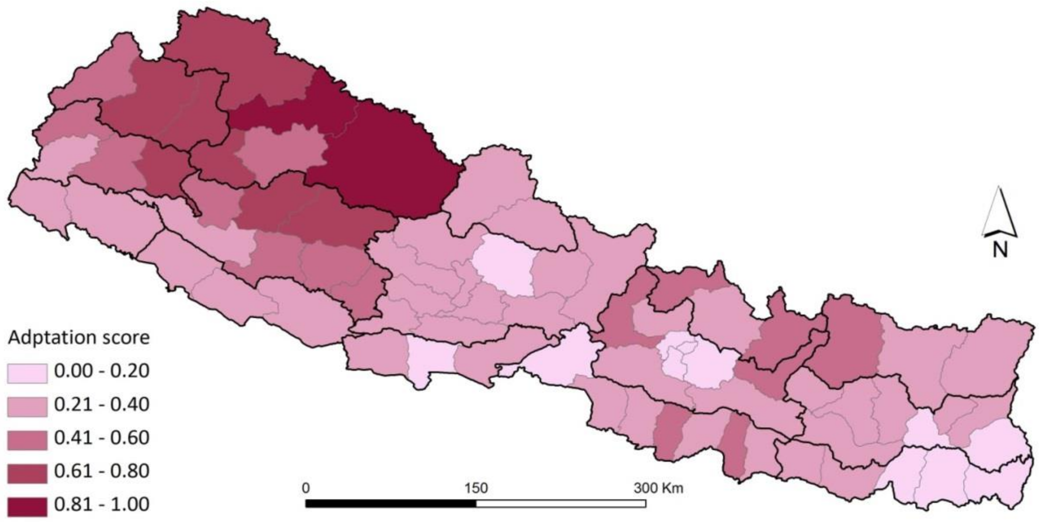


Figure 7: Distribution of composite adaptation index by district, Nepal

3.2.2.5 Composite of all three Components of Vulnerability

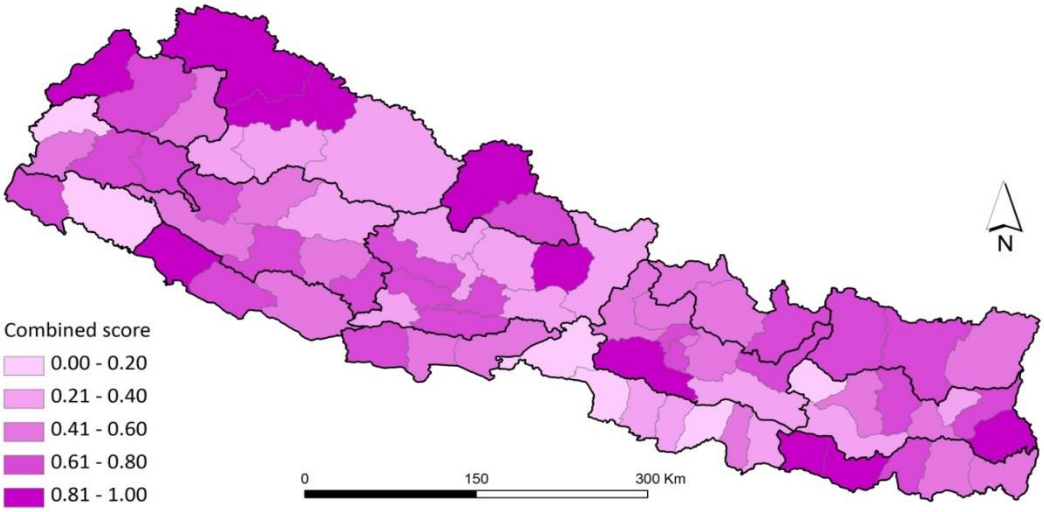


Figure 8: Spatial distribution of aggregate vulnerable values by district, Nepal

Figure 9 depicts the spatial distribution of aggregate average values of the three components by district. The average value of all districts is considered as a benchmark or basis of analysis of the vulnerability.

The average composite index value of all three components for the country as a whole is 0.53. There are 43 districts above the mean value, signifying more vulnerable and the rest 32 districts are less vulnerable. In terms of score, Achham (HFW) with 0.93 is the highest vulnerable district, which is followed by districts such as Siraha (TE), Kalikot (MMW) , Dailekh (HMW), Humla (MMW) with score >0.80 Ilam (HE) Kabhrepalanchok (CH) and Parbat (WH). with <0.2 score indicating the least vulnerable districts.

Districts with lowest aggregate values are spotted across the western half hill and mountain regions and likewise the districts with higher to highest aggregate values are scattered across the country except in the mountain region.

By the cluster region, the combined composite index mean score is highest (0.77 score) for the Far Western Hill, meaning greatest vulnerability (Table 10). This is followed by the Far Western Mountain (mean score at 0.74). This combined composite index gives the lowest vulnerability to the Far Western Tarai (Table 10).

Table 10: combined vulnerability score by cluster region

Cluster region	Vulnerability score	
	Average	SD

ME	0.51	0.10
MC	0.60	0.18
MW	0.30	0.06
MMW	0.73	0.17
MFW	0.74	0.07
HE	0.54	0.23
HC	0.49	0.23
HW	0.46	0.19
HMW	0.63	0.15
HFW	0.77	0.15
TE	0.51	0.36
TC	0.56	0.11
TW	0.32	0.09
TMW	0.25	0.00
TFW	0.15	0.00
G Average	0.53	0.22

3.3 Relationships between current and past weather/climate conditions and health outcomes of current climate variability

However, the relation of climate variability to several climate sensitive health outcomes is yet to be established. The study conducted trend analysis to decipher any probable relationship between climate and disease occurrence throughout Nepal.

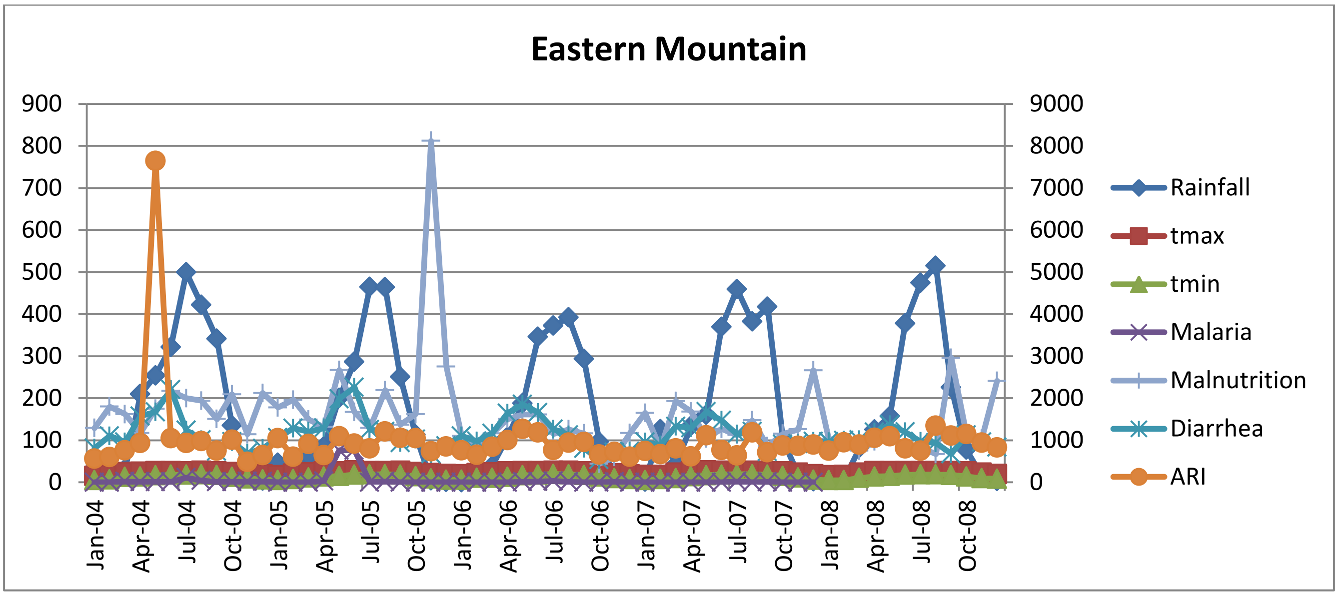


Figure 9: Health Outcome and Climate Variability- Eastern Mountain

The climate of Eastern Mountain (Cluster 1) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall varied throughout the years and was seen in at its peak in Aug 2008 (514mm). The trend of malaria cases and maximum temperature showed that, with minimum change in temperature, the number of cases increased. Similar trend was observed when cases were compared against minimum temperature. Maximum malarial cases were reported in 2005 May, June (76 cases). The diarrhoeal cases also changed with changing maximum temperature level (Tmax). Higher diarrhoeal cases were reported in July of every year when maximum rainfall was observed. ARI trend was dramatically higher in 2004 (7644) and fluctuated throughout other years with similar trends while Malnutrition was seen to be maximum in 2005 (267) and reduced in later years.

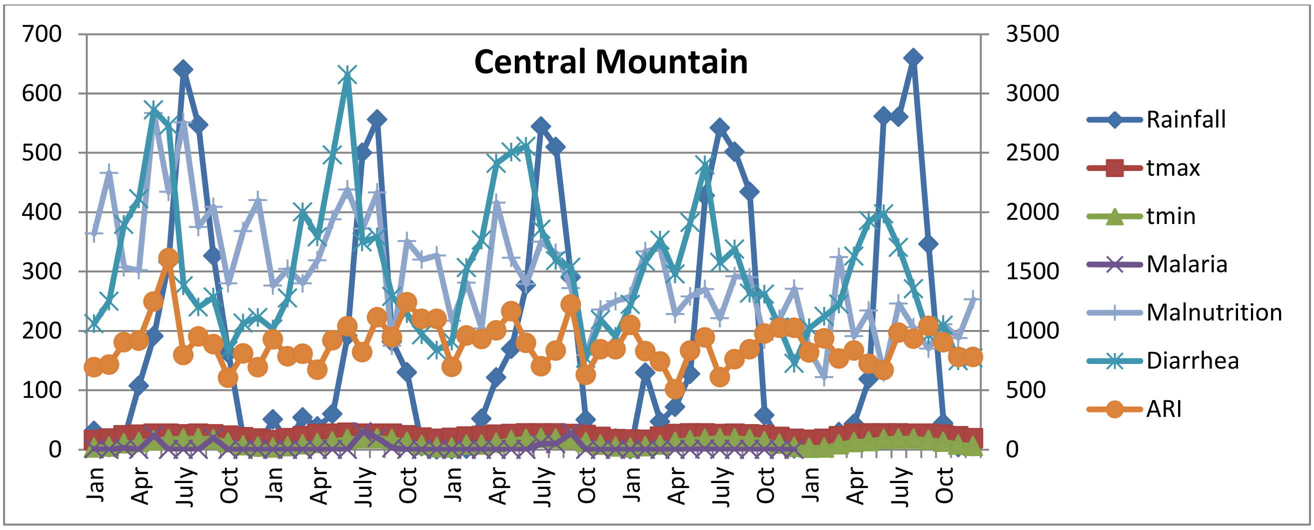


Figure 10: Health Outcome and Climate Variability- Central Mountain

The climate of Central Mountain (Cluster 2) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. Similar rainfall fluctuated each year. The trend of malaria cases and maximum temperature showed that, with minimum change in temperature, the number of cases increased. Similar trend was observed when cases were compared against minimum temperature. Maximum malarial cases were reported in 2005 (July and August). The diarrhoeal cases also changed with changing maximum temperature level (Tmax).Higher diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. ARI trend was higher in 2004 and 5 and fluctuated throughout other years with similar trends while Malnutrition was seen to be maximum in May 2004 (567) and reduced in other years.

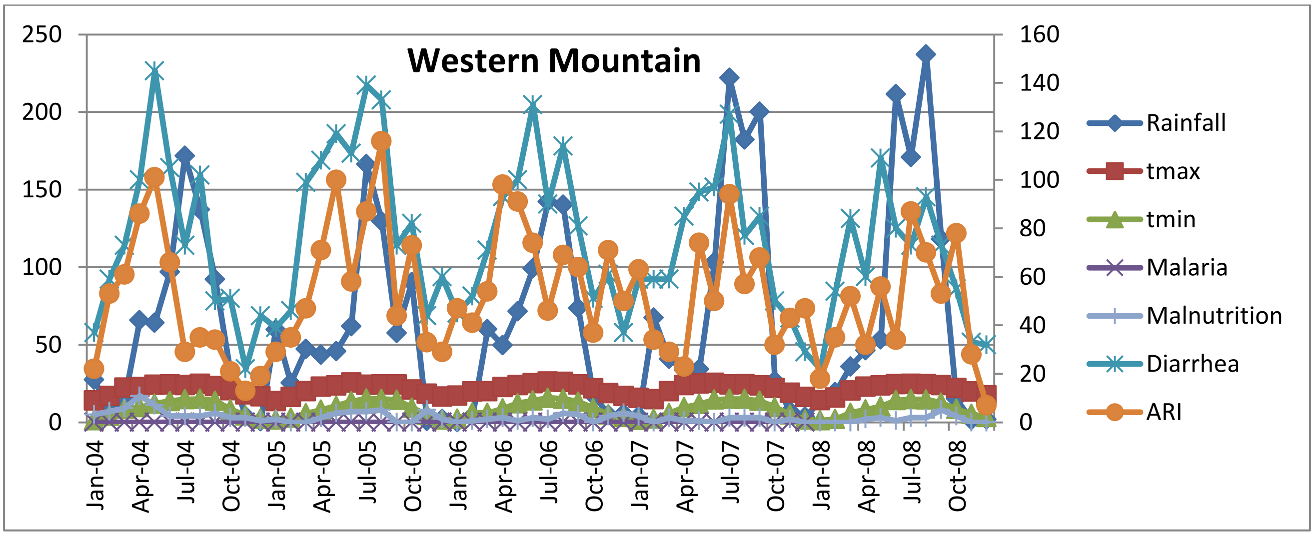


Figure 11: Health Outcome and Climate Variability- Western Mountain

The climate of Western Mountain (Cluster 3) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was seen to be increasing with every successive year. Rainfall was at its peak in 2008. No incidences of malaria were reported in Western Mountain in these 5 years. The diarrhoeal cases also changed with changing rainfall level. Higher diarrhoeal cases were reported in May-July of every year when maximum rainfall was observed. ARI trend constantly fluctuated throughout years and malnutrition was very low in this region of Nepal.

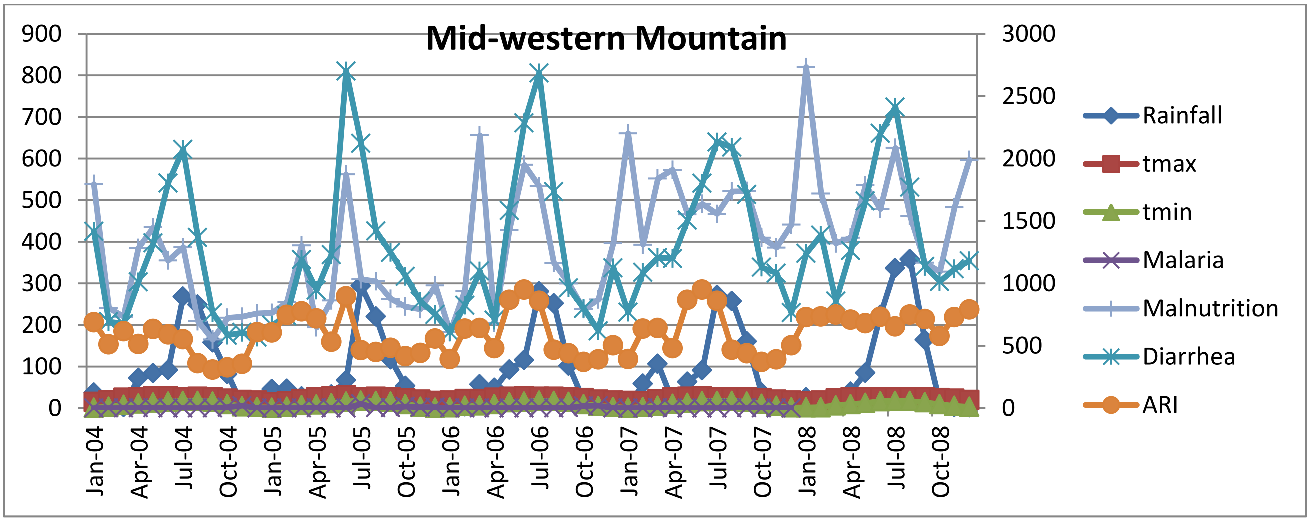


Figure 12: Health Outcome and Climate Variability- Mid-Western Mountain

The climate of Mid-Western Mountain (Cluster 4) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was seen to be increasing with every successive year. Rainfall was at its peak in 2008. Very few malaria positive cases were reported each year. The diarrhoeal cases also changed with changing rainfall level. The trend of diarrhoeal diseases is increasing. Maximum diarrhoeal cases were reported May-July of every year when maximum rainfall was observed. ARI trend constantly fluctuated throughout years and malnutrition was seen in increasing trend in this region of Nepal with highest cases in 2008 (626 cases).

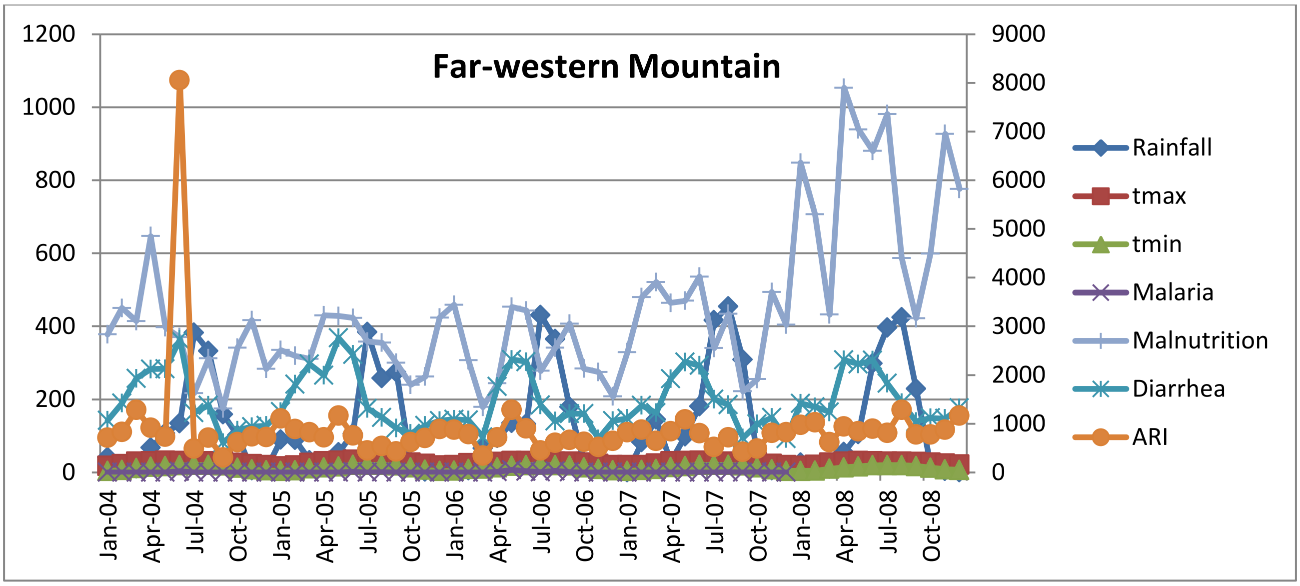


Figure 13: Health Outcome and Climate Variability- Far-Western Mountain

The climate of Far-Western Mountain (Cluster 5) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was seen to be increasing with every successive year. Rainfall was at its peak in 2008. Malarial cases were consistently lower in this region. The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. ARI trend constantly fluctuated throughout years with significantly higher number in June 2004(8054 cases) and malnutrition was seen in increasing trend in this region of Nepal with highest cases in 2008 (1053 cases).

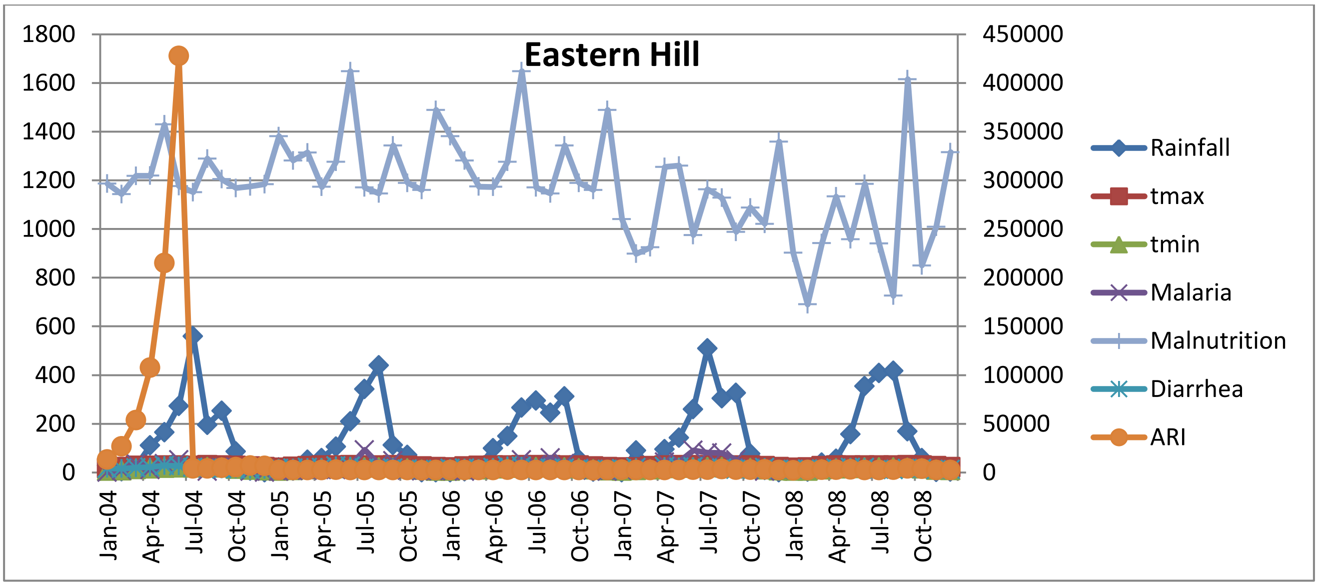


Figure 14: Health Outcome and Climate Variability- Eastern Hill

The climate of Eastern Hill (Cluster 6) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constant in all 5 years. However, the rainfall varied throughout the year. It was at its peak in July, August of each year. Malaria is seen in increasing trend. Higher incidences of malaria were reported in July in 2005 (93 cases) .The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-May of every year when maximum rainfall was observed. ARI trend constantly fluctuated throughout years with significantly higher number in 2004 and malnutrition was constantly changing throughout the years.

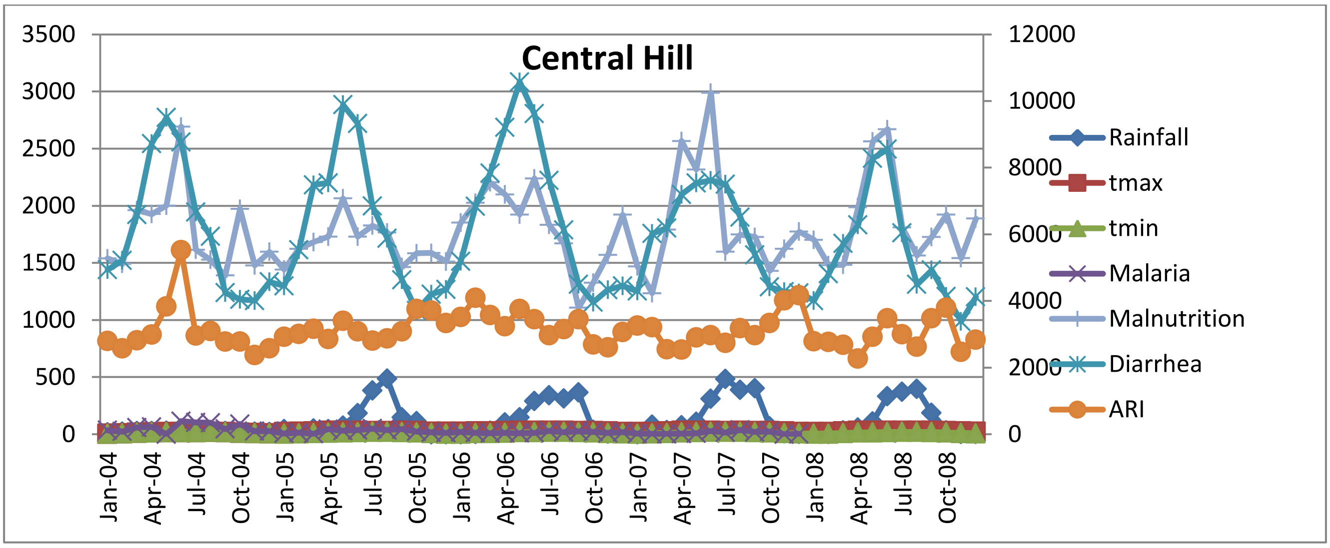


Figure 15: Health Outcome and Climate Variability- Central Hill

The climate of Central Hill (Cluster 7) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed very constantly changing in all 5 years. However, the rainfall varied throughout the year. It was at its peak in July, August of each year. Higher incidences of malaria were reported in June 2004 and very less in following years .The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-May of every year when maximum rainfall was observed. ARI trend constantly fluctuated throughout years with significantly higher number in 2004 and malnutrition was seen in an increasing trend with maximum cases in 2007.

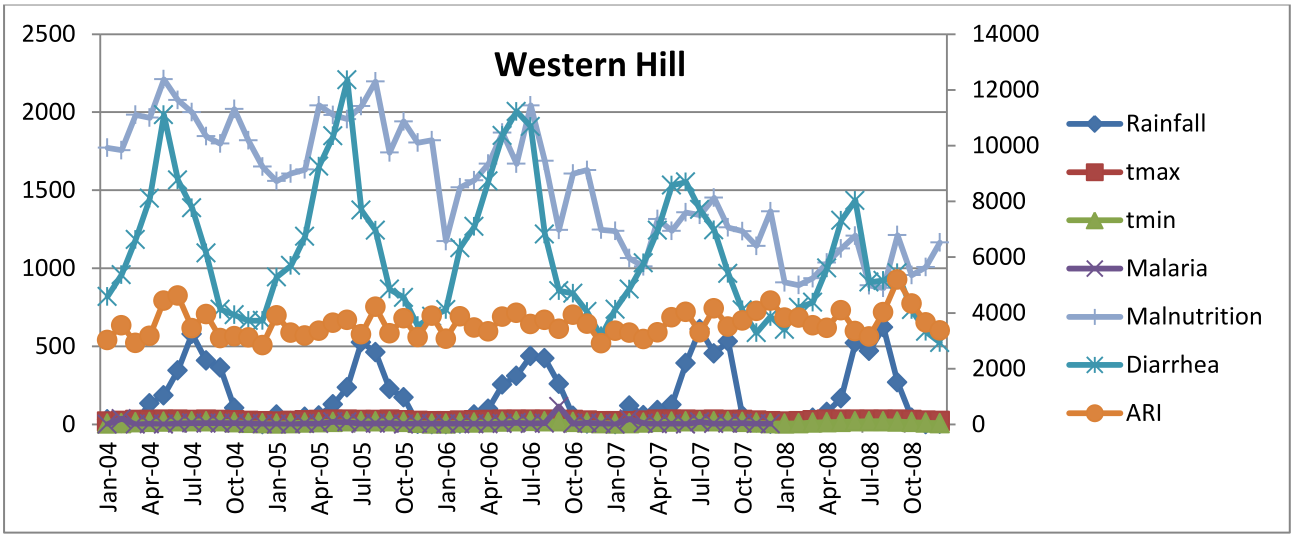


Figure 16: Health Outcome and Climate Variability- Western Hill

The climate of Western Hill (Cluster 8) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was seen to be fluctuating and increasing with every successive year. Rainfall was at its peak in July 2007 (610mm). Very lower incidences of malaria were observed in all 5 years with a bit of higher cases seen in September 2006 (114 cases).The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Diarrhoeal cases were comparatively higher in June 2005(12357 cases). ARI trend constantly fluctuated throughout years with significantly higher number in 2008 and malnutrition was seen in increasing trend in this region upto 2006 and began to drop after that.

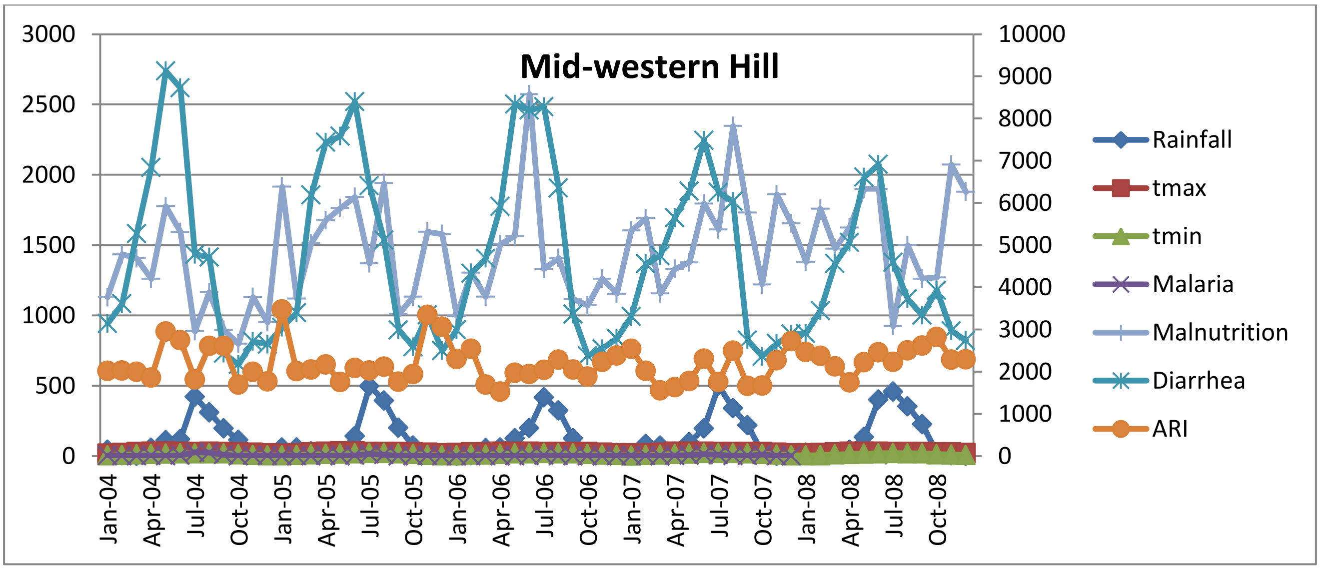


Figure 17: Health Outcome and Climate Variability- Mid-Western Hill

The climate of Mid-Western Hill (Cluster 9) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in 2007(498 mm). Very lower incidences of malaria were observed in all 5 years showing almost constant trend. The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in May 2004 (9126 cases). ARI trend constantly fluctuated throughout years malnutrition was seen in increasing trend with maximum cases reported in 2006.

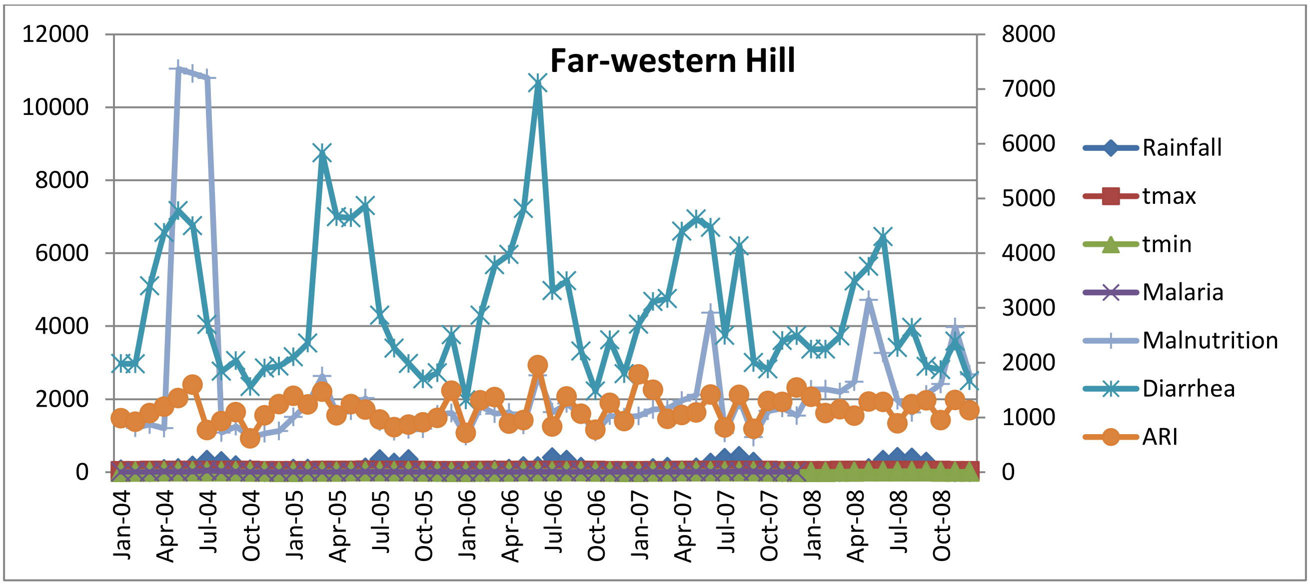


Figure 18: Health Outcome and Climate Variability- Far-Western Hill

The climate of Far-Western Hill (Cluster 10) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in 2008. Very lower incidences of malaria were observed in all 5 years showing almost constant trend. The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in June 2006 (7115 cases).

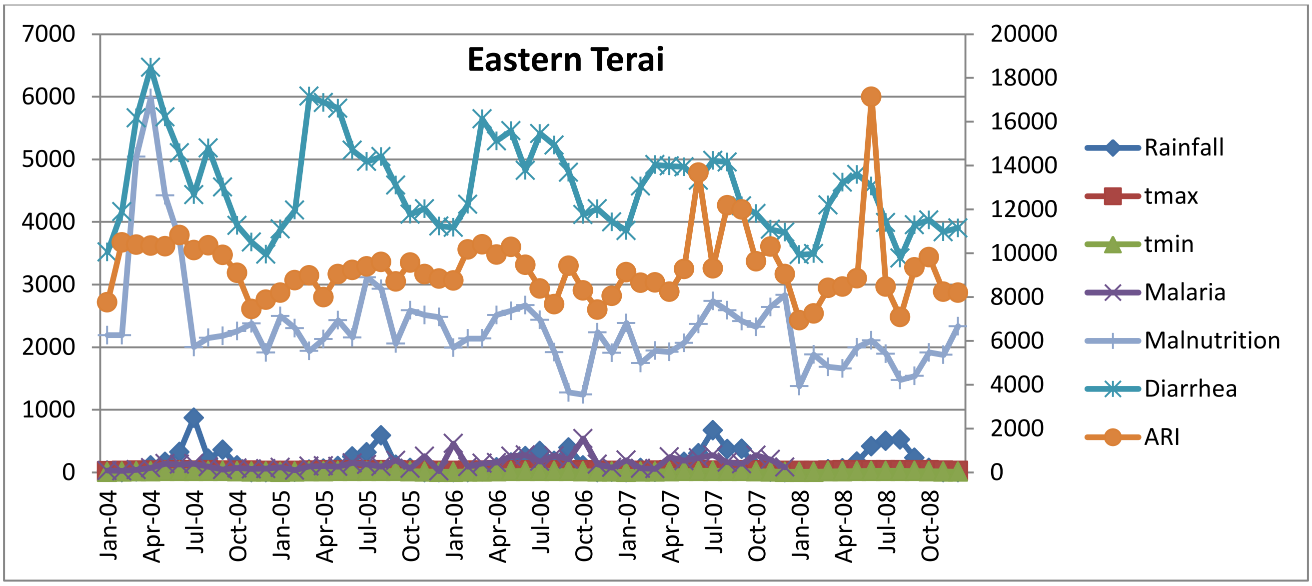


Figure 19: Health Outcome and Climate Variability- Eastern Terai

The climate of Eastern Terai (Cluster 11) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly very low in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in 2004. The incidence of malaria was seen in increasing trend along with increasing temperature. Dramatic rise in malarial cases was seen in Jan 2006 (462 cases) and Oct 2006 (540 cases).The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in May 2004 (16211 cases). ARI trend constantly fluctuated throughout years with significant number of cases in May 2008 (17134 cases). Malnutrition was seen dramatically higher in Apr 2004(5980) and later in decreasing trend.

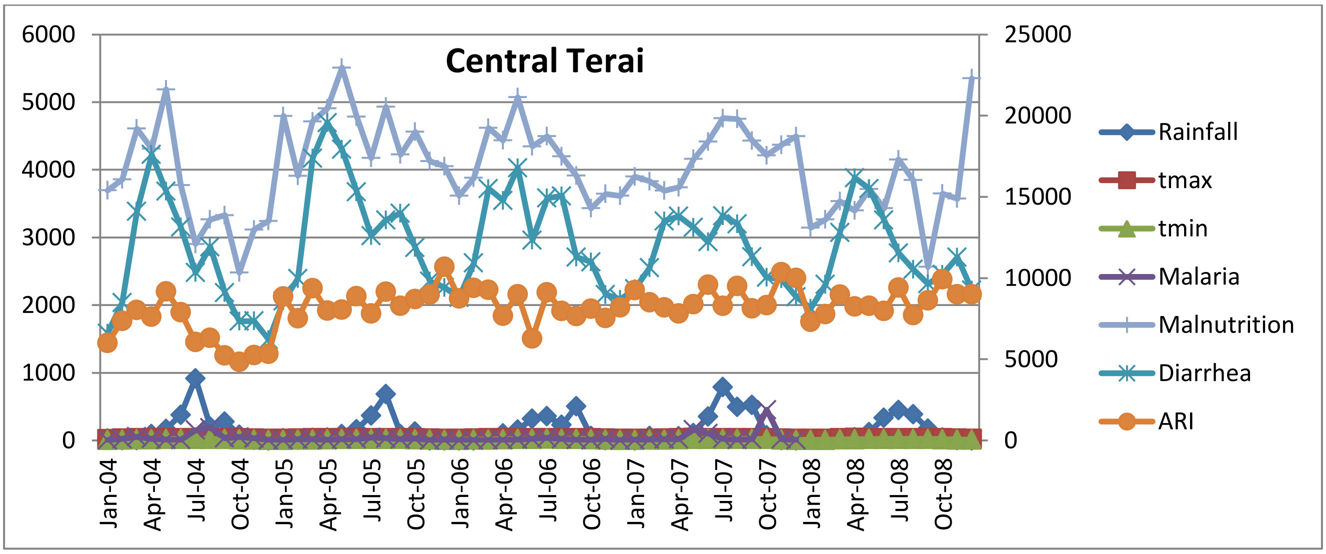


Figure 20: Health Outcome and Climate Variability- Central Terai

The climate of Central Terai (Cluster 12) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly changing in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in 2004. The incidence of malaria was seen in increasing trend along with increasing temperature. Dramatic rise in malarial cases was seen in Oct 2007 (453 cases).The diarrhoeal cases also changed with changing rainfall level. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in Apr 2005 (19570 cases). ARI trend constantly fluctuated throughout years with significant number of cases in Dec 2005 (10692 cases). Malnutrition was seen dramatically higher in May 2005 (5510 cases) and later in decreasing trend.

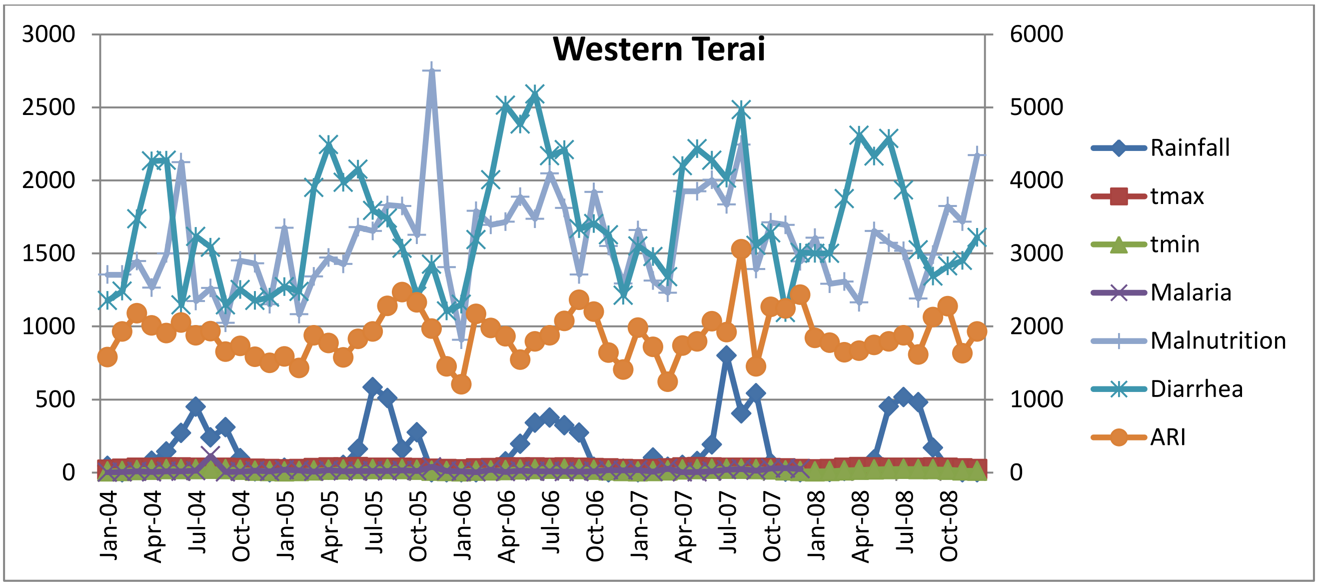


Figure 21: Health Outcome and Climate Variability- Western Terai

The climate of Western Terai (Cluster 13) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly changing in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in July 2007(801 mm). The incidence of malaria was seen in decreasing trend. Maximum malarial cases were reported in Aug 2004 (115 cases). The trend of diarrhoeal disease was in increasing trend. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in May 2006 (5181 cases). ARI trend constantly fluctuated throughout years with significant number of cases in Aug 2007 (3054 cases). Malnutrition was seen dramatically higher in Nov 2005 (2750 cases) and the trend is increasing.

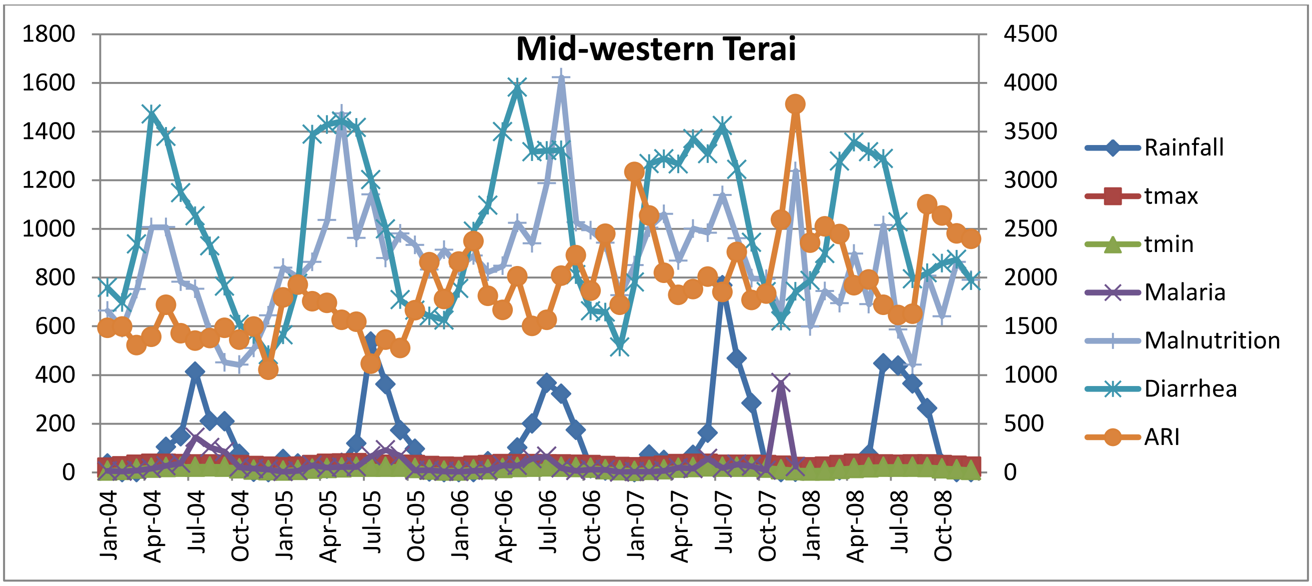


Figure 22: Health Outcome and Climate Variability- Mid-Western Terai

The climate of Mid-Western Terai (Cluster 14) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly changing in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in July 2007(768 mm). The incidence of malaria was seen in increasing trend. Higher malarial cases were reported in 2004 then cases dropped down constantly upto 2006 and dramatic increment in cases was seen in 2007.Maximum malarial cases were reported in Nov 2007 (368 cases). The trend of diarrhoeal disease was in increasing trend. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in May 2006 (3953 cases). ARI trend constantly fluctuated throughout years with significant number of cases in Dec 2007 (3781 cases). Malnutrition was seen dramatically higher in July 2006 (1187 cases) and the trend is decreasing

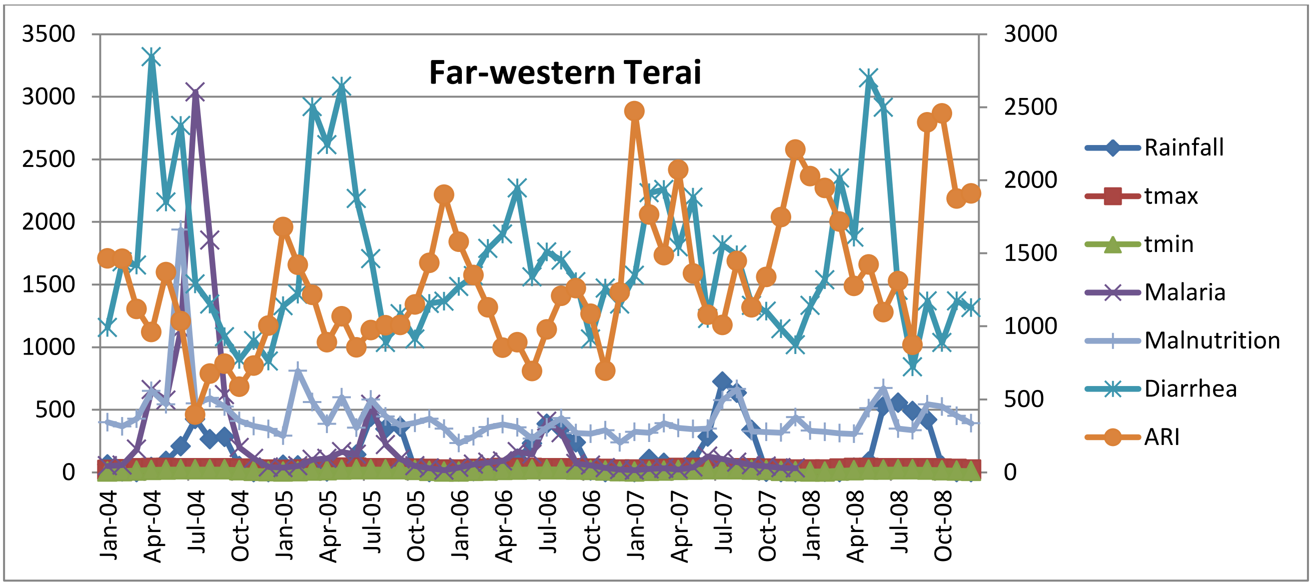


Figure 23: Health Outcome and Climate Variability- Far Western Terai

The climate of Far- Western Terai (Cluster 15) was fluctuating throughout the years. The parameters of climate i.e. Maximum and Minimum temperatures both were observed constantly changing in all 5 years. However, Rainfall level was found to be fluctuating every year. Rainfall was at its peak in July 2007(724mm). The incidence of malaria was seen in decreasing trend. Higher malarial cases were reported in 2004 then cases dropped .Maximum malarial cases were reported in July 2004 (3038 cases). The trend of diarrhoeal disease was in increasing trend. Maximum diarrhoeal cases were reported in April-July of every year when maximum rainfall was observed. Maximum diarrhoeal cases were reported in Apr 2004 (2845 cases). ARI trend constantly fluctuated throughout years with significant number of cases in Jan 2007 (2472 cases). Malnutrition was seen dramatically higher in June 2004 (1938 cases) and the trend is decreasing.

3.4 Trends in climate change-related exposures

Nepal is located along the southern slope of this Asiatic high Himalayas extending from longitudes 80º 14'E and 88º 12'E, latitude varies but lies within 26º 22'N and 30º 27'N. The length of the country is about 885 km from west to east and north-south width varies from 145 km to 241 km. within this range altitude varies from about 60 metres above sea level (MASL) in the southern plains to 8848 metres (Mt. Everest) in the north. Nepal is predominantly mountainous country with a total area of 147,181 km2 covering five physiographic regions: the Terai, Siwalik, Middle mountain (Mahabharat range and Midland valleys), High Mountains and Higher Himalayas. 86% of the total area is covered by mountains and only 14% is flatland (Terai). The location map of Nepal is provided in Figure 25.

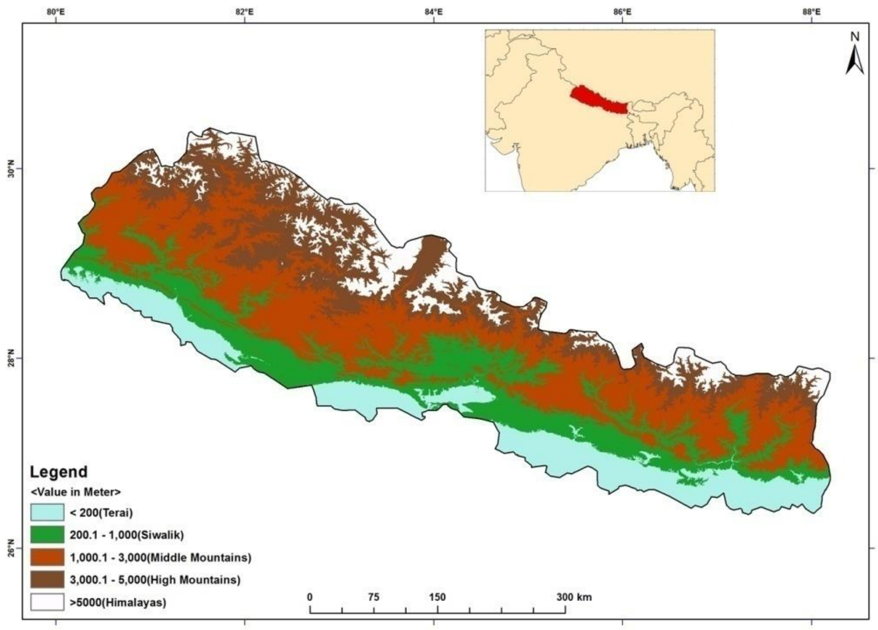


Figure 24: Physiographic and location map of Nepal.

Terai is a narrow belt of fertile agricultural flat land located at the southernmost part of the country and is part of the alluvial Gangetic Plains ranging mostly from 60-200 metres (m) in altitudes. It forms nearly continuous belt from east to west, exceptions being Chitwan and Rapti valley. Southernmost hill ranges of the Himalaya .i.e. north of Terai, are generally called Siwalik (also known as Churia). Generally they rise abruptly from the plains of Terai. Siwalik Hills typically range in elevation from 200-1000 m and in many places it exceeds 1300 m. Though most part of the range is covered by thick forest, it is very dry from December to early June. Due to fragile character of rocks, during the monsoon a great amount of sediment is washed from Siwalik Hills into the river. Most of the Siwalik rivers carry water only during the peak monsoon period.

Mahabharat range and Midland valleys are part of middle mountains. The Mahabharat range (also known as lesser Himalaya) is the southern part of the Himalaya, rising high above the Siwalik Hills to the south and the Midlands to the north. It reaches up to 3000 m in places and extends the length of the country. It is breached only by few big rivers – the Koshi, Gandaki , Karnali and Mahakali – which cut deep, narrow gorges through which drains almost all the water of Nepal. It also forms the first effective barrier to the monsoon clouds entering the Himalaya and exerts considerable influence on the rainfall distribution. Mahabharat range continues beyond Nepal's western border through the Indian hill ranges. Midlands also within the middle mountains are the subdued hills and wider valleys and is bounded by the towering snow clad higher Himalayas and high mountains in the north and Mahabharat range in the south with an range of elevation from 200 m (in river valleys) – 2,000 m. Due to gentle topography and temperate climate, this zone is densely populated.

All along the Nepal Himalaya, a transitional zone can be recognized between Midlands (middle mountains) and the Higher Himalayas. This zone ranges in altitude from 2,000 m to 5,000 m. Climate and vegetation of this zone is distinct from those of the middle mountains and higher Himalaya. The topography is much rugged and the slopes are steeper than in the middle mountains. The climate is much colder with snow in winter, although summers are quite warm. Northernmost part of the mountain gives way to the snow-capped High Himalayas. Nepal not only contains the highest peak of the world (Mt. Everest or Sagarmatha, 8,848 m) but also the greatest number of peaks over 8,000 m altitude. Unlike other physiographic zones, Himalaya is not a single range but rather discontinuous echelon of parallel ranges running east to west, north-west to south-east, and north-east to south-west. Topographically, this mountain range shows extremely rugged terrain with very steep slopes and deeply cut valleys. Generally, all terrain above 5,000 m is covered by permanent snow. There are number of valleys situated north of High Himalayan ranges known as Trans Himalayan Valleys. These include Dolpa, Mugu, Mustang and Manang. Lying in rain shadow zone, they remain dry throughout the year. However, rain-bearing clouds do reach these valleys through deep river gorges bringing some precipitation and supporting some vegetation.

It is the extremes in altitude, from lowlands in the south to the high Himalaya in the north and coupled with rainfall varying from 160 mm to 5000 mm, causes the extreme climatic contrasts in Nepal. North-south gradient exists throughout the length of about 800 km within Nepal and beyond. In the south, its elevation is less than 100 m where, as in the north, it rises above 7000 m within less than 200 km and hence, one can find various types of climate (Nayava, 1974; Inoue, 1976;Subrahmanyam et al. 1984). The high Himalayan region fits into polar climate due to altitude and tropical climate exists in the southern plains (Terai). Studies have shown that aerial distribution of precipitation is not linear mainly due to the varied topography (Subrahmanyam and Upadhyay, 1984; Chalise 1994; Shrestha 2000).

3.4.1 Data and methodology

Department of Hydrology and Meteorology, Nepal operate and maintain more than 300 meteorological stations throughout the country. These stations are established during different years. Al though current program on "Vulnerability and Adaptation assessment program" demand only 10 years of data, as recommended by World Meteorological Organization (WMO), 30 years of data was used to build the present climatology. In order to bring uniformity in the temporal data distribution, only stations established prior to 1981 was selected for this study. To cover the spatial extent, some stations not having 30 years of data but having at least 15 years of data were also considered.

Since the rainfall and temperature measurements are taken from network of stations, an interpolation scheme has to be used to obtain areal rainfall from the scattered point values. For the present analysis, ordinary kriging was used for interpolation as this method was found to be best suitable over the Himalayan region (Basistha et al. 2007).

Kriging, a geostatistical method, is an optimal interpolation based on regression against observed (values rainfall measured) from surrounding data points, weighted according to spatial covariance values. All interpolation algorithms (inverse distance squared, splines, radial basis functions, triangulation, and others) estimate the value at a given location as a weighted sum of data values at the surrounding locations. Almost all assign weights according to functions that give a decreasing weight with increasing separation distance. Kriging assigns weights according to a (moderately) data-driven weighting function, rather than an arbitrary function, but it is still just an interpolation algorithm and will give very similar results to other methods in many cases (Isaaks and Srivastava 1989; Clark 2001). The weights attributed to different observations depend on the variability structure of the rainfall field. This variability structure is taken into account using the variogram function. The variogram is a quantitative descriptive statistic that can be graphically represented in a manner which characterizes the spatial continuity (i.e., roughness) of a data set. An empirical variogram for Nepal has been calculated by Shrestha et al (2013) using observed datasets and a variogram model was fitted using 'SURFER' software (http://www.goldensoftware.com/) and Geostatistical tool in ArcGIS (http://www.esri.com/).

For kriging interpolation computer program written in FORTRAN77 by Deutsch and Journel (1998) was downloaded and locally customized. Since the source code is written in FORTRAN77, it is hardware independent and could be used in any computer. For the current interpolation, sill (value of the ordinate at which the variogram levels off) and range values (lag distance) 5.0 and 0.8 was used respectively. The search distance was set to 2.0 degree. Fortran source code was compiled using gfortran (GNU Fortran) compiler freely available from http://gcc.gnu.org/wiki/GFortran.

Further, Fortran programs and GrADS script (programming language) were developed wherever necessary. Grids Analysis and Display System (GrADS),a visualization software, was used to perform spatial analyses. The software can be downloaded freely from http://opengrads.org/.

Conventions used in this report some of which are also being used by the "CLIMDEX" (discussed in later part of the report) software are provided here.

PPT precipitation
TMAX annual average maximum temperature
TMIN annual average minimum temperature
TXx maximum of the maximum temperature
TXn minimum of maximum temperature
TNx maximum of minimum temperature
TNn minimum of minimum temperature

3.4.2 Rainfall

According to WMO, normal values are computed from 30 years of data starting from 1901. Normal values are computed from 1901-1930, 1931-1960 and so on. Since 1956, WMO has recommended that normal values be updated every 10 years, i.e., 1901-1930, 1911-1940, and so on. Present analysis is based on the monthly gridded data for the period 1981 to 2010. Seasonal rainfall along with its associated statistics is provided in Table 92. In an average Nepal receives 1872 mm annually with standard deviation of 184 mm. Most of the rain is received during monsoon season (80% of the annual total). Annual rainfall variability is 10% which is also same for the monsoon season but higher for other seasons.

Table 9: Seasonal rainfall and its associated statistics.

	DJF	MAM	JJAS	ON	Annual
Mean (mm)	62	230	1497	83	1872
S.D. (mm)	31	57	155	48	184
C.V. (%)	50	25	10	58	10
% of the total	3	12	80	5	
MIN (mm)	134	388	1736	222	2247[1998]
MAX (mm)	6	136	1169	19	1474[1992]

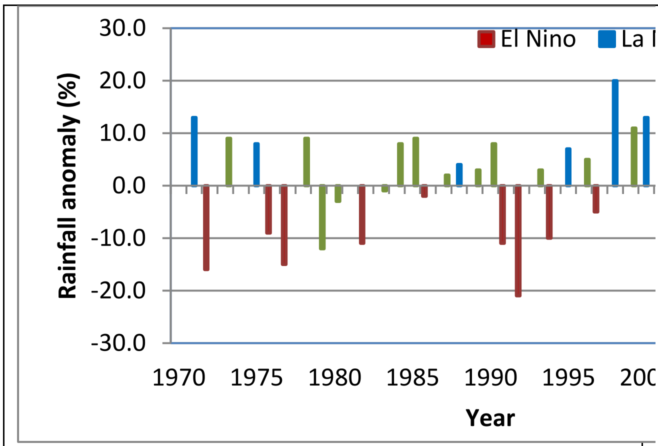


Figure 25 Interannual variation of rainfall anomaly.

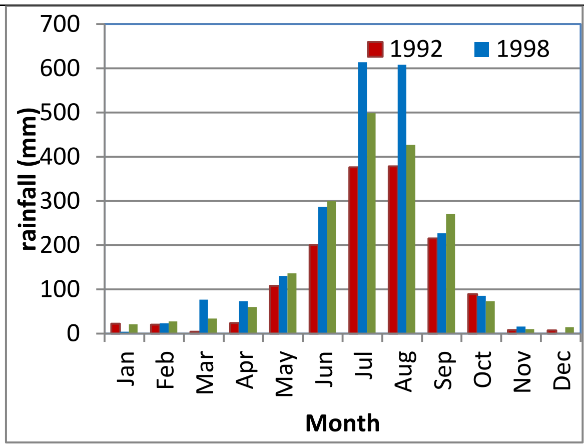


Figure 26 Monthly distribution of rainfall.

Inter-annual rainfall anomaly map expressed in percentage is provided in Figure 256. The figure is also colour coded to investigate its teleconnection withEl Niño / La Niña episode over Niño 3.4 region in the central Pacific. There exist distinct teleconnection between El Niño / La Niña episode and Nepalese rainfall. Except for one or two year, all the El Niño year resulted into deficiency of rainfall and La Niña episode into excess rainfall. Similar results were obtained by Shrestha (1998) with Nepalese rainfall and Southern Oscillation Index (SOI).

In a 30 years period, Nepal received highest amount of rainfall in 1998, a La Niña year, when it received total amount of 2247 mm which was 20% above normal. Similarly in 1992, an elongated El Niño event year, received only 1474 mm of rainfall. This amount was less than 21% of the normal value. This exceptionally dry event has been linked with Pinatubo aerosol (Shrestha et al. 2000) (1992 experienced Mount Pinatubo eruption which led to cooling of Tibetan plateau and hence weak monsoon!). In Figure 27, monthly rainfall for year 1992, 1998 and long term mean is provided for comparison. It is clearly seen that rainfall received in monsoon season especially during the months of July and August influences the overall annual total.

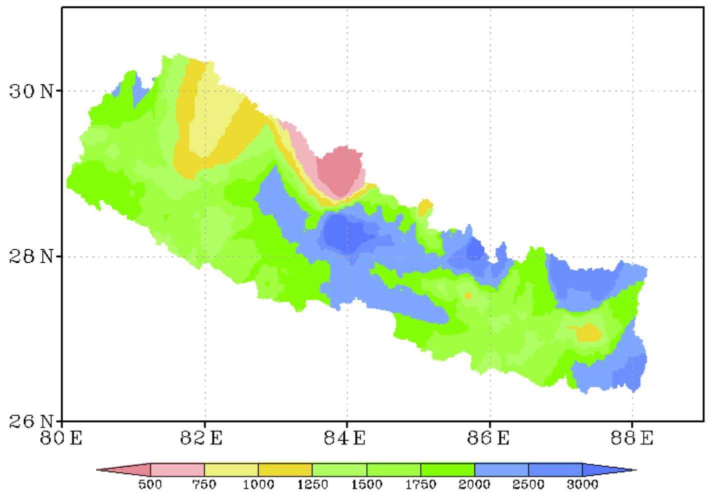
Although monsoon season is considered from June through September, it comprises approximately 105 days. Monsoon duration based on onset and withdrawal dates show statistically insignificant increasing trend indicating increase in variability (not shown).

3.4.2.1 Spatial distribution of rainfall

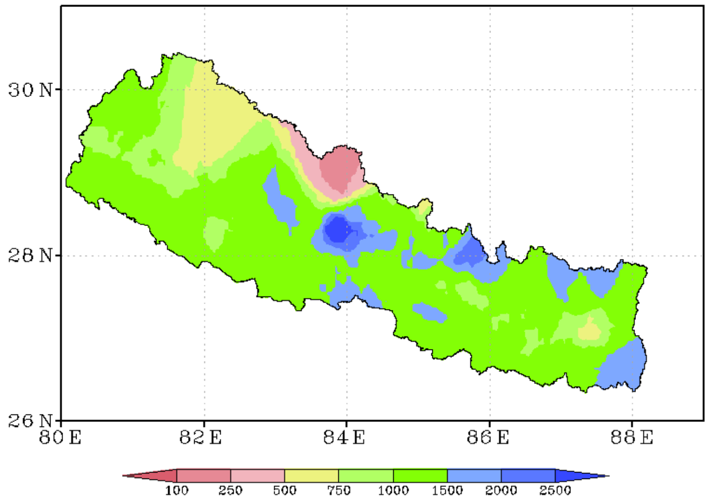
Spatial distribution of rainfall for annual, summer and winter season is presented in Figure 28. Highest amount of rainfall is centered over 83.80° E and 28.30° N (Lumle,Kaski) where the amount is more than 5000 mm. North of this pocket area is the rain shadow zone (Manang) over trans Himalayan area where the rainfall is less than 500 mm. Since 80% of the annual total occurs in monsoon season, monsoon distribution is similar to annual pattern. But the winter distribution is different where higher amount is received in the west part of the country and progressively decreases towards east. This is due to western disturbances which is common in winter season.

In Figure 29 percentage contribution of monsoon total is provided. Contribution of monsoon rainfall is more along the southern plains and decreases northward. Contribution is highest along the southern plains of the western Nepal. Coefficient of variation or rainfall variability is shown in Figure 29. High value indicates the unreliability on the rainfall. Except for rain shadow area over the north and few other places the variability is more than 30% else where it is less.

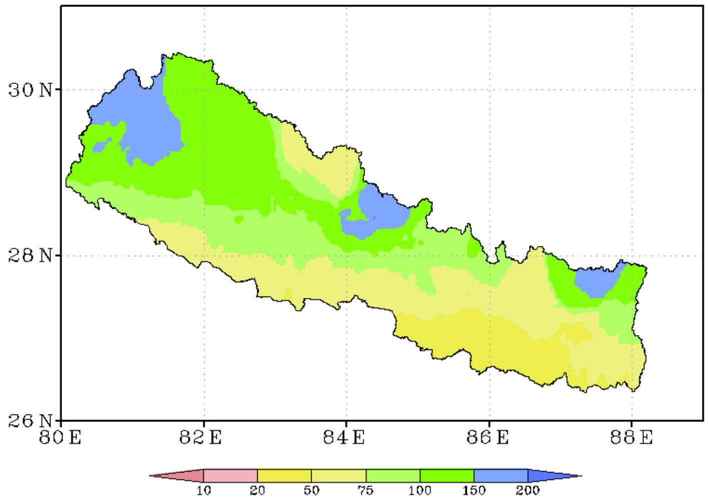
Rainfall 24 hour intensity map is provided in Figure 31. Rainfall intensity is calculated from the annual total and is divided by number of rainy days. A rainy day is considered if the amount of rainfall received is at least 1.0 mm or more. It is found that rainfall intensity is higher over southern part in the Terai belt. Total number of rainy days is shown in Figure 32. Rainy days are less over the area where rainfall intensity is high. This indicates that the chances of floods (flash) are high over these areas during rainfall period.



(a)



(b)



(c)

Figure 27 Spatial distribution of average rainfall (a) Annual, (b) Monsoon (JJAS) and (c) Winter (DJF). (note: scales are different)

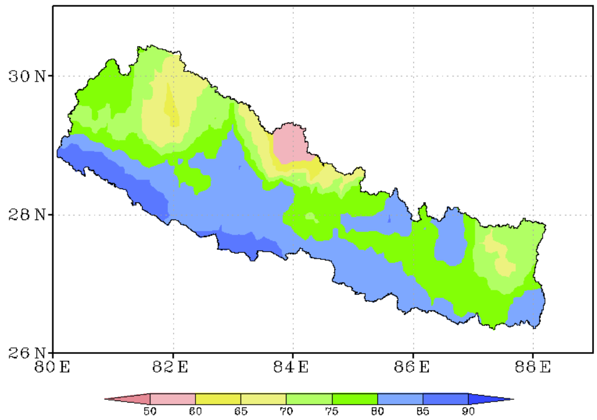


Figure 28 Contribution of monsoon season rainfall in percentage (%) as part of the annual total.

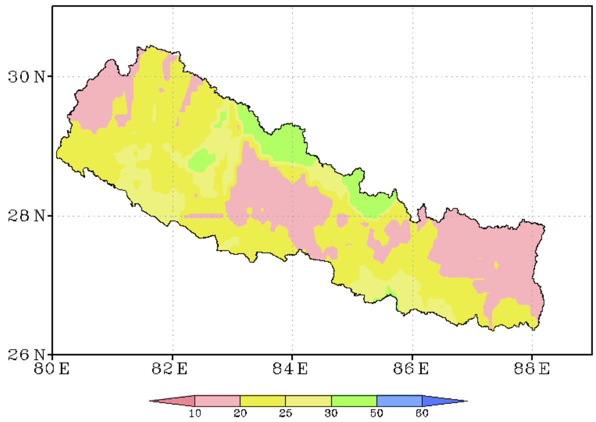


Figure 29 Rainfall variability (coefficient of variation) expressed in percentage (%).

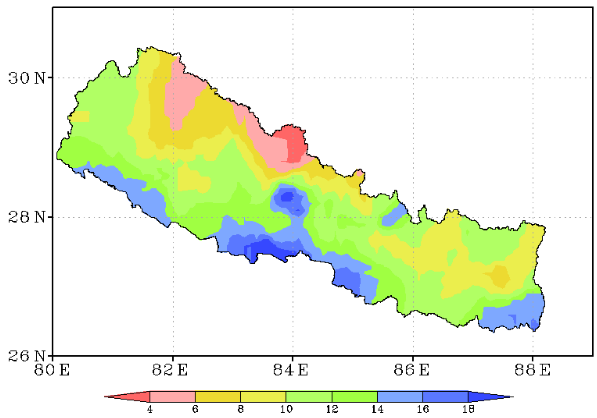


Figure 30 Intensity of rainfall in a rainy day (mm/day).

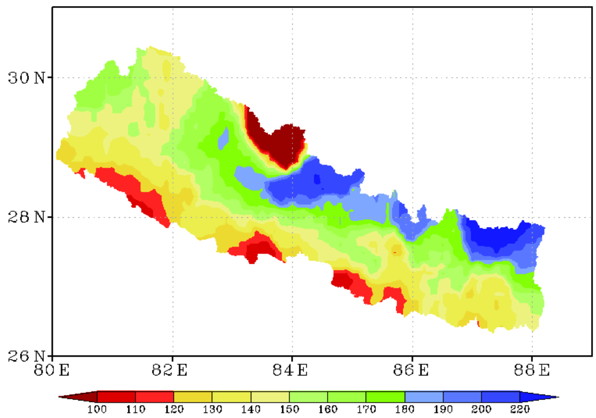


Figure 31 Number of rainy days in a year.

Highest amount rainfall map is provided in Figure 33. There could be as much as 200 mm or even more rainfall in a single day. The map is based on 30 years of data ranging from 1981 to 2010. In Figure 34, difference between highest rainfalls from the period of 1971 to 2000 to the period of 1981 to 2010 is shown. Green and blue colour indicates increasing trend and yellow to red indicate decreasing trend. The result is a mixed as there are some spots where the extreme rainfall is increasing and some place it is decreasing.

Similarly in Figure 35 and Figure 36, difference between the total rainfall for two normal periods (1971-2000 & 1981-2010) for annual and monsoon season is shown respectively. The difference is expressed in percentage departure from 1971-2000. From both the maps one could see the increase in precipitation over eastern and western section of the country especially during the monsoon season. Whereas over the central parts, especially in the middle mountains and Siwalik Hills areas (see Introduction) it is decreasing. But the changes are only 5% from the normal value.

Since rainfall is the highly variable element of the meteorological phenomena, it is extremely difficult to spot small changes brought out by climate change.

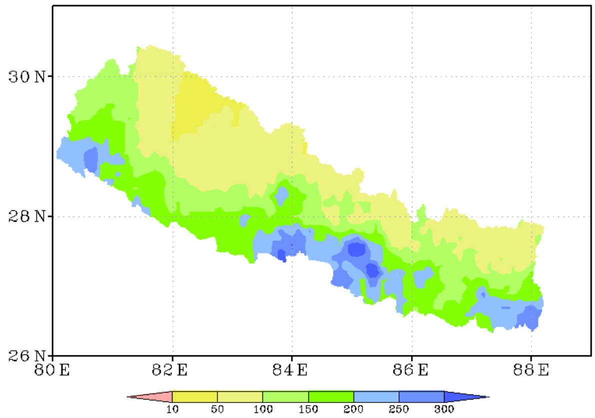


Figure 32 Highest amount of rainfall for the period of 1981 – 2010 (mm).

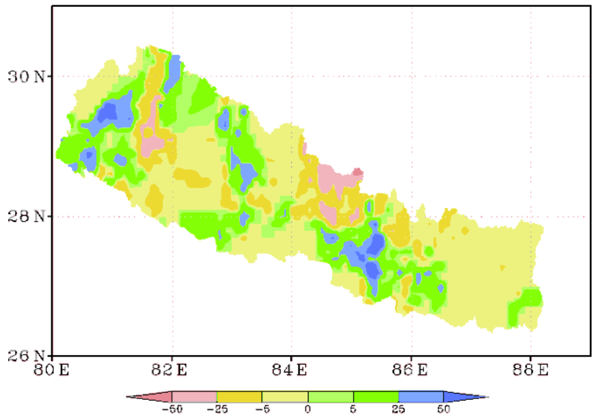


Figure 33 Difference of highest rainfall between two normal preiods (1971-2000 & 1981-2010)(%).

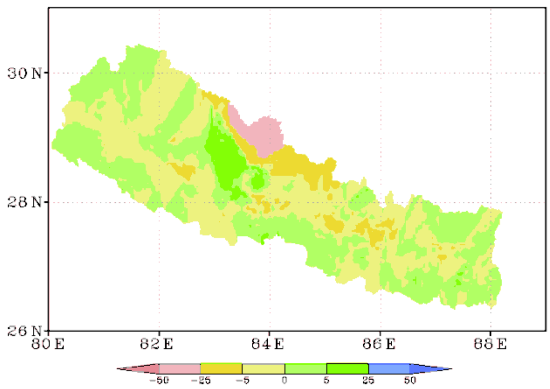


Figure 34 Difference in annual total rainfall for two normal periods (1971-2000 & 1981-2010)(%).

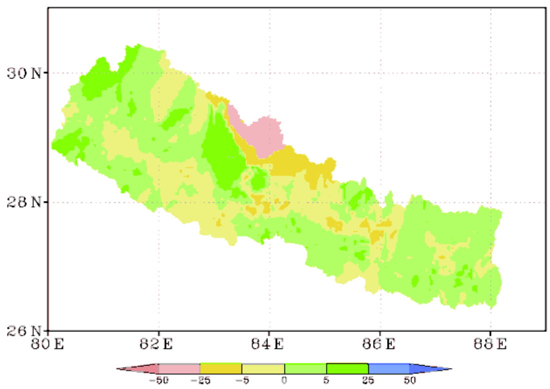


Figure35 Same as Figure 11 but for monsoon total.

3.4.3 Temperature

Seasonal and annual statistics of maximum temperature over whole Nepal is presented in Table 13 and within Table 13, seasonal maximum temperature values are given in section (a) and seasonal minimum values in section (b). Summer season (JJAS) maximum temperature for overall Nepal was found to be 28.5° C with standard deviation of 0.4° C. maximum temperature for this season varied from 27.9° C to 19.6° C. Maximum temperature during winter season (DJF) is about 19.1° C with slightly higher standard deviation of 0.9° C. Standard deviation is highest during the pre-monsoon season. This is probably due to variation in cloud development due to orographic convection. Average values for each decade show a consistent rise in maximum temperature each season. This is also reflected in annual figure.

Table 10:(a): Seasonal and annual statistics of maximum temperature for period of 1981-2010 for all Nepal.

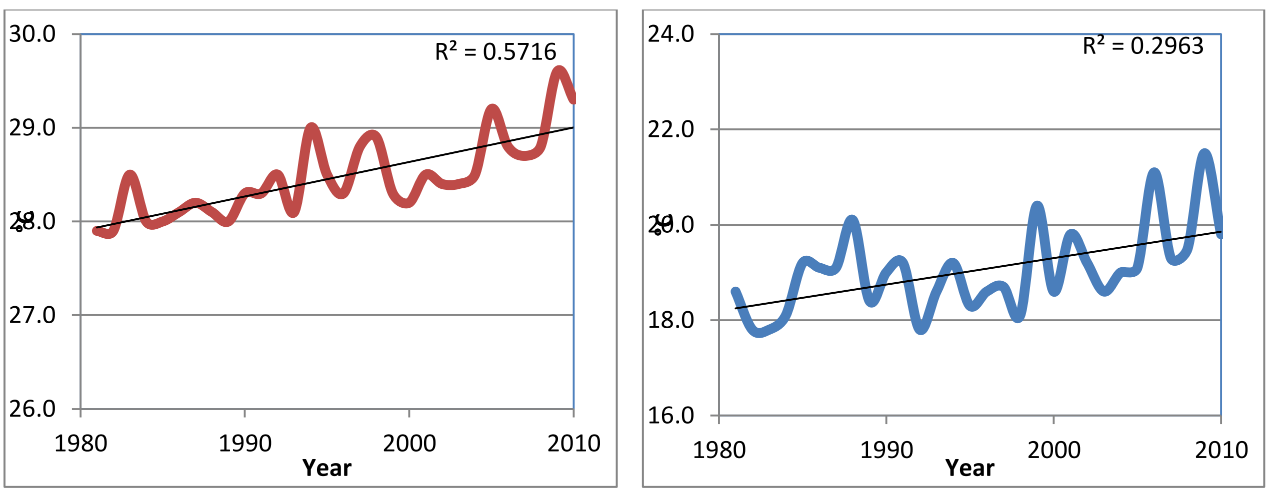
MAXIMUM TEMPERATURE					
	DJF	**MAM**	**JJAS**	**ON**	**Annual**
Mean	**19.1**	**27.5**	**28.5**	**24.5**	**24.9**
S.D.	**0.9**	**1.1**	**0.4**	**0.7**	**0.6**
MIN	17.8	25.3	27.9	23.1	23.7
MAX	21.5	29.9	29.6	25.6	26.2
1981-1990	18.7	26.8	28.1	24.1	24.4
1991-2000	18.8	27.5	28.5	24.6	24.9
2001-2010	19.7	28.0	28.8	24.9	25.4

(b): Seasonal and annual statistics of minimum temperature for period of 1981-2010.

MINIMUM TEMPERATURE					
	DJF	**MAM**	**JJAS**	**ON**	**Annual**
Mean	**5.6**	**13.3**	**19.2**	**11.6**	**12.4**
S.D.	**0.6**	**0.8**	**0.4**	**0.7**	**0.4**
MIN	4.6	11.8	18.5	10.2	11.4
MAX	7.3	14.9	19.9	13.1	13.4
1981-1990	5.6	13.1	19.2	11.3	12.3
1991-2000	5.4	13.0	19.0	11.5	12.2
2001-2010	6.0	13.7	19.4	11.9	12.8

Minimum temperature statistics are provided in section (b) of Table 13. The winter season minimum temperature as whole was found to be 5.6° C with standard deviation of 0.6° C. Similarly the minimum temperature during summer season was19.2° C with standard deviation of 0.4° C. Decadal averages show rise in minimum temperature from period 1981-1990 to -1980 to 2010-2010 by as much as helf degree. During the 90s (1991-2000) decade, there is decrease in temperature for each season except for post-monsoon.

Year to year variation of summer season maximum and winter season minimum from 1981 to 2010 is shown in Figure 37. Consistent rise in maximum temperature is quite evident. According to Shrestha et al. 1999, temperature rise in Nepal started since only late seventies. Mann-Kendall non-parametric trend test also resulted in significant at 99.9% level. Minimum temperature also shows rising trend. R^2 value is lower than that of the maximum temperature. This is probably due the decrease of temperature during the 90's decade. Mann-Kendall test suggest significant at only 95% level.



a b

Figure 36 Year to year variation of maximum and minimum temperature (a) summer season maximum temperature and (b) winter season minimum temperature.

3.4.3.1 Spatial distribution of temperature

Seasonal distribution of maximum and minimum temperature is provided Figure 38. Temperature distribution closely follows latitudinal and topographical effect. Temperature distribution is higher over the southern plains and decreases toward north. The maps are processed at 0.1° resolution and are displayed in 0.01° resolution for better display. Maximum temperature during summer season exceeds

30°C over the southern plains and Siwalik Hills. The distribution of minimum temperature is shown in Figure 38(b). It also follows topography but the temperature values are lower. During winter very few places show temperature less than zero. However it should be kept in mind that temperature distribution over northern is warm biased so the absolute values are far lower than the map depicts. It is due to the fact that meteorological stations are located at lower elevation.

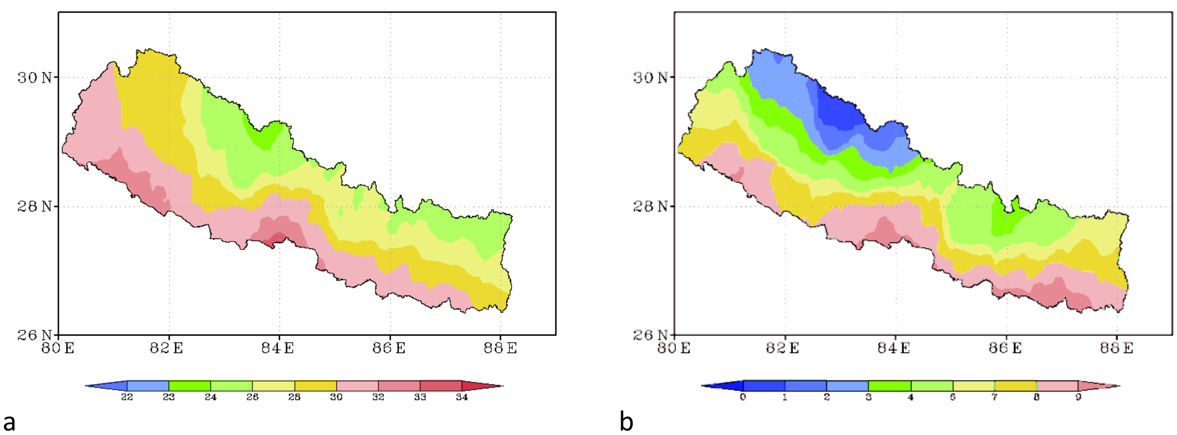


Figure 37 Seasonal distribution of temperature (a) Summer season maximum temperature (b) winter season minimum temperature.

In Figure 39 the difference between the maximum and minimum temperature or the range of temperature variation is shown. For both the season the range is minimum over northeast corner of Nepal and higher over northwest corner. Generally the range increases from east to west. The temperature range is higher during the winter season in comparison with summer season.

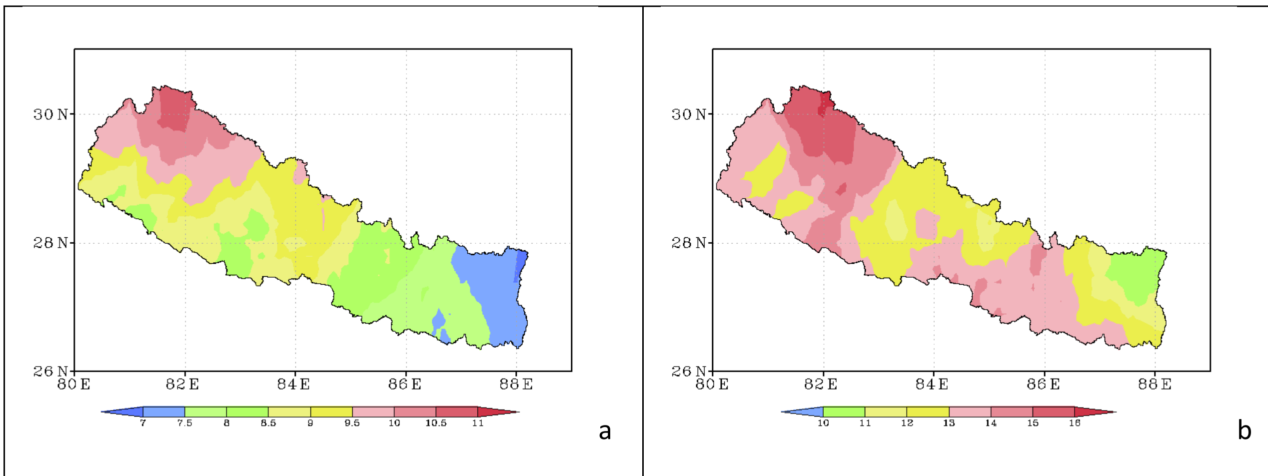


Figure 38 Maximum - Minimum temperature difference range (a) summer season and (b) winter season.

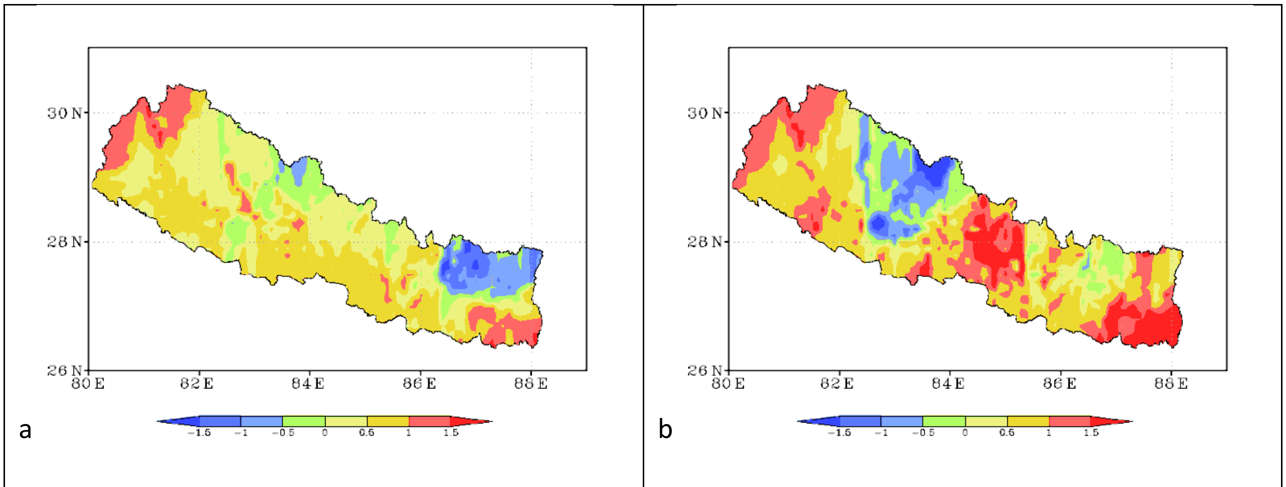


Figure 39 Changes in maximum temperature from baseline period of 1981-1990 (a) 1991-2000 and (b) 2001-2010.

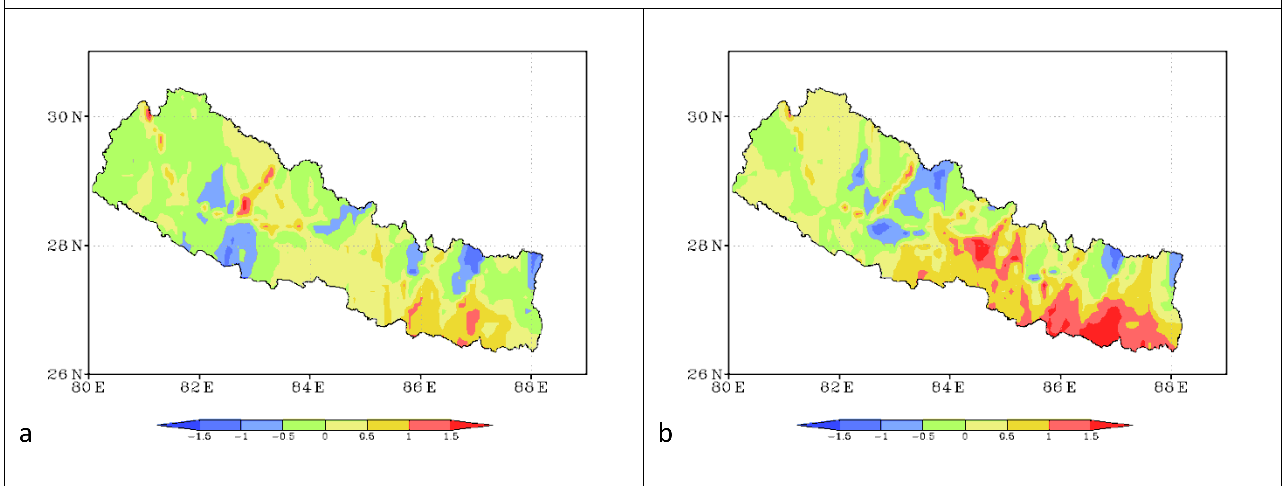


Figure 40 Same as Figure 16 but for minimum temperature.

Year to year march of seasonal temperature for both maximum and minimum was shown in Figure 42. For both the cases, increasing trend is quite obvious. Hence seasonal change of temperature from decade to decade is examined and is presented in Figure 43(maximum temperature) and Figure 44(minimum temperature). For the comparison, decade average for the period of 1981-1990 was chosen as baseline. In the figures, yellow (less) and red (high) indicate increase in temperature. Similarly, green (less) and blue (high) indicate decrease in temperature. Increase in maximum temperature 90s is subtle with less than 1°C over most part of the country. This continues to increase and is more than 1°C in many areas. Storyline for minimum temperature is different for 1990s. In fact, many place especially over west Nepal and the northeast portion experienced decrease in temperature. In the last decade

(2001-2010), minimum temperature started increasing. The increase is more than 1°C over the eastern Terai. There are also many place where the temperature id still decreasing from the baseline period.

3.4.3.2 Highest maximum and lowest minimum temperature

a b

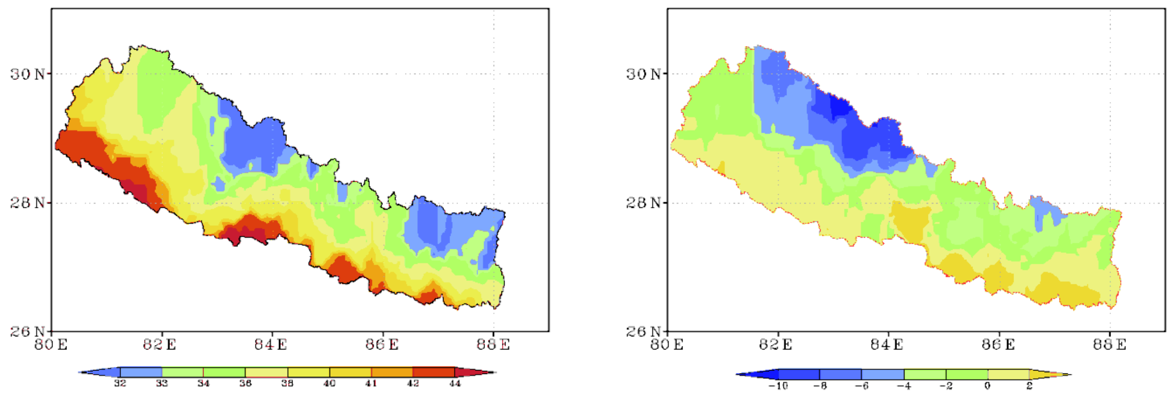


Figure 41: (a) Highest maximum temperature for normal period 1981-2010 and (b) Lowest minimum temperature for normal period 1981-2010.

Highest maximum and lowest minimum temperature as observed in the 30 years period is provided inFigure 46(a). Although extreme temperature also follows topography, most part of the Terai region exceeds 40° C where as it exceeds 30° C all over the country. Similarly, lowest minimum temperature distribution is shown in the Figure 47(b). Except for Terai and Siwalik Hills, most of the parts in middle mountains experienced sub-zero during the last 30 years. (As stated earlier, due to the location of meteorological stations over low elevation area, the map is warm biased.)

3.4.3.3 Extreme rainfall and temperature analysis

There is a general consensus within the climate community that any change in the frequency or severity of extreme climate events would have profound impacts on nature and society. It is thus very important to analyze extreme events.However, there is no prior definition for extreme events. It depends upon the climatic situation of the region and location. To compute different climate indices, the higher and lower threshold values were pre-determined based on maximum mean temperature for hottest month and minimum mean temperature for coldest month. In addition, 75th, 85th and 95th percentile values were used as threshold values to detect trends if any, in maximum temperature distribution. Similarly 25th, 15th and 5th percentile values were used to detect trends in minimum temperature events. In case of extreme rainfall for different intensities, 75th, 85th and 95th percentile values were used as threshold values to determine increasing or decreasing trends (if any).

The monitoring and detection of changes in climate extremes usually require daily data. Therefore, daily rainfall data for Nepal as a whole was derived from the stations data scattered over the country. "RClimDex Software Version 1.0"(http://etccdi.pacificclimate.org/software.shtml) developed in "R" environment [The R Foundation for Statistical Computing Platform- http://www.r-project.org/] is used to calculate climate indices. Same program "FClimDex.f" written in FORTRAN77 is also available which could be used to automate multiple datasets at one go.

CLIMDEX software first conducts simple quality control on input daily data to filter the outliers and then computes 33 core indices. An over view of 33 indices are provided in Table 14. Out of these 33 indices, 5 of them are calculated based on user provided threshold values. There are 10 indices from the rainfall data and 18 indices from the temperature field. Temperature related indices such as annual frost days, icy days, tropical nights and summer days may not reflect true nature. In such case, indices based on user provided threshold value are used to detect trend.

Table 11: Overview extreme climate indices

	ID	Name	Description	Units
PRECIPITATION	CDD	Consecutive dry days	Highest number of consecutive days when PPT<1.0 mm	days
	CWD	Consecutive wet days	Highest number of consecutive days when PPT>=1.0 mm	days
	R10mm	Rainfall > 10.0 mm	Annual count of days when PPT >=10.0 mm	days
	R20mm	Rainfall > 20.0 mm	Annual count of days when PPT>=20.0 mm	days
	RX1day	24 hour highest	24 hour highest PPT	mm
	RX5day	5 day accumulation	5 day accumulation highest PPT	mm
	SDII	Simple daily rainfall intensity index	Simple daily rainfall intensity index (PRCPTOT÷rainydays)	mm/day
	R95p	Very wet days	Annual total when PPT>95th percentile	mm/year

	R99p	Extremely wet days	Annual total when PPT>99th percentile	mm/year
	PRCPTOT	Annual total	Annual total when PPT >=1.0 mm	mm/year
TEMPERATURE	FD0	Frost days	Annual count of days when minimum of TMIN<0°C	days
	ID0	Icy days	Annual count of days when minimum of TMAX<0°C	days
	CSDI	Cold spell duration indicator	Count of days when 6 consecutive days are TMIN<10th percentile	days
	WSDI	Warm spell duration indicator	Count of days when 6 consecutive days are TMAX>90th percentile	days
	TR20	Tropical nights	Count of days when TMIN>20.0°C	days
	SU25	Summer days	Count of days when TMAX>25.0°C	days
	TN10p	Cool nights	Percentage of days TMIN<10th percentile	% days
	TX10p	Cool days	Percentage of days TMAX<10th percentile	% days
	TN90p	Warm nights	Percentage of days TMIN>90th percentile	% days
	TX90p	Warm days	Percentage of days TMAX>90th percentile	% days
	TMAX	Mean maximum	Average maximum temperature	° C
	TMIN	Mean minimum	Average minimum temperature	° C
	DTR	Diurnal temperature range	Difference between maximum and minimum	° C
	TNn	Lowest minimum	Minimum of the minimum temperature	° C
	TNx	Highest minimum	Maximum of the minimum temperature	° C
	TXn	Lowest maximum	Minimum of the maximum temperature	° C
	TXx	Highest maximum	Maximum of the maximum temperature	° C
	GSL	Growing season length	Annual count of days when TMAX>5°C for 6 days	days

USER	R mm	Rainfall > 25.0 mm	Annual count of days when PPT>=user given value	days
	TR	Tropical nights	Annual count of days when TMIN**>** user given °C	days
	SU	Summer days	Annual count of days when TMAX**>** user given °C	days
	FD	Frost days	Annual count of days when TMIN**<** user given °C	days
	ID	Icy days	Annual count of days when TMAX**<** user given °C	days
Bold ID – calculated and determined monthly and averaged yearly.				

A good number of indices (Table 16) for the rainfall parameters at different thresholds named R10mm (number of heavy precipitation days when precipitation ≥10 mm), R20mm (number of heavy precipitation days when precipitation ≥20 mm), R25mm (number of heavy precipitation days when precipitation ≥50 mm), R95p (very wet days when rain rate > 95^{th} percentile), R99p (extremely wet days when rain rate > 99^{th} percentile), CDD (consecutive dry days when rain rate <1 mm) and CWD (consecutive wet days when rain rate >1 mm) were obtained. Similarly, temperature indices called TXx (maximum of daily maximum temperature), TXn (minimum of daily maximum temperature), TNx (maximum of daily minimum temperature) and TNn (minimum of daily minimum temperature) were obtained. To calculate the five users defined extreme climate indices, 28.5°C and 19.0°C were provided for upper and lower threshold values for maximum temperature. Similarly 19.0°C and 5.5°C were provided as input for minimum temperature upper and lower threshold values. These were the winter and summer mean values for maximum and minimum temperature. For rainfall, 25 mm was used as 24 hour maximum threshold value.

Consecutive dry days and wet days are shown in Figure 48 and Figure 49 respectively. The graph has increasing trend for dry days where as wet days do not show any trend. In Figure 48 number of days exceeding 10 mm, 20 mm and 25 mm rainfall is shown. All the three graphs do not show any trend. Similarly 24 hour highest and 5 day total highest shown in Figure 49 also do not show any trend.

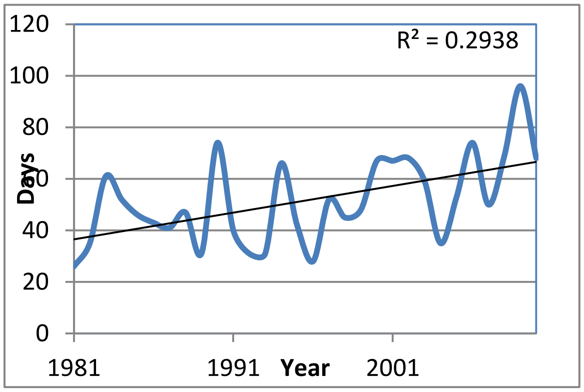


Figure 42: Consecutive dry days.

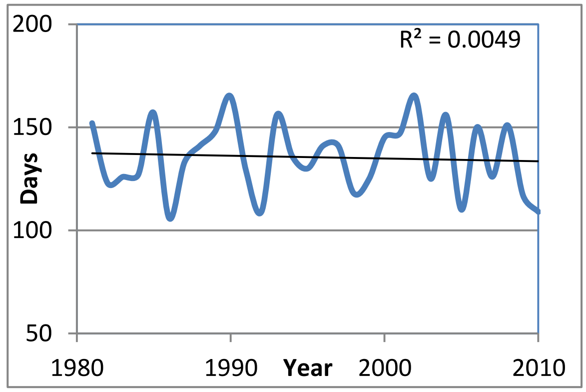


Figure 43: Consecutive wet days.

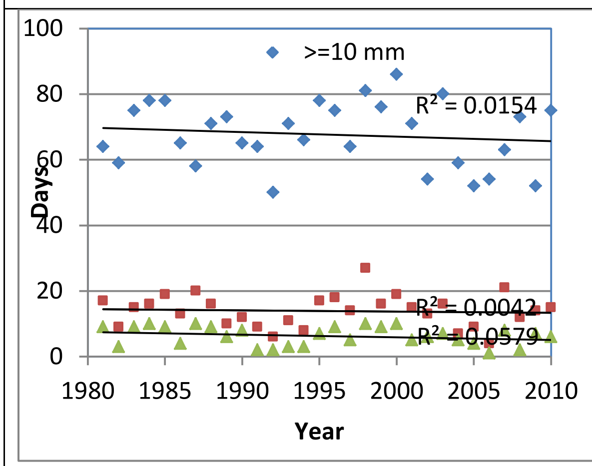


Figure 44: Days with rainfall greater or equal to 10 mm (blue diamond), 20 mm (red square) and 25 mm (green triangle).

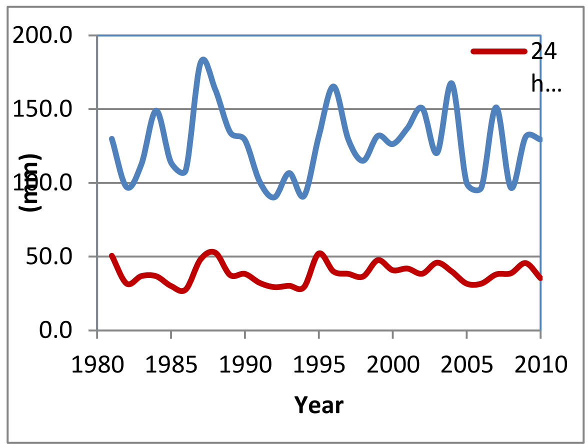
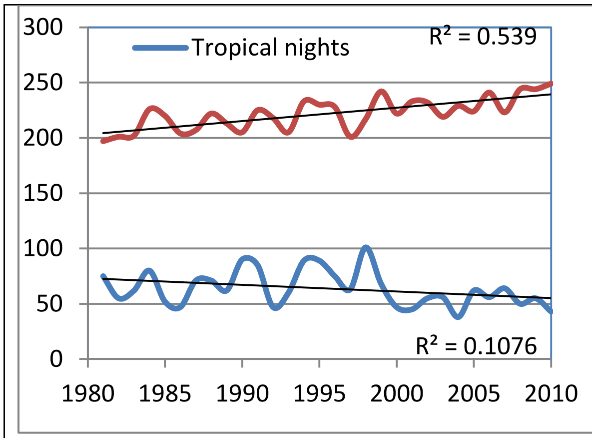


Figure 45: Highest rainfall in 24 hour (red) and 5 day total highest (blue).

Trend analysis for summer days and tropical nights are provided in Figure 47. Summer days (number of days when TMAX >= 25.0°C) show increasing trend which is also statistically significant. Tropical nights (number of days when TMIN >= 20°C) do not so any significant trend. In Figure 48 diurnal temperature range (DTR) is provided. DTR show increasing trend which is statistically significant.



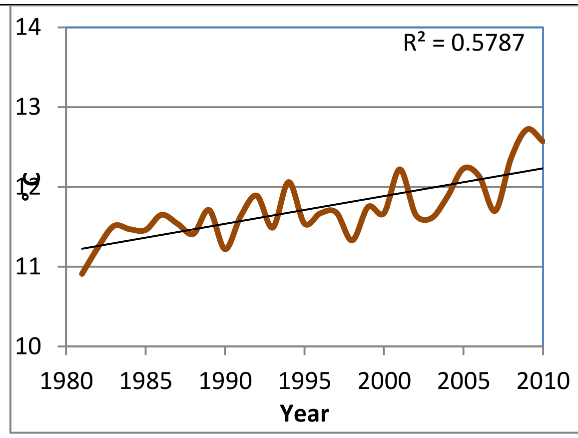
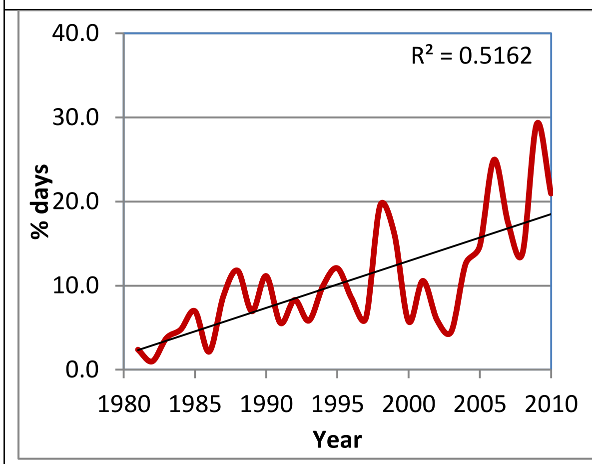


Figure 46: Annual trend of the summer days (red) and tropical nights (blue).

Figure 47: Diurnal temperature range (DTR).



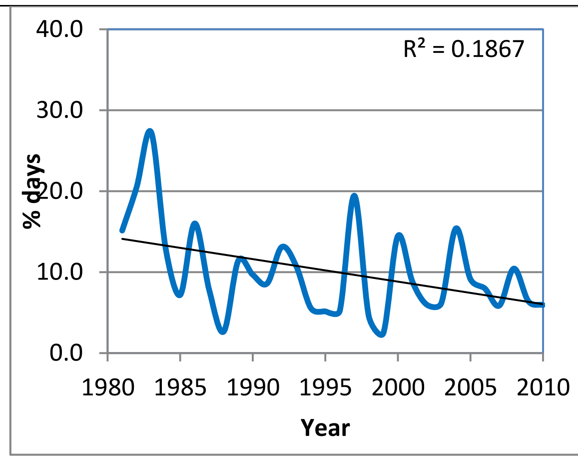


Figure 48: Percentage of days when TMAX > 90th percentile.

Figure 49: Percentage (%) of days when TMIN < 10th percentile.

Annual percentage of days when maximum temperature was greater than 90th percentile is shown in Figure 49. The graph depicts increasing trend with slope estimation of 0.56 and R^2 close to 52%. Similarly in Figure 50, annual percent days are shown when minimum temperature was less than 10th percentile. The slope estimation is -0.28 with R^2 close 20 only 19% indicating warming but not at the pace of maximum temperature.

3.5 Interactions between environmental and socioeconomic determinants of health

3.5.1 Assessing Environmental Burden of Diseases

The climate variability and change affect the environmental components at global, regional, national and local levels. The likely affected environmental indicators are forest, water, soil and air, and ultimately the human health[9]. Nepal exhibits huge spatial and temporal variations of climatic elements. Based on the findings of various studies, discussions with the communities, and perceptions of the people, the NAPA report (2010) has found that the variations in temperature have direct impact on health of the people. A number of possible climate change-related impacts can therefore be expected to occur on human health as well as on ecosystems of the various environments in the country. It has also been observed that the feature of the Monsoon rainfall pattern has changed, for instance the intensity of rainfall pattern has increased but the total volume of precipitation has decreased. It is noted that it has affected the ecosystem such as loss of biodiversity, threatening to food security through adverse impacts on winter and spring crops, shifting of hydrograph cycle including drying up of water resources, increasing flash floods, possible droughts, and glacial lake outbursts. These changing environmental conditions will eventually affect the human health through emerging different types of new diseases[12].

3.5.2 Water and Sanitation related diseases

Water, sanitation, and hygiene related global disease burden are principally diarrhoeal diseases. The estimated of the disease burden from water, sanitation, and hygiene is to be 4 percent of all deaths and 5.7 percent of the total disease burden (in DALYs) occurring worldwide which is largely preventable[13].

Water is essential for drinking and all other domestic purposes. In Nepal the water sources such as springs, rivers and groundwater are being reduced or dried up due to exposure to extreme heat[12]. Water shortage is one of the causes for poor sanitation and water-washed diseases like skin disease, worm infestation, eye infections, etc. Limited and poor quality drinking water is responsible to spread water borne diseases like typhoid, diarrhoea, dysentery, cryptosporidiosis, giardiasis, amoebiasis, gastritis and infectious hepatitis[9]. Available studies indicate that heavy rainfall events transport terrestrial microbiological agents into drinking water sources, resulting in outbreaks of those infectious diseases[14]. At national level, incidence of diarrhoeal diseases per 1000 new cases children under 5 years of age has increased consistently from 131 in 1995 to 498 in 2011, while case fatality rate has decreased remarkably from 0.6 per 1000 new cases in 1996 to 0.01 in 2011. Further, morbidity with an average of over 3.3 episodes per child has been recorded. Likewise, there has been an increased trend of typhoid fever, from over 400 cases in 2001 to nearly 1000 cases in 2005 (Patan Hospital Record 2005). Likewise, the hospital record in 2005 has shown a close relationship between temperature and precipitation, and typhoid cases; both climatic phenomena have risen during four months (June-September) and meanwhile typhoid cases of children under-5 years of age ranged from 270 to 193/1000 new cases were among the highest, while in the winter months, the cases have low record along with low temperature and rainfall[15].A total of 282 people died in May – August 2009 due to the outbreak of diarrhoea and cholera in the Mid Western Development Region of Nepal, which was mainly due to the consumption of contaminated water and poor sanitation, as well as due to the lack of adequate water (EDCD 2009). Most of the local water sources have been dried up due to long drought which may be due to variation in the climate[12].

3.5.2.1 Prevalence of diarrhoea

Diarrhoea in Nepal is always in the top 5 diseases listed in the OPD (Out Patients Department) visits. The occurrence of this disease shows a definite monthly pattern or a positive relation with the amount of precipitation. Diarrhoeal disease has a direct relationship with the increased rainfall pattern. The highest diarrhoea occurrence is recorded in the months of June and July (Figure 58).

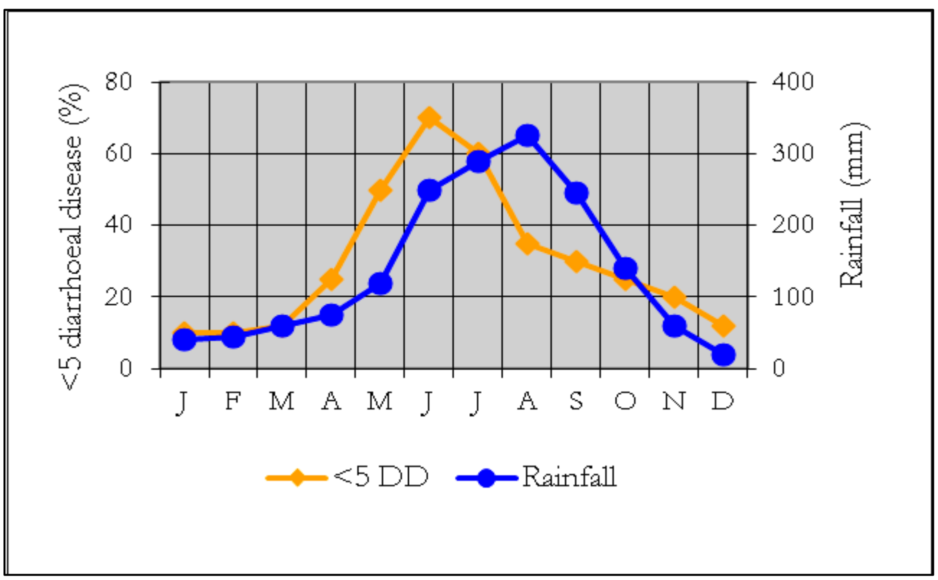


Figure 50: Prevalence of diarrhoeal disease (DD) among children of under-five years of age and rainfall pattern over months, Nepal

(*Source: DOHS (2005) and DHM (2005)*

Table 14 shows that the trend of diarrhoea morbidity has shown an increasing trend. The case fatality rate is in decreasing trend which may be due to interventions at different levels.

Table 12: Trend of diarrhoeal disease of children under five years

Reporting status	1996	2001	2006	2011
New cases of incidence of diarrhoea/1,000 <5 children	131	177	219	598
Case fatality rate of diarrhoea/1,000 <5 children	0.6	0.4	0.31	0.01

Source: DOHS 1997, 2002, 2007 and 2012

Based on the district health care institution records, the spatial distribution of incidence of water borne disease is depicted in Figure 59. Most districts of the Mid-Western and Far Western regions are seen most vulnerable with highest diarrhoeal incidence. This pattern can be related to the pattern of mortality due to diarrhoea, which is also seen over the same regions (Figure 60).

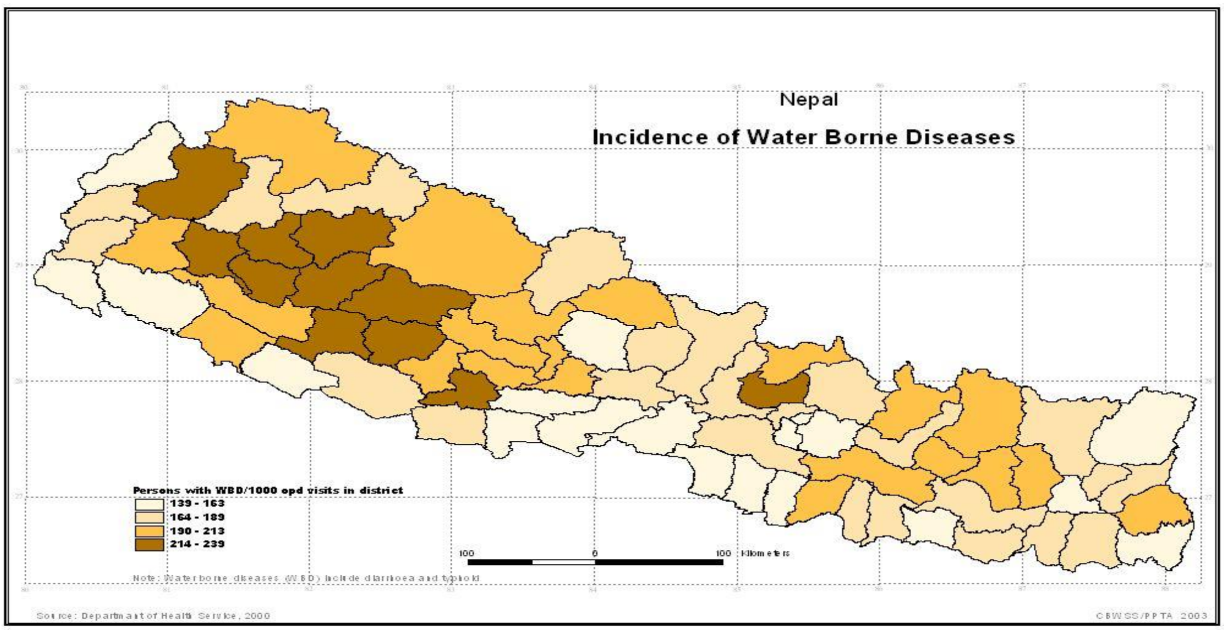


Figure 51: Spatial distribution of incidence of water borne disease by district, Nepal, 2001

Despite different types of interventions by the governmental and non-governmental agencies, the situation of diarrhoeal mortality rate has not improved. Every year about 10,500 children die due to diarrhoea (Water aid 2008). There is a rising trend of diarrhoea incidence per 1000 children of under-five years of age from 1997 to 2009.

The clusters with the values against the months with yellow highlighted indicate incidence of diarrhoea. The most risk months in terms of diarrhoea disease range loosely from March through August, but the

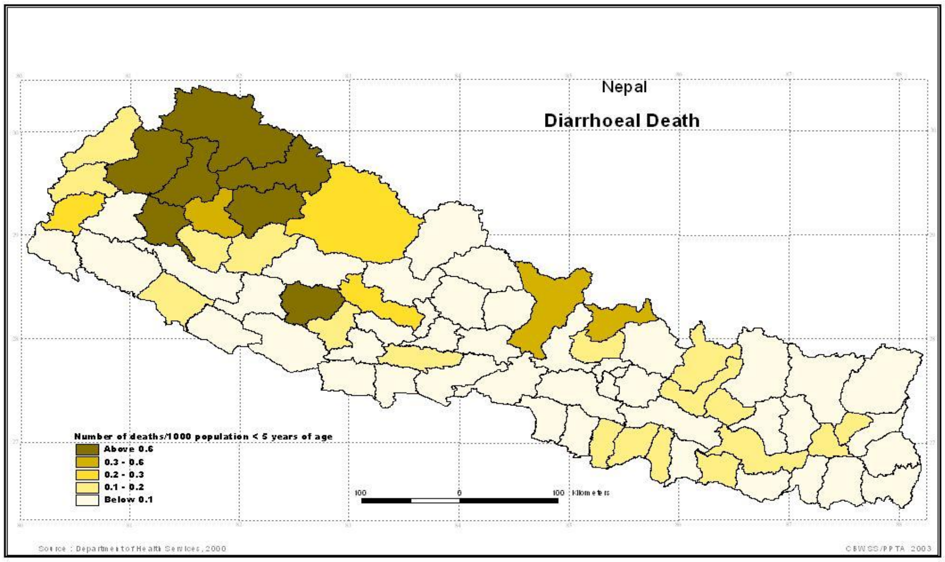


Figure 52: Spatial distribution diarrhoeal deaths by district, Nepal, 2001

intense occurrence of the disease lies mainly during April through June (Table 15). On the whole, there are cases of diarrhoea in all cluster regions throughout all twelve months.

Table 13: Distribution of average prevalence of diarrhoeal disease (2002-2007)

Cluster region	Months											
	J	F	M	A	M	J	J	A	S	0	N	D
TE	6.9	7.6	9.7	10.0	9.7	9.0	8.6	8.7	8.0	7.5	7.3	7.1
TC	5.8	6.9	10.3	11.5	11.0	9.3	8.8	9.0	7.7	7.1	6.6	5.9
TW	6.4	6.8	8.7	10.9	11.5	9.9	9.2	9.3	7.2	7.1	6.7	6.4
TMW	6.0	7.7	10.0	11.5	11.8	10.8	10.0	8.8	6.7	5.9	5.6	5.1
TFW	7.0	8.4	10.9	11.5	12.6	10.5	8.2	6.7	6.6	5.4	6.3	5.9
HE	7.0	8.0	9.3	10.2	11.8	11.3	8.4	7.6	7.0	6.7	6.8	5.9
HC	6.3	7.8	9.2	10.7	12.6	12.1	9.6	8.1	6.5	5.6	5.6	6.0
HW	5.8	7.1	10.5	11.6	12.6	14.2	7.6	8.0	5.6	4.7	6.3	5.8
HMW	5.4	6.8	9.1	10.9	13.5	14.1	10.9	9.4	5.4	4.8	5.1	4.8
HFW	5.8	7.1	10.5	11.6	12.6	14.2	7.6	8.0	5.6	4.7	6.3	5.8
ME	7.2	7.6	8.4	10.2	12.4	13.0	8.6	8.0	5.7	6.8	5.9	6.2
MC	5.5	9.0	9.3	10.1	12.5	13.8	9.1	8.2	6.9	5.5	5.2	4.7
MW	4.3	5.8	8.2	10.9	12.2	11.5	11.3	11.9	8.5	6.3	4.6	4.4
MMW	6.0	6.5	6.6	9.3	14.0	14.7	10.8	8.9	5.9	5.5	5.7	6.0
MFW	6.8	8.1	8.4	11.8	13.7	13.7	8.3	7.3	5.1	5.6	5.5	5.8

A study (NDHS 2011) shows that, diarrhoeal disease is higher at the age of 12-23 months and female children are less affected than male children (Table 16). The study also shows that the diarrhoeal difference among the children consuming improved water and unimproved water was 13.9% and 13.2 % respectively.

Table 14: Diarrhoea pattern among the children

Age in months	Diarrhoea cases in the two weeks preceding the survey		
	All diarrhoea	Diarrhoea with blood	Number of children
<6	12.9	0.8	531
6-11	24.1	1.2	491
12-23	23.9	5.0	1,000
24-35	14.2	2.0	1,013
36-47	8.2	1.3	1,106
48-59	5.2	1.2	999
Male	15.5	2.5	2,649
Female	12.0	1.7	2,490

Diarrhoeal disease is climate sensitive. The change of diarrhoeal morbidity shows a relationship with the variation in temperature. The long-term hospital record of diarrhoeal disease shows that it increases by 8% for 1°C rise of temperature (WHO 2009). The study done in Fiji based on the dose-response relationship has shown 3% increase for each 1°C increase in temperature[16].

Diarrhoeal disease occurs due to scarcity of drinking water, but mainly due to consumption of faecal contaminated water. River flash floods due to excessive rainfall also affect human health. In areas with poor water supply as well as poor sanitation system, transmission of enteric pathogens may occur during the rainy season. Lama et al indicate that excessive increase in temperature also has caused high episodes of diarrhoeal disease per person[17]. Unusual drought is also due to climate change that causes water scarcity, which in turn affects the availability of drinking water supply at the household level and eventually affects health and hygiene condition of the people and create favorable situation for diarrhoeal disease.

3.5.2.2 Water and Sanitation Status

Department of water supply and sewerage (DWSS) is the designated lead agency for the water supply and sanitation in Nepal. The primary aim of the DWSS is to provide access to safe water supply and sanitation facilities to all by 2017. In Nepal, number of surveys on WASH situation has been carried out by various agencies from 1991 and status is shown in Table 1.

Table 1: Drinking water supply situation in Nepal

Survey and years	Water supply coverage (%)		Sanitation coverage (%)	
	Urban	Rural	Urban	Rural
NFHS 1991	94	66.7	65.8	12.0
NDHS1996	90	76.9	71.3	13.4
Census 2001	97.1	88.7	72.3	33.6
NLSS 2001	95.6	82.0	76.6	19.4
NLSS 2004	93	79.0	79.5	25.3
NDHS 2006	90	80.0	77.0	29.4
NMIP 2010	**80.4**		**43.0**	
NMIP 2014	**83.6**		**70.3**	

Source: NMIS/DWSS 2014

Diarrhoea is linked to drinking water coverage and sanitation status of community. The drinking water coverage for two census years – 2001 and 2011 is shown in Figure 62 and 63. The drinking water coverage districts range from below 10 percent to 88 percent of the households, but none of the district shows 100 percent drinking water coverage. However, little improvement in the water coverage is seen between 2001 and 2011. It is found that the Mid-Western Hill and Mountain districts had very low drinking water coverage below 20 percent in 2001 which improved to below 75 percent coverage in 2011, showing still high vulnerability. Higher coverage of drinking water districts are scattered, particularly in the Western and Central Hills and Tarai regions. The most commonly available water at household level is either by pipe water or tube well.

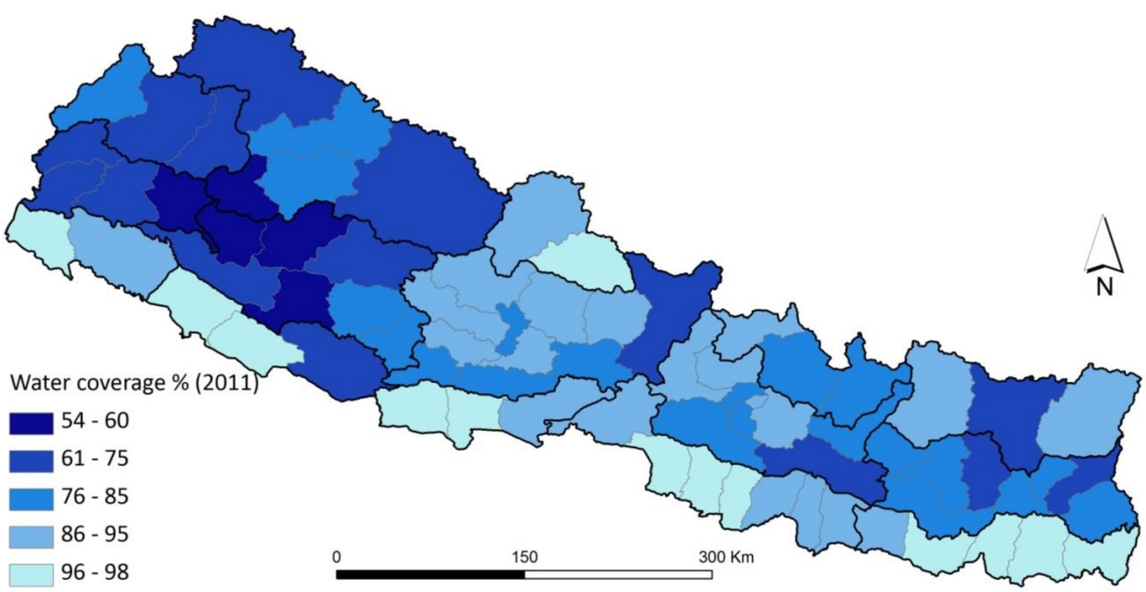


Figure 54: Distribution of drinking water coverage by district, 2011

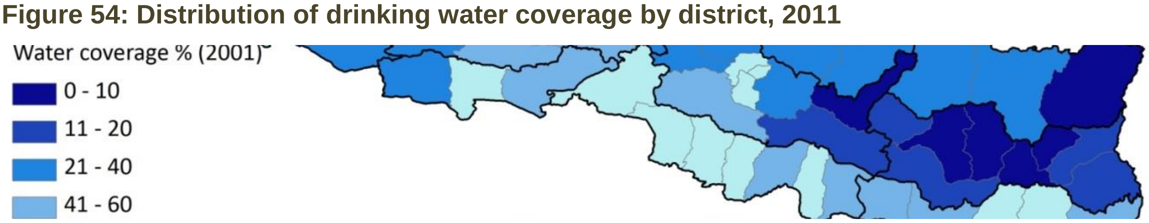


Figure 53: Distribution of drinking water coverage by district, 2001

3.5.2.3 Drinking Water Supply Coverage, Quality and Targets

In 2009, about 80.4% of the population had an access to improved drinking water. The common sources of water for drinking are surface water and groundwater. The water is being collected from different sources such as spring, pipe water, and tube well, dug well, stone spout, river, ponds, and lake. Spring water and pipe water are considered relatively safe (MPPW 2007).

The National drinking water standard has clearly indicated that "Water Suppliers" are responsible for safe water to the population in the country. To ensure the quality, it has indicated parameters such as frequency of monitoring, sampling, and testing of water supplies (DWSS 2005). However, the preparation of drinking water surveillance guideline is in the process. The targets for drinking water and sanitation set by Water and Energy Commission Secretariat in 2005 are shown in Table 17. As per NMIP/DWSS 2014 It about 15.3% population are served with higher quality of water supply system which however comply the target of National Water plan of 15% by 2012 (WECS 2004).

Table 15: Target set by the National Water Plan 2005

Year	Basic Services	Medium-High Services	Provision of safe sanitation
2007	85%	8%	50%
2012	90%	15%	70%
2017	100%	27%	100%
2027	100%	50%	100%

Source: WECS (2005), National Water Plan.

According to the NMIP/DWSS (2014), the coverage figures of water supply and sanitation have been increased to 83.6 percent and 70.3 percent and showing the achievement of MDG target against 73 percent and 53 percent of water supply coverage and sanitation coverage respectively by 2015. There is not much noticeable changes in water coverage but in sanitation it has changed 27.3% from 2010 to 2014. The abrupt change is the sanitation is mainly due to the increasing numbers of ODF in terms of VDCs and Municipalities of the districts. Similarly the changes in water and sanitation coverage with respect to geographical regions have been shown in Table 18. Altogether, 15 districts, 17 municipalities, 1615 VDCs officially declared as open defecation free (ODF) (NMIP/DWSS 2014)

Table 18: Percentage of water sanitation coverage and ODF status

Region	2010 (%)		2014 (%)		ODF (2014)
	Water	San	Water	San	%
Mountain	77.6	33.6	80.2	74.5	42.7
Hill	79.9	52.9	84.9	87.1	57.5
Tarai	81.2	35.6	84.8	56.9	17.9

Nepal	80.4	43.3	83.6	70.3	41.1

Source: NMIP (2014)

The latest information has shown that the national water supply coverage is slightly increased and has reached to 83.6% . The coverage is more than 80% in all development regions. Among them highest (85.21%) coverage is in the central development region and lowest in (80.92) in mid-western development region. Geographically, the highest (84.9%) water supply coverage in the hill and lowest (80.9%) in the mountain region. In case of sanitation coverage the hill has the highest coverage of 87.1% and the lowest coverage in the Tarai of 56.6 (Figure 65).

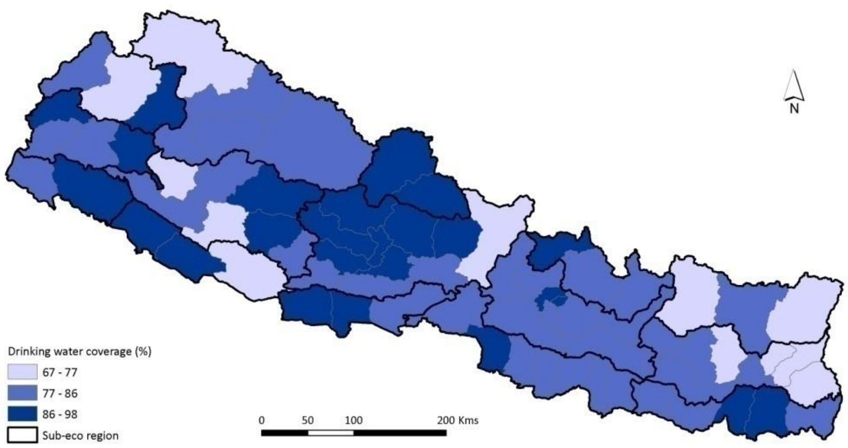


Figure 65: Percentage of drinking water coverage of Nepal, 2014

Table : Distribution of water coverage by cluster region

Cluster region	Average water coverage (%)	STD
ME	74.3	7.1
MC	86.3	4.5
MW	96.0	1.0
MMW	79.6	4.5
MFW	82.0	6.2
HE	78.6	4.8
HC	84.7	5.5
HW	86.7	6.1
HMW	81.7	6.2
HFW	86.5	2.3
TE	84.2	3.3
TC	83.0	3.5
TW	89.7	6.0
TMW	83.0	7.1

TFW	85.0	3.0
GT	83.6	6.5

3.5.2.4 Sanitation coverage

The sanitation indicator is represented by the toile coverage. The GIS mapping as shown in

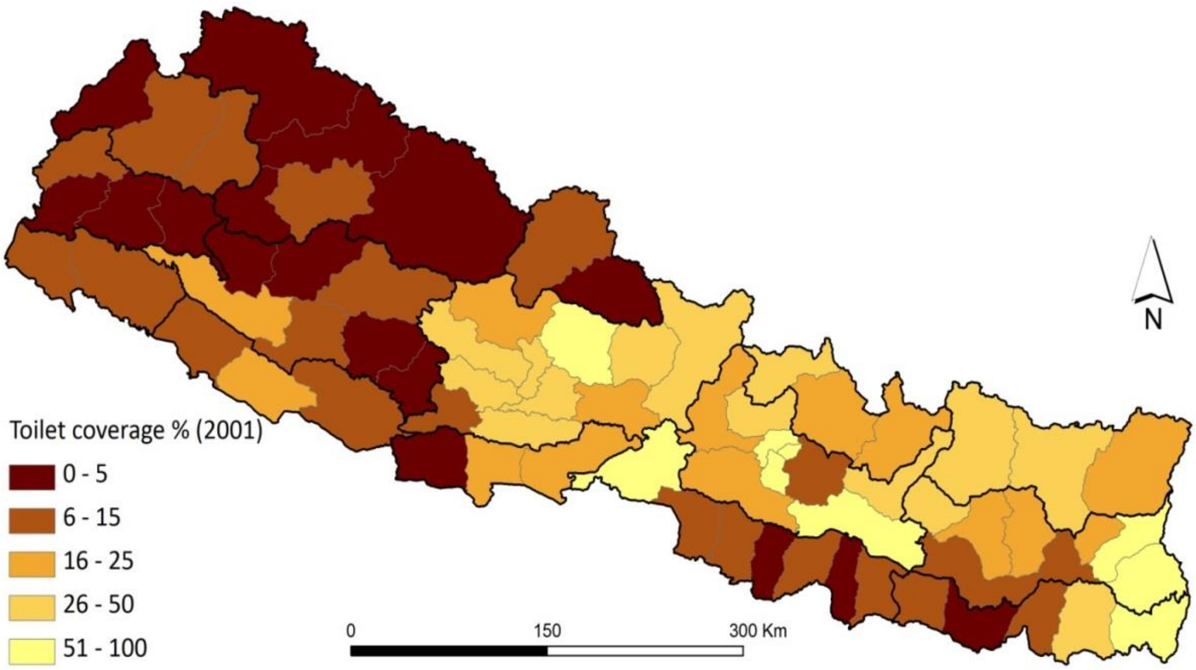


Figure 55: Distribution of toilet coverage household by district, 2001

Figures 14 and 15 indicates that the lowest toilet household coverage (with below 15%) lies mostly in the districts of the Mid- and Far-Western and some of the Central and Western Tarai regions. Some improvements at household level toilet coverage, particularly in the districts of the Western half of the country have appeared in 2011, but yet they represent below 75 percent toilet coverage.

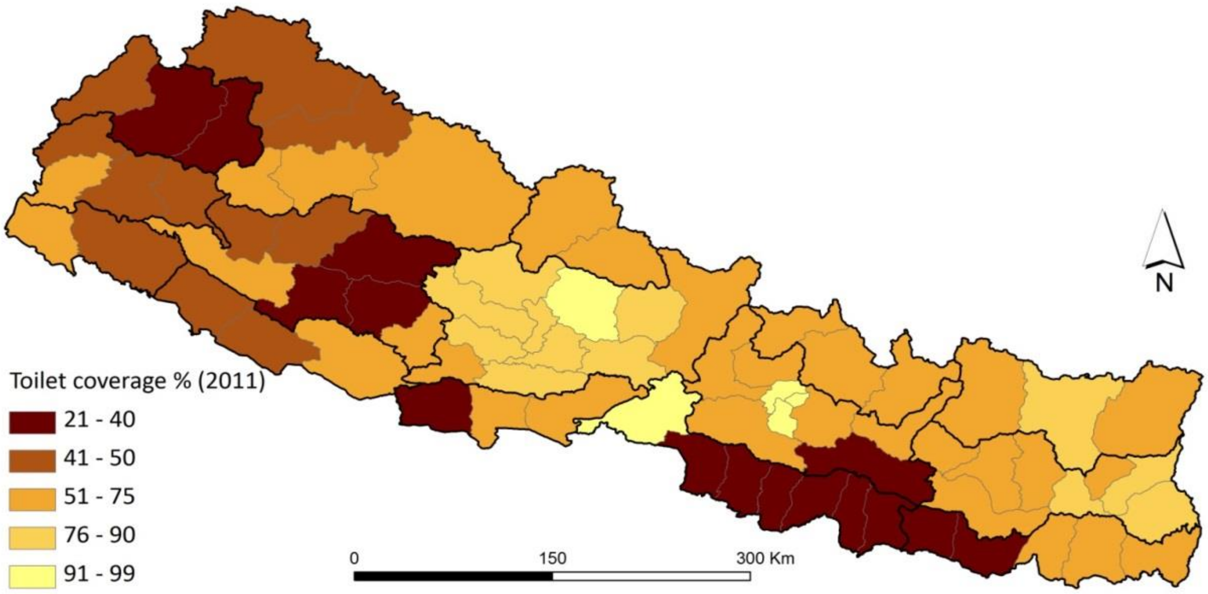


Figure 56: Distribution of toilet coverage household by district, 2011

Further, the toilet coverage has improved, but its spatial distribution pattern has not changed. Still most districts of the Central Tarai and the Mid-Western Hills and Mountains have relatively less toilet coverage, indicating higher vulnerable to sanitation related diseases. This happens during the summer rainy and pre-monsoon dry seasons.

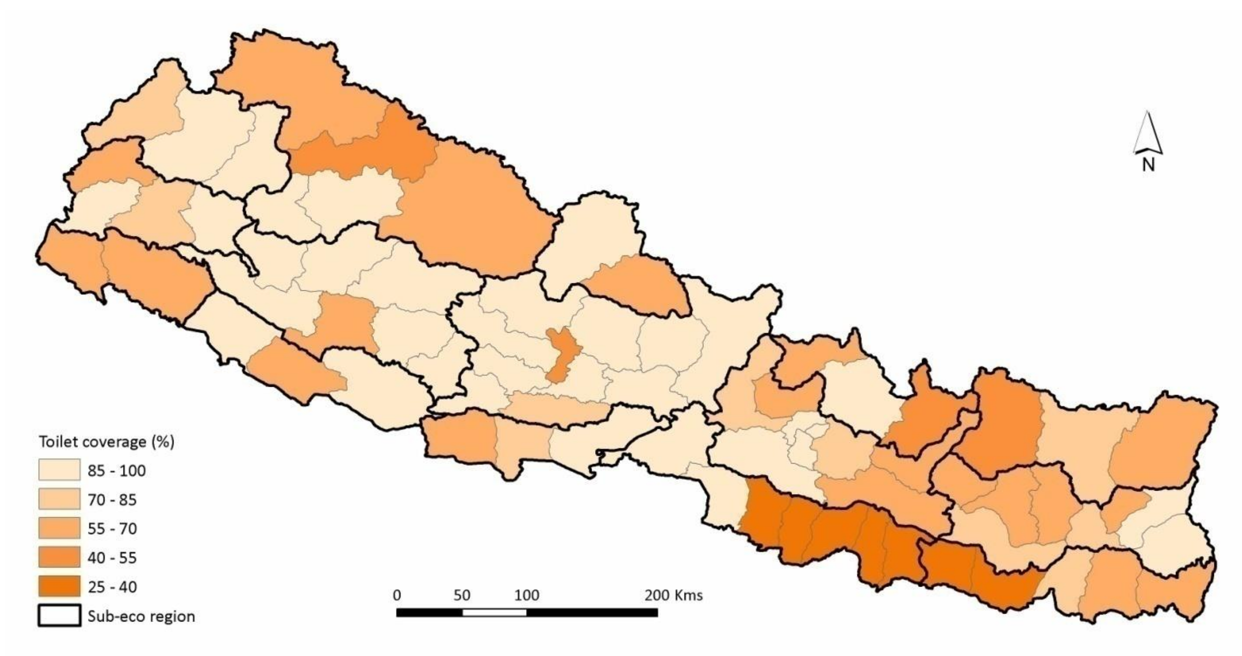


Figure 16: Distribution of toilet coverage household by district, 2014

In hill region has highest percentage of toilet coverage followed by mountain region and Tarai has relatively lowest percent (Table 18).

Table 18:Distribution of sanitation coverage

Cluster region	San coverage (%)	SD
ME	61.0	19.0
MC	69.7	22.4
MW	80.0	28.3
MMW	75.2	22.9
MFW	88.3	9.0
HE	75.9	15.1
HC	79.4	16.4
HW	90.2	18.0
HMW	90.3	10.8
HFW	86.8	15.7
TE	53.0	24.9
TC	50.4	34.1
TW	74.7	16.6
TMW	84.0	21.2
TFW	69.5	0.7
Average	70.3	22.4

Source: NMIP/DWSS (2014)

The sanitation coverage in the country has increased from 6% in 1990 to 70.3% in 2014 (Table) . The annual growth rate of sanitation stands at 2.7%. About 42 % of the districts are below the national sanitation coverage. The sanitation coverage in urban areas is 78% as against 37% coverage in rural areas. The urban toilet coverage has been stagnated at around 80% since 2000. About 12% urban households are connected to the sewer systems or to open drains. Estimates also reveal that about 83% of the total wastes generated are household solid waste, whereas agricultural wastes are 11% and industrial waste 6%. Studies show that only about 45 percent of urban residents are served by waste collection systems and more than half the waste is not collected properly (DWSS 2011).

Table 16: Trend of sanitation coverage by national, urban and rural

Year	Rural	Urban	National
1990	3	34	6
1995	18	67	22
2000	25	80	30
2005	30	81	39

2010	37	78	43
2012	51	81	54
2014	67	84	70
MDG Target 2015	52	67	53
National Target 2017	100	100	100

Source: GoN (2010), Sanitation and Hygiene Master Plan, NIMP/DWSS(2014)

3.5.2.5 Pollution-related health effect - ARI

ARI and pneumonia is one of the major public health problems in Nepal. ARI is one of the top five diseases in Nepal. ARI and chronic bronchitis account for 8.72 and 3.04 percent respectively of the total out-patient department (OPD) visits of the health service units (DOHS 2010). The occurrence of diseases in the mountain region shares 13.6 percent of the total OPD visits, as compared to 10 percent in the Tarai region. The hospital record across the country shows that the deaths among the children below five years of age by these diseases account for over 30 percent.

The disease burden from solid fuel use is most significant in populations with inadequate access to clean fuels. So, one of the risk factor of ARI and pneumonia is indoor smoke from kitchen where primary source of cooking is solid biomass fuel, particularly cold rural regions. Women and their youngest children are most exposed because of their household roles. Solid fuel use is most firmly associated with acute lower respiratory infections (including pneumonia) in young children, and chronic obstructive pulmonary disease and lung cancer in women (and to a lesser degree in men). Each of these three health outcomes is a major disease category in most societies and thus household solid fuel use is likely to be a major cause of disease burden in communities where it is prevalent.

Table 22 shows that over 80 percent domestic fuel is being used for cooking and out of the total most pollutant animal dung fuel was being used in the Terai region of Nepal.

Table 17: Solid fuel used by region

Cluster region	Solid fuel used		Animal Dung (%)	Cluster region	Solid fuel used		Animal Dung (%)
	Number	%			Number	%	
EM	1456	96.1		FWH	2058	98.7	
CM	1471	97.4		ET	1382	64.0	18.2
WM	1813	99.1		CT	2182	77.4	14.3
EH	1891	90.0		WT	1327	61.2	11.5
CH	984	51.4		MWT	1701	77.9	4.4
WH	1526	67.3		FWT	1494	79.2	0.3

MWH	1965	90.0		Total	21250	80.7	

Source: NDHS (2011)

Figure 66 indicates the trend of incidence rate of ARI among <5 years of children/1000 from 1999 to 2009. ARI is one of the killer diseases among the children. Hence this disease has been considered as the most priority by government program. However, the trend of incidence of the disease is seen increasing (Figure 66). It is known that about 66 percent of the total cases of ARI being managed at the community level, while FCHV alone has managed more than 50 percent of the cases. If more preventative measures sensitive to climate change are provided at community level, the increasing trend of incidence of ARI can

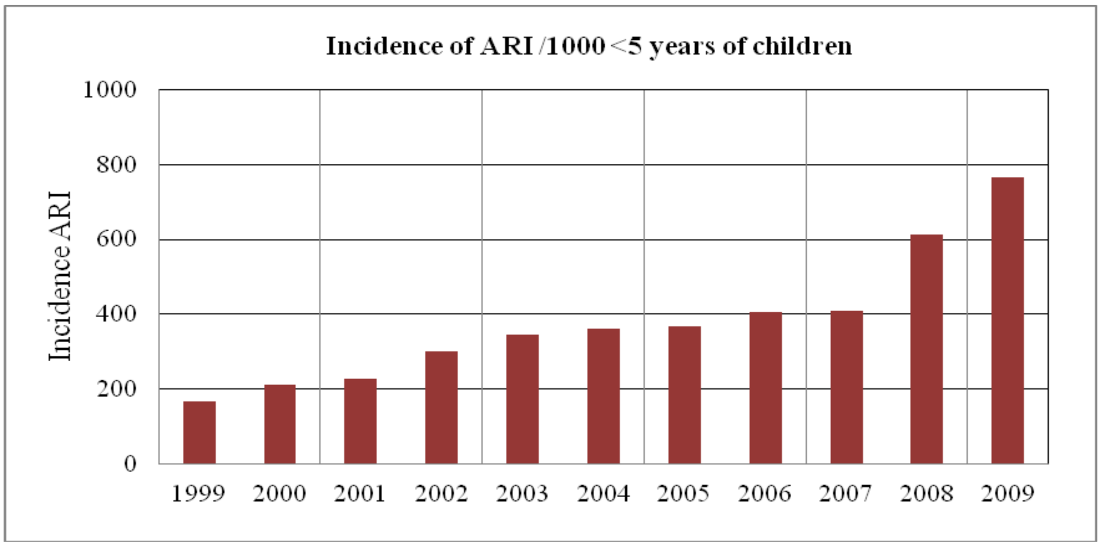


Figure 57: Incidence of ARI/1000 under 5 years of children

In Figure 67, a series of GIS generated maps show spatial distribution pattern of incidence of ARI among children <5 years over three different years.

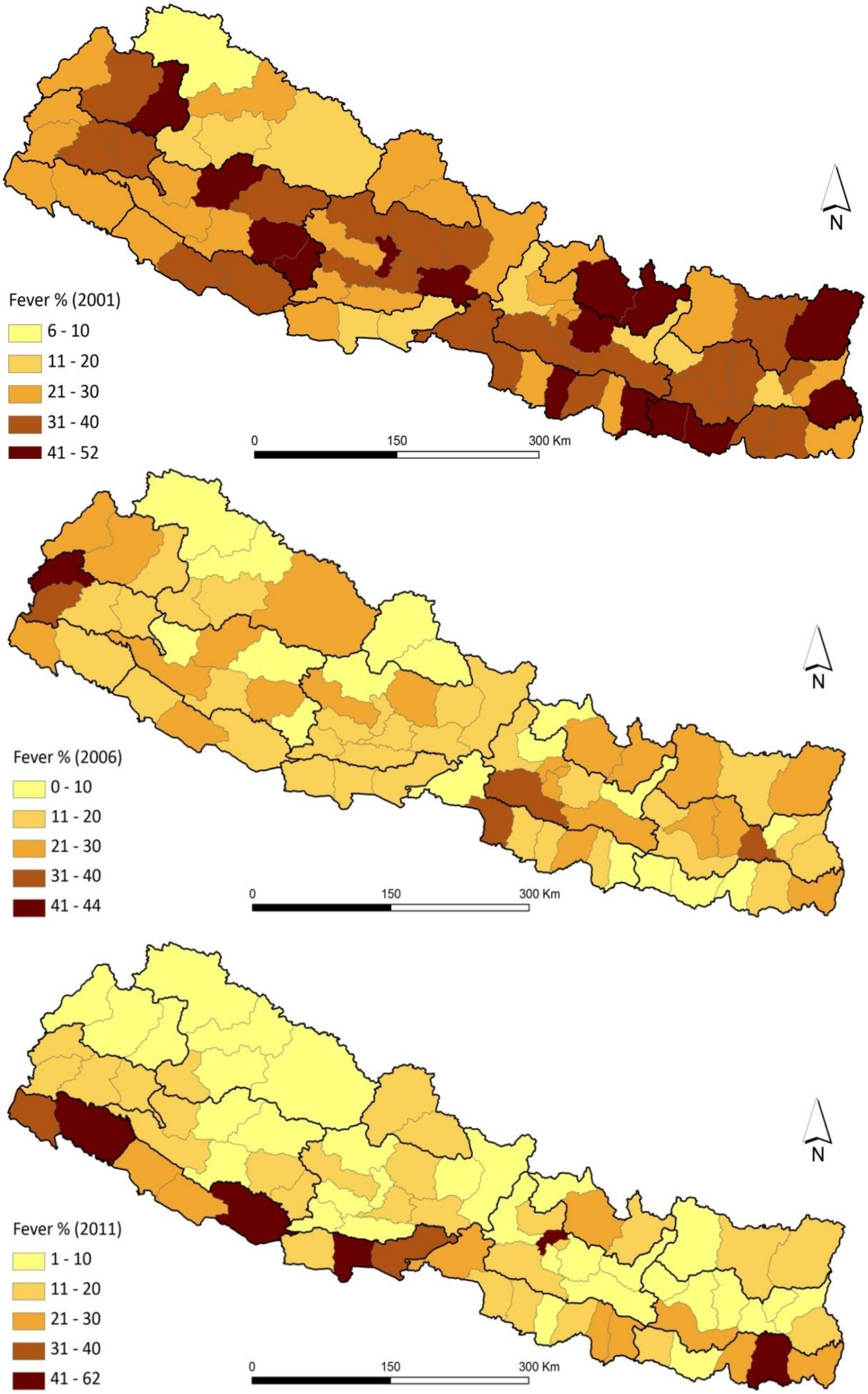


Figure 58: Spatial distribution of incidence of ARI among children <5 years over years

A study (NDHS 2011) shows that, ARI symptom is higher at the age of 12-23 months (Table 23).

Table 18: Symptoms of ARI

Age in months	Symptoms of ARI (%)	Number of children
<6	3.9	531
6-11	7.5	491
12-23	7.9	1,000
24-35	4.1	1,013
36-47	3.6	1,106
48-59	2.1	999
Sex		
Male	4.6	2,649
Female	4.7	2,490

Source: NDHS (2011).

3.5.2.6 Assessing Socio-Economic Determinants of Health

According to DOHD (2011), the economic index is used based on inequalities in household income, use of health services and health outcomes which is an indicator of the level of wealth that is consistent with expenditure and income measures[18]. The economic index has been constructed using household asset data including ownership of a number of consumer items ranging from a television to a bicycle or car, as well as dwelling characteristics, such as source of drinking water, sanitation facilities and type of material used for flooring. Each asset is assigned a weight (factor score) generated through principal components analysis, and the resulting asset scores were standardized in relation to a normal distribution with a mean of zero and standard deviation of one (Gwatkin et al., 2000). Each household was then assigned a score for each asset and the scores were summed for each household; individuals were ranked according to the score of the household in which they resided. The sample was then divided into quintiles from one (lowest) to five (highest).

3.5.2.7 Wealth Quintiles

Table 21 shows the percent distribution of population by wealth quintiles, according to sub regions, Nepal (NDHS (2006).

Table 19: Distribution of wealth index

Sub-regions	Wealth index				
	Poorest	Poorer	Middle	Richer	Richest
EM	36	25	22	16	1
CM	26.2	17.9	21.4	30.0	4.5

WM	55.5	18.5	13.1	11.3	1.5
MWM	55.5	18.5	13.1	11.3	1.5
FWM	55.5	18.5	13.1	11.3	1.5
EH	41.2	20.4	12.4	19.4	6.6
CH	24.5	14.3	9.5	17.7	34.0
WH	20.0	17.6	17.2	21.2	24.0
MWH	57.7	16.6	10.7	7.1	8.0
FWH	64.5	13.6	12.2	7.1	2.7
ET	3.3	19.5	29.0	28.6	19.6
CT	14.0	26.2	26.2	17.4	16.2
WT	6.9	14.8	22.4	27.9	28.0
MWT	8.7	31.1	25.5	19.9	14.8
FWT	13.5	31.1	15.0	18.2	22.2

Table 20: Percent distribution of population by wealth quintiles, 2011

Subregion	Wealth quintile				
	Lowest	Second	Middle	Fourth	Highest
Eastern mountain	37.1	28.5	23.4	10.0	1.0
Central mountain	18.9	41.3	29.3	9.9	0.6
Western mountain	60.1	24.5	10.7	4.7	0.1
Mid western mountain	60.1	24.5	10.7	4.7	0.1
Far western mountain	60.1	24.5	10.7	4.7	0.1
Eastern hill	34.4	27.9	19.5	14.0	4.2
Central hill	19.8	13.2	5.0	12.8	49.2
Western hill	23.3	26.2	22.9	14.9	12.7
Mid-western hill	55.8	17.4	10.7	9.2	6.9
Far-western hill	58.6	21.0	13.9	6.0	0.5
Eastern Tarai	3.6	12.7	20.3	30.9	32.4
Central Tarai	9.4	19.7	29.3	26.8	14.8
Western Tarai	2.8	14.8	18.1	31.9	32.4
Mid-western Tarai	21.1	20.7	23.8	18.3	16.1
Far-western Tarai	10.1	26.4	26.0	22.0	15.3
Total	20.0	20.0	20.0	20.0	20.0

Source: DHS (2011): Table 2.6, pp 20

One of the components of vulnerability is low adaptive capacity which has been analyzed by cluster and wealth quintile, which is shown in figure 18. The wealth quintile analysis of the sub-regions shows that the population of the Mountain Region is relatively high vulnerable as this region has high percentage of lowest wealth quintile, followed it by the Mid-Western Hill and Far-Western Hill. The population of the Central hill shows highest wealth quintile and followed it by the Eastern Tarai and the Western Tarai, showing less vulnerability, as shown in Figure 69.

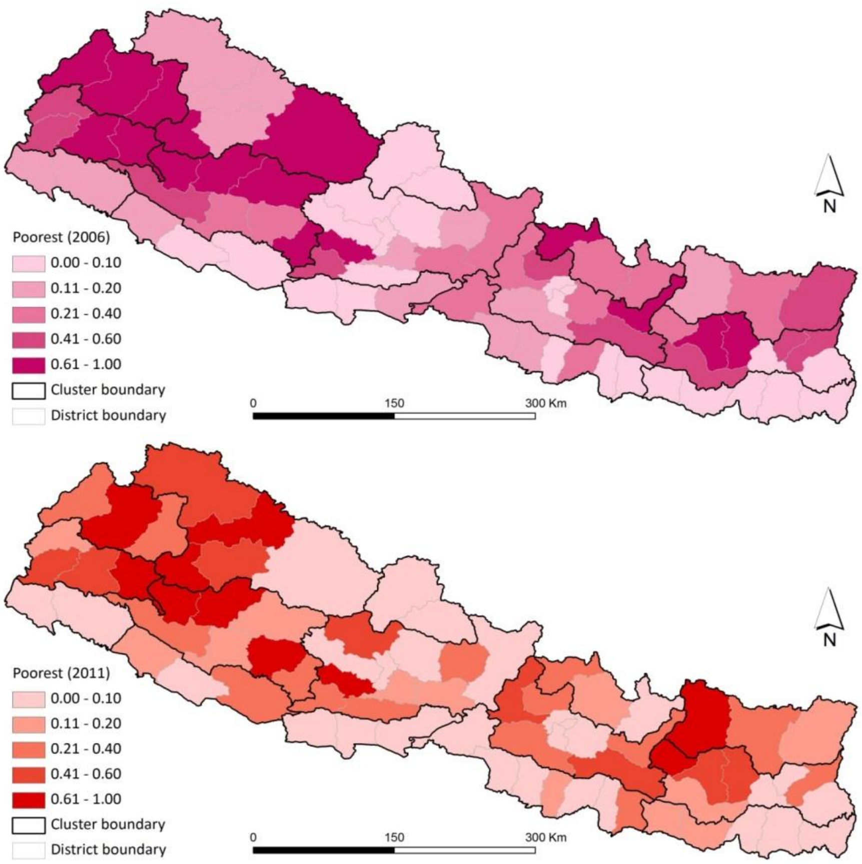


Figure 59: Wealth quintile index by district

3.5.2.8 Poverty

Over the past 15 years, Nepal has made significant gains in poverty reduction, from a rate of 40 percent in 1995/96 to 25 percent in 2010/11. This has been matched by a corresponding reduction in the proportion of the population experiencing hunger and chronic under nutrition. In spite of the progress made, some households are falling behind, and amongst some of the poorest households, there is evidence that vulnerability may have increased in recent years. Table 26 shows poverty index comparison by cluster regions between 2006 and 2011.

Table 21: Poverty index comparison

Cluster Region	SAE 2006			SAE 2011		
	Poverty Incidence	**Poverty Gap**	**Poverty Severity**	**Poverty Incidence**	**Poverty Gap**	**Poverty Severity**

EM	0.49	0.15	0.07	0.25	0.05	0.02
CM	0.41	0.12	0.05	0.28	0.06	0.02
WM	0.24	0.06	0.02	0.38	0.10	0.04
MWM	0.45	0.13	0.05	0.51	0.14	0.05
FWM	0.44	0.13	0.06	0.58	0.17	0.07
EH	0.48	0.15	0.06	0.18	0.04	0.01
CH	0.32	0.10	0.04	0.19	0.04	0.01
WH	0.35	0.11	0.04	0.19	0.04	0.02
MWH	0.50	0.15	0.06	0.31	0.07	0.02
FWH	0.44	0.13	0.05	0.46	0.13	0.05
ET	0.22	0.05	0.02	0.23	0.05	0.02
CT	0.25	0.06	0.02	0.23	0.05	0.02
WT	0.35	0.10	0.04	0.23	0.06	0.02
MWT	0.43	0.13	0.05	0.27	0.07	0.02
FWT	0.46	0.14	0.06	0.33	0.08	0.03
Mean	**0.39**	**0.11**	**0.05**	**0.31**	**0.08**	**0.03**
SD	**0.09**	**0.03**	**0.02**	**0.12**	**0.04**	**0.02**

Source: WFP (2006 & 2013)

3.5.2.9 Malnutrition

Malnutrition is one of the most important constraints to achieving the MDGs. It is notable that the proportion of people who suffer from hunger (as measured by the percentage of children under five who are underweight) is an indicator of MDG1. Nepal is not on track to achieve MDG1 if current nutrition interventions continue with "business as usual. The World Bank 2011 has estimated that, 2-3 % of GDP (US$ 250 to 375 million) is lost every year in Nepal on account of vitamin and mineral deficiency alone.

The magnitude of under nutrition remains high in the country. An estimated 1.6 million children under five years of age (out of an estimated total population of 3.5 million) are suffering from chronic under nutrition and its long-term consequences. While over 500,000 children are suffering from acute under nutrition, or wasting. The high prevalence of chronic under nutrition among infants under six months of age, and the fact that more than fifty percent of children are stunted by the time they reach two years of age, highlights the importance of targeting interventions during the "first 1,000 days," from the prenatal period through pregnancy and the first two years of life.

Table 24 describes nutrition status and percent of population with food energy deficiency. The mountain and hill districts are comparatively more food deficiency and therefore nutrition deficiency than the Tarai districts.

Table 22: Diet quantity 2010/2011

Regions	Average kilocalories consumed per capita/day	% of the population food energy deficient
Nepal	**2536**	**38**
Urban	2525	43
Rural	2539	37
Regions		
Mountains	2403	45
Hill	2524	42
Terai	2553	38
Hills - Eastern	2542	43
Hills - Central	2422	45
Hills - Western	2452	42
Hills – Mid and Far Western	2331	49
Terai - Eastern	2640	28
Terai - Central	2762	23
Terai - Western	2590	34
Terai – Mid and Far Western	2515	37

Source WFP/NPC 2012

Table 28 describes diet diversity and percent of calories from staples by cluster regions.

Table 23: Diet diversity and percent of calories from staples 2010/11

Population	Average % of calories from staples	Household Dietary Diversity Score*
Nepal	**72**	**6.49**
Urban	66	7.01
Rural	74	6.35
Regions		
Mountains	77	6.03

Hills - Eastern	72	6.25
Hills - Central	73	6.19
Hills - Western	70	6.42
Hills - Mid and Far Western	76	6.07
Terai - Eastern	75	6.52
Terai - Central	76	6.57
Terai - Western	72	6.63
Terai - Mid and Far Western	76	6.30

*Excluded small quantities (less than 15 grams)

Source: WFP/NPC (2013)

There is higher percentage of children suffering from anemia due to deficiency of nutrition (Figure 72).

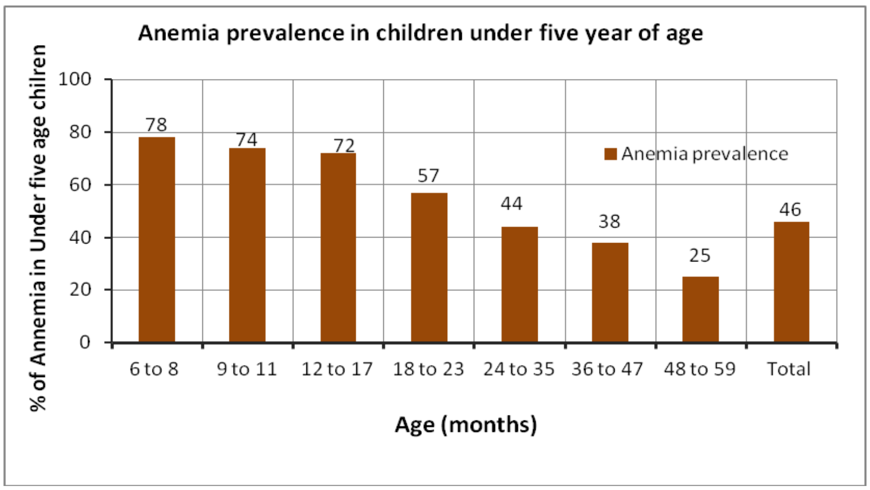


Figure 60: Anemia prevalence in Children under five years of age

3.5.2.10 Education level of female

Education especially female plays a crucial role in addressing the vulnerability of the population. Table 29 depicts that larger percent of population in the Mid and Far Western mountain is without education.

Table 24: Distribution of education status (N = 22529)

Regions	Distribution of education status (%)			
	No	Primary	Secondary	> Secondary
Eastern mountain	36	33.9	28	2.1
Central mountain	49.4	28.9	20.1	1.5
Western mountain Mid-western mountain Far-western mountain	54.6	31.2	13.0	1.1
Eastern hill	37.4	32	27.6	2.4
Central hill	33.7	26.6	26.3	13.4
Western hill	39.4	29.0	28.1	3.4
Mid-western hill	41.7	31.7	22.7	3.9

Far-western hill	49.2	32.0	21.2	1.6
Eastern Tarai	33.7	30.6	30.4	5.3
Central Tarai	53.6	25.6	17.7	3.1
Western Tarai	35.6	29.2	29.5	5.5
Mid-western Tarai	41.7	32.2	23.5	2.6
Far-western Tarai	41.6	30.3	24.2	3.9

3.5.2.11 Migration status

Migration is playing crucial role in the socioeconomic status of the people. Both male and female migrations are recorded and highest migration rate of both male and female have been recorded from western hill region of Nepal (Table 30). Percentage distribution of men and women who migrated in 10 years before the survey 2011 is shown in Table 30.

Table 25: Migration of men and women in Nepal

Regions		Distribution of migration (%)		
		Men	Women	Average
Eastern mountain		2.0	2.0	2.0
Central mountain		3.1	3.0	3.1
Western mountain		2.2	2.1	2.2
Eastern hill		8.9	9.5	9.2
Central hill		9.0	11.1	9.9
Western hill		16.4	17.1	16.7
Mid-western hill		5.2	4.4	4.9
Far-western hill		3.3	2.7	3.0
Eastern Tarai		14.9	14.6	14.8
Central Tarai		17.6	16.9	17.3
Western Tarai		8.1	7.8	8.0
Mid-western Tarai		3.7	3.9	3.7
Far-western Tarai		5.5	4.8	5.2
Total	%	100	100	100
	Number	6,829	5,002	11,831

Source: NDHS (2011)

Table 31 shows the distribution of the households by level of food insecurity in percentage, according to eco-regions of Nepal 2011.

Table 26: Status of food security

Cluster regions	Food secure	Mildly food insecure	Moderately food insecure	Severely food insecure	Total	Number of Households
Eastern mountain	56.8	15.4	17.4	10.3	100.0	206
Central mountain	44.3	15.1	33.3	7.3	100.0	266
Western mountain	25.4	23.1	25.8	25.8	100.0	289
Eastern hill	49.6	14.4	25.3	10.7	100.0	847
Central hill	58.4	11.7	21.0	8.9	100.0	1,386

Western hill	46.6	11.6	34.5	7.2	100.0	1,415
Mid-western hill	28.9	11.4	30.8	29.0	100.0	577
Far-western hill	29.3	13.7	40.2 9	16.8	100.0	33
Eastern Tarai	59.1	8.9	16.0	16.0	100.0	1,632
Central Tarai	50.1	10.7	17.8	21.4	100.0	1,975
Western Tarai	59.1	10.9	15.3	14.7	100.0	889
Mid-western Tarai	39.8	13.5	26.1	20.6	100.0	519
Far-western Tarai	37.4	12.7	29.0	20.9	100.0	487

NDHS (2011) pp37

Table 32 shows the causes of household food insecurity among the sample households (n= 5496) with food insecurity and the distribution of food insecurity households due to various causes, according to the physico-eco regions of Nepal 2011 (NDHS 2011).

Table 27: Distribution of food insecure households

Regions	Distribution of food insecure households (%)				Sample households
	Drought/ crop failure	Flood/ landslide	Financial problems	Other cause s	
Mountain	56.4	5.1	95.1	11.8	453
Hill	31.7	2.0	95.4	8.7	2,409
Tarai	13.9	1.2	96.0	3.7	2,634
Eastern mountain	43.1	2.0	94.1	14.3	89
Central mountain	49.3	5.1	94.8	13.7	148
Western mountain	66.7	6.4	95.7	9.5	216
Eastern hill	52.4	1.1	93.9	9.8	427
Central hill	24.2	3.3	95.7	8.0	577
Western hill	10.3	0.8	99.0	8.4	755
Mid-western hill	60.4	2.2	89.3	13.2	410
Far-western hill	31.3	3.7	96.8	2.0	239
Eastern Tarai	12.4	1.4	96.4	4.8	668
Central Tarai	13.2	0.5	96.2	3.2	986
Western Tarai	11.0	0.0	98.0	3.8	364
Mid-western Tarai	16.8	0.0	93.9	0.8	312
Far-western Tarai	19.9	5.5	94.5	5.6	305

Source: NDHS (2011)

3.5.2.12 Coping strategies of households with food insecurity

Table 33 depicts the distribution of sample households (5,496) with food insecurity in terms of percentage using various coping strategies in the eco-regions and sub-regions of Nepal, 2011.

Table 28: Coping strategies of households with food insecurity

Regions	Loan borrowed	Consumed seed	Sold livestock	Sold household assets	Worked as labourer
Mountain	73.1	28.1	40.7	8.0	10.8
Hill	72.4	23.1	37.3	7.2	4.0
Tarai	67.5	13.7	23.9	10.2	2.7
Eastern mountain	81.6	27.4	56.5	5.4	0.2
Central mountain	61.0	17.7	36.6	4.9	10.8
Western mountain	77.9	35.5	37.1	11.2	15.2
Eastern hill	74.9	17.6	55.6	8.1	0.0
Central hill	61.3	17.5	29.4	6.0	0.6
Western hill	66.8	14.0	29.8	4.3	5.5
Mid-western hill	87.7	49.0	47.7	14.2	12.1
Far-western hill	86.5	30.4	30.0	5.7	0.8
Eastern Tarai	69.4	8.1	30.1	12.7	2.9
Central Tarai	68.8	11.8	21.7	9.3	0.6
Western Tarai	65.3	12.8	17.8	5.5	7.3
Mid-western Tarai	51.7	18.6	22.8	12.9	3.3
Far-western Tarai	77.6	28.4	26.2	10.5	3.1

Source: NDHS (2011) Pp 38

3.5.2.13 Child mortality rate

A trend of mortality rate of under-five age children is decreasing except the neonatal mortality rate which has remained constant from 2006 to 2011. At these mortality levels, one in every 22 Nepalese children dies before reaching age 1 and one in every 19 does not survive to his or her fifth birthday. Infant mortality has declined by 42 percent over the last 15 years, while under-five mortality has declined by 54 percent over the same period. Childhood mortality is relatively higher in the Mountain Region than in the Tarai and Hill regions. It is highest in the Far-Western Region, among the five development regions. The neonatal mortality rate in the past five years was 33 deaths per 1,000 live births, which is two and half times the post neonatal rate.

3.6

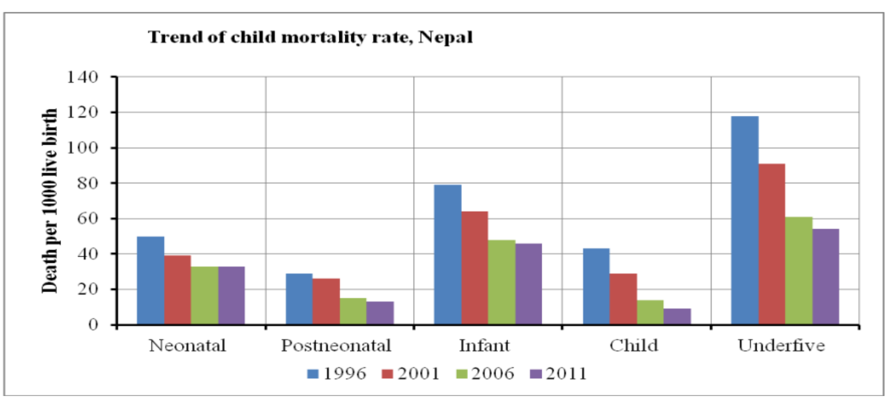


Figure 61: Trend of child mortality rate (Source: NDHS (2011)

3.7 Extreme weather events and its impact on human health

The occurrences of extreme weather events pose grave threat on human health. Although, there are direct effects of climate change in human health in the form of climate sensitive diseases and ailments (such as malaria, dengue discussed in former part of this report), these extreme weather events have indirect but substantial effect on well-being and health of people. This is why their occurrences and events must be understood so that better adaptive strategies can be formulated.

Nepal is the 20th most disaster-prone country in the world. During the period 1971-2007, more than 27,000 people died due to natural disasters. That is an average daily loss of two lives and places Nepal at the top of the list of disaster-related deaths in South Asian countries (MoHA, 2011). Nepal ranks 10th, 12th, and 32nd globally in terms of vulnerability to landslides, floods and earthquakes respectively (PreventionWeb, 2012). It ranks 4th in terms of vulnerability to climate change and is 16th most vulnerable among the poorest countries around the world.

Nepal is exposed to multiple geophysical and hydro-meteorological extreme events (hazards) with the potential to escalate into disasters: earthquakes, floods, landslides, cold waves, heat waves, windstorms, hailstorms, fires, glacial lake outburst floods, and avalanches. Climate change is expected to make such events more frequent. Nepal's topography—its steep and fragile mountainous terrain—amplifies the risks.

Climate extremes can have devastating effects on human and societal health and wellbeing. Two main effects of climate change—warming and greater weather variability—will expose millions of people to an ever-greater risk of infectious disease. Though non-climate change-related exposure also poses a great threat, today climate-sensitive health outcomes are among the leading causes globally of current morbidity and mortality. Millions of cases of malnutrition, infectious diseases, injuries, disability and deaths are the outcome of extreme events.

Climate change has increased the intensity and frequency of disasters and had a significantly adverse impact on human health. Climate change-related alterations in the frequency, intensity and duration of disasters pose an increasing threat[1]. Each year, these events affect millions of people, damage critical public health infrastructure, and cause economic loss. The frequency and intensity of some extreme weather events are expected to increase in the coming decades as a consequence of climate impacts (IPCC, 2007b), suggesting that the associated health impacts could increase.

[1] Heat waves, floods, droughts and windstorms,

3.7.1 Impacts of Extreme Events on Human Health

Extreme climate events in Nepal are expected to become more frequent as a result global warming and climatic variability and, as discussed above, Nepal is a disaster-prone country because of the sheer number of extreme events it is subject to. Water and climate-induced extreme events include heat and cold waves, floods, droughts, windstorms, hailstorms, thunderstorms and lightning strikes, glacier lake outburst floods (GLOFs), and avalanches. Landslides and earthquakes are geologically-induced extreme events whereas fires are both natural and accident-induced extreme events. Epidemics are categorized as biologically-induced extreme events. Each type has a range of adverse effects on human health, especially that of rural, vulnerable and marginalized populations.

3.7.1.1 Heat Wave

3.7.1.1.1 Number of heat waves

A total of 25 heat waves occurred between 2001 and 2010 (DesInventar, 2001-2010) but none fell in either the year 2001 or the year 2008 (see Table 5). The greatest number of heat waves occurred in 2009 and 2010. The increasing trend reflects the rise in average temperatures.

3.7.1.1.2 Impacts of heat waves

Heat waves killed 25, injured 8, and affected 280 (Table 32). The correlation between the number of heat waves and the number of deaths was strong, especially in the years 2009 and 2010. In 2007, 160 people were affected by just two heat wave events whereas in 2010 only 20 people were affected by seven heat waves (Table 32). The decrease may be attributable to the increase in awareness and preparedness mechanisms in place at the family and community levels.

Table 29: Impacts of heat waves between 2001 and 2010

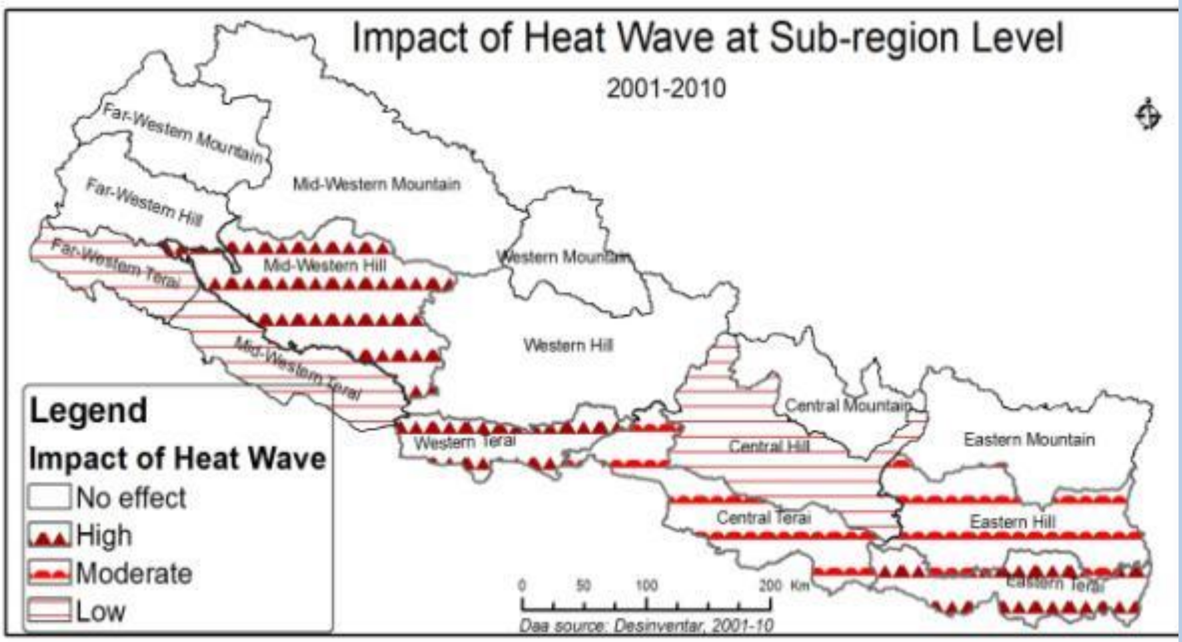
Year	Events (no.)	Deaths (no.)	Injured (no.)	Affected (no.)
2001	0	0	0	0
2002	1	1	0	0
2003	2	3	0	0
2004	3	2	0	0
2005	1	1	0	0
2006	3	1	8	0
2007	2	1	0	160
2008	0	0	0	0
2009	6	9	0	100
2010	7	7	0	20

Grand Total	**25**	**25**	**8**	**280**

Source: DesInventar, 2001-2010

The ranking (highly affected, moderately affected and least affected) was determined by the value of a composite index, with bigger values ranked lower than smaller ones. The smaller the rank is, the greater the effect is. The eastern and western Terai and mid-western hill sub-regions are most prone to heat waves and the central Terai and eastern hill sub-regions are moderately affected (see Map 1). The

Map 1: Impact of Heat Wave at Sub-region Level



central hill and mid-and far western Terai regions are least affected.

A people's vulnerability is exacerbated by poverty, marginalization, exposure and poor preparedness. Heat waves can pose serious threats to all individuals, irrespective of their age and health status (Sherwood and Huber, 2010), but older people, children and those suffering from respiratory and cardiovascular disorders are most affected. Families and individuals who earn daily wages from outdoor work, like rickshaw pullers, construction workers, and farmers, will also be badly affected.

An increase in heat and precipitation might cause an increase in cases of water-, vector- and rodent-borne diseases (Charron et al., 2008), including, in Nepal, malaria, Kala-azar, Japanese encephalitis[2] and arboviral diseases (DoHS, 2005). Heat waves can cause heat strokes among the vulnerable. Heat waves

[2] A potentially severe viral disease that is spread by infected mosquitoes and the leading cause of childhood encephalitis (an acute inflammation of the brain).

also cause hyperthermia as the evaporation of perspiration, the process that cools the human body, slows down and the body has to work harder to maintain a normal core body temperature or 35-37 ^{0}C. High temperatures, heat waves and humidity increase evaporation rates and result in a depletion of water sources. Personal hygiene (bathing and washing clothes and dishes), cooking food properly and toilet use are all negatively impacted. Severe water shortages for drinking and personal hygiene are common as is the contamination of water sources. Poor personal hygiene can result in many water borne-communicable diseases like diarrhoea, dysentery, and typhoid.

3.7.1.2 Cold Wave

3.7.1.2.1 Number of cold waves

Two hundred sixty-two cold waves were recorded between 2001 and 2010 (see Table 7). The years 2001 and 2002 were comparatively warm: no cold waves were recorded. Except in the years 2003 and 2004, the number of cold waves is on an upward trend. In 2010 alone, cold waves were recorded in 58 different locations.

3.7.1.2.2 Impact of cold waves

The impacts of cold waves are presented in Table 4. In 10 years, 376 people died, 80 were injured, and 1,793 people were affected. Cold was also responsible for the deaths of 662 heads of cattle.

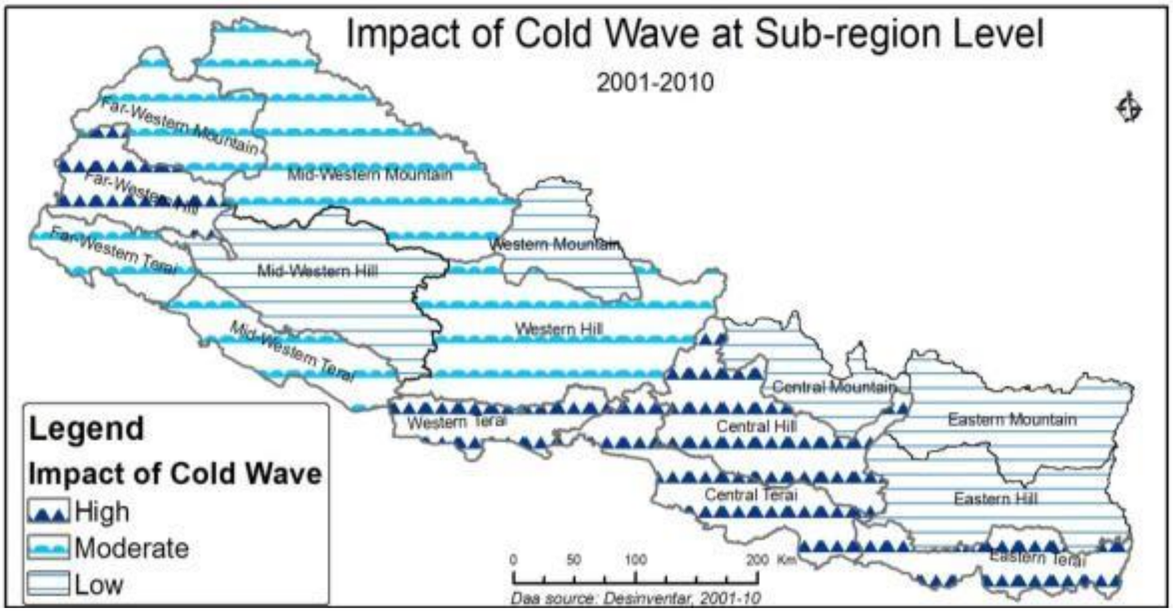
Table 30: Impacts of cold waves by year (2001-2010)

Year	Deaths (no.)	Injured (no.)	Affected (no.)	Losses (NRs.)	Damage to crops (ha.)	Lost cattle (no.)
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	52	0	242	0	1.5	47
2004	108	0	377	0	0	531
2005	17	0	0	0	0	0
2006	26	80	234	0	0	0
2007	33	0	0	0	0	0
2008	39	0	843	350,000	0	84
2009	37	0	97	100,000	0	0
2010	64	0	0	0	0	0
Total	376	80	1793	450,000	1.5	662

Source: DesInventar, 2001-2010

On average, 37 people died due to the cold wave per year, highest in 2004 (see Table 8). The numbers of deaths were highest in recent years, specifically 2008 and 2009, but fewer cattle died and fewer hectares of crops were destroyed. The decrease may be because of the impacts of disaster

Map 2: Impact of Cold Wave at Sub-region Level



preparedness activities.

Map 2 indicates that the eastern Terai, central Terai and hill, western Terai and far-western hill sub-regions are highly affected by cold waves. While the mid-and far-western Terai, western hill, and mid- and far-western mountain sub-regions are moderately affected.

The poor and marginalized, especially the elderly, children, the ill, pregnant women and the disabled, are most vulnerable to the health impacts of a cold wave. Families which live in sub-standard housing also suffer, as do those who lack adequate clothing, food, and fuel wood.

Cold-related diseases like viral flu, coughs, "cold diarrhoea," fever and respiratory problems are common, as are asthma, common cold, and pneumonia. It may also exacerbate the cases of arthritis among elderly.

3.7.1.3 Flood

3.7.1.3.1 Number of floods

A total of 1,609 floods were recorded between 2001 and 2010. The years 2002 and 2008, with 371 and 250 floods respectively, were the most flood-affected. The fewest floods occurred between 2005 and

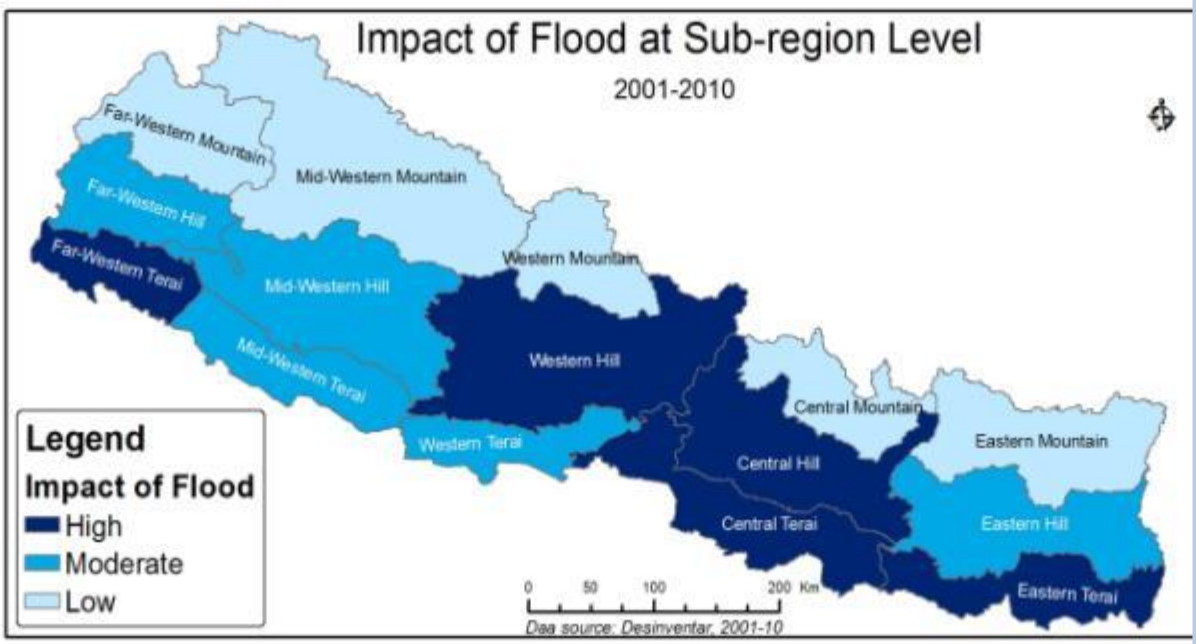
2007 (see Table 10). The increase after 2008 may reflect high volumes of precipitation and changes in rainfall patterns.

3.7.1.3.2 Impacts of floods

The numbers of deaths, injured and missing people in the first decade of the 21st century have not changed much, but crop damage and economic losses have increased, suggesting the severity of inundation in the recent year is severe. Floods claimed 746 lives; injured 259 and resulted in the disappearance of 188.

The Terai is most prone to flooding and inundation, with the eastern, central and far-western sub-region more vulnerable than the western and mid-western. The central and western hills are also highly

Map 3: Impact of Flood at Sub-region Level



affected (see Map 3). The differences in vulnerability reflect the uneven distribution of rainfall. Year-on-year changes in rainfall patterns make it difficult to predict flood-prone areas with great certitude.

The most vulnerable include those with prior health problems, the poor, those with dependents, children, pregnant women and older people. The poor suffer because they have no access to basic resources, such as land, food, shelter, health and education (Dixit, 2003). Remote rural areas with low population densities and poor health coverage are more vulnerable to flood-related diseases especially as they are often unable to evacuation abilities.

The health-related effects of flooding include mortality (mostly from flash floods), injuries (such as sprains, strains, lacerations, and contusions), infectious diseases (diarrhoea, cholera, vector borne diseases), respiratory illnesses, poisoning, snake bite, stress-related diseases, and hypothermia. The number of deaths associated with flooding is closely related to the local characteristics of floods and to the behaviour of victims. Some studies demonstrated that flood also provoke chronic diseases: asthma and high blood pressure worsens, cardiac arrest and renal infections are more common, joint stiffness increases, and blood sugar levels grow more erratic.

The loss of or injury to loved ones and destruction or damage of homes can have a long-term psychological impact on survivors. A flood can cause both emotional and physical stress and increase the rates of common mental disorders, such as anxiety and depression.

3.7.1.4 Drought

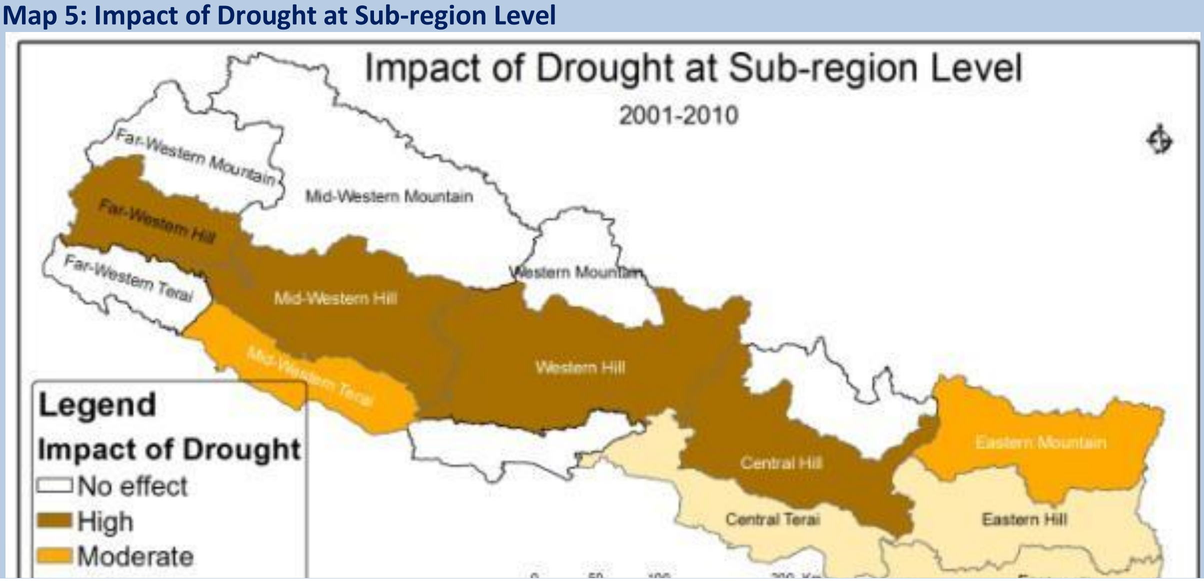
3.7.1.4.1 Number of droughts

Twenty droughts cases were recorded between 2001 and 2010. There were no droughts in 2001 or 2008. The most drought-affected years were 2006 and 2005, in that order.

3.7.1.4.2 Impacts of droughts

They cost the nation NRs. 10 million and damaged 19,000 hector of crops. Even though only two droughts were recorded in 2003, the economic loss—NRs. 10,000,000—was substantial. In 2009, more than 10,000 ha of crops were damaged. The eastern mountain and mid-western Terai sub-regions are moderately affected.

Map 5: Impact of Drought at Sub-region Level



Drought leaves farmers who practice rain-fed cultivation vulnerable to losing tons of crops every year.

It is difficult to establish the direct link between drought and health as it is complicated by factors such as wealth, the distribution of income, the status of public health infrastructure and facilities, the provision of preventive and acute medical care, and access to and appropriate use of health care information. Some indirect impacts are summarized below.

Hunger and famine are results of drought conditions because there is too little water to support food crops. When a drought is severe and continues over a long period, famine may occur. The WHO (2011) points out that drought-caused water and food shortages not only jeopardize the physical health of people but cause mental health problems like depression and anxiety once poor families fall into the poverty trap.

3.7.1.5 Glacier Lake Outburst Floods(GLOF)

The high mountains of Nepal, which cover about 15% of the total area, are susceptible to land degradation caused by GLOFs. These mountains, with an average elevation of 4500 m, are covered with snow and ice throughout the year but Nepal's glaciers are retreating faster than the world average and the number and size of glacier lakes are increasing along with the increase in temperature, thereby increasing the risk of floods (Agrawala et al., 2003).

Glacier retreat also contributes significantly to stream flow variability in the spring and summer (Agrawala et al., 2003). GLOFs can cause serious damage to infrastructure, houses, and the environment along the flood path downstream. The discharge of glacier-fed rivers is projected to increase for some time in the future as glaciers melt and then, once snowfall is less and glaciers smaller, it will decrease. People living along the flood zone of snow-fed rivers are most vulnerable to the risk of GLOFs.

3.8 Current capacity of health and other sectors to manage the risks of climate-sensitive health outcomes

3.8.1 Human Resources

Well performing health workers are needed to achieve the best health outcome possible. This includes sufficient numbers and a mix of qualified competent and productive staff to deliver health promotion and protection and take account of location and seasonal demands for staff. It also includes capacity development to build skills ranging from health policy and management to newer discipline such as application of metrological information to health policy.

Human resource management has improved since 2004, but challenges still remain. A study carried out in 2006 by the Ministry of health showed that 76% of health personnel posts were filled in comparison to sanctioned posts. The main problem of human resources is deployment and retention of physicians, nurses and other basic health services staff in peripheral health facilities.

Deployment and retention of human resources (HR) is a major problem in the health sector. Although the position has improved in recent years, two-thirds of positions for doctors and nurses are filled and have staff actually present at posts. The situation is worse in remote rural areas. The problem is the reluctance of trained staff to serve in rural and remote areas.

Staff attendance and motivation problems need to be addressed. Productivity across the sector has been low although variable, and the low average number of patients seen reflects the barriers of cost and poor quality of service provision that have until recently kept utilization down. Although there is spare capacity, some form of incentive may nevertheless be needed, because the higher productivity required of staff as utilisation increases will reduce the time available to staff for private practice, and will have financial consequences for them.

3.8.2 Capacity Building

Since knowledge on climate change impacts and climate related health outcomes is generally limited in the health sector, capacity building is considered one of the immediate priorities in the design of adaptation framework. Several divisions under the MOHP and DOHS have been relevant to the health concerns in the context of climate change

3.8.3 Service Delivery Mechanism

Nepal has a good structure and system in place from VDC to the central level. Health Service delivery should combine inputs to provide effective, safe, good quality health interventions in an efficient and equitable manner. Health services may need to prepare for staffs or additional burdens, requiring revisions of organizational and management process and the timing and location of service delivery.

Since delivery of public health depends upon individuals and community use of public health services through increased awareness through public health education. Partnerships across stakeholders groups including public are poor in engaging them and empowering the general public including beneficiaries of health services for their own health protection.

3.8.4 Financing Mechanism

Adequate funds are needed to maintain core health system functions including in the case of emergency. In addition to providing funds for core health and public health services (water/sanitation /environmental hygiene/disaster and health emergency preparedness), it is necessary to plan for insurance or replacement costs for health facilities and equipment lost or damaged due to extreme weather conditions.

Ministry of Finance prepares annual budget for the Govt. of Nepal, which is approved by the parliament. Health budget accounts for around 6% of the total national budget. Government budget covers regular vector borne diseases control activities including indoor residual spraying, diagnosis and treatment, and regular surveillance among others. Regular governmental budget is not enough to scale-up essential interventions like LLIN, new diagnostic and treatment products like RDTs and ACTs especially in high malaria risk districts. GFATM support has been mainly streamlined towards scaling up of capacity of health care institutes through supply of laboratory equipment for diagnosis, trainings, LLINS and BCC activities. WHO has been providing technical support for guidelines/protocols development and capacity building of human resources. Since last three years, there has been delay in release of the budget due to delayed approval of the budget.

The MOHP has good experience in implementing several financial schemes such as free drug policy, delivery incentive schemes, which offer opportunity for the poor to overcome financial obstacles for qualified health care. Such types of schemes could be further explored and expanded to cover health care services in the context of climate change, since the poor are most vulnerable to climate change.

Besides, the MOHP has received funding support from several development partners for specific health care activities for vector borne diseases, diarrhoea, nutrition and disaster management .These funding can be expanded to cover some urgent health adaptation activities, such as prevention and control vector borne diseases, conducting surveillance, and capacity building of officials. Potential funding can also be tapped from the CCCA Trust Fund for supporting urgent training activities for most relevant officials, especially those are members of the Health Working Group for Climate Change. Possible Special Health Fund for climate change can be developed with some potential donors such as UNDP, USAID, WHO, and AUSAID.

The financial gap analysis for implementing the Nepal Malaria Strategic Plan 2011-2016 is based on the estimated budget in the planned strategy minus available resources in the country allocated by the Government of Nepal through its own internal funding resources and the funding support ascertained by GFATM through RCC and Round 7 proposals.

Problems in financial management include slow disbursement, lower than desirable efficiency and effectiveness in budget implementation, and a generally weak control environment.

The Ministry has been addressing the problems by implementing a financial management improvement plan, now incorporated in the governance and accountability action plan. There has been progress in some areas, for example the rate of budget execution has improved. The MOHP is focusing on timely distribution of grants to health facilities; alternative assurance arrangements such as social and performance audits; implementation of transparency and disclosure measures; capacity development supported by technical assistance; and general systems development and integration at central, district and facility levels.

3.8.5 Information Resources/ Health Information System

Health information system that ensures the production and application of reliable and timely information on the health determinants, health system performance and health status are essential for managing climate related health risks.

Health information system resources and functions include data collection, analyzing communication and reporting, hazard and vulnerability assessments, early warning systems, overall information infrastructures (hardware and network) and the coordination mechanisms to link relevant information to inform health decisions.

The health sector has developed and maintained a good Health Management Information System (HMIS) under the Management Division under DOHS related to all health care services and diseases for Nepal. The HMIS compiles reports from SHP to tertiary level hospitals.

However, the HMIS does not have climate change variables and indicators along with health indicators such as prevalence of dengue fever and malaria incidents, thus is not sufficient for climate-health analysis.

HMIS does not cover unsecured areas and private sector health care. HMIS reports sometimes are not complete and timely. There is no regular data verification mechanism at district level. The annual health facility and community-based surveys for assessing coverage of outcome indicators in relation to diagnosis and treatment and vector control are in place. Population based malaria prevalence surveys are carried out time to time to compare with the regular surveillance data.

Good register keeping system is not up to the mark in some of the health facilities. The current data collection, collation and reporting system requires strengthening to achieve the target of timely, accurately reporting and timely and appropriately responding the outbreaks and case based surveillance and identification of malaria foci in order to eliminate the indigenous malaria foci requires an analysis of current reporting system and comprehensive strengthening.

The HMIS can be improved by provision of appropriate training on collection and maintenance of climate variables, including data analysis and modelling. Therefore coordination and standardization of climate data and health indicators among institutions can help reduce the cost and provide accurate information for analysis, projection, and monitoring and evaluation purpose. Data sharing among institutions remains a common constraint but can be resolved through better coordination, communication and dialogue.

3.8.6 Leadership and Governance

There is a good commitment of the political leaders of the MOHP in addressing climate change issues affecting public health. Two working groups were setup to work on climate health related projects as the following:

Political will is high on the agenda to take action to address the health risks of climate change which is essential for developing strategic policy framework, implementing adaptation plans and ensuring effective monitoring and management such as formulation of NAPA and through active engagement of the health sector for a project worth 150 million USD. There are many INGOs and EDPs partners having necessary coalitions between health sector and partners for climate sensitive health outcomes such as Malaria, nutrition, and disaster management including international climate policy mechanisms. However, there is lack of communication to increase and improve their understanding about the risk associated to climate change in the health sector remains poor and therefore, community support in this area remains a challenge .

3.8.7 Coordination

Health is a cross cutting goal in government policies and different sectors, therefore coordination is critical to ensure effective health outcomes for climate sensitive diseases. Several areas such as sanitation and hygiene, food security, early warning and emergency preparedness and relief, are the responsibility of the different ministries. Currently MOHP has experienced good cooperation with NCDM by playing very active role in provision of health care services during and after disaster management and emergency relief. This mechanism can be used to address other problems related to health risks and impacts, e.g. sanitation, hygiene, water supply and food safety/security with those relevant agencies. Even public education or specific prevention programs on vector-borne and water borne diseases cannot be achieved by MOHP alone and should be promoted through involvement of many actors at different levels, e.g. NGOs, civil society and EDPs. Many NGOs and INGOs are involved in successful implementation of activities for combating malaria, diarrhoea, and nutrition and disaster management and should be further strengthened. A good practice has been at the VDC level that FCHVs are playing an important role in providing information and basic services in malaria, diarrhoea and nutrition across the country.

Additional mechanism can be explored in the form of Climate Health Network or Forum to serve as a learning platform for exchange of knowledge and experience among experts, specialists, managers and researchers.

3.8.8 Monitoring and Evaluation

The MOHP has developed a set of core indicators for monitoring and measuring the success of NHSSP, which can be used for monitoring and evaluation of health indicators related to climate change. There are missing indicators regarding water-borne and food borne diseases, including health impacts of extreme weathers. Those missing indicators will be added to the core indicators, which will be defined based on the health statistics of the HMIS. Furthermore, a set of monitoring indicators should be developed to complement the core indicators related to diseases and health programs related to climate change.

There is however a general lack of knowledge and understanding on the causal-effect relationship of climate variables with health impacts since health outcomes are the functions of both climate and non-climate factors. Since health is the primary goal of sustainable development and includes physical, social and psychological well-being, it is crucial that the health impacts of climate change be understood and properly addressed.

4 CONCLUSION

The scope of this vulnerability and adaptation assessment was based on the framework of WHO and the purpose was to assess the vulnerable population and geography along with the current capacity of the health system of Nepal to adapt to the ongoing climate change and its effect on human health.

The public health policies and program that address climate sensitive health outcomes were assessed. Nepal developed policy level provision regarding to adaptation policy called National Adaptation Programme of Action to climate change (NAPA). The Nepal Health Sector Plan has envisioned strengthening health system of Nepal to cope with the health effect of climate change. Nepal is implementing its Health Sector Strategy that also includes a chapter on climate change and health.

Current risks of climate-sensitive health outcomes including the most vulnerable populations and regions were assessed. Based on the existing studies, the potential vulnerable population groups of Nepal are identified, such as children and women, squatter settlement and slum dwellers, rag pickers, street children and child workers, elderly population etc. A sensitive index was calculated to figure out the geographical regions with different level of risk which showed a highest score to the Western Mountain – the Mustang district, indicating very sensitive or risk to climate change. The index analysis depicts that highest exposure index value is found in most districts of the Mid- and Far-Western Hills and Mountain regions, signifying greater vulnerability to climate change health impacts. Adaptive capacity index was also calculated and the lowest adaptive index score is to the Central Hill and Eastern Tarai cluster regions, meaning low vulnerability. It means the Tarai districts are relatively more vulnerable to health outcomes.

A relationship between climate conditions and health outcomes were established. This is to show the trend analysis to decipher any probable relationship between climate and disease occurrence throughout Nepal. The trend of malaria cases and maximum temperature showed that, with minimum change in temperature, the number of cases increased. Similar trend was observed when cases were compared against minimum temperature. The diarrhoeal cases also changed with changing maximum temperature level.

Further, interactions between environmental and socioeconomic determinants of health were also assessed. Regarding the environmental burden of diseases, the likely affected environmental indicators identified were forest, water, soil and air, and ultimately the human health. It has been observed that the feature of the Monsoon rainfall pattern has changed, for instance the intensity of rainfall pattern has increased but the total volume of precipitation has decreased. It is noted that it has affected the ecosystem such as loss of biodiversity, threatening to food security through adverse impacts on winter and spring crops, shifting of hydrograph cycle including drying up of water resources, increasing flash floods, possible droughts, and glacial lake outbursts. Similarly, while exploring the socio-economic determinants of health, it was found that the wealth quintile in the Mountain Region was relatively high vulnerable as this region has high percentage of lowest wealth quintile, followed it by the Mid-Western Hill and Far-Western Hill. The spatial mapping of poverty indexes by district showed improving situation in socio-economic status of the districts of eastern and southern part of Nepal between 2006 and 2011.

Similarly, the child mortality rate was assessed at national level as a climate sensitive health outcome at regional and national level, which was relatively higher in the Mountain Region than in the Tarai and Hill regions. It is highest in the Far-Western Region, among the five development regions.

Moreover, the occurrences of extreme weather events pose grave threat on human health and it has indirect but substantial effect on well-being and health of people. Every disaster has serious implications for human health.

The current capacity of the health system needs to be assessed so as properly to manage the risks of climate-sensitive health outcomes. Since knowledge on climate change impacts and climate related health outcomes is generally limited in the health sector, capacity building is considered one of the immediate priorities in the design of adaptation framework.

There is however a general lack of knowledge and understanding on the causal-effect relationship of climate variables with health impacts since health outcomes are the functions of both climate and non-climate factors. Since health is the primary goal of sustainable development and includes physical, social and psychological well-being, it is crucial that the health impacts of climate change be understood and properly addressed.

A time series modelling was conducted to assess the association between the climate variables and health outcome which showed that the daily cremation counts in Kathmandu, versus temperature showed a negative association between cold temperatures and mortality that strengthened with increasing lag time over 2-21 days, and a more acute positive association between mortality and hot temperatures after a lag of 0-7 days.

A model of the observed spatial patterns of malaria in relation to average climate at district scale suggested that malaria risk is strongly associated with long term average temperature in Nepal. Observed spatial patterns of malaria were also consistent with the results of a theoretical model.

Projections of temperature increase for the year 2050 suggested that, other things being equal, the spatial distribution of malaria risk would expand northwards as a result of climate change. Comparable results were obtained using the empirical model and the theoretical model.

The impacts of climate change on public health are becoming more apparent in Nepal. However, still public health system are implementing activities according to their annual work plan without much linking and considering the climate change.

While the failure to understand the link between the growing health problems and climate change among the concerned health professions, medical experts and implementing partners has failed to deliver effective results from the health programmes, the issue of public health agenda is left behind in the government and donor funded climate change adaptation and mitigation programmes.

Advocate for the strengthening of primary health care (including primary prevention) services to support capacity of local communities to become resilient to climate-related health risks. Waterborne diseases are a major public health problem in Nepal. Therefore, changes in climate will increase their incidence. Health professionals need to be trained on climate change and its impacts on human health to deal with future adversity and provide technical support for building capacity to assess and monitor vulnerability to climate change-related health risks.

The government in association with NGOs/research organizations working on climate change and health issues may initiate training programmes for health professionals. Increase public awareness and action on prevention of climate change-sensitive diseases. Support the assessment of the effectiveness of health emergency management measures in reducing the impact of extreme events on health with the development of appropriate evaluation methods and pilot studies.

Recommendations

Health sector lacks to integrate the impacts of climate change into the public health sector in Nepal. The National Adaptation Programme of Action (NAPA), prepared in 2011 to address the immediate and short-term adaptation measures concerning climate change impacts, has already identified that the rising temperature accompanied by the changing climatic and weather patterns are leading to a broad range of health problems, including rising cases of diarrhoea, cholera and respiratory diseases, among others, in the country.

The following are some of the possible measures that Nepal should take to improve the capacity of health sector to reduce the health impacts from climate change:

On policy enhancements

- A national policy and strategy should be developed on climate change adaptation for health.
- Operational guidelines for the DOHS should be developed with sustained funding and functioning of DOHS TWG on climate change with creation of climate change unit under MOHP/DOHS

On surveillance systems

- Government agencies should initiate surveillance measures for climate sensitive diseases separately or include a separate component for such measures in the existing national disease surveillance programme. A nationwide integrated epidemiological entomological surveillance needs to be put high on the priority to address dengue by health policy-makers.
- Guidelines for operationalization of event-based surveillance and response system (ESRC), with core functions of case detection, verification and response should be developed including ESRC user's manual, on disease outbreak investigation for diarrhoea and dengue
- Trainings should be conducted including development of training materials facilitator’s guide and reference manual;

- Health communications plan should be developed together with IEC materials posters and leaflets on climate change sensitive diseases, namely diarhoea dengue, malaria, disaster and nutrition and advocacy materials for local health providers and local communities
- Periodic newsletter on climate change and health should be issued and disseminated with health sector accomplishments, lessons learned and best practices

On improving Service Delivery

- Advocate for the strengthening of primary health care (including primary prevention) services to support capacity of local communities to become resilient to climate-related health risks
- Design integrated projects and programmes mechanism responsive to local needs Consultations should be made regarding design, planning and implementation of initiatives are necessary to generate ownership.
- The need to integrate Communication activities into existing promotional activities of the various health programmes,
- Waterborne diseases are a major public health problem in Nepal. Therefore, changes in climate will increase their incidence. To address such problems and to reduce the possibility of incidences of climate sensitive diseases, initiatives such as taking policy decisions; undertaking scientific research to confirm earlier findings; and building institutional capacity to handle adverse consequences of climate change, need to be considered
- The government should develop a dataset for climate-sensitive diseases, as well as vector data based on geographical distribution to facilitate further research and prediction.
- Health professionals need to be trained on climate change and its impacts on human health to deal with future adversity and provide technical support for building capacity to assess and monitor vulnerability to climate change-related health risks.
- The government in association with NGOs/research organizations working on climate change and health issues may initiate training programmes for health professionals.
- Increase public awareness and action on prevention of climate change-sensitive diseases.
- Support the assessment of the effectiveness of health emergency management measures in reducing the impact of extreme events on health with the development of appropriate evaluation methods and pilot studies.

On Resource Mobilization

- Mobilize resources from various donors and development partners are necessary to enhance national and local government’s capabilities to adapt to climate change.

- Optimize the use of resources, by avoiding duplication of similar initiatives, delayed submission of deliverables and no-use of project outputs.

REFERENCE

1. Haines, A., Kovats, R. S., Campbell-Lendrum, D. & Corvalan, C. Climate change and human health: Impacts, vulnerability and public health. *Public Health* **120,** 585–596 (2006).

2. McMichael, A. J., Woodruff, R. E. & Hales, S. Climate change and human health: Present and future risks. *Lancet* **367,** 859–869 (2006).

3. IPCC. *Climate change 2001: impacts, adaptation and vulnerability: contribution of Working group II to the second assessment report of the IPCC*. (Cambridge University Press, 2001).

4. Patz, J. A., Campbell-Lendrum, D., Holloway, T. & Foley, J. A. Impact of regional climate change on human health. *Nature* **438,** 310–317 (2005).

5. HMGN/NPC/MOPE. *Sustainable Development Agenda for Nepal*. (2003).

6. GoN/MoE. Climate Change Policy of Nepal. (2011).

7. MCCICC | Ministry of Science, Technology and Environment. at <http://moste.gov.np/mccicc>

8. Bhandari, G. P., Dhimal, M., Gurung, S. & Bhusal, C. Climate Change and Malaria in Jhapa District of Nepal: Emerging Evidences from Nepal. *J. Health Manag.* **15,** 141–150 (2013).

9. IPCC 5th Assessment Summary Report. (2014). at <https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf>

10. Kristie Ebi, Peter Berry, Diarmid Campbell-Lendrum, Carlos Corvalan, J. G. *Protecting health from climate change in albania*. *WHO/BMU, MOH for Albanian Institution* (2012). doi:10.1037/e538072010-007

11. MOPH Nepal & New Era. *Nepal Demographic And Health Survey 2011*. *Macro International* (2011). at <http://www.measuredhs.com/pubs/pdf/FR191/FR191.pdf>

12. GoN/MoE. *National Adaptation Programme of Action to Climate Change*. (2010).

13. Pruss, A. & Havelaar, A. H. in *Water Quality: Guidelines, Standards and Health* 43–59 (2001). at <http://books.google.com/books?hl=en&lr=&id=Wl6UQUV6dF4C&oi=fnd&pg=PA43&dq=The+global+burden+of+disease+study+and+applications+in+water,+sanitation+and+hygiene&ots=aXmfYDnNX_&sig=gSz6SlIARNHzZWINk3VYas1_14w>

14. ICIMOD. Diarrheal Diseases. (2005). at <http://www.icimod.org/?q=6017>

15. SK Baidya, R. R. & M. S. *Climate Profile and Observed Climate Change and Climate Variability in Nepal*. (2007).

16. Singh, R. B. *et al.* The influence of climate variation and change on diarrheal disease in the Pacific Islands. *Env. Heal. Perspect* **109,** 155–159 (2001).

17. Lama, J. R., Seas, C. R., León-Barúa, R., Gotuzzo, E. & Sack, R. B. Environmental temperature, cholera, and acute diarrhoea in adults in Lima, Peru. *J. Heal. Popul. Nutr.* **22,** 399–403 (2004).

18. S Rutstein. *Wealth versus Expenditure: Comparison between DHS wealth index and household expenditure in your departments of Guatamala*. (1999).