2009

Final Report

Review of Emerging Health Risks due to Climate Change and Develop an Inventory of Good Practice and Adaptation Measures to Reduce the Adverse Health Implications of Climate Change in the context of Different Ecological Conditions in Nepal

Submitted to
World Health Organization
Country office, Nepal

Submitted by
Nepal Health Research Council
Ramshah Path, Kathmandu

Study Team
Dr. Mahesh Kumar Maskey
PI/Research Advisor
Mr. Meghnath Dhimal
Co-PI/Coordinator
Ms. Lila Bhattarai
Research Assistant

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At last but not the least, I would like to thanks all who participated in our study during the field visit in Chitwan, Rasuwa and Sunsari districts.

Dr. Mahesh Kumar Maskey
Research Advisor/ Executive Chairman
Nepal Health Research Council

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1. Introduction

1.1Background

It is now universally acknowledged that the climate change we are witnessing will continue for a long time. This obviously has serious implications for human health. Clearly Nepal is facing climate change-induced consequences in many spheres of society and development. While some have been studied, data are still scarce and it is difficult to draw clear conclusions for future adaptation measures. How climate change will affect health is also not clear and often missing in all sectoral studies. On September 1, 2007 the Health Ministers from 11 Member States of WHO's South East Asia Region adopted the "Thimphu Declaration on International Health Security in the South-East Asia Region". The Thimphu Declaration recognizes natural and manmade health emergencies, emerging infectious diseases and climate change as threats to international health security. The Declaration calls on countries to develop national mitigation and adaptation plans to address the health impact of global warming and climate change. To give follow-up to the Thimpu Declaration, Nepal Health Research Council (Under Ministry of Health and Population) with the support of World health Organization Country Office, Nepal organized " National Workshop on Climate Change and Human Health: Potential Impact, Vulnerability and Adaptation in Kathmandu, Nepal (19-21 December, 2007". The workshop was really a unique and probably first time in Nepal bringing together concerned sectors together and placing the health impact at the center of discussion. One of the key recommendations of the workshop was to generate the evidences for the uncertainties presented in the workshop and develop strategies for adaptation measures. Protecting health from climate change was the theme for World Health Day (7 April 2008) and WHO's 60th anniversary celebration. The World Health Day 2008 was celebrated successfully in Nepal with the active participation of senior officers of Ministry of Health and Population.

Identifying specific climate change trends and their implications to health, environment, economy and development processes are the basis for further planning. Creating a baseline with business as usual scenario is a basic task for assessing impacts and remedial policy responses. However, gathering evidences of climate change impacts on any local pattern is a challenge as it involves complex task of building long-term data, analysis of the data and interdisciplinary studies. It is further difficult task in a country like Nepal where climatic database is comparatively weak in terms of network coverage, duration and quality. Inadequate database, however, can't be a reason for delayed planning of adaptation programme aimed at addressing public health concerns in changed environmental contexts. Initially priorities should go for pin-pointing most vulnerable communities and areas where climate change-led hazards would affect directly or indirectly to public health. Weaker sections of the communities who live on marginal income in socio-economically backward conditions would find their livelihoods and health more vulnerable owing to weather hazards and productivity loss. However this is only one aspect of policy issue when entire country and their residents are at risks of climatic hazards at different scales. Enhancing overall food security, addressing water and vector borne diseases, and mitigating extreme weather hazards would be some of the key areas that climate change adaptation policy needs focus. Nepal is highly vulnerable to climate change for two main reasons. First, higher number of extreme climatic incidents is likely to occur resulting in more loss of lives, properties and source of livelihoods. Second, already facing resource crisis, Nepal is not in position to afford huge costs of implementing adaptation measures, thus, very likely to remain trapped in vicious cycle of poverty. Indeed, Nepal has already been suffering from climate change-led impacts such as depletion of snow cover, glacier retreat and glacial lake out-burst flood. At community level, problems like erratic rainfall patterns, water hazards, water shortage and vector borne diseases are reported to be growing.

There are very few researches on impact of climate change on human health and need to do many more research to know the pathways how climate change is affecting the health of Nepalese people and how to safeguard the health of those vulnerable population. In order to give the follow up of the programs and explore the evidences, NHRC is conducting the activity entitled "Assessment of emerging health risks due to climate change in Nepal and Develop an Inventory of Good Practice and Adaptation measures to reduce the adverse health implications of Climate Change, in the context of different Ecological Conditions in Nepal”

1.2 Objectives

The general objective of the study is to assess the emerging health risks due to climate change in Nepal and develop an inventory of good practice and adaptation measures to reduce the adverse health implications of climate change, in the context of different ecological conditions in Nepal

Specific objectives

- To review climate change phenomenon of Nepal
- To review and analyze the climate sensitive diseases of Nepal
- To assess the linkages between disease pattern with climatic data
- To review good practice and adaptation measures to reduce adverse impacts of climate change from international literature review (particularly from South East Asia Region if any)
- To explore the practice and adaptation measures of local communities of ecological regions to reduce health implications of climate change in Nepal
- To develop outlines of strategy of adaptation measures

2.0 Methodology

2.1 Formation of study team

A study team of following members consisting of persons of diverse filed was formed. The team members were from public health and environmental science.

2.2. Literature review

The relevant literature on climate change and human health was assessed from the websites of concerned organization. From the websites of both national and international organization, information about climate change impact on human health and adaptation measures were cited. The unpublished (grey literature) was also reviewed. Climate sensitive diseases that are prevalent in Nepal, and those that are in the increasing trend, are studied with special focus on Malaria, Dengue, Kalazar, Encephalitis, Filariasis, Cholera and Meningococcal meningitis are mostly found to be occurring in Nepal, among all other climate-sensitive diseases.

2.3 Collection of climatic data of Nepal

The analyzed climatic data is collected from various sources. The disaggregated data of rainfall and precipitation from 1975 to 2005 was collected from Practical Action Nepal and rainfall and precipitation data of 2006 and 2007 was collected from Department of Hydrology and Meteorology, Babarmahal. The disaggregated data of climate sensitive diseases was collected from Annual Report of Department of Health Services, Ministry of Health and Population, Teku.

2.4 Review and analysis of climate sensitive diseases pattern (vector-borne diseases in Nepal)

The climate sensitive diseases are identified from published literature. The major climate sensitive diseases in our context and annual rainfall and temperature data were analyzed using the data from Annual report to observe linkages.

2.5 Consultative Meeting with experts for comments and suggestion

A technical committee meeting was organized on May 6, 2008. The committee was formed for organizing National Consultation Workshop on Climate Change and Human Health: Potential Impact, Vulnerability and Adaptation in Nepal (December,19-21 2007) and same committee was continued to ensure the sharing of activities of different organizations working on climate change issue. The committee members shared the activities of respective organizations and suggest that the ongoing activities of NHRC will be very crucial for preparing National Adaptation Plan of Action (NAPA) in Nepal. The Environmental Health Research Officer of NHRC as well as Coordinator of this project activity shared international experience on the issue climate change mitigation and adaptation which he obtained from Swedish International Development Cooperation (SIDA) Advanced International training Course on Climate Change Mitigation and Adaptation, Norrkoping, Sweden in 2008. Similarly, second steering committee meeting was organized on July 2, 2009 with objective to disseminate the findings of study and share the experiences of different stakeholders on climate change impact and adaptation aspect in Nepal. The findings of the study were presented by Mr. Meghnath Dhimal, Co- Principal Investigator of the Project. The findings were discussed among the members. The committee members appreciated the findings of the study. At the mean time members suggested to take caution in generalizing the findings of the study because every thing can not be blamed to climate change. Steering committee members also suggest incorporating the findings of the study while formulating the National Adaptation Plan of Action (NAPA) of Nepal.

2.6 In-depth Interview and Field Observation

The Rasuwa, Chitwan and Sunsari districts were visited and in-depth interview was taken with the key informant of communities about the impact of climate change they have perceived and adaptation measures they have adapted. Similarly, observation was also done. The Focus Group Discussion was conducted in Sunsari District to identify the impact of extreme climatic events such as flood and extreme cold and adaptation measures adopted to reduce the impact The information obtained from them is documented manually.

3.0 Result

3.1 Climate Change Phenomenon in Nepal

Nepal has a great deal of variations in climate. Although Nepal lies near the northern limit of the Tropics, a very wide range of climates from Subtropical in the southern Terai to Arctic in the northern high Himalayas exists here. The remarkable differences in climatic conditions are primarily related to the enormous range of elevation within a short north-south distance. The presence of the east-west extending Himalayan massifs to the north and the monsoonal alteration of wet and dry seasons also greatly contribute to local variations in climate.

Nepal experiences the seasonal summer monsoon rainfall from June to September. Most of the days during June to September are cloudy and rainy. Heavy incessant rains and periods of dry spells are not uncommon during these months. About 80 % of the annual precipitation in the country falls between June and September under the influence of the summer monsoon circulation system. The amount of precipitation varies considerably from place to place because of the non-uniform rugged terrain. However, the amount of summer monsoon rains generally declines from southeast to northwest. Although the success of farming or crop harvest is almost fully dependent on the timely arrival of the summer monsoon, it periodically causes problems such as landslides, subsequent losses of human lives and farmlands, loss of other infrastructures (not to mention great difficulty in the movement of goods and people) and large scale flooding in the plains. Conversely, when prolonged breaks in the summer monsoon occur, severe drought and famine often result.

The winter months December to February are relatively dry with clear skies. However, few spells of rain do occur during these months. The winter rain decreases in amount from northwest to both southward and eastward direction. During April to May the country experiences pre-monsoon thundershower activities. The pre-monsoon rainfall activities are more frequent in the hilly regions than in the southern plains. The period of October and November is considered as a post monsoon season and a transition from summer to winter. During October the country receives a few spells of post-monsoon thundershowers, similar in character to the pre-monsoon ones. The annual mean precipitation is around 1800 mm in Nepal. But owing to the great variations in the topography, it ranges from more than 5000 mm along the southern slopes of the Annapurna range in the central Nepal to less than 250 mm in the north central portion near the Tibetan plateau.

The onset of the monsoon in early June checks the increase in daily temperature over the country. Therefore, the maximum temperature of the year occurs in May or early June. Temperature starts decreasing rapidly from October and reaches the minimum of the year in December or January. Although normally the temperature decreases with height, there are also spatial variations in temperature in Nepal influenced by topography. Terai belt is the hottest part of the country, where the extreme maximum temperature reaches more than 45º C.

Very recently in 2008, Practical Action Nepal has compiled the monthly rainfall and temperature data of last 30 years (1976-2005) from Department of Hydrology and Meteorology (DHM) and data were analyzed. They have taken the data of 166 rainfall stations and 45 temperature stations. The followings are the major results of the analysis from Practical Action Nepal.

3.1.1Mean Annual Rainfall Analysis

The country receives highest precipitation in the month of July and lowest in the month of November. Similarly the country receives 79.6%, 4.2%, 3.5% and 12.7% during Monsoon, Post-monsoon, Winter and Pre-monsoon seasons respectively. Highest annual precipitation is recorded at *Lumle* at an elevation of 1740 m.a.s.l., windward side of *Annapurna* range and lowest annual precipitation is observed at *Lomanthang*, *Mustang* at an elevation of 3705 m.a.s.l. leeward side of *Annapurna* range. It was observed three highest rainfall pocket areas, one at Southern slope of *Makalu* range in the Eastern Development Region, second *Juga*l range in the Central Development Region and third *Annapurna* in the Western Development Region. Whereas, two lowest rainfall pocket areas were observed at the leeward part of High Mountain: *Manang* and *Mustang* areas.

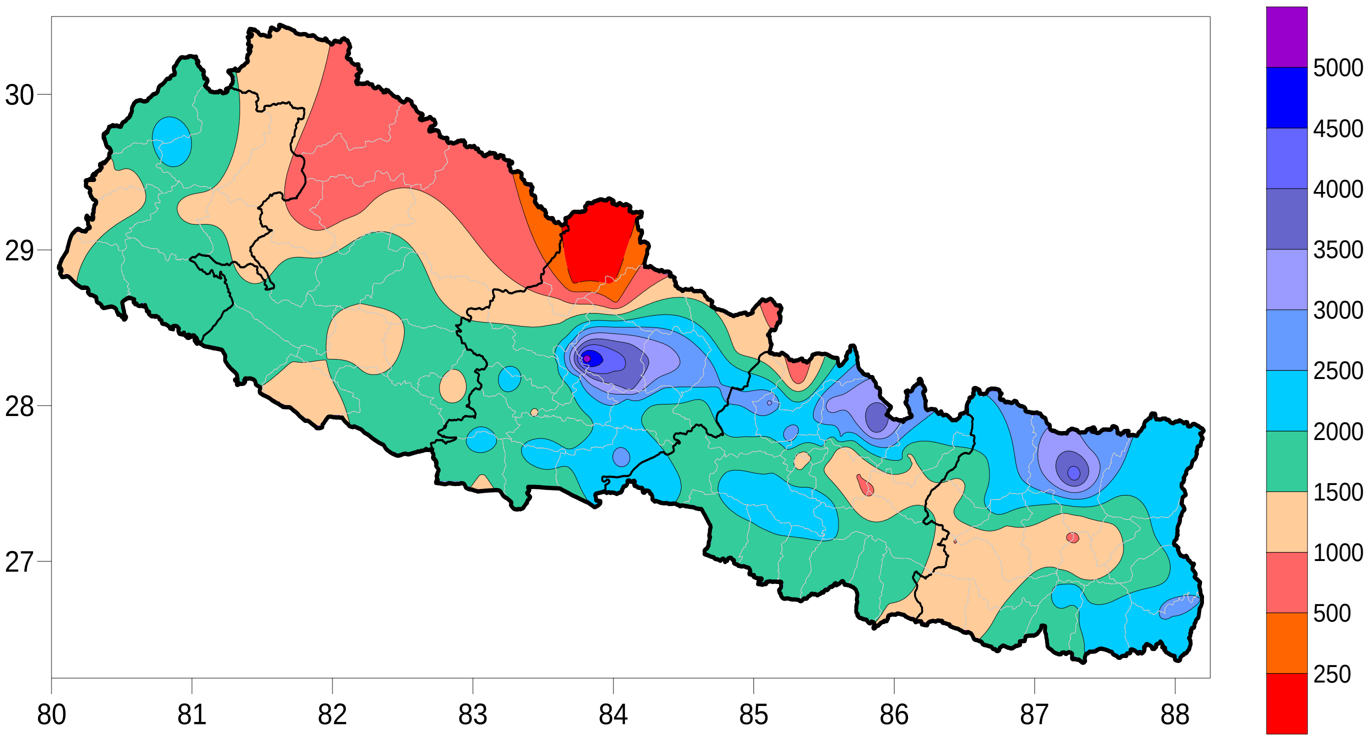
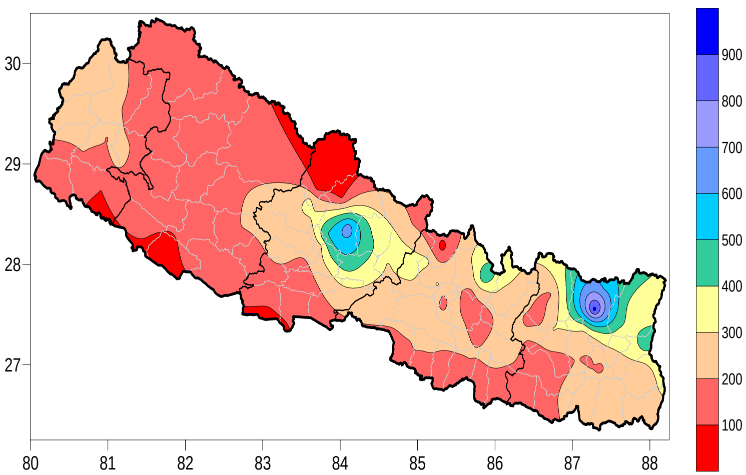
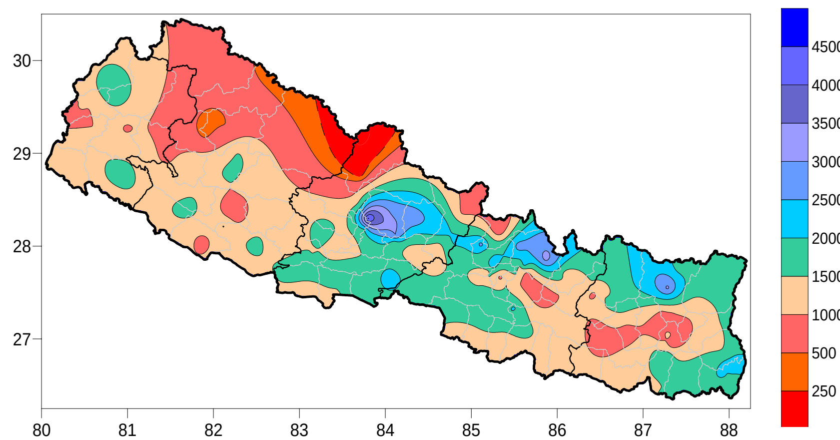


Figure 1: Annual Rainfall Analysis (1976-2005)

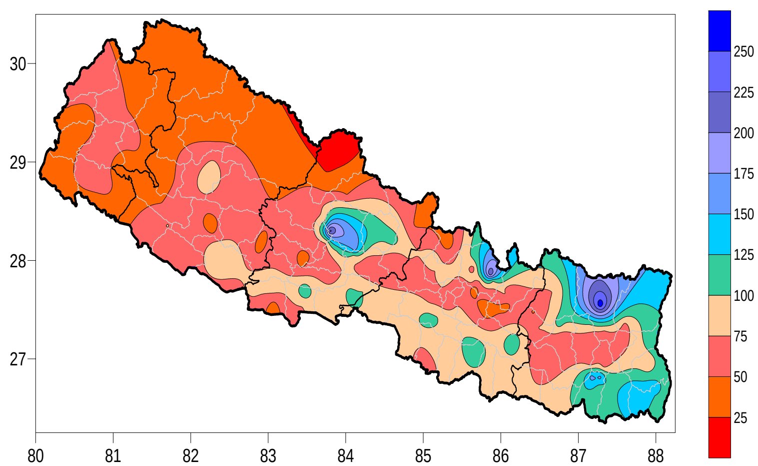
3.1.1 Seasonal Rainfall Analysis

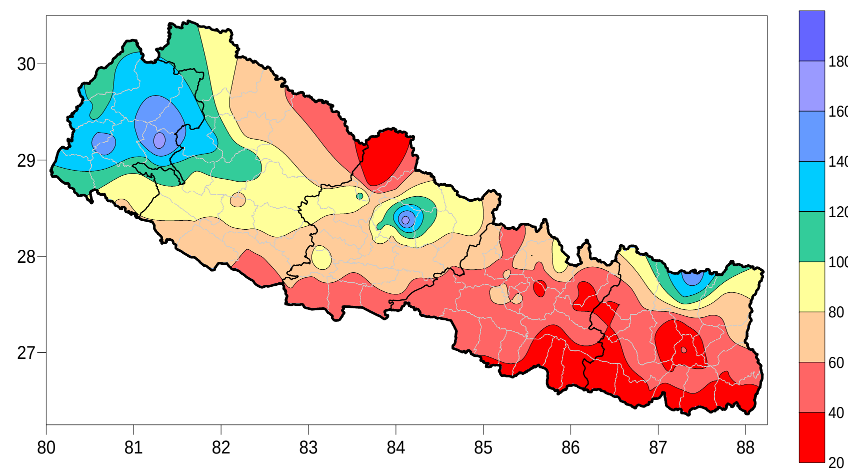


Pre-monsoon (12.7%)



Monsoon (79.6%)





Post monsoon (4.2%) **Winter (3.5%)**

Figure 2: Seasonal rainfall analysis

3.1.2 Extreme Rainfall Analysis

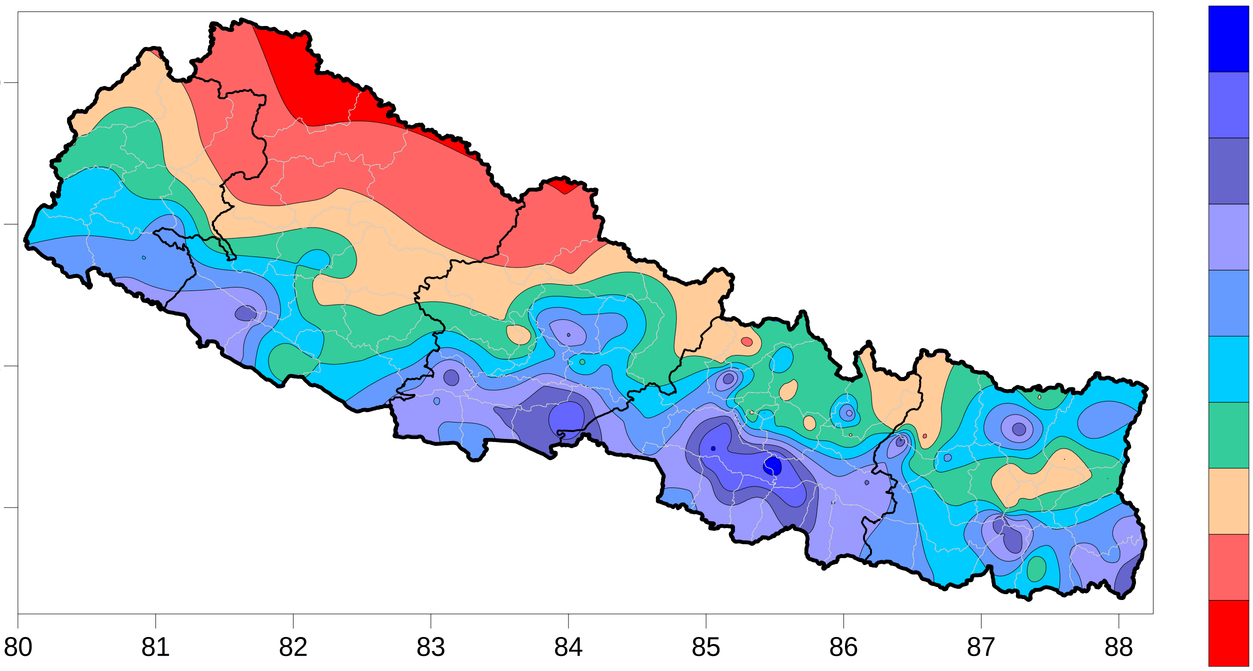


Figure 3: Extreme rainfall analysis (24 hour extreme rainfall)

Siwalik and the Terai belt which generally receives less total seasonal rainfall receive the highest 24 hour rainfall in contrary to the seasonal total rainfall distribution. Maximum and minimum of 24 hour extreme rainfall was found in Hetaunda (482.2 mm) and Mustang (51 mm) respectively. The highest extreme rainfall was found mainly in the foothills of Mahabharat and Siwalik in the Central Development region whereas it was found in the foothills of Siwalik in the Western Development region.

3.1.3Annual Rainfall Trend Analysis

In overall, Eastern, Central, Western and Far-western Development Regions showed the positive trend in annual rainfall. Some small pocket areas even observed over 40 mm/year increase in annual precipitation. Most of the Mid-western Development Region showed the decreasing annual rainfall trend. The region in and around *Dolakha* district observed the largest decreasing trend of up to -40 mm/year.

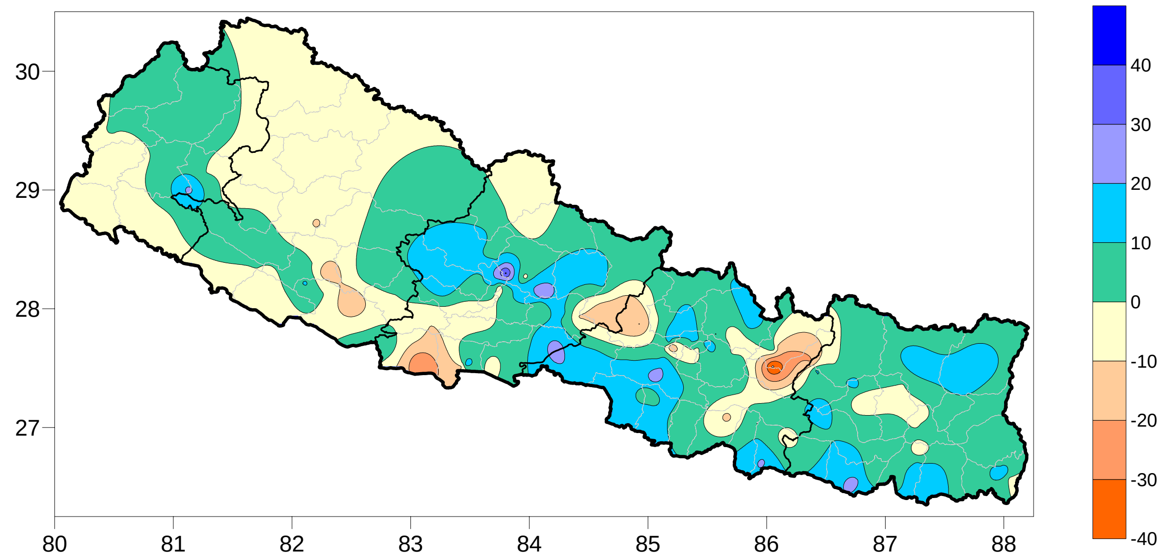


Figure 4: Annual rainfall trend analysis

3.1.4 Analysis of Mean Annual temperature

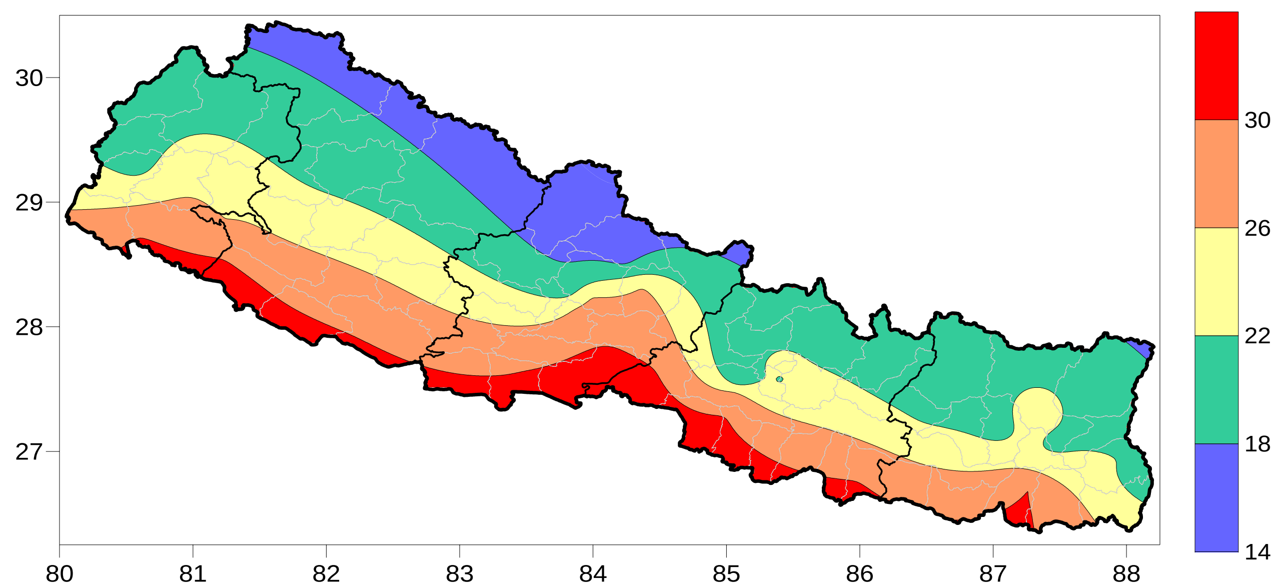


Figure 5: Mean annual temperature

Temperature is directly related with season and altitude of the location. Therefore, the spatial variations in temperature are influenced by altitude. The hottest part of the country is in the southern Terai belt and the coldest part lies in the high Himalayas in the North. Mean Monthly temperature varied between above 22°C in the Terai and Siwalk to less than 12°C in the north-western parts.

3.1.5 Analysis of mean maximum temperature

Mean maximum temperature in the Terai belt reached above 30°C which gradually decreased following the topography towards North. Over the Siwalik range the maximum temperature varied between 26° to 30°C. The maximum temperature ranged between 22°C to 26°C in the middle mountain regions and reached below 22°C in the high mountains and Himalayas.

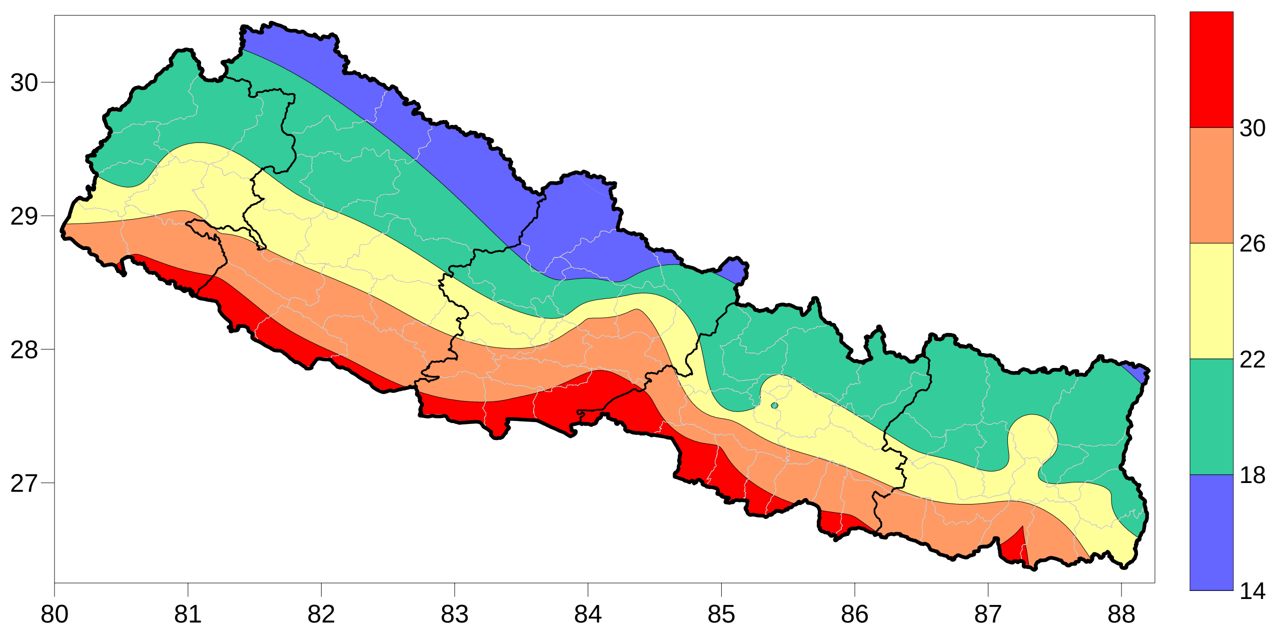


Figure 6: Maximum Mean Temperature

3.1.6 Minimum Mean Temperature Analysis

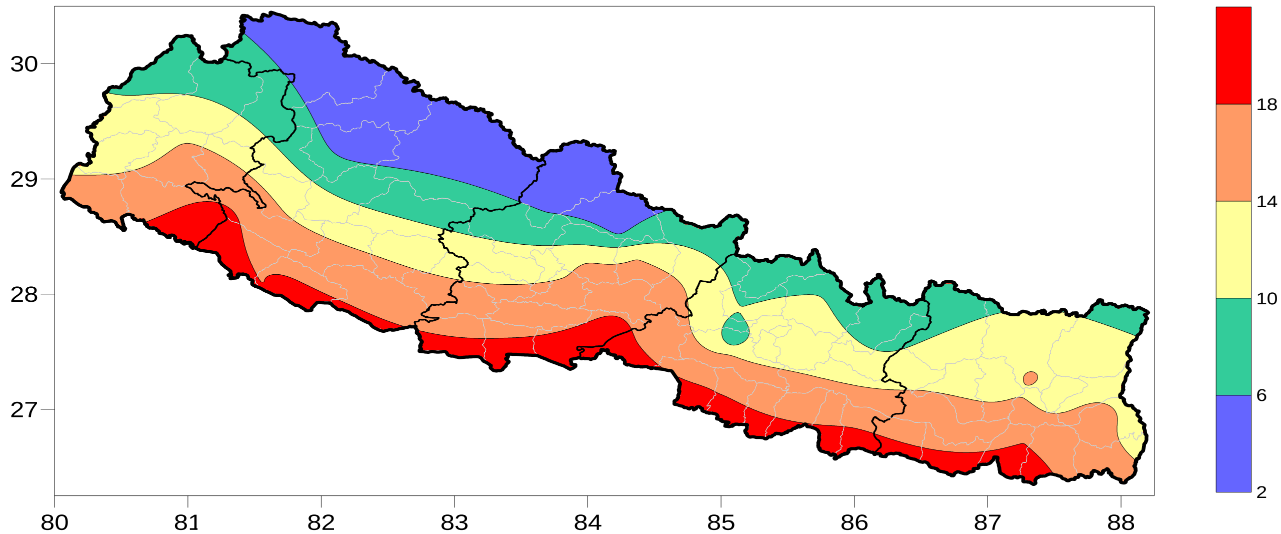


Figure 7: Mean of Annual minimum temperature

Mean minimum temperature varied between above 18°C in the Terai to less than 6°C in the north-western parts

3.1.7 Annual Temperature Trend Analysis (Maximum)

The spatial pattern of mean maximum temperature trend showed increasing trend in almost the entire country except in a few isolated places such as in *Sankhuwasabha*, *Sunsari*, *Nawalparasi*, *Banke*, *Bardiya* districts. Generally, the trend was observed to be lower in the southern parts (low altitude) and higher in the North (high altitude). The regions in and around *Dhankuta*, *Dadeldhura* and *Okhaldhunga* districts showed higher trend in the maximum temperature

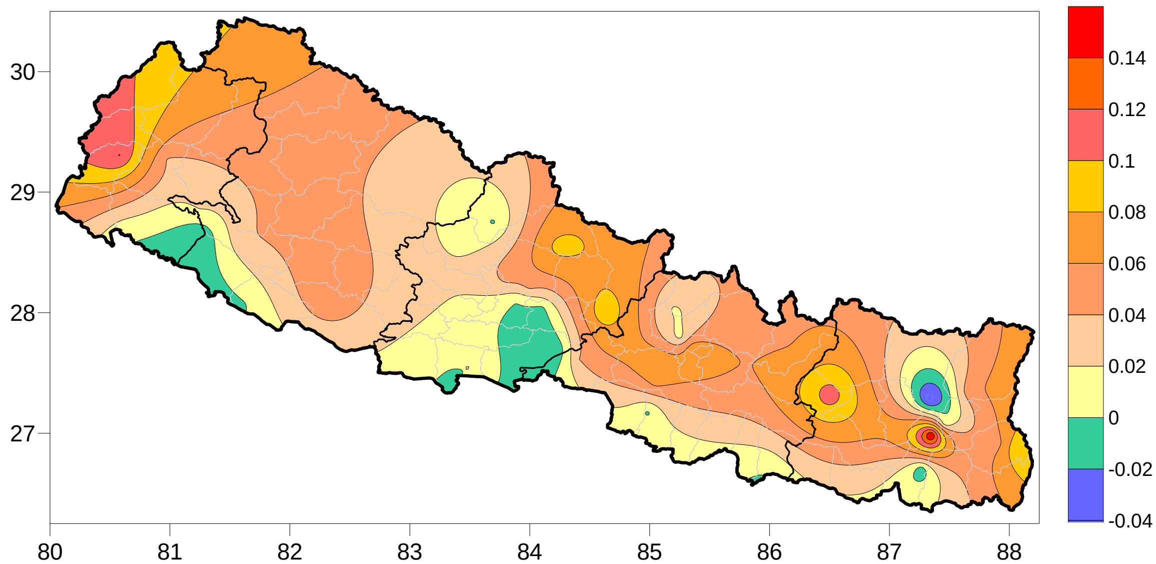


Figure 8: Annual temperature trend analysis (Maximum)

3.1.8 Annual Temperature Trend Analysis (Minimum)

The mean minimum temperature trend showed decreasing trend in northern parts and large portion of Mid-western/Far-western Development Regions. Most of the southern parts of the country however showed the increasing trend. *Doti*, *Sankhuwasabha* and northern parts of *Nuwakot* districts showed large decreasing trend of less than -0.07°C/year. Large increasing trend was observed in *Lamjung*, southern parts of *Nuwakot*, *Chitawan* and *Dhanusa* districts

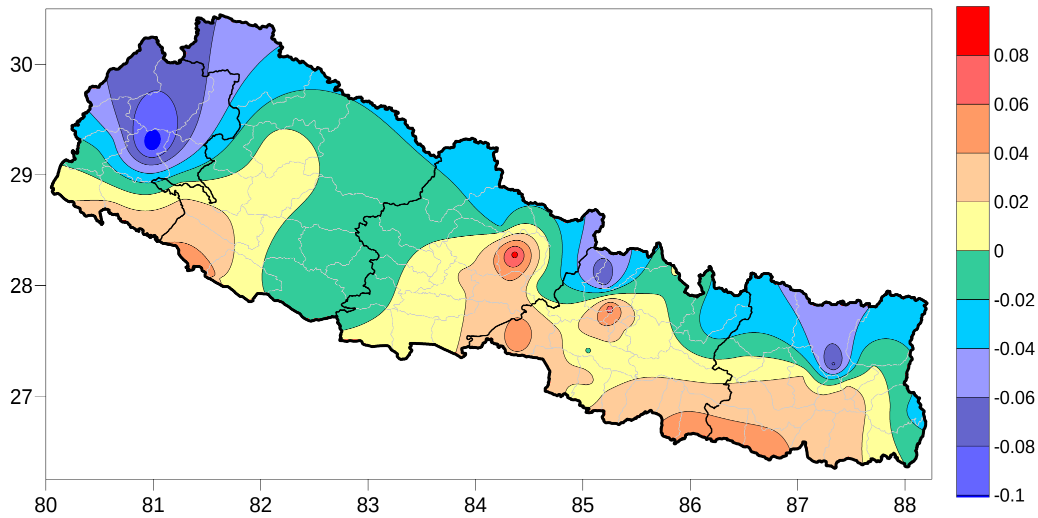


Figure 9: Annual Temperature trend analysis (minimum)

3.2 Review and analysis of the climate sensitive diseases of Nepal

The climate sensitive disease can be categorized into following types:

Vector-borne

- Malaria
- Dengue fever
- Lyme disease
- Rocky Mountain spotted fever
- Encephalitis: St. Louis, Murray Valley, Western Equine
- Rift Valley fever
- Ross River fever
- Ehrlichiosis
- Hantavirus pulmonary syndrome

- Leishmaniasis
- African trypanosomiasis
- Tularemia
- Plague
- Onchoceriasis (river blindness)

Water and Food borne

- Cholera
- Other non-cholera *Vibrio* spp..(i.e., *V. vulnificus*, *V. parahaemolyticus*)
- Leptospirosis
- Schistosomiasis
- Sea bather's eruption
- Giardiasis
- Cryptosporidiosis
- Human enteric viruses (Enteroviruses,.Norwalk and Norwalk-like viruses)
- Campylobacteriosis
- *Cyclospora cayetanensis*
- *Salmonella enteritidis*

Airborne (and others)

- Meningococcal meningitis
- Coccidioidomycosis
- Respiratory syncytial virus (colds)

- Legionnaires' disease
- Influenza

  (Source: Health, Climate, and Infectious Disease: A Global Perspective, AAM, http://www.asmusa.org

Among the above mentioned diseases following diseases are frequently found to be occurring in Nepal:

1. Vector-borne

- Malaria
- Dengue fever
- Japanese Encephalitis
- Leishmaniasis (Kala-azar)
- Filariasis

2. Water and Foodborne

- Cholera
- Giardiasis
- Cryptosporidiosis
- Human enteric viruses (Enteroviruses,.Norwalk and Norwalk-like viruses)
- Campylobacteriosis
- *Cyclospora cayetanensis*
- *Salmonella enteritidis*

3. Airborne (and others)

- Meningococcal meningitis
- Respiratory syncytial virus (colds)

- Legionnaires' disease
- Influenza

Despite the variety of diseases related to climate change the study focuses especially on vector borne diseases in Nepal.

3.2.1 Malaria

Malaria is the most important vector borne disease in the world today, causing more than one million deaths worldwide annually, over 80% occurring in the Sub-Saharan Africa.(WHO/UNICEF,2005). It is a disease of tropical and temperate countries, prevalence generally increasing towards the equator. Epidemic malaria is a particular cause for concern and affects all age groups among immunologically vulnerable populations, and is estimated that it may cause 12-25% of malaria deaths worldwide.

Outbreaks often occur following periods of increased rain and or temperature. It is thought that this is primarily the result of positive effects on vector breeding, development rates, and parasite sporogony and vector survival. The impact of epidemics is even severe following prolonged periods of draught and famine.

The early detection, containment and prevention of malaria epidemics constitutes one of the four main elements of WHO's global malaria control strategy, 4. During the last 20 yrs, a few countries have begun to develop EWS which use climatic indicators of transmission risk. Progress towards operational systems has been limited, however, because of poor intersectoral collaboration and lack of evidence of cost effectiveness of malaria EWS , WHO has supported the development of malaria EWS by establishing a technical support network together with a framework that defines generic concepts, identifies early warning and detection indicators with the potential to predict the timing and severity of malaria epidemics and outlines how these can be related to control decisions(WHO). Quantitative spatial models of the relationship between malaria and climatic factors have often been used for geographical mapping of disease risk, with an overwhelming focus on Africa. Such risk mapping is a useful preliminary stage, as it can be used to differentiate areas that experience epidemic or highly seasonal transmission from those with more stable transmission patterns where EWS are likely to be useful. It can also be used to explore those areas where predicted climate change is most likely to be reflected in changing patterns of malaria transmission.

Monitoring of malaria cases can be used in the early detection of an epidemic if collection and notification are timely. However, in most epidemic regions there is yet a lack of regular surveillance that could result in an appropriate response. For complex emergencies and for settings where no historical data are available for comparison, "a clustering of severe cases and deaths" should raise an alarm. Early detection of malaria can potentially be supplemented by prediction. Climatic and non-climatic risk factors can be studied for establishing relationship between these risk factors and diseases. (Source: WHO, 2005)

Malaria in Nepal

The history of Malaria in Nepal dates back to 1954. The first attempt to control malaria in Nepal was initiated in 1954 through the Insect Borne Disease Control Program, supported by USAID. Prevailing ecological, epidemiological and socio-economic factors suggested changes in the malaria control strategy, and as a result the current strategy was revised in accordance with the Global Malaria Control Strategy (GMCS) 1992 of WHO. Malaria control services are provided to approximately 15.6 million people in malaria-risk areas of 64 districts of the country. Though decreased for a few years it is now increasing at a higher rate. Seeing the magnitude of the situation, the government has to introduce new strategies to prevent and control the malaria.

DISTRIBUTION OF MALARIA IN NEPAL

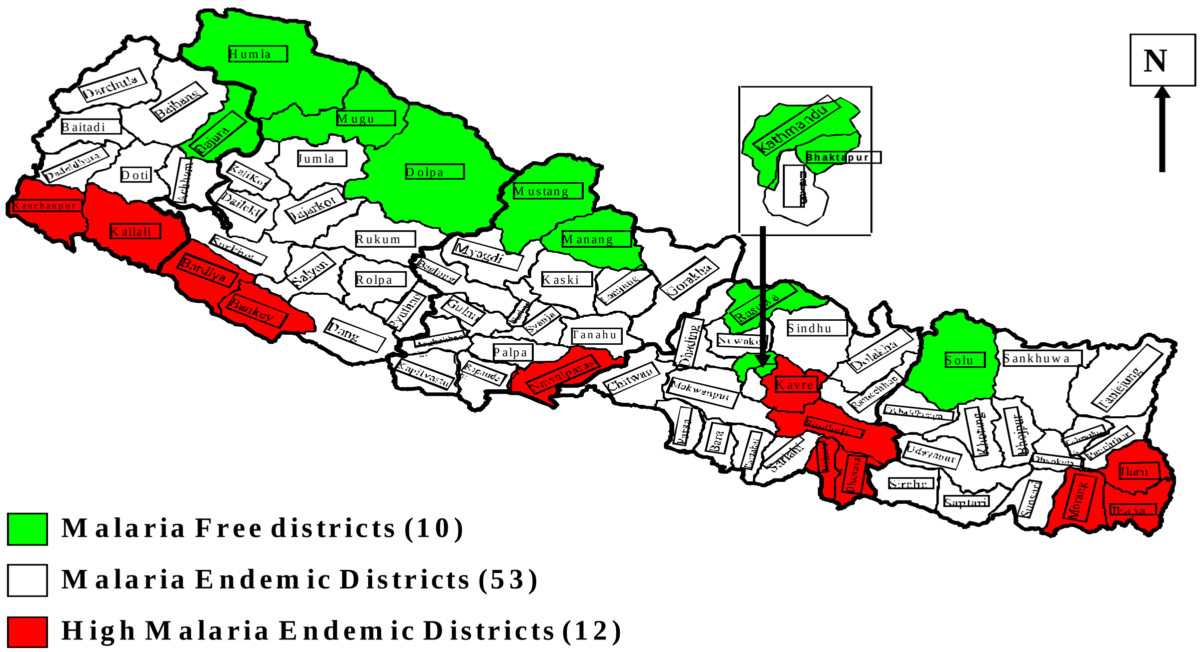


Figure 10: Distribution of malaria in Nepal

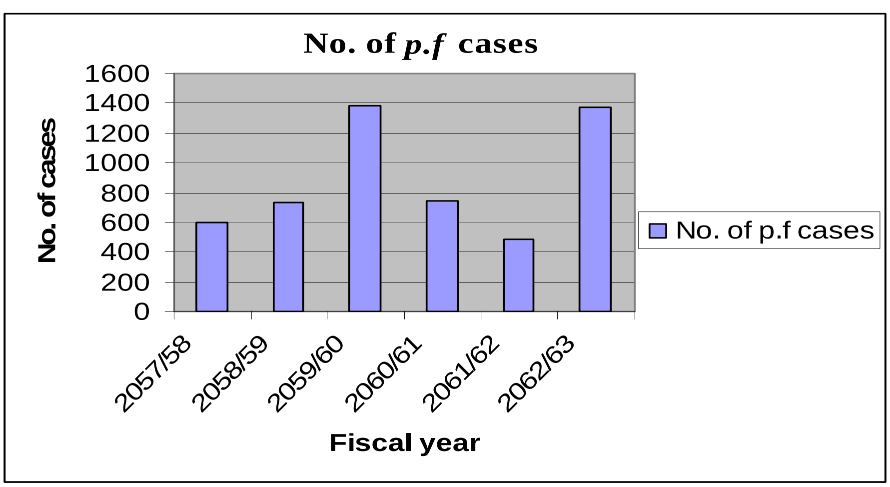


Figure 11: Malaria Situation in Nepal

(*Source: Department of Health Services, Annual report 2057/58-2062/63)*

3.2.2 Dengue Hemorrhagic fever

Dengue epidemics in urban areas are due to transmission by *Aedes aegypti* and can affect up to 70-80% of the population. Dengue has comparatively high impact in epidemic and endemic areas.

Passive surveillance of Dengue and DHF cases is currently undertaken in most endemic countries. The WHO-managed Dengue Net system for global surveillance of Dengue and DHF which collects and analyses case data reported by participating partners. The data can be entered directly and accessed via the internet. Historically, outbreaks of Dengue and DHF have characteristically been associated with the direct and indirect effects of high rainfall as well as elevated temperature and humidity on pathogen and vector biology. Intrinsic factors such as population immunity are more likely than climate to be the driving factors behind the epidemics. (Source: WHO, 2005)

Dengue in Nepal

Dengue virus transmitted by Aedes mosquito is one of the important causes of health problems in world. Dengue fever and more severe and often fatal forms namely dengue hemorrhagic fever and dengue shock syndrome are emerging health problems in many part of the globe.i Dengue fever, which has killed more than 60 people in the Indian capital and affected over 6,000, can now be diagnosed in Nepal.

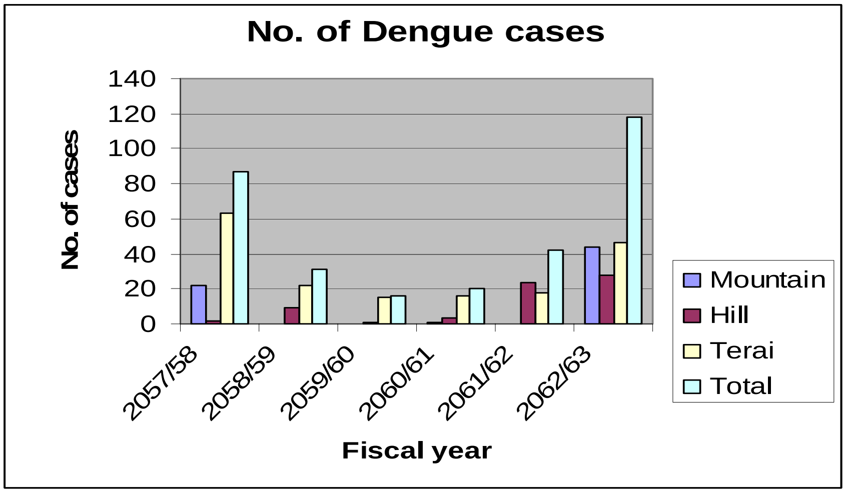


Figure 12: Dengue situation (2057to 2063)

(*Source: Department of Health Services, Annual report 2057/58-2062-63)*

The dengue cases reported in annual report are not laboratory confirmed cases and might be imported cases. Hence, it can not be generalized or linked up with climatic elements.

3.2.3 Leshmaniasis (Kalazar)

Leshmaniasis is caused by a protozoan parasite which is transmitted by the bite of *phlebotomine* sand flies. Visceral Leshmaniasis (VL) is epidemic in certain areas, for e.g. large areas of North Africa, South West Asia and South America. Outbreaks of VL have been associated with population movements, environmental modifications such as dam constructions, deforestation, and changes in the availability of zoonotic reservoirs. It is suggested that there is a significant positive relationship between the incidence of zoonotic CL, soil moisture and temperatures. In addition, the seasonal abundance of sand flies in South-west Asia has been shown to be dependent on temperature and humidity.

Kala-zar in Nepal

Kala-zar (Visceral Leishmaniasis) is an endemic disease in 12 Terai districts of Nepal. It is mainly confined to the southern plains of Eastern and Central regions of the country bordering Kala-zar endemic districts of Bihar and West Bengal States of India. However, a few sporadic cases are reported from other parts of the country every year. More than 5.6 million people living in these districts are believed to be at risk of this disease. Since 2037 (1980) to this Fiscal year (2062/63), a total of 21,837 cases and 297 deaths have been reported from this disease. Similarly the Case Fatality Rate (CFR) has shown a decreasing trend 1.7 in 2061/62 to 1.3 in 2062/63. From the graph below we can see that the no. of cases in the mountain region is zero and very less in the hilly region. But, the no. of cases in the Terai seems to be nearly equal to the national total.

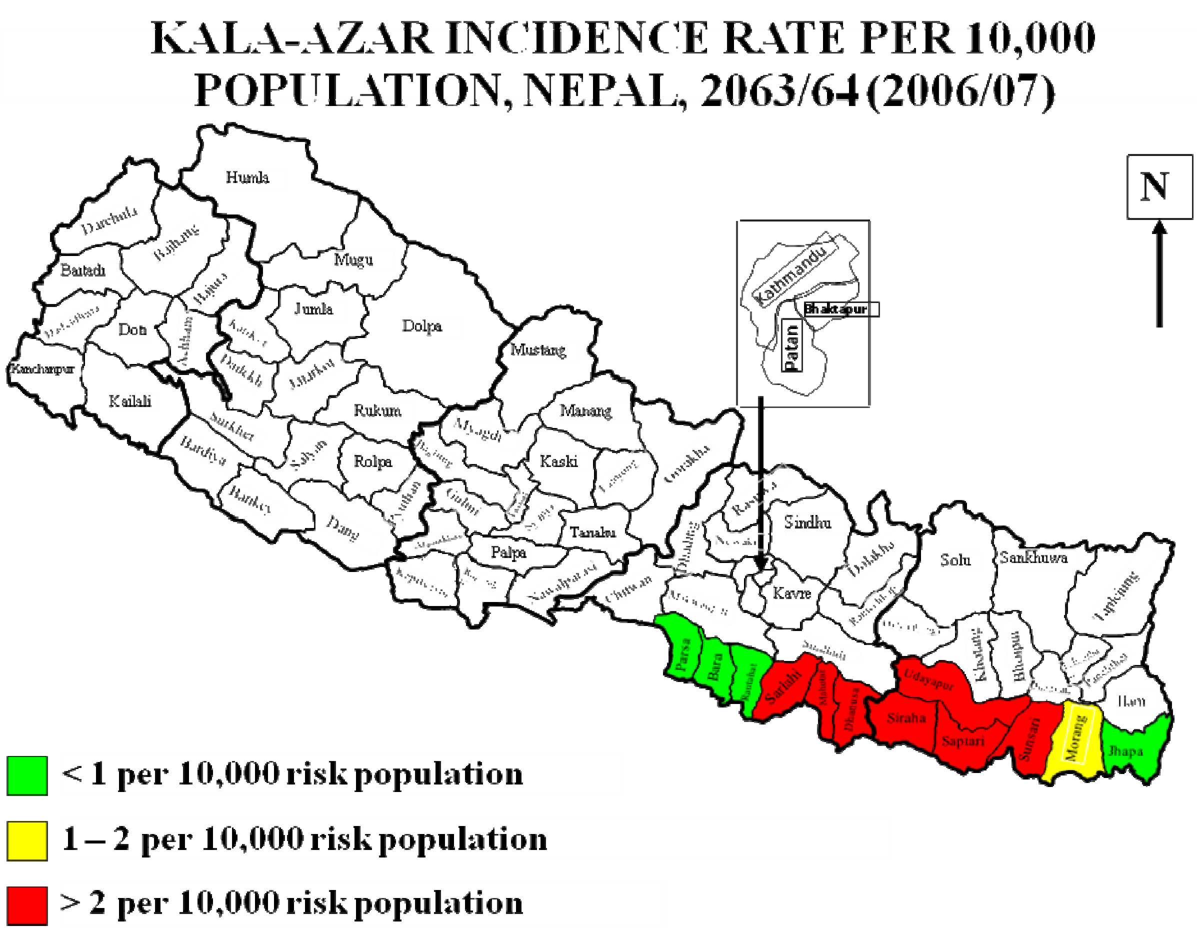


Figure 13: Distribution of Kala-azar in Nepal

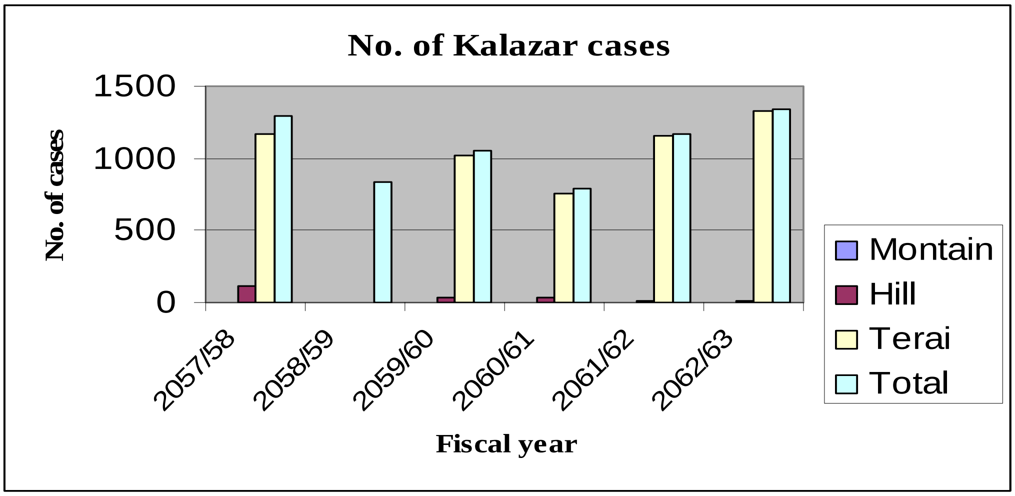


Figure 14: Kala-azar situation (2057-2063)

(Source: Department of Health Services, Annual report 2057/58-2062/63))

3.2.4 Japanese Encephalitis

JE is the leading cause of viral encephalitis in Asia with 30,000-50,000 cases reported annually. The disease is transmitted by culex mosquitoes among water birds, with pigs acting as amplifying reservoirs, and humans as dead-end hosts.

JE causes severe epidemics which are highly seasonal, occurring during the monsoon season when temperature reaches 30℃ or above. Studies have shown that the no. of cases of JE in India peaked as temperature and rainfall increased, whereas epidemics in China have been shown to be associated with particular phases of the rice cultivation cycle. (Source: WHO, 2005)

JE in Nepal

Clinical cases of Japanese Encephalitis (JE) were first reported in Nepal in 1978 from the Western Development Region. Now, 24 districts of Terai and inner Terai are affected and 12.5 million people are estimated to be at risk of the disease. Since 1978 seasonal outbreaks of JE have been reported annually. At present, in terms of morbidity and mortality this disease is one of the major public health problems in Nepal. Annually between 1000-3000 total cases and 200-400 deaths occur. More than 50% of the affected populations are children i.e. between 1 and 15 years of age. The ratio of the affected males and is 1.3:1. The incidence of encephalitis is seen to be increasing in the recent years. And, Terai region is the most affected region of this disease.

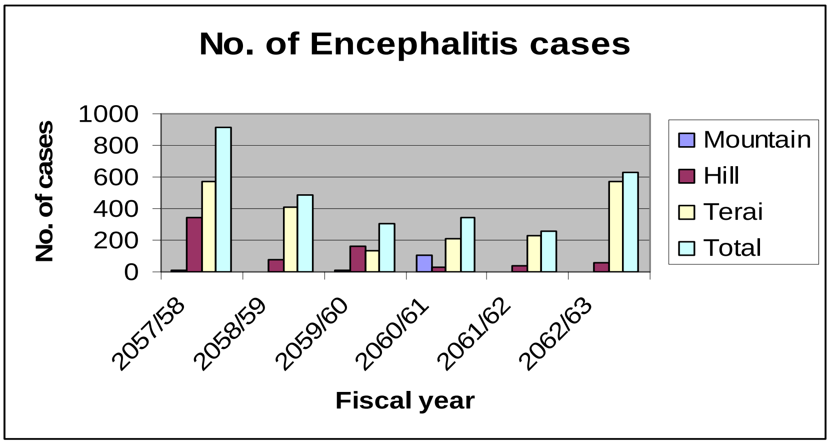


Figure 15: JE situation (2057-2063)

(Source: Department of Health Services, Annual report 2057/58-2062/63)

3.2.5 Filariasis

Lymphatic Filariasis is widespread throughout the country except mountainous and high hilly areas. According to the recent LF mapping, It has been estimated that 60 of 75 districts are endemic for lymphatic filariasis with about 24 million people living in those districts are at risk. The epidemiological mapping for filarial infection by ICT (Immunochromatography) card test carried out in 2001 in 37 districts revealed that 33 districts (89 percent) were endemic. More filarial cases are found in the Terai than in the hills.

Wuchereria bancrofti is the only recorded parasite in Nepal. The mosquito, *Culex quinquefasciatus*, an efficient vector of the disease has been recorded in all the endemic areas of the country. With WHO's global strategy to eliminate lymphatic filariasis as a public health problem and the government's political commitment, the Epidemiology and Disease Control Division, Department of Health Services, Ministry of Health and Population has formulated a National Plan of Action (2003-2018 A.D.) for elimination of lymphatic filariasis in Nepal. Government of Nepal, Ministry of Health and Population has also established a National Task Force for the Elimination of Lymphatic Filariasis (NTF-ELF) headed by Director General, Department of Health Services. [4]

Filariasis situation in Nepal:

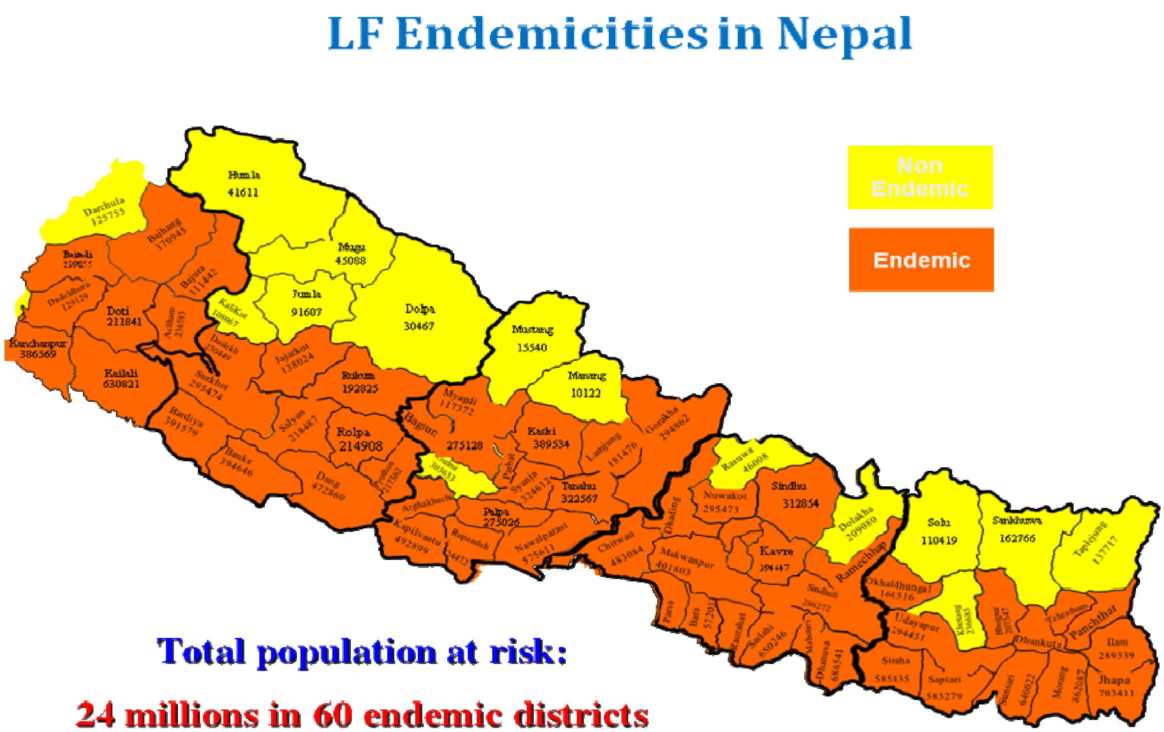


Figure 16: Distribution of Filaria in Nepal

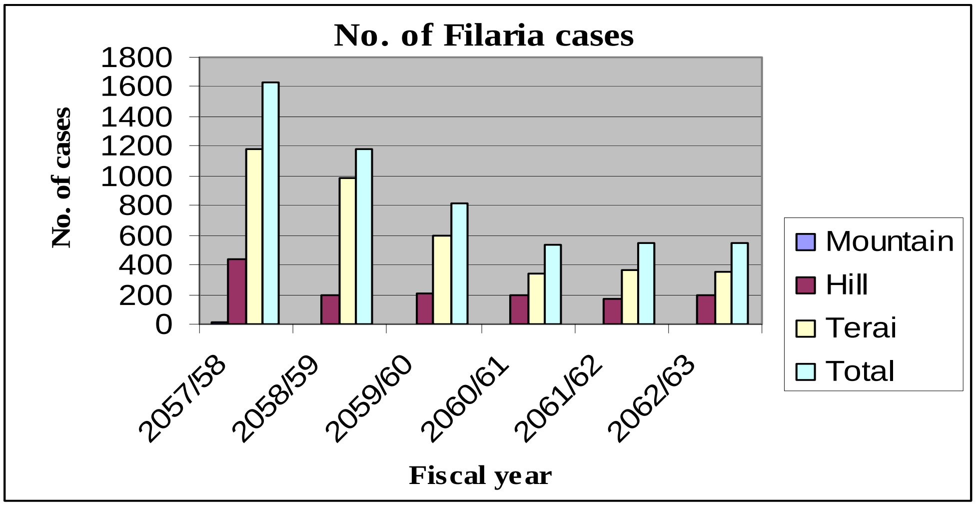


Figure 17: Filaria situation (2057-2063)

(Source: Department of Health Services, Annual report 2057/58-2062-63)

3.3 Assessment of the linkages between disease patterns with climatic data in Nepal

Vector-borne diseases have been a public health problem in terms of their mortality morbidity and the subsequent overall impact on the national economy of Nepal. Vectorborne diseases that have important public health implications in the national context include malaria, kala-azar, lymphatic filariasis, Japanese encephalitis and — more recently — dengue. Malaria, once believed to be confined to the forest and forest-fringe areas of the *terai* and inner *terai* regions is now distributed over almost 67 districts of the country. Japanese encephalitis, first identified in 1978, is now present in 24 districts. Kala-azar was not a problem up to 1980 but is now present in 12 districts of eastern and central *terai* regions. Lymphatic filariasis is endemic in 60 districts, while in 2006 dengue and its vector were identified in some border districts.

Nepal is striving to control or eliminate these diseases. The key strategies that have been adopted to address these diseases include enhanced surveillance, early diagnosis and treatment, mass treatment (e.g. for eliminating lymphatic filariasis), integrated vector control and community-based environmental modifications, and protecting those susceptible with inoculations in the case of Japanese encephalitis.

The Department of Health Services, Nepal, has institutionalized the process of annual review of all priority programmes: starting first, at the district level, then at the regional level and finally, at the central level. Besides, programme divisions like the Epidemiology and Disease Control Division have also been evaluating vector-borne diseases like malaria, kala-azar and Japanese encephalitis periodically. The analysis in such reviews and evaluations usually covers performance indicators like incidence, prevalence and the associated mortality, and factors that affect the integrated vector control initiatives like vectoral distributions and behaviour, change in the habitat, urbanization, migration, developmental changes affecting the breeding sites of vectors, and host population characteristics. Until now, the analysis has not covered the climatic changes or variations taking place and the distribution of vector-borne diseases throughout the country. This paper attempts to analyse the effects of climatic factors like temperature, precipitation and humidity on the occurrence of malaria and kala-azar in a few specific locations of the country.

3.3.1 Malaria situation

Malaria in its various forms has been the cause of mortality in Nepal through the ages. It also constitutes one of the most important causes of economic misfortune. There is no documented record of the prevalence of malaria in Nepal during the Nineteenth century apart from a few historical descriptions. The first documented epidemiological survey dates back to 1925. It was undertaken by Major Phillips of the Indian Military Service in the Makwanpur and Chitwan valley. Out of 889 children examined, 712 or 80% had enlarged spleen. In 1954, with the objective of controlling malaria mainly in the southern *terai* belt of central Nepal, a large-scale malaria control project: Insect Borne Disease Control (IBDC), supported by the United States Agency for International Development (USAID), was started in Nepal. Another planned malaria control project was taken up in the Rapti Valley by His Majesty's Government (HMG)/WHO and USAID during 1956-1958 to obtain baseline data and to recommend an appropriate strategy for malaria eradication programme. The National Malaria Eradication Programme (NMEP) was launched as a vertical programme in 1958 with the objective of eradicating the disease from the country. A major event in the 1960s was the incrimination of *An. minimus* and *An. fluviatilis* as being responsible for transmission of malaria in the *terai* belt and *An. willmori* as the vector responsible for transmission of malaria at an altitude of 6500 feet above the mean sea level (MSL) in Mugu district of the mid-western region. The virtual disappearance of *An. minimus* as the primary vector with high anthropophilic index (>90%) and high sporozoite rate (up to 16%) was a magnificent achievement.

In 1978 the "eradication" programme was converted into "control" of malaria programme according to WHO's Global Strategy of Malaria Control. Evidence of malaria, which was previously believed to confine itself with regard to its endemicity and epidemicity to the forest and forest-fringe areas of the *terai* and inner *terai* regions, was observed even at an altitude of almost 2000 meters above MSL. However, so far there is no entomological evidence to explain the distribution of malaria in terms of altitude.

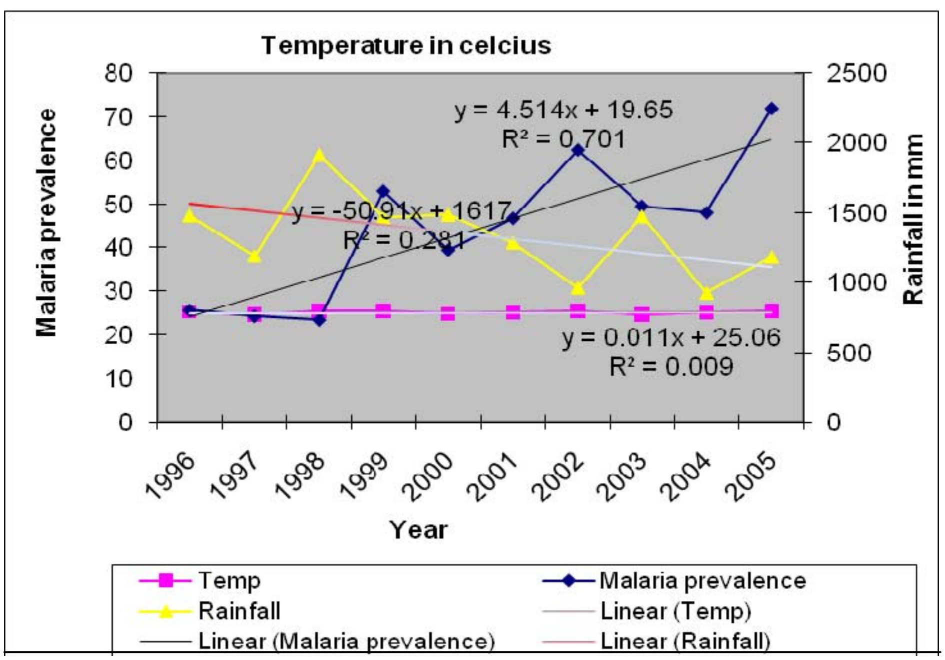


Figure 18: Malaria prevalence, temperature and rainfall of Banke district

Malaria is now prevalent in 67 districts of the country with high endemicity in 12 districts. And Banke is one of them. Since 1970, the country has overcome a number of outbreaks in 1974, 1985, 1991, 2002, 2005 and 2006. The highest number of cases was observed in 1999, 2002 and 2005(Fig 17). The program has however made remarkable progress in controlling malaria in terms of its incidence, which has been curtailed to a figure between 5000 and 7000 cases annually. Knowledge about the effect of climate change on the epidemiology of malaria has remained elusive in the absence of specific studies. However, the existing body of knowledge suggests that the disease in terms of its vectors and parasites is very much sensitive to changes in climatic factors such as temperature, humidity and rainfall.

It is well known that malaria is influenced by climatic factors such as temperature, precipitation and relative humidity. While there is increasing evidence of temperature rise in Nepal, more research needs to be carried out on the correlation between rainfall, humidity and outbreaks of malaria. There is an evident need to further explore these associations so as to better understand the link between climate change and malaria,and institute relevant adaptation measures.

3.3.2 Dengue situation

In 2006, there were reports of suspected DF outbreaks in Banke district. The clinical observation, pathological and laboratory investigation results proved introduction of DF in Banke, Bardiya, Dang, Kapilbastu, Parsa, Rupandehi, and Jhapa districts. A total of 70 serum samples from suspected DF cases were collected from 19 districts. So far, 22 cases of DF have been laboratory confirmed and many patients have travel history to India. It was also reported that many patients having similar symptoms visited India for treatment and confirmed as DF. Seventy-five per cent DF cases were reported in October and few cases were reported in September and November. Only 11 per cent patients had travel history to India in past two week period prior to clinical manifestation of DF. Ninety-four per cent patients were adults and male to female ratio was 4:1.

Table 1 Distribution of Estimated and Detected DF Cases, Nepal, 2006

District	Affected area	Detected DF cases	Estimated DF cases	Remarks
Banke	Urban/suburban	10	50	India-2
Bardiya	Urban/suburban	3	15	Rajasthan-1
Dang	Urban/suburban	6	30	No
Jhapa	Suburban	1	5	No
Parsa	Urban	4	20	No
Rupandehi	Urban	2	10	No
Kapilvastu	Urban	1	5	Unknown
Dhading	Urban	1	1	Unknown
Kathmandu	Urban	4	4	India-1
Total districts-9	Urban/suburban	Total detected-32	Total estimated-140	Imported cases-4

(Source: WHO 2006)

Under reporting is expected in the absence of diagnostic facilities at the field level and it may be reported either as viral fever or Pyrexia of Unknown Origin (PUO).

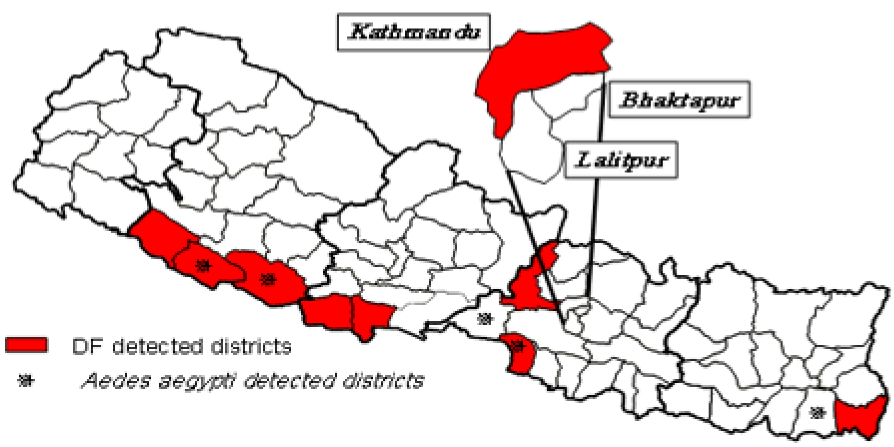


Figure 19: Map of Nepal showing the Dengue affected districts

(Source: WHO 2006)

Dengue and climatic factors

There is limited information available on dengue infection in Nepal. Sporadic case were noticed in foreigners in 90's and the first case of DF was reported in the year 2004 from chitwan district.(Pandey et al) However, no other cases of DF and DHF were reported in Nepalese patients until 2006. In September and October 2006, after the dengue after the dengue epidemic in India, Nepal's Central and western terai and Kathmandu hospital reported 12 laboratory confirmed cases. This is the first report of dengue outbreak in different locations of Terai region of Nepal, where *aedes* mosquito persist bordering with India state of Bihar(EDCD2006, WHO,2007, Pandey et al).

Studies related to dengue and its association with climatic factors must be conducted in an extensive scale. It is well known that dengue is affected by climatic determinants like temperature, rainfall and humidity. There is need to further explore the linkages between climate change and dengue transmission and prevalence.

3.3.3 Kala-zar situation

Visceral leishmaniasis, also termed kala-azar, has been known to be endemic in the southern *terai* area of Nepal. During the 1960s and 1970s, visceral leishmaniasis ceased to be a public health problem. This development was attributed mainly to the countrywide malaria eradication activities involving spraying of dichloro-diphenyl trichloroethane (DDT). With progress in malaria eradication activities and improvement of the malaria situation, insecticide spraying was reduced. After more than a decade of curtailment of insecticide spraying particularly in the southern *terai* areas, cases of visceral leishmaniasis again began to be detected: they were first recorded in 1980 with an incidence rate of 1.5 per 100 000 population and a case fatality rate of 5.88%.

Kala-zar and climatic factors

The growing risk of Kala-zar is considered as the potential impacts of climate change on human health as warmer temperatures may create favorable conditions for more vectors and germs spread such mosquitoes. *(Climate change and Nepal perspective CEN factsheet 2007).*

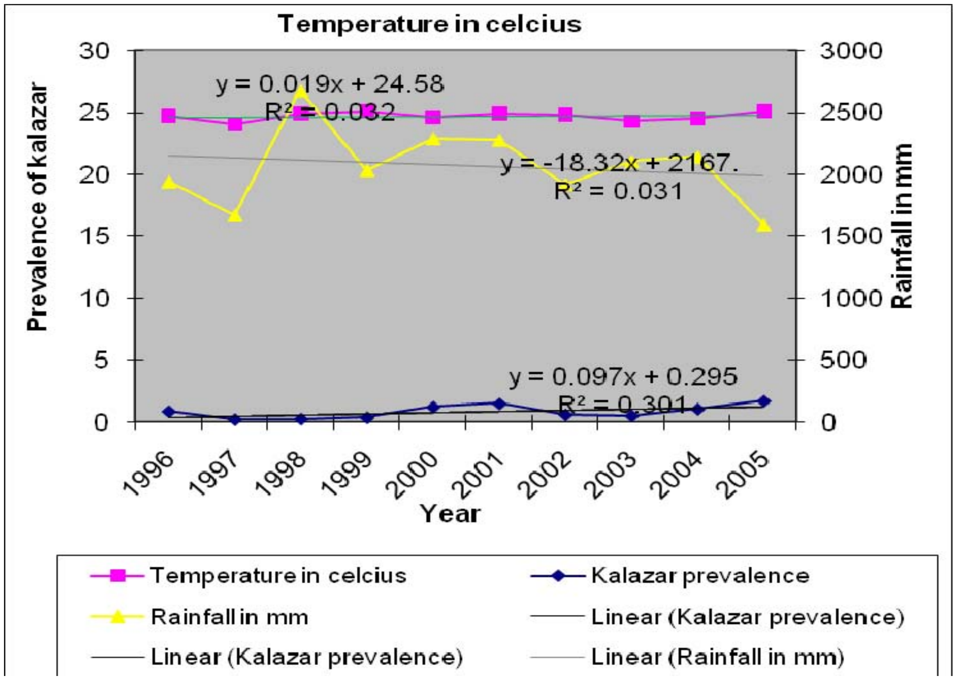


Figure 20: Temperature, rainfall and Kala-zar prevalence of Morang district

We can see from the above graph that in 2000, 2001 and 2005 its prevalence is higher. An increasing trend is seen in the prevalence of Kala-zar. Still more researches into the association of climatic factors and Kala-zar must be conducted so as to institute relevant adaptation measures.

3.3.4 JE situation

The disease was first recorded in Nepal in 1978 as an epidemic in Rupandehi district of the Western Development Region (WDR) and Morang of the Eastern Region (EDR). At present the disease is endemic in 24 districts. Although JE as found endemic mainly in tropical climate areas, existence and proliferation of encephalitis causing viruses in temperate and cold climates of hills and valleys are possible. Total of 26,667 cases and 5,381 deaths have been reported with average case fatality rate of 20.2% in an aggregate since 1978. More than 50% of morbidity and 60% mortality occur in the age group below 15 years. Upsurge of cases take place after the rainy season (monsoon). Cases start to appear in the month of April - May and reach its peak during late August to early September and start to decline from October. There are four designated referral laboratories, namely National Public Health Laboratory (Teku), Vector Borne Diseases Research and Training Center (Hetauda), B.P. Koirala Institute of Medical Sciences (Dharan) and JE Laboratory (Nepalgunj), for confirmatory diagnosis of JE. For prevention of JE infection; chemical and biological control of vectors including environmental management at breeding sites are necessary. Altogether 224,000 children aged between 1 to 15 years were vaccinated in Banke, Bardiya and Kailali districts during 1999. From China also, 2,000,000 doses of inactivated vaccine were received in 2000 and a total of 481,421 children aged between 6m to 10 yrs were protected from JE during 2001/2002. Ministry of Agriculture, Department of Livestock Services has vaccinated around 200,000 pigs against JE in terai zone during February 2001.(Bista, M B (MB); Shrestha, J M (JM)).

Infectious diseases, particularly the insect vector-borne diseases such as malaria, dengue fever and Japanese encephalitis are sensitive to the impact of climate change. Rising temperatures shorten the time needed by insect vectors to grow and thus increase the frequency of their feeding on the blood of human beings and animals. This also alters the geographic distribution of vectors: they usually spread to high-altitude areas that previously had no such disease vectors, thereby increasing the probability of their spreading the disease to new populations.

Associations between climate change and JE needs to be studied in order to formulate prevention and control measures as well as to institute adaptation measures of climate change and its effects.

3.3.5 Filariasis situation

Available data shows that since four to five decades the patients of filaria come to health facilities for treatment in the different parts of the country. This shows that in most of the districts, this infection has been transmitted from one person to another. Filaria is more prevalent in people living in urban and rural areas of Terai than those in the high hilly regions. Passive forms of disease are more common than the active forms in Nepal.

Studies have shown that an adult filaria patient has 4.2 times greater chances of filarial fever attacks and causes inability to work for nearly 30 days.

The Filaria prevention program has been started in Nepal since 2003. In 2006, 60 lakh people of 11 affected districts were distributed with Albendazole and Diethylcarbamazine(DEC), the effective drug of filaria for prevention and control of this disease.

Filaria and climatic factors

Filaria can be regarded as an influence of climate change. Filaria endemic districts are increasing and now there are 60 out 0f 75 districts where filaria is endemic. Recent introduction of transmission due to natural or man made ecological changes, such as dam construction or the adoption of large scale irrigated rice fields. Its main vector culex mosquito breeds in warm and humid temperature and in clean water. With the increasing temperatures, the culex is found in almost districts thus filaria being endemic in those districts.

Associative studies of climatic factors and filaria prevalence needs to be done extensively to establish their relationship. And to design the appropriate adaptation measures.

3.4 Review of the health risks due to climate change and the good practices, adaptation and mitigation measures to reduce adverse impacts of climate change on health (particularly from South East Asia Region)

"Climate change" is a regular phenomena but over the past decades, it had become more clear that climate change due to global warming have accelerated and this has been mainly attributable to human activities. Due to the climate change, the frequency and severity of extreme weather events, such as intense storms, heat waves, droughts and floods have increased. Moreover, their frequency in future will further increase and the consequences in terms of mortality and morbidity will be profound (1). The most severe threats are to developing countries, more specifically Himalayan country like Nepal, which do not have sufficient capacity to deal with such extreme events and its consequent effects (2, 3). There are already enough evidences that its impact on health in the developing nations is profound (4). The main objective behind this review is to establish a knowledge base for climate change and health: identify what may be the potential health impacts of the climate change in Nepal where within very short distance, great climatic variability can be found (from tropical to alpine) as well as identify and outline major adaptation and mitigation strategies undertaken by other countries that can be beneficial for developing country like Nepal.

HEALTH RISKS:

The AR4 report had summarized the main health outcomes attributed to climate change as follows (5):

- ✓ Human-induced climate change significantly amplifies the likelihood of heat waves, increasing the possibility of heat strokes, cardiovascular and respiratory disorders.
- ✓ More variable precipitation patterns are likely to compromise the supply of freshwater, increasing risks of water-borne diseases like cholera, and outbreaks of diarrhoeal diseases.
- ✓ Rising temperatures and variable precipitation are likely to decrease the production of staple foods in many of the poorest regions, increasing risks of malnutrition.
- ✓ Meeting increasing energy demands by greater use of fossil fuels will add to the number of respiratory disorders, such as asthma.
- ✓ The increase in frequency and intensity of extreme weather events will translate into loss of life, injuries and disability.
- ✓ Changes in climate are likely to lengthen the transmission season of important vector-borne diseases (like dengue and malaria) and to alter their geographic range, potentially reaching regions that lack either population immunity or a strong public health infrastructure.
- ✓ Rising sea levels increase the risk of coastal flooding, and may lead to displacements of population.

- ✓ Loss of livelihood will increase psychosocial stress in the affected populations.

The extent to which human health is affected depends on: (i) the exposures of populations to climate change and its environmental consequences, (ii) the sensitivity of the population to the exposure, and (iii) the ability of affected systems and populations to adapt (6). The factors such as population density, level of economic development, food availability, income level and distribution, local environmental conditions, pre-existing health status and the quality and availability of public health care determines the vulnerability of a population. IPCC in its AR4 mentions that people at greatest risk include the very young, the elderly, and the medically frail especially those of the developing countries where there is already significant burden of climate sensitive infectious diseases and poor public health capability to respond. Moreover, it's very unfortunate and unjust that climate change is mainly occurring due to the developed countries but it is the people of the developing countries that are most affected (5).

All of the above mentioned health problems are of prime concern in Nepal and contributes to substantial share of health problems. Diarroheal diseases are still the leading cause of morbidity and mortality in Nepal especially among the children and so is malnutrition (7). Moreover, the frequency of natural disasters (landslides and floods) and corresponding increase in the number of injured and died in Nepal is very high in Nepal and climate change will definitely further complicate the problem. According to a study by UNDP/BCPR (UNDP, 2004), among 200 countries, Nepal stands at 30th with regard to relative vulnerability to flood (8, 9).

Now, let us explore the emerging evidences of climate change effects on human health with particular focus on South-East Asian countries. These evidences have primarily been extracted from the Human Health chapter of the *the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. (4)[*]

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[*] for further references, the report is available from: URL:http: http://www.ipcc.ch/ipccreports/assessments-reports.htm

Heat and cold health effects:

In Asia, the main health concerns under climate change and variability are malaria and cholera, but thermal stress and air-pollution related ill-nesses also are important. Malaria still is one of the most important vector-borne diseases in India, Bangladesh, Sri Lanka, Thailand, Malaysia, Cambodia, the Lao People's Democratic Republic, Viet Nam, Indonesia, Papua New Guinea and parts of China. Vector resistance to insecticides, and parasites' to chloroquine, compound the problem of malaria control. The IPCC concluded that changes in environmental temperature and precipitation could expand the geographical range of malaria in the temperate and arid parts of Asia.

Water-borne diseases such as cholera, and various diarrhoeal diseases such as giardiasis, salmonellosis and cryptosporidiosis, occur commonly with contamination of drinking water in many South Asian countries. These diseases could become more frequent in many parts of South Asia in a warmer climate.

According to IPCC, eighteen heatwaves were reported in India between 1980 and 1998. A heatwave in 1988 caused 1 300 deaths, while another one in 2003 caused more than 3 000 deaths. Heatwaves in South-East Asia cause high mortality in rural populations, and among the elderly and outdoor workers. Examples are the reported cases of heatstroke in metal workers and in rickshaw pullers in Bangladesh. Cold waves also affect the people in South Asia region which are mainly accidental in nature killing vulnerable and poor people.

Wind, storms and Floods:

Floods are the most frequent natural disaster and its impacts range from deaths, injuries, infectious diseases and toxic contamination, to mental health problems.

Though mental health is one of the prime concerns during climate induced distasters studies in both low and high-income countries indicate that the mental health aspect of flood-related impacts had been insufficiently investigated. Populations with poor sanitation infrastructure and high burdens of infectious disese often experience increased rated of diarrhoeal diseases after flood events. Increases in cholera, cryptosporidiosis and typhoid fever have been reported in low and middle income countries such as India, Brazil and Bangladesh. In terms of deaths and populations affected, floods and tropical cyclones have the greatest impact in South Asia and Latin America. Environmentally degraded areas are particularly vulnerable to tropical cyclones and coastal flooding under current climate conditions.

In 2006, Bhutan reported increased loss of life from frequent lash loods, glacier lake outburst loods and landslides. Rises in lood-related diarrhoeal disease have been reported in India and Bangladesh. In 2007, four monsoon depressions—double the normal number— caused severe loods in Bangladesh, India and Nepal, but also in the Democratic People's Republic of Korea causing death, loss of livelihood and displacement of millions. In November 2008, tropical cyclone Sidr made landfall in Bangladesh, generating winds of up to 240 km/h and torrential rains. More than 8.5 million people were affected and over 3 300 died. Nearly 4.7 million people saw their houses damaged or destroyed, most of them belonging to the poorest of the poor. (5)

Drought, nutrition and food security

The causal chains through which climate variability and extreme weather influence human nutrition are complex and involve different pathways (regional water scarcity, salinisation of agricultural lands, destruction of crops through flood events, disruption of food logistics through disasters, and increased burden of plant infectious diseases or pests). Both acute and chronic nutritional problems are associated with climate variability and change. The effects of drought on health include deaths, malnutrition (undernutrition, protein-energy malnutrition and/or micronutrient deficiencies), infectious diseases and respiratory diseases. In Gujrat, India, during a drought in the year 2000, diets were found to be deficient in energy and several vitamins. In this population, serious effects of drought on anthropometric indices may have been prevented by public-health measures. Similarly, a study in Bangladesh found that drought and lack of food were associated with increased risk of mortality from a diarrhoeal illness. Drought and the consequent loss of livelihoods is also a major trigger for population movements, particularly rural to urban migration. Population displacement can lead to increases in communicable diseases and poor nutritional status resulting from overcrowding, and a lack of safewater, food and shelter. The transmission of some mosquito-borne diseases is affected by drought events.

Droughts are also associated with respiratory health effects due to dust storm and water-washed diseases due to scarcity of water.

Food Safety:

Several studies have confirmed and quantified the effects of high temperatures on common forms of food poisoning, such as salmonellosis. Contact between food and pest species, especially flies, rodents and cockroaches, is also temperature-sensitive. Fly activity is largely driven by temperature rather than by biotic factors. In temperate countries, warmer weather and milder winters are likely to increase the abundance of flies and other pest species during the summer months, with the pests appearing earlier in spring.

Water and disease:

Climate-change-related alterations in rainfall, surface water availability and water quality could affect the burden of water related diseases. Water-related diseases can be classified by route of transmission, thus distinguishing between water-borne (ingested) and water-washed diseases (caused by lack of hygiene).

In many countries cholera transmission is primarily associated with poor sanitation. The effect of sea-surface temperatures in cholera transmission has been most studied in the Bay of Bengal. In sub-Saharan Africa, cholera outbreaks are often associated with flood events and faecal contamination of the water supplies.

Air quality and disease

Weather at all time scales determines the development, transport, dispersion and deposition of air pollutants. Ground-level ozone is both naturally occurring and, as the primary constituent of urban smog, is also a secondary pollutant formed through photochemical reactions involving nitrogen oxides and volatile organic compounds in the presence of bright sunshine with high temperatures. In urban areas, transport vehicles are the key sources of nitrogen oxides and volatile organic compounds. Exposure to elevated concentrations of ozone is associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma, allergic rhinitis and the respiratory diseases, and with premature mortality.

Concentrations of air pollutants in general and fine particulate matter (PM) in particular, may change in response to climate change because their formation depends, in part, on temperature and humidity. Evidence for the health impacts of PM is stronger than that for ozone. In some regions, changes in temperature and precipitation are projected to increase the frequency and severity of fire events. Forest and bush fires cause burns, damage from smoke inhalation and other injuries.

Aeroallergens and disease

Climate change has caused an earlier onset of the spring pollen season in the Northern Hemisphere. It is reasonable to conclude that allergenic diseases caused by pollen, such as allergic rhinitis, have experienced some concomitant change in seasonality.

Vector-borne, rodent-borne and other infectious diseases:

Vector-borne diseases (VBD) are infections transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, triatomine bugs, sandflies and blackflies. VBDs are among the most well-studied of the diseases associated with climate change, due to their widespread occurrence and sensitivity to climatic factors.

Dengue

Dengue is the world's most important vector-borne viral disease. Several studies have reported associations between spatial or spatiotemporal patterns of dengue and climate. However, these reported associations are not entirely consistent, possibly reflecting the complexity of climatic effects on transmission, and/or the presence of competing factors.

While high rainfall or high temperature can lead to an increase in transmission, studies have shown that drought can also be a cause if household water storage increases the number of suitable mosquito breeding sites. Climate-based (temperature, rainfall, cloud cover) density maps of the main dengue vector *Stegomyia* (previously called *Aedes*) *aegypti* are a good match with the observed disease distribution. The model of vector abundance has good agreement with the distribution of reported cases of dengue in Colombia, Haiti, Honduras, Indonesia, Thailand and Vietnam. Approximately one-third of the world's population lives in regions where the climate is suitable for dengue transmission.

Malaria

The spatial distribution, intensity of transmission, and seasonality of malaria is influenced by climate in sub-Saharan Africa; socio-economic development has had only limited impact on curtailing disease distribution.

Rainfall can be a limiting factor for mosquito populations and there is some evidence of reductions in transmission associated with decadal decreases in rainfall. A systematic review of studies of the El Nino-Southern Oscillation (ENSO) and malaria concluded that the impact of El Nino on the risk of malaria epidemics is well established in parts of southern Asia and South America. The effects of observed climate change on the geographical distribution of malaria and its transmission intensity in highland regions remains controversial. Analyses of time-series data in some sites in East Africa indicate that malaria incidence has increased in the apparent absence of climate trends. The proposed driving forces behind the malaria resurgence include drug resistance of the malaria parasite and a decrease in vector control activities.

However, the validity of this conclusion has been questioned because it may have resulted from inappropriate use of the climatic data. Analysis of updated temperature data for these regions has found a significant warming trend since the end of the 1970s, with the magnitude of the change affecting transmission potential. An analysis of data from seven highland sites in East Africa reported that short-term climate variability played a more important role than long-term trends in initiating malaria epidemics, although the method used to test this hypothesis has been challenged.

Despite the known causal links between climate and malaria transmission dynamics, there is still much uncertainty about the potential impact of climate change on malaria at local and global because of the paucity of concurrent detailed historical observations of climate and malaria, the complexity of malaria disease dynamics, and the importance of non-climatic factors, including socio-economic development, immunity and drug resistance, in determining infection and infection outcomes. Given the large populations living in highland areas of East Africa, the limitations of the analyses conducted, and the significant health risks of epidemic malaria, further research is warranted.

Other infectious diseases

Recent investigations of plague foci in North America and Asia with respect to the relationships between climatic variables, human disease cases and animal reservoirs have suggested that temporal variations in plague risk can be estimated by monitoring key climatic variables.

There is good evidence that diseases transmitted by rodents sometimes increase during heavy rainfall and flooding because of altered patterns of human–pathogen–rodent contact. There have been reports of flood-associated outbreaks of leptospirosis (Weil’s diseases) from a wide range of countries in Central and South America and South Asia. Risk factors for leptospirosis for peri-urban populations in low-income countries include flooding of open sewers and streets during the rainy season. The distribution of schistosomiasis, a water-related parasitic disease with aquatic snails as intermediate hosts, may be affected by climatic factors. In one area of Brazil, the length of the dry season and human population density were the most important factors limiting schistosomiasis distribution and abundance. Over a larger area, there was an inverse association between prevalence rates and the length of the dry period. Recent studies in China indicate that the increased incidence of schistosomiasis over the past decade may in part reflect the recent warming trend.

Occupational health

Changes in climate have implications for occupational health and safety. Heat stress due to high temperature and humidity is an occupational hazard that can lead to death or chronic ill health from the after-effects of heatstroke. Both outdoor and indoor workers are at risk of heatstroke. The occupations most at risk of heatstroke, based on data from the USA, include construction and agriculture/forestry/fishing. Acclimatisation in tropical environments does not eliminate the risk, as evidenced by the occurrence of heatstroke in metal workers in Bangladesh and rickshaw pullers in South. Several of the heatstroke deaths reported in the 2003 and 2006 heatwaves in Paris were associated with occupational exposure.

Hot working environments are not just a question of comfort, but a concern for health protection and the ability to perform work tasks. Working in hot environments increases the risk of diminished ability to carry out physical tasks, diminishes mental task ability, increases accident risk and, if prolonged, may lead to heat exhaustion or heatstroke.

Ultraviolet radiation and health

Solar ultraviolet radiation (UVR) exposure causes a range of health impacts. Globally, excessive solar UVR exposure has caused the loss of approximately 1.5 million disability-adjusted life years (DALYs) (0.1% of the total global burden of disease) and 60,000 premature deaths in the year 2000. The greatest burdens result from UVR-induced cortical cataracts, cutaneous malignant melanoma, and sunburn (although the latter estimates are highly uncertain due to the paucity of data). UVR exposure may weaken the immune response to certain vaccinations, which would reduce their effectiveness.

However, there are also important health benefits: exposure to radiation in the ultraviolet B frequency band is required for the production of vitamin D in the body. Lack of sun exposure may lead to osteomalacia (rickets) and other disorders caused by vitamin D deficiencies.

Climate change will alter human exposure to UVR exposure in several ways, although the balance of effects is difficult to predict and will vary depending on location and present exposure to UVR. Greenhouse-induced cooling of the stratosphere is expected to prolong the effect of ozone-depleting gases, which will increase levels of UVR reaching some parts of the Earth's surface. Climate change will alter the distribution of clouds which will, in turn, affect UVR levels at the surface. Higher ambient temperatures will influence clothing choices and time spent outdoors, potentially increasing UVR exposure in some regions and decreasing it in others. If immune function is impaired and vaccine efficacy is reduced, the effects of climate-related shifts in infections may be greater than would occur in the absence of high UVR levels.

However, climate change is also projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure, and some mixed effects such as changes in range and transmission potential of malaria in Africa. In countries like the United Kingdom, where there is a high level of excess winter mortality, the beneficial impact may outweigh the detrimental. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.

Table 2: Impacts of Global warming and climate change on weather events and health outcomes and most affected populations

Enhanced weather event/ environmental determinant	Affected health outcomes	Most vulnerable populations
Heat waves	Heat stress, strokes, cardiovascular disorders	Youngest, eldest, people with respiratory disease, open air workers
Air pollution, increase in ground ozone levels and allergens	Respiratory disorders, asthma	Youngest, eldest, people with respiratory disease, open air workers in urban

		areas
Extreme weather events(heavy rains, storms, cyclones)	Injuries, drowning, disability, mental health	Coastline and low lying communities, fisher folk, landless, slum dwellers
Droughts, floods	Water and food borne diseases	Communities depending directly from ecosystem delivery
	Malnutrition, hunger	Youngest, oldest, pregnant and lactating women, farmers
Warmer temperatures	Vector borne diseases	Slum dwellers, far flung communities
Sea-level rise, salinasation of soil of water sources	Injuries, drowning Water and food borne diseases Psychological stress	Islanders, coastline and low lying communities, fisher folk, slum dwellers, landless
Glacier melting, flash floods	Injuries, water borne diseases, malnutrition Psychological stress	Mountain communities, women and children
Ecosystem disruption	Malnutrition Psychological stress	Farmers, fisher folk, children, pregnant and lactating women
Migration and relocation	Psychological stress	Displaced communities and individuals, children

Source: WHO, SEARO, 2008

3.5 Assessment of the practice and adaptation measures of local communities of ecological regions to reduce health implications of climate change in Nepal

There is no doubt that climate change affects the human health directly or indirectly. In order to assess the knowledge about the health impact and mitigation measures of climate change, an exploratory study was done in Chitwan and Rasuwa District through in-depth interview. Based on interview, case studies were also prepared. Local people have perceived many changes in elements of climate such as precipitation and rainfall over the time and impact in the various aspects of their life. They perceived that days and nights during winter seasons used to be very chilly in a few decades back and in recent years, they are experiencing less chilly winter days and nights. Similarly during summer season, the days are becoming hotter. According to the community people, the most significantly observed changes are decrease in rainfall amount, delayed monsoon, and shorter period of rainy season. At the same time, unusual and untimely rainfall, heavy rainfall at once, and decreased winter rainfall are other important changes experienced by the local community. From the informal discussion with the community people, the following risks or types of exposure, which were directly or indirectly related to climate change and variability, were identified: natural disasters (floods, landslides, drought), water scarcity for drinking and irrigation, reduced agriculture and food production and human health risks. Community people asserted there have been an increase in health problems in the village such as eye diseases (red eye), skin diseases (including rashes, itching and dry skin), fever, headache, flue-like symptoms, diarrhea, jaundice, pneumonia and typhoid fever. They believe this is linked to significant variations in the climate. However, in-depth analytical study is required to confirm these facts.

Case Study 1: Kavilas VDC Jugedi, Chitwan

The Practical Action Nepal initiated the Community Based Adaptation program for combating the Climate Change in 2003. The project has been developed and implemented in participatory approach. The community people have formulated a Climate Change Impact and Disaster Management Group including 3 women after the heavy flood in Bharyang Khola in 2060B.S. One effective way for communities to cope with increased flood and threat to their land is being managed by growing a range of new and different crops that have a higher market value. They have introduced the crops that are more resilient to the changes in rainfall patterns; crop diversification also allows alternative crops to be cultivated at a different time of the year, despite of changes to the weather. To support those activities, Practical Action Nepal had offered seedlings and trainings in crop diversification. The farmers have been growing off-season tomatoes-but also cereals at the seasonal times. The farmers are now moving into different types of vegetables, goat rearing, bananas farming and Slope Agricultural Land Technology (SALT). One of the farmers of Kavilas VDC expressed “Though I’m an old person but I want to establish myself with modern thoughts and scientific practice. It’s better now that I and my family are growing bananas as well as other crops. The seedlings of rice I cut and gave to cattle when there was no rainfall in rice planting season some years back. Now I don't have to spend so much time on the land ether, which means that I'm not just farming-I'm also directly selling some of my products at market, which means I have some extra income for health and education. I have a better life now and I am full of hope for the future". Practical Action has also helped to provide an irrigation system which ensures that village can contribute to grow crops even in the context of more erratic rainfall. Using support from Practical Action, the community has built a dam as source of water irrigation and check dams in the streams and river to control floods. They have planted and grown the greenery in slope land and stream to prevent flood and landslides.

Case Study 2: Sauraha Chitwan

The people have experienced that in recent years the number of hotter days is increasing. The farmers could not work in the field till late afternoon and could not go to work earlier in day time as before because of hotter days. Hence, the working hours in day time has decreased. Similarly, early morning are being colder which also restrict to go in the farm early morning. Till late night, there will be hotter temperature and make difficulty in sleeping. They have observed that total rainfall has decreased and irregular rainfall occurs. Due to high temperature in day time, it has affected the skin of many people. They have experienced that over the years viral fever, respiratory diseases, diarrheal diseases has increased in the community. In their observation, number of mosquitoes and harmful insects has also increased and sporadic cases of malaria have also reported every year. For the adaptation at local level, emphasis should be given to

- Reducing poverty
- Selection of construction materials for building of housing
- Use of organic fertilizer rather than mineral fertilizer
- Increased greenery in settlement areas and
- Strengthening health services at local level.

Case Study 3: Rasuwa District

Mr. Chiring Fingo, is residing in Syaprubeshi, Rasuwa since 2041 B.S. In his observation, greenery has increased over the years. Days and nights are getting warmer. Back to decades, there used to fall 5-6 inch thick snow but now it is very rare and even if there is snow fall it is very thin 1-2 inch. There is an increase in irregular rainfall with more rainfall leading to floods in some years, and less rainfall leading to draught and untimely rain in some years. In his opinion only very few people have heard and know about climate change. In recent days, cases of paralysis, diarrhea, common cold, fever and gastrointestinal diseases have increased. The sanitation situation has been poorer and number of mosquitoes has increased. Before 15-16 years, there was no appearance of any mosquitoes. The load carrying capacity of porters have reduced in latter days due to high intensity of light.

Case Study 3: Impact of Extreme Climatic event on Health in Sunsari District

Three focus group discussion were conducted to identify the impact of extreme climatic events flood and extreme cold in Sunsari district, eastern terai of Nepal in January 2009. Almost all the participants were worried about the extreme cold and had stressed that they were affected by this winter and were already being affected by flood as well. All of them had the problem of cold weather. They said that there were many people continuously suffering from throat pain, running nose, cough, fever, whole body ache and difficulty in sleeping in spite of taking medicine. Cold extremities and joint pain were common among the elderly and some of them were harassed by the frequent attack of multiple joint pain. Chest pain, difficulty in breathing and increased frequency of chronic cough was reported by some of them. Most of them found difficulty in working, laziness and cold to touch especially in dawn, dusk and night. Some of them said that they were suffering from headache, difficulty in swallowing, tooth ache and numbness of hand and feet and tingling and loss of sensation of hands. One of them reported that a member in the family was living only with liquid food because of difficulty in swallowing. Some addressed the extreme cold as great problem because of thick fog and very late rising of the sun. Almost all of them agreed that throat pain and back ache were high in number. Children were suffering from pneumonia frequently and some of them were ill looking all the time. They blame the cold for not getting well. Some of them said that there existed some cases of diarrhea. They were suffering very much from the extreme cold and said that the diseases were due to cold weather.

There were people suffering from abdominal problem. Abdominal pain was prevalent more among the females than males. Swelling was also complained by some of them. There were some females complaining of white discharge. There were pregnant women who were getting medicine and check up. They were aware of district hospital, Inaruwa for the delivery.

The other problems such as prolapsed uterus, menstrual problem, disfigurement of legs, cataract and ocular injury and gall bladder stone were reported. One of them told that there were 2 to3 cases of HIV/AIDS in nearby camps. Some said that their children were afraid of flood even now saying that “flood’s there, flood’s there”. Many of them said that the existing provision of medical care was inadequate for them in spite of getting treatment.

All of them noticed that they were feeling colder than the previous year. One of them loudly said that they did not get enough food as they were used to have around 25 kilograms per person per month to satisfy. This winter made it worse as they said that they did not have enough food and more over their appetite increased in winter. There was a conflict among the participants about the return to the native place. They were feeling colder than before and did not have adequate foam, blanket and shawl to overcome the cold. Water used to drip in at night and difficult to sleep. Some of them used to make fire to get warm and some had collected hay and leaves of sugarcane to get warm. Many of them were devoid of any means of getting warm and used to wait for the coming morning. All of them were asking for help.

The people living other than the flood affected area in Terai said that the winter was different from the previous one. It was like shivering cold and colder than before. Most of them found difficulty in working in the field. Some of them lost their interest to work. Knee pain, shoulder pain, back ache and headache were common among them. Some of them were suffering from frequent attack of multiple joint pains. Children were suffering from cough, running nose and fever. Death due to cold had also been reported. Some of them could not sleep well. Potato and tomato farming had also been affected. They used to wear warm clothes and make fire to overcome the cold. They used to eat warm food and drink warm water. They had blankets for night. Some of them did not have enough to do to live happily in the cold winter.

During the discussion, almost all the participants were serious about the consequences of the flood. Though they were informed about the flood from their friends, neighbors, relatives and concerned authority they could not carry their belongings with them and had to run away with their families together and fetched the safe place, the east-west highway nearby. Most of them had lost their earnings including the farming, cattle and poultry. Some of them suffered from injury and back ache while running due to fear. One of them with tears in eyes said there were suffers and casualties. One of them even viewed that there were about 20-22 deaths. They were helped by the nearby villagers and rescue team to land in safe place, afterwards in the camp. There were difficulties for the children and women. Some of them used to go to their dwellings to see the destruction and returned back sadly looking none of their cattle and the place full of water. At that time the cases of injury, fever and back ache were big in number and no adequate health worker and medicine to treat the diseased persons for almost 2 weeks. Foreign body in eye was also reported. Almost all of them mentioned that there were many cases of diarrhea. One of them had noticed a paralyzed old man. They said that they had difficulties in getting adequate care. They felt assured and ease after the distribution of foods, clothing and arrangement for shelter but that too was not enough for living. The number of men who used to go for work was far more than that of women. The children had already started to go to school. Almost all of them knew that district hospital in Inaruwa was providing care for delivery and space for mother and new born.

In depth interviews were also conducted in the study site. The impact of extreme climatic events including extreme cold and flood were discussed. It was said that the winter was colder than the previous one and affecting the flood victims more than others. Children and elderly suffered more than others. Children suffered from cough, running nose and fever and some of them even diagnosed pneumonia. Older men and women suffered from whole body ache, multiple joint pain, cough, head ache and difficulty in sleeping. Some of the elderly were having frequent attack of chronic cough. Young ones were suffering from head ache and running nose. There was difficulty in sleeping. Few cases of diarrhea had also occurred. The sufferings had the opportunity to get the medical care. There was distribution of woolen sweeter for the children less than 15 years.

Other health problems like skin diseases, piles, hydrocele, hernia, ear disease white discharge and uterine prolapse were also prevalent among the population. There had been treatment for uterine prolapse. Abdominal pain was seen mostly in women. It was said that diarrhea occurred frequently before the start of winter. Young girls were feeling some sort of freedom from family than before.

Various organizations were helping the flood victims. Distribution of pads to the adolescent girls was also done. UNICEF was supporting for the provision of latrines and cleanliness. World vision 24 Nepal was distributing litto for the under five children. IOM was engaged in camp management. WFP distributed food. Save The Children was helping the disabled children and distributing clothes. There were also other organizations helping the victims.

Children were receiving their regular immunization. Temporary school for the children was already established.

4. Conclusion and Recommendation

4.1 Conclusion

Research on health risks at local level due to climate change and adaptive capacity in Nepal is very limited and is a key research need. Availability of data and quality of available data are major challenges for conducting the research studies on linkages between climate change and health in Nepal. However, substantial literature of other countries as well as in other fields (economic development, sustainable development, resource management) can provide insights into the likely key determinants of adaptive capacity. These experiences and action of various developing nations can help to develop appropriate preliminary strategies to curb the health problems associated with climate change in its early. The task is however not easy and requires inter-sectoral coordination and committed higher authorities. Moreover, the subsequent researches on climate change should be utilized and accordingly the policies and strategies should be reviewed for more concrete and evidence based action.

4.2 Recommended Adaptation and Mitigation Strategies

It is, thus, necessary for a developing country like Nepal to act against climate change immediately and rigorously through various adaptation and mitigation measures. Adaptation measures reduce vulnerability and increase resilience of populations that are likely to be the most affected. Public health adaptation to climate change includes public health measures, strategies and policies that offset or reduce the effects of climate change and variability on human health and well-being. Mitigation measures on the other hand aims at reducing GHG emissions that are the primary cause for human-induced climate change. The following are the recommended adaptation measures

4.2.1 Strengthening public health system

Most of the climate sensitive diseases are the current public health problems especially in developing countries and climate change is sure to complicate the situation. The maintenance of national public health infrastructure is, thus, a crucial element in determining levels of vulnerability and adaptive capacity. The 1990s witnessed the resurgence of several major climate-sensitive diseases once thought to have been controlled such as tuberculosis, diphtheria and sexually-transmitted diseases. The major causes were deteriorating public health infrastructure (especially the vaccination programme) as well as socioeconomic instability and population movement (10). Moreover, strengthening public health system has 'no regret' benefits.

Various countries including South East Asian countries such as Bhutan, Maldives and Thailand have implemented public health measures to strengthen existing health programmes that are already addressing climate-sensitive health outcomes. Bhutan, which shares similar topographical features as Nepal, have already started taking imminent measures especially strengthening public health system to adapt to the impact of climate change on human health. In Bhutan, the country aims at strengthening existing health programmes that are already addressing climate-sensitive health outcomes by 2009. These include community-based clean water supply schemes, health hygiene campaigns, integrated vector management, capacity building for emergency medical services. While promoting the concept of healthy islands and healthy buildings, Maldives envisages strengthening the capacity for healthcare delivery and medical emergency. The country will prioritize campaigns to promote better nutrition and integrated vector management. More research on climate change related diseases is also planned (11).

These public health measures in Bhutan will be considered by the Ministry of Health, RGoB, by integrating it in the next Five-Year Plan, 2008- 2013 (12).

Moreover, IPCC in its fourth assessment report have synthesized experiences from various countries and strongly suggested the strengthening public health measures as “the most important, cost-effective and urgently needed” strategy to cope the climate change impact on human health. IPCC 4th assessment report strongly outlines measures as building health systems that work well, treating people fairly and providing universal primary health care; providing adequate education, generating demand for better and more accessible services; and ensuring that there are enough staff to do the required work. Health-service infrastructure needs to be resilient to extreme events. Efforts are needed to train health professionals to understand the threats posed by climate change (4).

Similarly, WHO has emphasized the importance of strong health systems as the front-line defense from the impacts of climate change on human well-being at the Sixtieth World Health Assembly in May 2007. With support form WHO, the South East Asia Region and Pacific Region have developed a regional framework to guide regional and national action towards reducing the potential burden of disease linked to the effects of global warming and climate change. The second objective of the regional framework deals with strengthening health systems capacity to provide protection from climate-related risks, and substantially reduce health system's GHGs emissions (13).

Moreover, WHO has tried to describe adaptive actions to reduce health impacts in terms of the conventional public health categories of primary, secondary, and tertiary prevention. Primary prevention refers to an intervention implemented before there is evidence of disease or injury: avoiding hazardous exposure, removing causative risk factors or protecting individuals so that exposure to the hazard is of no consequence. For example, bed nets can be supplied to populations at risk of exposure to malaria and early warning systems (e.g. extreme heat health warnings, famine early warning) established to provide information on hazards and recommended actions to avoid or reduce risks. Primary prevention largely corresponds to anticipatory adaptation. Secondary prevention involves intervention implemented after disease has begun, but before it is symptomatic (e.g. early detection or screening), and sub- sequent treatment that averts full progression to disease. Examples include enhancing monitoring and surveillance; improving disaster response and recovery; and strengthening the public health system's ability to respond quickly to disease outbreaks. Secondary prevention is analogous to reactive adaptation.

Finally, tertiary prevention attempts to minimize the adverse effects of an already present disease or injury (e.g. better treatment of heat stroke, improved diagnosis of vector-borne diseases). As the adverse health outcome is not prevented, tertiary prevention is inherently reactive (14).

4.2.2 Awareness, capacity building and promotion of local adaptive knowledge

In addition, building capacity is an essential step in preparing adaptation strategies. Education, awareness raising and the creation of legal frameworks, institutions and an environment that enables people to take well-informed, long-term, sustainable decisions, all are needed (14).

In Bhutan, besides focusing of health system development, it has also identified obtaining stakeholder engagement through advocating and creating awareness, notably at the level of local communities, an important strategy (12). This will also help to identify the local adaptation techniques which can be applied across similar communities. A database of local adaptation techniques and coping practices is available at IPCC website ***www.ipcc.com.***

For example, in Asia, farmers have traditionally observed a number of practices to adapt to climate variability, for example intercropping, mixed cropping, agro-forestry, animal husbandry, and developing new seed varieties to cope with local climate. Various water use and conservation strategies include terracing, surface water and groundwater irrigation; and diversification in agriculture to deal with drought.

African agricultural farmers have been practicing range of agricultural practices such as intercropping and crop diversification; use of home gardens, diversification of herds and incomes, water conservation techniques.

4.2.3. Coordination and ensure integration of health impacts due to climate change into broader developmental plans and related activities

Coordination with other sectors and ensuring that health effects are given due importance is also very important. For example, coordination with other sectors such as agriculture to address the issues of food security and energy sector to deal with the problem of air pollution can help reduce their adverse health effects. Moreover, early preparedness and management by the Disaster Management Department can help prevent various epidemics and mass casualties. Among the main policy lessons emerging from experience with disasters in recent years is the importance of integrating disaster prevention and natural disaster risk management as parts of development plans, poverty reduction strategies and investment projects (15).

In Indonesia, the National Climate Change Inter-sectoral Committee is led by the Ministry of Environment, with the Ministries of Forestry, Energy, Industry, Agriculture, Health, Planning Board, Public Work and Universities as co-members. The Committee is currently incorporating health concerns and actions related to health implications from climate change into the new Five Year National Development Plan. At provincial and district levels, these concerns are being streamlined into the Healthy Cities Programmes (14).

In Nepal also, a workshop on Climate change and its effects on health was conducted by Nepal Health Research Council in support of WHO which have identified various adaptation measures to cope the current scenario. Moreover, the workshop was successful in bringing various stakeholders and policy makers at the same forum and garner commitment that health would be focused while designing the sector specific plans (16). In addition, WHO has been supporting such workshops in various South-Asian countries and foster effective coordination (13). The draft National Policy of Nepal on Climate Change has identified health as one of the most vulnerable sector and formulated some important polices and stratifies to respond it. Nepal is also preparing National Adaptation Plan of Action and may integrate the Health Aspect as a one of the major component of the Plan.

4.3 Mitigation measures

It is likely that unmitigated climate change would eventually exceed the capacity of natural and human systems to adapt, both due to increasing costs of adaptation and because adaptation cannot avoid all damages, particularly for the most vulnerable groups, consequently, reducing the rate and amount of climate change itself through reducing global GHG emissions from a vital part of protecting human health from climate change (17).

Health sector:

The regional framework has reiterated that programmes which are aimed at reducing GHG from the health sector should be established as a result of which it also serve as a best practice model for other sectors(13).

Energy and transport sector:

Energy use in house hold activities has been attributed as the highest producer of GHGs and next comes transport sector. Various countries have realized this and have taken imminent steps.

Sri Lanka is also focusing on the promotions of energy efficient technologies, incentives to public transport systems and use of railways to reduce greenhouse gas (GHG) emissions that will benefit human health in the long run.

Thailand is taking action to reduce GHG emissions in absolute terms by incorporating state-of-the-art technologies and a careful adoption of energy-efficiency measures. The specific policy instruments to reduce GHG emissions include (a) regulations; (b) fiscal incentives; (c) information; and (d) research, development and demonstration, and will contribute to health gains in terms of air quality, physical activity and reduction of road injuries (11).

Agriculture sector:

Agriculture sector also contributes to production of high amount of GHGs. Sri-Lanka is promoting intermittent irrigation in rice cultivation to reduce methane emissions from paddy fields, as well as integrated approaches to control pests so as to secure good yields and reduce the need for pesticides (11).

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