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CAPACITY STRENGTHENING IN THE LEAST DEVELOPED COUNTRIES (LDCS) FOR ADAPTATION TO CLIMATE CHANGE (CLACC)

CLIMATE CHANGE AND HEALTH IN BHUTAN

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FOREWORD

The Royal Society for Protection of Nature (RSPN) carried out this study on "Human Health and Climate Change" under the Capacity Strengthening of Least Developed Countries (LDCs) for Adaptation to Climate Change (CLACC) network. The primary objective of the study was to create awareness among health professional in Bhutan by showing some in-country review and analysis of the relationship between human health and climate change including variability and extreme weather events.

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List of Abbreviations

ARI	acute respiratory infection
RGoB	Royal Government of Bhutan
CLACC	Capacity Strengthening in LDCs on adaptation on climate change
COP	Conference of Parties
GHGs	Greenhouse Gases
GLOF	Glacial lake outburst flood
IIED	International Institute for Environment and Development
LDCs	Least developed countries
MDGs	Millennium Development Goals
MOH	Ministry of Health
NAPA	National Adaptation Programmes of Action
PEAP	Poverty Eradication Action Plan
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation

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Section I

1 Introduction

1.1 Country situation

The Kingdom of Bhutan is situated in South Asia which has one-fifth of the world's population, and is sandwiched between the world's most populous countries – India and China. The terrain is among the most rugged and mountainous in the world. The Himalayas form a formidable natural boundary in the north and the plains of India border the southern part of the country.

The resident population of Bhutan is 634,982 (RGoB 2005). It covers an area of approximately 38,394 square kilometres with a maximum longitudinal distance of 330 kilometres and a latitudinal distance of 180 kilometres.

Bhutan can be divided into three major areas: the southern foothills, the inner Himalayas and higher Himalayas with elevation stretching from 100 meters above sea level in the southern foothills to over 7,550 meters in the north. Bhutan today is seen as a model for proactive conservation initiatives and has received international acclaim for its commitment to the maintenance of its biodiversity. This is reflected in the decision to maintain at least sixty percent of the land area under forest cover, to designate more than a quarter of its territory as national parks, reserves and other protected areas, and most recently to identify a further 9% of land area as biodiversity corridors. Currently, 72.5% of the total land area is forested and protected areas make up 28% of the total land with 9% designated as Biological Corridors. Only 7.8% of the land area is used for agriculture.

1.2 Climate

Bhutan's climate is influenced mainly by the monsoon, which blows in from the Bay of Bengal, local topography and the variation in elevation as one move from south to the north. In general, it has three distinct climatic zones corresponding broadly to the three main geographical divisions: the southern foothills; the inner Himalayas; and higher Himalayas.

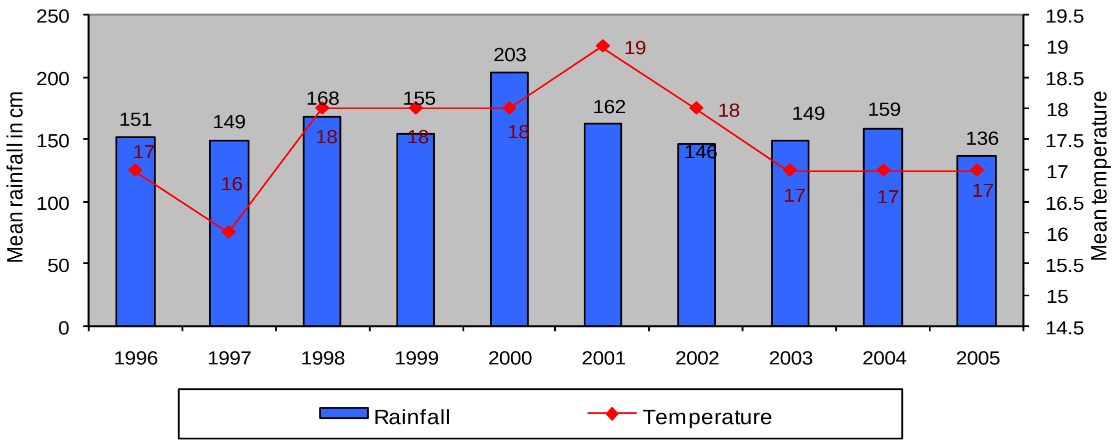
While southern Bhutan is generally hot and humid with temperatures ranging from 15-30 degrees Celsius and rainfall between 2,500 and 5,000 millimetres. The central inner Himalayas have a cool, temperature climate, with annual average rainfall of about 1,000 millimetres, while the inner Himalayan Mountain in the northern borders of the country experience severe alpine climate and are under perpetual snow. However, the climate can vary considerably between the valleys and within the valleys depending on levels of altitude and aspects. Rainfall in particular can differ considerably within relatively short distances due to rain shadow effect.

Analysis of the month-wise annual profile of surface air temperature (maximum, minimum and mean) of Bhutan for last ten years (1996-2005) indicates a wide range of seasonal and spatial variation of temperature. The highest temperature recorded was 34.85 °C measured in the month of May in Chukha district and the lowest was -11.5 °C measured in Gasa in June 2000. The highest rainfall was recorded in August 2000 in Dagana. However, the frequency distribution indicates that less than 85% of the rainfall measurements were below 300 cm and only 5% above 1000 cm (Figure 1).

Table 1: Descriptive meteorological statistics for the period 1996-2005.

	N	Minimum	Maximum	Mean	
Max temp	2328	4.37	**34.85**	22.17	
Min temp	2328	**-11.50**	31.13	13.00	
Av temp	2328	-.47	32.27	**17.58**	
Rainfall	2329	.00	**5684.00**	157.86	

Figure 1: Comparative table showing annual mean temperature and rainfall.



1.3 Health systems

Modern medical care in Bhutan began in the early 1960s. Since then the Royal Government (RGoB) has been providing free health care services and it has been the national health policy to provide an integrated, equitable, cost effective and well balanced health services to all Bhutanese.

Following the WHO's Alma-Ata Declaration (WHO/UNICEF 1978) on primary health care (PHC), RGoB chose to use PHC as its core thrust to reach the rural population scattered over the rugged mountainous terrain of Bhutan. Therefore Bhutan has committed itself to the ideals of 'Health For All'.

Today, four and half decades after the establishment of first health centre in Langjophakha, Thimphu, there are 29 hospitals providing both allopathic and indigenous modern medical care, 176 Basic Health Units (BHUs) and 476 Outreach Clinics (ORC) spread over 203 gewogs providing primary health care services.

Staffing these facilities, there are about 143 medical doctors, 598 health workers, 395 nurses, 438 technicians, 70 drungtshos and menpas (Indigenous Physicians). Apart from these regular service providers, there are 1200 active village health volunteer workers (VHWs) continuously assisting the health workers in delivering the health care services. Currently, there are 1.8 doctors per 10,000 people and 14 hospital beds per 10,000 people.

1.4 Health status and trends

Since the inception of the health system in Bhutan, the primary objective has been to prevent and reduce morbidity and mortality in the population. To this end, the health system has striven to provide quality care and treatment through all stages of life – from pregnancy to delivery, childhood to adolescence, and youth to old age. At the same time, specialized interventions have been put in place to deal with the threats of malaria, leprosy and HIV/AIDS, etc.

Bhutan's resident population is 634,982 with 69.1% of the population still residing in rural areas. The Total Fertility Rate has reduced from 5.6 (1994) to 2.6 (2005), meaning that on an average a Bhutanese woman now delivers 2.6 children during her life time compared to 5.6 in mid-1990s. The rate of growth (natural increase: the difference between the number of births and deaths in a population) is 1.3 per 1000 population compared to 3.1 in 1994.

The infant mortality rate has been reduced to 40 per 1000 live birth from 70.7 per 100 live births in 1994. That means that currently 40 children out of every 1000 babies born die before reaching age one (Office of the Census Commissioner 2005), while in 1994 70.7 children died per 1000 live births.

Hygiene and Sanitation

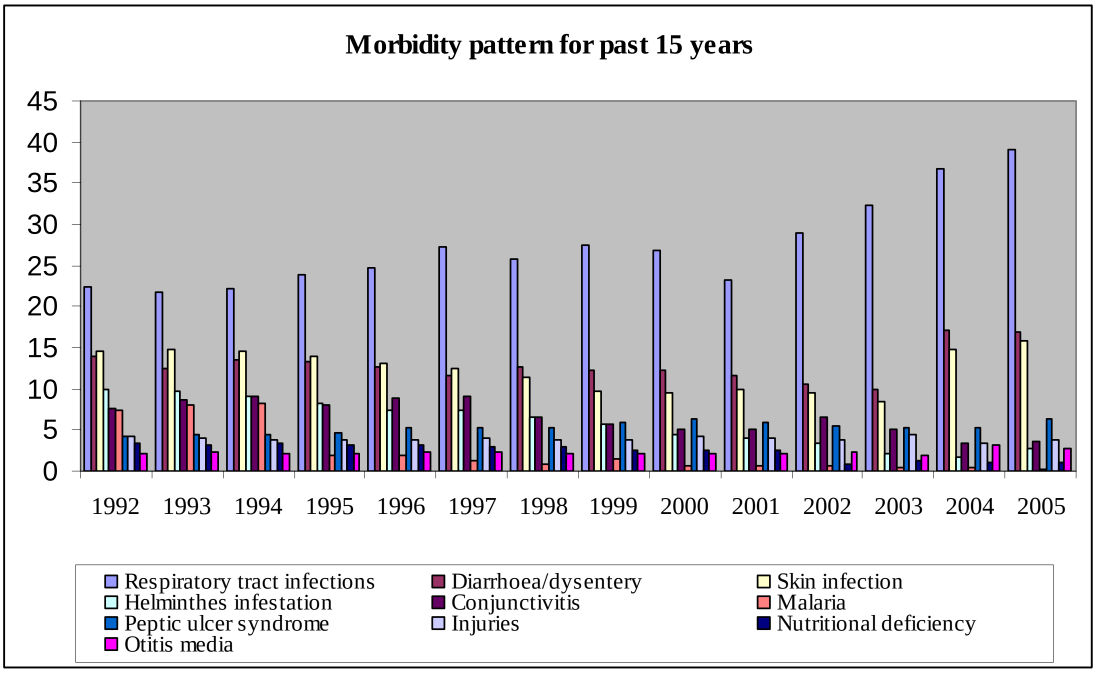
Access to safe drinking water in the community is important parameter as there is a high association between safe drinking water, hygiene, sanitation and morbidity.

The underlying causes of most diseases are related to water and sanitation (diarrhoea, skin diseases, acute respiratory infection, etc). Currently, 84% of the households drink from piped water either within the house (22.7%) or piped water outside the house (61.5%). In terms of sanitation, only 10% of the houses do not have toilet facilities; 90% have either independent flush toilets or pit latrines (Office of the Census Commissioner 2005).

Trends in leading cause of morbidity.

The Health Information and Management System (HMIS), Ministry of Health, currently enumerate a total of 89 diseases as a major cause of morbidity. The overall picture of morbidity as reported from hospitals and BHUs have maintained the same pattern over the years in which acute respiratory infection (ARI) and diarrhoeal diseases lead in the ten most common diseases in the country (Figure 2). Following this, skin infection, viral and/or bacterial intestinal infections, gastritis & peptic ulcer, conjunctivitis, malaria and other infectious diseases are most prevalent. ARI alone contributes to an average 20-25% of the morbidity cases followed by diarrhoeal diseases contributing to another 10-15 % of the morbidity cases. The top three diseases alone contribute to 40-50% of the overall morbidity cases in Bhutan.

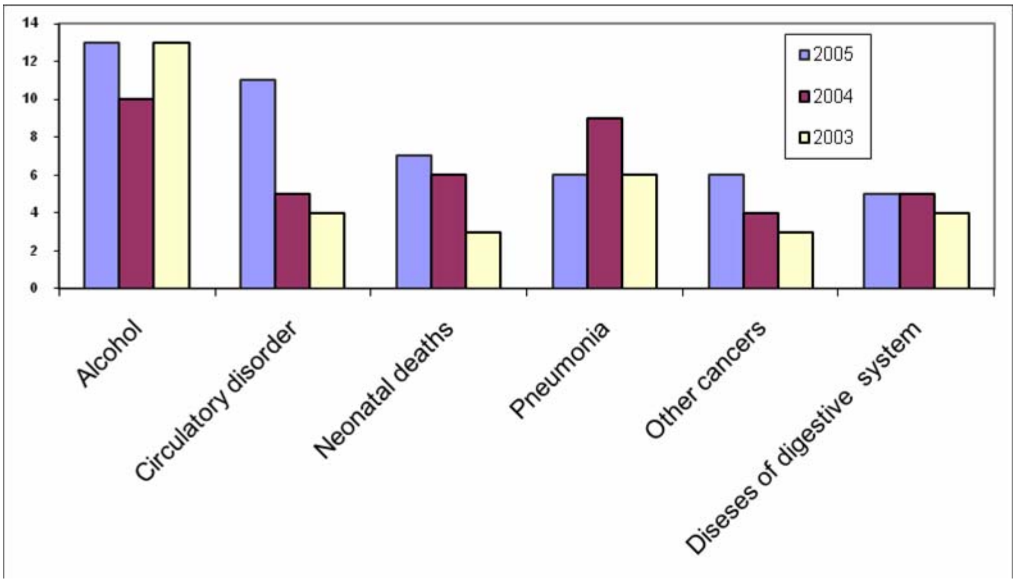
Figure 2: Morbidity pattern for past 15 years (% of total morbidity)



Mortality trends

Mortality data for Bhutan are still very limited, although routine collection of annual vital statistics has been a regular activity of health centres, the quality and coverage remains highly questionable due to various reasons like underreporting. The accuracy in the diagnosis of a disease for the underlying cause of deaths is another weak area in the mortality data being generated from different levels of health facilities.

Figure 3: Top six causes of mortality for all age groups (%)



The summary of past three years morbidity and mortality reports from health centres (Figure 3) reveal that alcohol is a leading cause of death, contributing to 10-13% of the total deaths, followed by circulatory disorders, neonatal deaths, pneumonia and diseases of digestive system. Data from death certification reporting instituted in 10 districts indicate cardiovascular disorder (18.7%) and cirrhosis of liver (7.8%) as the top two causes, contributing to 26.5% of the total deaths. Hence cardiovascular disease, cirrhosis of liver and injuries of primary unintentional are the most common causes of morality. Malignancy is another emerging cause of death, though the incidence of communicable diseases like acute respiratory infections (ARI), diarrhoeal/dysentery and tuberculosis still remain high.

Table 2: Summary of Key National Indicators (WHO data)

INDICATORS	1984	1994	2000	2005
Total Fertility Rate	*NA*	*5.6*	*4.7*	*NA*
Population Growth rate (%)	2.6	3.1	2.5	1.3
Crude Birth Rate (per 1000 live births)	39.1	39.9	34.09	20
Crude Death rate (per 1000 live births)	13.4	9.0	8.64	7
Infant Mortality Rate (per 1000 live births)	102.8	70.7	60.5	40.1
Under five Mortality Rate (per 1000 live births)	162.4	96.9	84	NA
Maternal Mortality Ratio (per 1000 live births)	7.7	3.8	2.55	NA
Malnutrition (under weight)[1]	37.9	NA	18.7	*NA*
Malnutrition (Wasting)	4.1	NA	2.6	*NA*

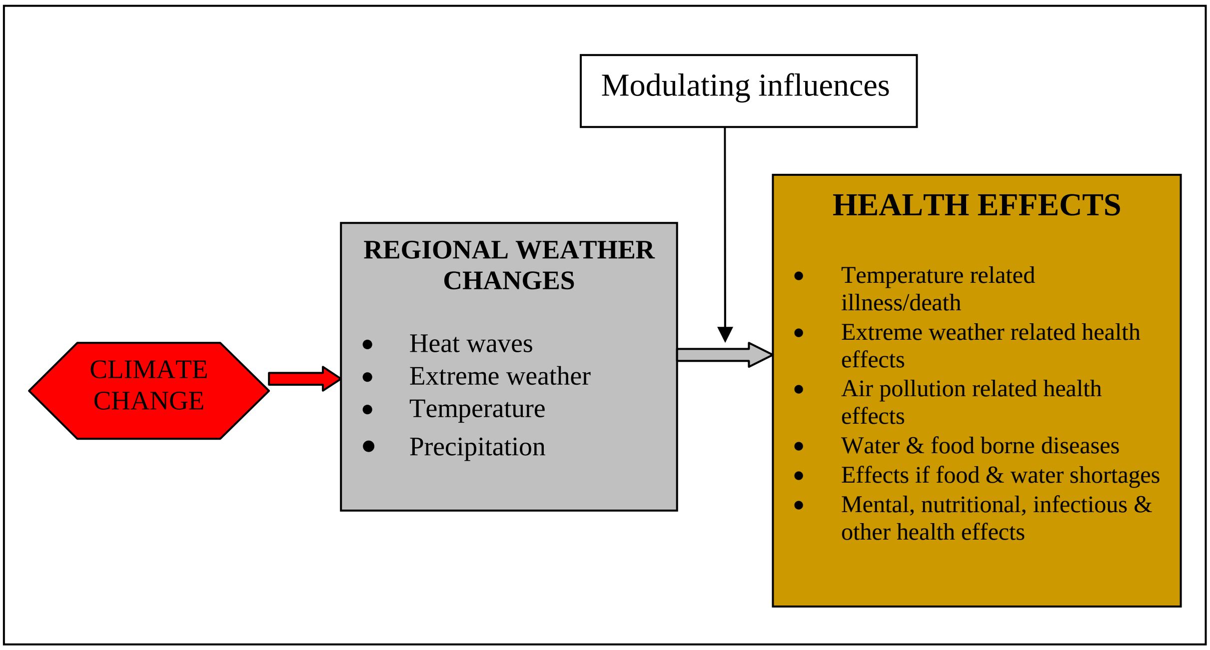
2 Potential effects of climate change on human health

Humankind's activities are altering the world climate and accelerating the "greenhouse effect" that makes the Earth habitable. It is said that most of the warming observed over the past 50 years is attributable to human activities. During the twentieth century, world average surface temperature increased by approximately 0.6 degree centigrade. The IPCC has estimated that global average temperature will rise by several degrees centigrade during this century (Watson and Core Writing Team 2001).

Change in world climate would influence the functioning of many ecosystems and their member species. Likewise, there would be impacts on human health. Some of these health impacts would be beneficial; for example, currently countries in hot regions would further increase in temperatures might reduce the viability of disease transmitting mosquito populations. However, overall, it is considered that most of the health impacts will be adverse. Figure 4 shows a conceptual framework on how climate change impacts human health.

Figure 4: Climate Change and Health: pathways by which climate change effects human health (Modified from McMichael et al, 2003)

[1] National Anthropometric survey: 1999: Ministry of Health.



Similarly, the climate change related impacts on mountain ecosystem could be caused by creating favourable conditions for disease vectors (mosquitoes), forest fires, avalanches, heavy snowfalls, major storms, floods, and drought; depth and duration of snow cover and length of snow free season; and changes in cloud cover and sunlight available. Thus climate change may have the following effects on health:

- Higher morbidity and mortality from extreme weather and climate events. Four types of floods are common in tropical Asia: riverine floods, flash floods, glacial lake outburst floods (GLOF) and breached landslide-dam floods. Flash floods are common in the foothill, mountain borderlands, and steep coastal catchments.

- Expansion of insect- and rodent-borne diseases: Many vector borne diseases are sensitive to ambient temperature and precipitation. Even small changes in temperature and precipitation, or in vegetation, host populations, or water availability, may increase or decrease the distribution and abundance of vectors, especially at the margins of their distribution, thus potentially changing their range.

- Increased water-related diseases: Diarrhoeal diseases are one of the major causes of morbidity and mortality in developing countries. In 2002, worldwide, diarrhoeal diseases caused 1 767 000 deaths. The World Health Report 2002 (World Health Organization 2002) estimates that climate change to be responsible in 2000 for approximately 2.4% of world wide diarrhoea, and 6% of malaria.

Weather has a profound effect on human health and well being including morbidity, short term changes in mood, emotional well-being, and aberrations from normal behaviour. It is also well known that weather is associated with birth rates, outbreaks of vector and food borne diseases, influenza, bronchitis etc.

Table 3: The known effects of weather and climate on human health.

HEALTH OUTCOMES	KNOWN EFFETS OF WEATHER & CLIMATE

Cardiovascular respiratory mortality & heat stroke mortality	▪ Short-term increase in mortality during heat waves ▪ Deaths from heat stroke increase during heat waves
Allergic rhinitis	▪ Weather affects the distribution, seasonality and production of aeroallergens
Respiratory & cardiovascular disease & mortality	▪ Weather affects concentration of harmful air pollutants
Deaths & injuries	▪ Flooding disrupts water supply & sanitation systems& may damage transport systems and health care infrastructures ▪ Floods may provide breeding sites for mosquito vectors & lead to outbreaks of disease ▪ Floods may increase post-traumatic stress disorders
Starvation, malnutrition & diarrhoeal & respiratory diseases	▪ Droughts reduces water availability for hygiene ▪ Drought increases the risk of forest fires ▪ Drought reduces food availability in population that are highly dependent on household agriculture productivity & /or economically weak.
Mosquito, tick-borne disease & rodent-borne disease (such as malaria, dengue, tick-borne encephalitis)	▪ High temperature shortens the development time of pathogens in vectors & increases the potential transmission to humans ▪ Each vector species has specific climatic conditions (temp/humidity) necessary to be sufficiently abundant to maintain transmission.
Malnutrition & undernutrition	▪ Climate change may decrease food supplies (crop yield & fish stocks0 or access to food supplies.
Waterborne & food borne disease	▪ Survival of disease-causing organism is related to temperature ▪ Climate conditions affects water availability & quality ▪ Extreme rainfall affects the transport of disease – causing organism into the water supply.

Climate change will affect health in countries in ways consistent with existing burdens of disease. Because of this, it is important to understand general demographic, health system, and mortality specifics of a country. Below in Table 4, are some selected indicators for Bhutan, which may be relevant to current and future magnitudes of the health impacts of climate change in the country.

Table 4: **Selected demographic, health system, and mortality indicators for Bhutan**

Indicator	Metric

Environment and public health workers density (per 10 000 population)	<1.0[A]
General government expenditure on health as percentage of total government expenditure	6.5[B]
Population with sustainable access to improved drinking water	
sources (%) Total	81
(%) Urban	98
(%) Rural	79
Population with sustainable access to improved sanitation	
(%) Total	52
(%) Urban	71
(%) Rural	50

All metrics from 2006 unless superscript: A= 2007, B=2005, C=2000, D=1999
Source: WHOSIS. http://www.who.int/whosis/data/Search.jsp

2.1 Direct effects of climate change on human health

Impacts that are directly related to weather or climate such as deaths due to thermal stress; hypothermia and heat stroke, death/injury in floods, storms and drought are considered as direct effects of climate/weather. Over the years, Bhutan has witnessed several Glacial Lake Outburst Floods (GLOF), flash floods and landslides that have washed away homes, paddy fields, damaged vital infrastructures and have resulted in deaths and these events could be related to climate or weather change.

Glacial Lake Outburst Floods in Bhutan

There are an estimated 2,674 glacial lakes with an area of 106.80 sq km out of which 24 lakes as potentially dangerous based on the condition of lakes, dams, associated mother glaciers and topographic features around the lake[2].

Table 5: Tabulation of major GLOF occurrence:

Year	*Cause*	*Impacts*	*Health Impacts*
Before 1950	Not known	There is no information, but a large number of missing end moraines in many of the glaciers in the high Himalayas of Bhutan indicate that GLOF events had taken place in the past.	Not known
1957	Bursting of Tarina lake	This GLOF event effected the Punakha-Wangdue valley, which destroyed part of Punakha Dzong.	Not known
1960	Bursting of some lakes in eastern Lunana	The flood destroyed part of Punakha Dzong. The flood is said to have lasted for 5 days.	Not known
1994 (7th October 1994)	Partial burst of Lugge lake	From a survey conducted on 20-23 Oct 1994, it was found that 17 lives were lost, 91 households were effected, 12 houses damaged, 5 water mills washed away, 816 acres of dray land 965 acres of pasture land were either washed away or covered with sand and silt, 16 yaks were carried away, 36 cowsheds and a full year's manure washed away, 6 tonnes of food grains lost, 2838 pieces of wooden shingles and 68 wooden beams washed away, 4 bridges washed away, 2 chortens destroyed and the temple at Tsojug was badly damaged.	**17 lives lost.** (Even here the health effects related to loss of food production, economic losses, diseases incidences related to safe drinking water, hygiene, sanitation, malnutrition etc were not assessed)
NAPA document warns the potential danger of Raphstreng and Thorthormi glaciers and lakes by 2010. The combination of these two lakes could result in a flow of over 53 million cubic meters of water that is more than twice the volume of 1994 GLOF.			

Flash floods and landslides and their impacts in Bhutan

Flash floods and landslides are common during the monsoon period extending from May to August. Records show that all districts are vulnerable and since 1996 about 100 hundred lives have been lost and damages worth in millions have been caused by sporadic flash floods and landslides. The 7th August, 1993 monsoon flooding in Samtse have been estimated to cause about Nu.60 million in damages mainly to Peden Cement Authority Limited (PCAL). Tala project estimates Nu.450 million in damages caused by monsoon flood in August 2000. Royal Insurance Corporation paid a record insurance

[2] Karma Chhophel, Flash floods & debris flow due to glacial lake outburst flods, Hydro-met services Division, Dept. of Energy

claim of Nu.214.5 million in 2000. Monsoon flooding in September 2000 caused an estimated damage of Nu.40million in Phuntsholing, Gelephu, Samtse and Samdrupjonkhar.

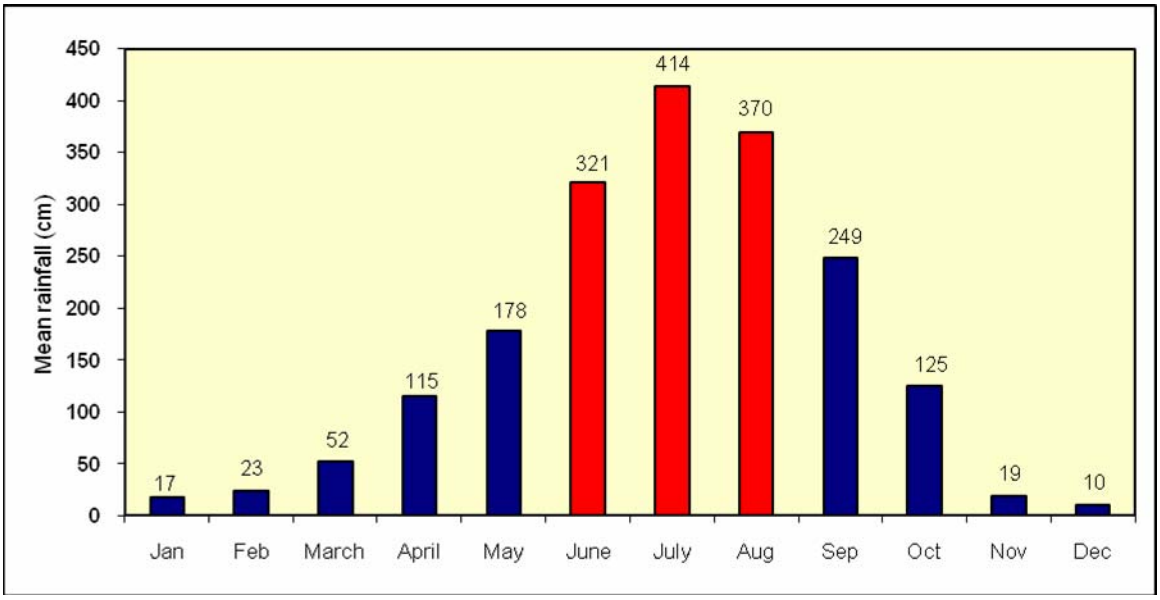
The eastern floods and landslides between July and August 2004 claimed 9 lives. A total of about 657 houses were either fully or partially damaged and a total of 161 acres of wetland and 503 acres of dry land was washed away. 350mt.of maize, 126 mt. of paddy, 2000 oranges trees and 2mt. of potatoes were lost affecting about 1437 households (National Environment Commission 2006).

Except for the number of deaths, other information on health and nutrition are not available. In natural calamities, there would be direct effect of the calamities such as mortality and injuries. Then, there would be outbreaks of diseases due to disruption of basic amenities like safe drinking water, health services (in terms of drug availability, damage to health centres, transportation and communication difficulty), loss of shelter and due to difficulty in maintaining basic hygiene and sanitation. Some of the common diseases targeted for prevention in such events are diarrhoeal diseases, acute respiratory infections, typhoid fever, worm infestation, scabies, tuberculosis, sexually transmitted diseases, cholera, meningitis and vector borne diseases such as malaria, dengue, Japanese encephalitis etc. The loss of food grains and arable land//paddy fields can immediately cause severe malnutrition and undernourished population is more susceptible to diseases.

Table 6: List of major flash floods and landslides with reported mortality.

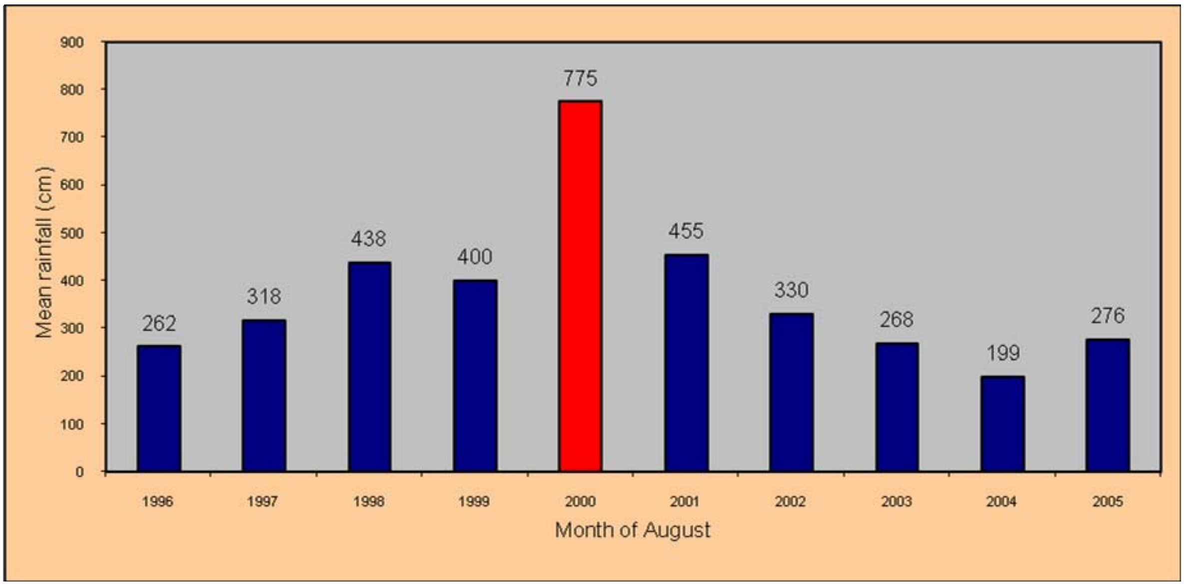
Sl.No	Year	Place	Type	Mortality
1	July 1993	Genju, Chukha	Monsoon Flooding	2 people killed.
2	August 1993	Samtse	Monsoon flooding	-
3	August 1993	Paro	Flashflood	4 people killed
4	September 1990s	Trashiyangtse	Flood	5 people killed
5	August 2000	Pasakha, Phuntsholing	Flood	43 missing, 400 families homeless
6	August 2000	Several dzongkhags	Monsoon floods	5 people killed
7	August 2000	Samtse	Monsoon floods	5 people killed
8	August 2000	Tala, Chukha	Landslide	6 people killed
9	August 2002	Tsirang	Landslide	2 people killed
10	May 2003	Phuntsholing	Landslide	2 people killed
11	August 2004	Phongmey	Flash flood	4 children killed
12	July 2004	Trashigang	Flash flood and landslide	3 people killed

Figure 5: Monthly mean rainfall between 1996-2005.



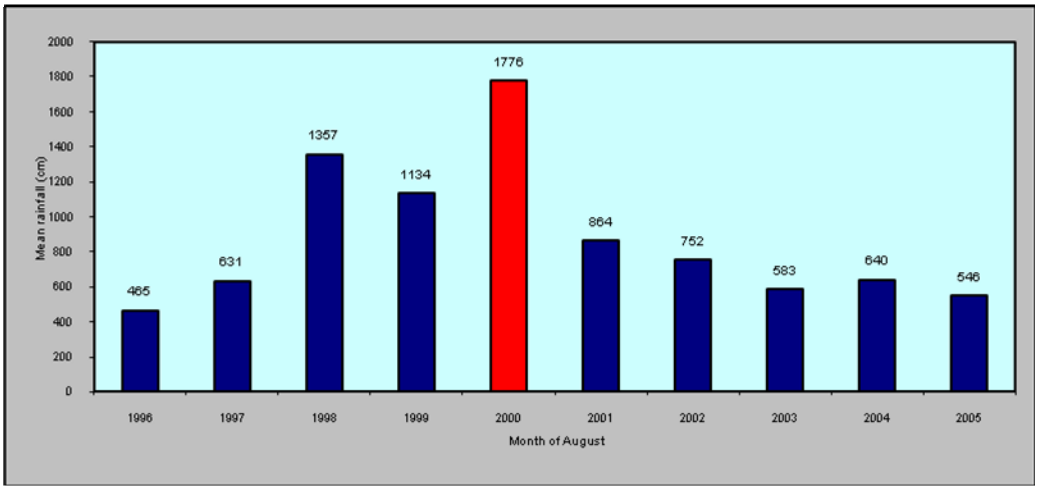
The highest rainfall occurs during the month of June, July and August, with almost two times the increase in the level of rainfall and it is during this three months (see table 6) that all major flash floods and landslides have occurred in Bhutan.

Figure 6: Mean rainfall for the month of August for ten years (1996-2005).



From table 6, the maximum flash flood and landslides occurred in August 2000. There were 4 major reported incidences of floods and landslides with total 16 deaths, 43 missing and 400 families made homeless. A simple tabulation of mean rainfall for the month of August for last ten years shows that, August 2000 saw the maximum mean rainfall of 775 cm which is almost two times the measurement of corresponding years for the same month. August 2000 saw a major flash flood in Pasakha and a landslide in Tala both in Chukha district (see table 6).

Figure 7: Rainfall for the months of August for Chukha district.



2.2 Indirect effects of climate change on human health

The health consequences of various processes of environmental change and ecological disruption that occur in response to climate change, e.g., change in the range and intensity of infectious disease, food– and water-borne diseases, changes in the prevalence of diseases associated with air pollutants and aeroallergens. Impacts resulting from consequences of climate induced economic dislocation, environmental decline, and conflict.

Food yield and nutritional status

There are many social, economic, and environmental influences on agricultural, horticultural, and livestock productivity. However, climate change represents an additional pressure on the food supply system as background climate and annual weather patterns are key factors in agricultural productivity as it effects the plant physiology, soil nutrition, pattern and risk of plant pests and pathogens etc.

In Bhutan, information relating to climate change and agriculture and livestock productivity is not available. However studies have been conducted on food insecurity and nutritional status of the population. In a 2001 national poverty assessment and analysis, 63 out of 224 responding *geogs* and towns reported food insecurity. Earlier food security assessment conducted by FAO and RGoB in 1993 showed high incidence of chronic and transitory food insecurity in several parts of the country and identified nine districts as food-insecure, virtually all in southern or eastern Bhutan. The report attributed food insecurity in southern Bhutan to climatic conditions there that make it difficult to successfully store grains and cereals for any length of time, as well as to pests consuming stored grains.

Food yield, types, storage and utilization has a direct implication on human health and well being which can be measured in nutritional status of the population. Though the percentage of children underweight (weight for age) has improved during the last ten years, a large proportion of children (40%) are still stunted according to the national anthropometric study conducted in 1999 (Ministry of Health 1999). This may be an indication that still a considerable number of children are experiencing a long-term malnutrition, possibly related to infection, care and inadequate food both in terms of quality and quantity at the household level. It is also important to note that decreases in food production and increases in food prices associated with climate change would increase the number of undernourished people.

The prevalence of wasting is less than 2% indicating that severe malnutrition conditions do not exist in the country which also means that there is no acute shortage of food supply. However, high prevalence of stunting and underweight do indicate that there is a persistent under nutrition in the population and climate change may play a part in this.

Table 7: Nutrition status of the children under-five in Bhutan (%).

Year	1988	1999
Weight for age (under weight)	38	17
Height for age (stunted)	56	40
Weight for height (wasted)	4.1	2.6

Infectious disease.

Climate plays a role in the transmission of many infectious disease and some of them are among the most important cause of mortality and morbidity in developing countries (Table 8). The natural transmission of these diseases is complex and usually involves birds, rodents and mosquito species. Epidemics of these diseases occurs when their natural habitat/ecology is disturbed in some way. This includes environmental changes such as metrological changes, forest clearing, changes in population densities etc. But it is difficult to know the exact influence of climatic factors on their distribution and incidence because of the complexities of their transmission cycles in nature.

Particularly for Bhutan, there is a lack of data on these diseases as well as on the metrological data to make any meaningful analysis. However, in this report we will make a descriptive presentation of dengue, encephalitis, airborne environmental pollutants/ asthma, diarrhoeal diseases (cholera) and malaria. These are some of the diseases of public health concern in Bhutan.

Table 8: List of selected common communicable diseases and sensitivity to climate

Disease	**Transmission**	**Climate - epidemic link**
Diarrhoeal Diseases (incl. cholera)	Food and Water borne transmission	++
Cholera (see diarrhoeal diseases)	Food and Water borne transmission	++++
Influenza	Air-borne transmission	++
Malaria	Transmitted by Anopheles mosquitoes	+++++
Meningococcal meningitis	Air borne transmission	+++
Leishmaniasis	Sandflies	+++
Dengue	Female Aedes mosquitoes	+++
Japanese encephalitis	female Culex and Aedes mosquitoes	+++
Rift Valley fever	female Culex and Aedes mosquitoes	+++
West Nile virus	female Culex mosquitoes	++

++ Climate plays a moderate role, +++ Climate plays a significant role, ++++ Climate is an important factor +++++ Climate is the primary factor in determining at least some epidemics, and the strength of the association between climate and disease outbreaks has been assessed on the basis of quantitative (statistical) rather then anecdotal evidence. **Source:** Kuhn, K., D. Campbell-Lendrum, et al. (2005). Using climate to predict infectious disease epidemics. Geneva, WHO.

Dengue: Dengue is the most important emerging tropical viral disease of humans in the world today. It is estimated that there are between 50-100 million cases of dengue fever (DF) and about 500,000 cases of dengue haemorrhagic fever (DHF) each year which requires hospitalization. Over the last decade DF/DHF has become a leading cause of hospitalization and death among children in the South East Asia Region of World Health Organization (WHO), following diarrhoeal and Acute respiratory infection according to WHO.

Dengue fever is caused by one of four viruses that are transmitted by infected Aedes mosquitoes. The transmission of the disease occurs when a mosquito bites an infected person and subsequently bites an uninfected person. Symptoms include high fever, rash, muscles and joint pains but usually the disease is followed by completed recovery. In a small number of cases, dengue hemorrhagic fever may develop, which has a much higher fatality rate in children and individuals. Diagnosis is made through blood tests that scan for antibodies to dengue viruses.

Dengue and DHF outbreaks are associated with direct and indirect effects of high rainfall and with elevated temperatures and humidity (Gubler, Reiter et al. 2001) and on pathogen and vector. Hales et. al (1999) suggested a positive relationship between monthly dengue incidence and temperature and rainfall in the south pacific but Hay et al (2000) found that interannual periodicity of dengue was not matched by similar periodic cycles in temperature and rainfall in Bangkok.

In Bhutan, dengue fever was first diagnosed and reported in July 2004 when an alarming number of people reported to Phuntsholing hospital with fever and rashes. Although the mosquito vectors *Aedes. aegypti* and *Aedes. albopictus* were identified and known to exist in the southern regions this was the first time that the disease was suspected and investigated. Blood samples from clinically diagnosed cases were sent for dengue serology to Bangkok and Kolkata to confirm the diagnosis. A total of 2616 and 2547 (68 are confirmed cases) suspected dengue cases were reported in 2004 and 2006 (till September 5th) respectively. Since then, dengue fever remained endemic during the monsoon period. There was no outbreak in 2004.

Table 9: Reported Dengue fever outbreak in Phuntsholing

Month	**Year**	
	2004	**2006**
July	2471	1255
August	125	1273
September (1-5th only)	19	19
October	1	
	2616	2547

Ae. aegypti is a mosquito that is domesticated and breeds in and around human dwellings; in flower pots, water storage jars, cisterns, metal cans, discarded tyres, and any other fresh water containers that people leave standing. The mosquito thrives in areas of high rainfall and where people often provide water containers for breeding. However it does not stand freezing weather and thus it is limited to tropical and subtropical regions. The two aspects of global warming (i.e. warming is expected to be more in temperate zones than in the tropics and secondly the warming is expected to be more marked at night than during the day) is particularly favourable to *Ae. aegypti* because it is the freezing which occurs at night that is most deleterious to the mosquito.

Ae. albopictus is another mosquito (vector) widely distributed in Asia. This species has evolved in its more northerly distribution in Asia that it withstands freezing. A shortened period of sunlight causes diapause, a physiological state of the egg that makes the egg resist cold temperature and delays hatching until spring. Thus mosquito survives freezing.

Source: Shope, R.E. 192. Impacts of global climate change on human health: Spread of infectious disease.

Encephalitis:
A significant number of encephalitis cases has been reported from various hospitals around the country. The majority of them are caused by viruses and it is suspected that Japanese Encephalitis (JE) might be one of significant ones. With frequent outbreaks occurring in neighbouring states of India it is evident that the disease exists in Bhutan too. However, due to limited facilities for isolating the virus or carrying out serological tests it could not be confirmed. Therefore all the cases are reported as viral encephalitis. Since the epidemiology of the disease involves vectors and secondary hosts, it is relevant to discuss this as an emerging concern and like other vector borne disease, its transmission to humans is dependent on the climate.

Japanese encephalitis: The virus causing JE is transmitted by mosquitoes belonging to the genus Culex (species *C. tritaeniorhynchus and C. Vishnu).* The diseases (virus) is transmitted by Culex mosquitoes among water birds, with pigs as amplifying reservoirs, and human as dead-end hosts. JE distribution is very significantly linked to irrigated rice production combined with pigs, in that the virus reproduce in pigs and infects mosquitoes that take blood meals. The virus then spills over into human population when infected mosquito population builds up and the human biting rate increases. JE epidemics are highly seasonal, occurring during monsoon season when temperature reach 30 degree centigrade or above (Mellor and Leake 2000) and in India the JE cases peaked as temperature and rainfall increased (Rao, Misra et al. 2000) where as in China the epidemics was associated with particular phases of the rice cultivation cycle (Okuno, Tseng et al. 1975).

Therefore, Bhutan with rice cultivation as a major agricultural practice and the existence of pigs as backyard live stock in all rural communities, the risk for JE incidence is very high. In humans, JE virus infections are mild but approximately 1 in 200 infections results in severe disease characterized by rapid onset of fever, headache, neck stiffness, disorientation, coma, seizures, spastic paralysis and deaths. The case fatality rate can be as high as 60% among those with disease symptoms.

Air Pollution and Respiratory infection

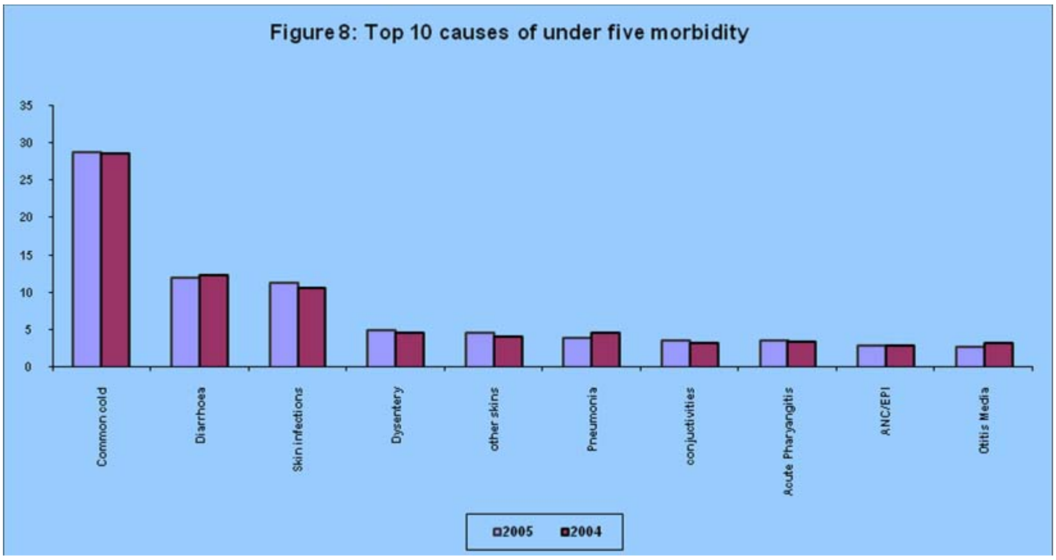
Weather conditions influence air quality through transport and/or formation of pollutants. Weather condition can also influence air pollutant emission, both biogenic emissions (such as pollen production) and anthropogenic emissions (such as caused by increased energy demand). Subsequently exposure to airborne allergens and chemicals can have many serious health effects namely respiratory disease-inflammation in the nose and in the lung and lung inflammation is often expressed as asthma. The obvious sources of air pollution are, burning of fossil fuels, the cutting of forests and burning of slash, the increasing use of agricultural and industrial chemicals, vehicle emissions, the creation of indoor working environments with poor ventilations.

The link between aeroallergens and allergic diseases such as asthma are well established (Burge and Rogers 2000; Nolte, Backer et al. 2001) and climate change may result in faster plant growth, earlier plant maturity, longer growing seasons, earlier pollen season, increased season duration, increases in both pollen quantity and ability to cause allergic conditions. Therefore increase in pollen quantity and extended pollen seasons due to climate change may contribute to the overall increase in asthma morbidity and severity. A study conducted in northern and southern Finland showed that environmental factors have a substantial effect on respiratory symptoms. In United States hospitalization has increased by 50% over the past 20 years and deaths from asthma have increased to more than 5000 per year.

In Bhutan, anecdotal data from medical doctors' indicate increased number of asthmatic cases every year and it is suspected that changes in the environment due to rapid urbanization and climatic changes could be relevant factors. The rapid increase in vehicle numbers and emissions from them (exhaust chemicals offer a number of pathogenic possibilities like carbon monoxide, nitrogen dioxide, benzene, formaldehyde etc) and smoke from Bukhari in urban areas could be possible factors, while indoor cooking/ firewood with poor ventilation are another possible factor for people residing in rural areas. Warming is like to further cause an earlier onset and may extend duration of flowering and pollen season for some species and pollens may exacerbate allergic rhinitis, asthma and other atopic disease. Subtle changes in the climate may also affect the lifecycle of minute arthropods (dust mites), influence construction and cleaning practices, all of which are common etiological factors for asthma.

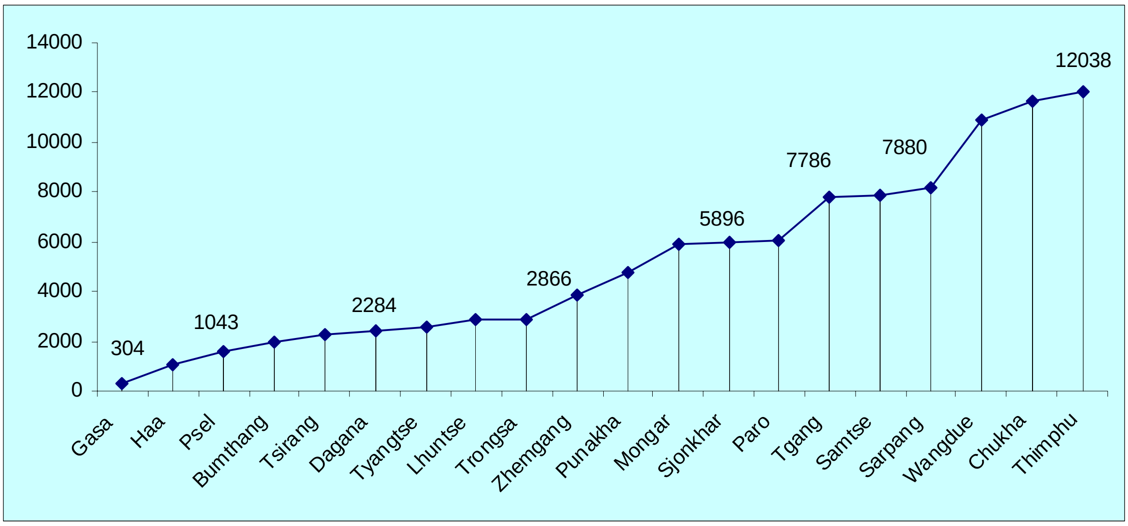
Diarrhoeal Diseases

A number of infectious diseases are sensitive to either temperature or rainfall indicating seasonal variation. Diarrhoeal diseases are known to peak during the hottest months of the year and this is true for *Salmonella* infections in Europe and for *Shigella* infections in south Asia. Climate change could influence water resources and sanitation either due to flooding (melting of snows and heavy rainfall) or due to drought. Lack of safe water supplies is an important factor in diarrhoeal diseases. The World Health Report 2002 (World Health Organization 2002) estimated that in 2000, climate change was responsible for approximately 2.4% of world wide diarrhoeal cases, and 6% of malaria in some middle-income countries.



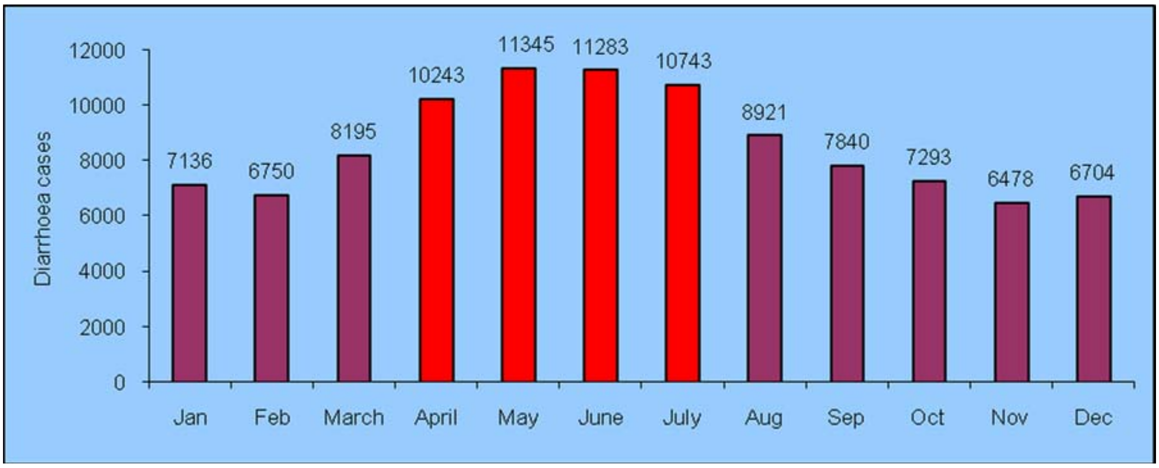
In Bhutan, diarrhoeal disease continues to be a major problem affecting the survival of the children in this country. Diarrhoeal disease has remained one of the top three causes of morbidity in Bhutan for last one decade and contributes to about 10-15% of the morbidity cases.

Figure 9: Cumulative annual diarrhoeal incidence for three years (2003-2005)



Thimphu reported the highest diarrhoeal cases because it has a large catchment area and functions as central referral point.

Figure 10: Monthly diarrhoeal cases for three years (2003-2005)



There is a gradual increase in the diarrhoeal episodes from the month of April to June and then the trend line goes down.

Section II

3 Case study: Malaria and climate change

Vector borne diseases, because of the dependence of the vectors and pathogens on climatic factors, are expected to change in distribution and intensity. Malaria is a vector-borne disease that is considered to be most sensitive to long term environmental change (World Health Organization 1999). The three main factors that affect malaria are temperature, rainfall and relative humidity and studies from Zimbabwe, Rawanda and Ethopia have demonstrated sensitivity of malaria to climate variations change (McMichael and Haines 1997). Van der Hoek et al (1997) correlated monthly rainfall and monthly malarial incidence in Kekirawa (Sri Lanka).

However, of the three climatic factors, temperature and rainfall are the most important on the transmission cycle of malaria (Pampana 1969). Increased temperature and changed rainfall would affect the range, proliferation, and behavior of vector organism and intermediate hosts and the viability and maturation rates of the infectious agents (McMichael and Haines 1997). It is also important to note that the relationships between these climatic factors is highly complex and varies from country to country and between the different Anopheline species.

Generally rainfall influences transmission by its role in the mosquito life cycle, while temperature acts as a regulatory force. Rainfall is largely responsible for creating the conditions which allow sufficient surface water for mosquito to breed. Increased rainfall may flush out breeding sites and actually reduce the mosquito populations. In other areas where mosquitoes breed in small puddles or pools, increased rainfall may provide breeding sites and therefore increase mosquito populations and is therefore, recognized as one of the major factors influencing malaria transmission.

Temperature also plays an important role in the variability of malaria transmission by regulating the development rate of mosquito larvae and influencing the survival rate of adult mosquitoes. Mosquitoes generally develop faster and feed earlier in their life cycle and at a higher frequency in warmer conditions. In addition, the Plasmodium parasite multiplies more rapidly in the mosquito in higher temperatures. The minimum temperature for mosquito development is between 8-10 degrees Celsius, and the minimum temperature for parasite development are between 15 degree Celsius for vivax and 19 degrees Celsius for falciparum. The optimum temperature for Anopheles vector species is 20-30 degrees Celsius and the maximum temperature for both vectors and parasites is 40 degrees Celsius (Bhattacharya, Sharma et al. 2006). Therefore an increased rainfall and higher temperatures may provide more breeding pools for mosquitoes and can quicken the development of mosquito larvae into adults.

3.1 Global burden of Malaria

Human malaria is caused by one or a combination of four species of Plasmodia: *Plasmodium falciparum*, *P.vivax*, *P.malariae* and *P. ovale*. The disease caused by each species is different in terms of the way the species responds to drugs, behaves in the mosquito phase and behaves once inside the human (Kreier, 1980). *P falciparum* causes malignant tertian malaria, which causes more death more often than the other species. However, *P. vivax* remains in the body longer than *P. falciparum*, causing a more gradual health deterioration. Plasmodium *falciparum* and Plasmodium *vivax* are both prevalent in

Bhutan and *P. falciparum* % has remained above 30% since 1973 and has been between 30 and 60%.

Malaria is the most important vector-borne disease in the world today, causing 400-500 million new infections and one million deaths worldwide annually (WHO 1998) It is the second most fatal communicable disease and is a public health problem in 90 countries of the world, where 40% of the human population live (WHO 1998). Malaria in the South East Asia Region accounts for 30% of the global morbidity and 5% of mortality.

In addition to the human toll, malaria is considered by health economists to be one of the four most common causes of poverty. People exposed to the infection may spend as much as 25% of their household income on malaria-related expenses: travel for treatment, medicines, bed nets, laboratory examinations and funerals for family members dying of the disease. Such individuals are less productive: absenteeism from jobs and debilitation resulting in inability to perform agricultural tasks are common. Children are often forced to remain at home because of illness or because of the need to replace adults performing subsistence agriculture.

3.2 Malaria status of Bhutan.

The National Malaria Control Programme was launched in 1964 and in 2003 it was renamed as the National Vector Borne Disease Control Programme (VDCP) as the surveillance activities expanded to other vector borne diseases like Japanese encephalitis, and Dengue fever/ Dengue Hemorrhagic fever.

Over the 25-year period from 1965 to 1989, Bhutan has witnessed dramatic changes in malaria morbidity and mortality. The Annual Blood Smear Examination Rate (ABER) during the last two decades was more than the minimum prescribed level of 10%. During the same period the Annual Parasite Incidence rate (API) was between 1.5 to 140. The Slide Positivity Rate (SPR) ranged from 2 to 30% and *Plasmodium falciparum* (Pf)% over the 15 year period ranged from 11% to 60%.

Over the next 14 year period from 1990 to 2005, the ABER was maintained way above the 10% minimum prescribed level, between 16.6 and 27.8, indicating the consistency in case detection mechanism. The point of concern to the program, however, was the increase in Pf rate observation over the same period from 31.5% to 59.3% with the lowest trend at 31.5% recorded in 1995. (see table 10).

Table 10: Malaria Incidence in Bhutan from 1965 to 2005.

YEAR	BSC	T+VE	T.PF	ABER	API	SPR	PF%
1965	**10189**	**518**	**85**	**11.0**	**5.5**	**5.1**	**20.1**
1966	7148	114	20	7.1	1.5	2.0	15.5
1967	15329	405	41	7.6	2.0	2.6	11.2
1968	12913	247	26	6.4	1.2	1.9	12.3
1969	25531	672	181	12.4	3.1	2.6	28.8
1970	30886	630	147	14.0	2.9	2.0	24.5
1971	31369	720	155	14.2	3.3	2.3	22.3
1972	38703	1376	337	16.2	5.7	3.6	25.3
1973	47909	3402	1221	21.5	15.2	7.1	37.3
1974	47874	4623	2193	21.3	20.5	9.6	48.4
1975	**48170**	**7929**	**4459**	**20.7**	**33.0**	**16.5**	**56.9**
1976	47699	8035	4271	31.3	50.6	16.9	53.0
1977	33619	3328	1597	29.0	27.5	9.9	48.0
1978	39518	3483	1474	30.3	28.7	8.8	42.0
1979	41079	5375	3172	43.2	44.3	13.1	59.0
1980	45487	3933	2145	41.5	45.9	8.7	55.7
1981	48361	4522	2722	35.0	32.7	9.4	60.4
1982	51939	6328	3043	34.8	42.4	12.2	48.2
1983	42633	5213	3072	32.6	39.3	12.2	59.0
1984	62667	18368	10147	48.0	140.0	29.3	55.9
1985	**31763**	**7043**	**3951**	**24.3**	**53.9**	**22.2**	**56.3**
1986	82639	19916	10361	52.5	126.4	24.1	52.0
1987	69029	13134	6174	53.9	120.7	19.0	47.3
1988	51164	11134	5169	44.6	97.2	21.7	46.8
1989	71653	19162	8429	20.4	54.7	27.0	43.9
1990	33973	9497	4126	19	54	28	43.5
1991	67699	22126	12966	19	63	33	59.3
1992	73986	28900	13910	21	83	39	48.7
1993	80980	28392	12779	23	81	35	45.9
1994	97425	39852	15998	28	114	41	42.3
1995	83899	23195	7326	24	66	28	31.5
1996	76019	15696	6026	22	45	21	38.3
1997	68153	9029	3614	19	26	13	40.0
1998	58086	6955	3403	17	20	12	49.0
1999	79859	12591	6380	23	36	16	**51.0**
2000	76445	5935	2738	22	17	8	46
2001	65974	5982	3177	19	17	9	53
2002	74696	6511	3496	20	18	9	54
2003	61246	3806	1680	17	9	5	44
2004	54892	2670	1090	9	5	5	41
2005	60152	1825	954	14	4	3	52

Note: BSC=Blood slide Collection, T+VE= Total Positive for Malaria, TPf= Total Positivem for Plasmodium falciparum; ABER= Annual Blood Examination Rate, API= Annual Parasite Incidence, SPR= Slide Positivity Rate, Pf=Plasmodium falciparum

In the process, the VDCP has adopted a dynamic treatment regimen. The recent treatment of uncomplicated falciparum is with coartem which is the combination of arthemether and lumifantrine. This regiment has short duration of treatment providing better patient compliance.

However, following the spurt in Annual Parasite Incidence (API) and Slide Positivity Rate (SPR) in 1995, the vector control strategy was changed and two rounds of Indoor Residual Spraying (IRS) with Deltamethrine at six months interval was introduced and this was continued for three years. As a result the API decreased between 1995 and 1998 with a declining trend from 111.1 in 1994 to 20 in 1998 and SPR from 40 in 1994 to 12 in 1998 (see table 8). From 1998, IRS was phased out and replaced by Insecticide Treated Bed Net (ITBN) program which resulted in marked increased in API and SPR and Pf% reached 51% indicating that vector control strategy was not adequate enough.

However, from 1999 onwards there has been steady increase in the populations under ITBN as a result of which API and SPR was reduced by 50% in 2002 as compared to 1999. The only concern was in spite of using the ACT the Pf% remained about 54% even in 2002. Therefore in 2003 focal IRS was done in high Pf areas in the endemic areas which led to further decline in API and SPR while Annual Blood Examination Rate was adequate the blood slide collection in the health centres also showed decline indicating the transmission reduction strategy by integrated use of IRS, up scaled ITBN and vector control strategies through weekly larviciding and environmental management methods was effective. In 2004 there was improved API, SPR and even some decline in Pf% but ABER is below 10%.It was noted in the KAP study which was conducted in 2002, that net impregnation was causing skin irritation which could be deleterious to net use. To overcome this, the programme has shifted to long lasting insecticide treated bed nets where the net fabrics are already treated during manufacture.

Population at risk of malaria

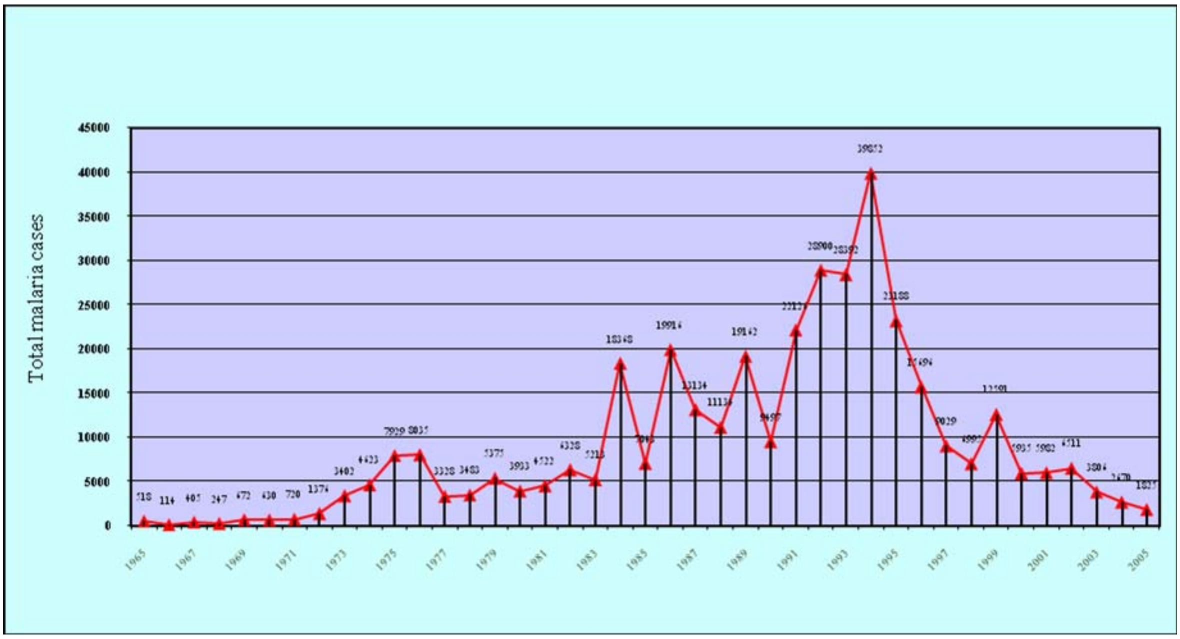
Over half the countries population, who are resident in malaria areas with varying degree of transmission intensity, are at risk of malaria. But the population living in the non malaria areas is also exposed to malaria infection due to increasing mobility of this group into the high malaria transmission localities. They are therefore at high risk of developing serious disease and are a major contributor to the high malaria mortality. People aged 15-49 years are at highest risk of malaria infection, followed by 5-14 years olds, who are about 50% less at risk of malaria then the 15-49 year olds (Ministry of Health 2001).

Epidemiological trend in malaria incidence:

Since the initiation of the malarial surveillance in 1964, the epidemiological trend in malaria incidence has been on the rise from 518 cases in 1965 to maximum 39 852 cases in 1994. Annual parasitic incidence was reported highest 140 in 1984. From 1984 to 1994, there was a progressive increase in the malaria cases (Figure 11). It was only from 1995, that the VDCP could bring the malaria cases under control and in 2005 only 1825 malarial cases were reported.

All through out the years, the Annual Blood Smear Examination Rate (ABER) was maintained above the minimum prescribed level of 10% indicating consistency in case detection mechanism.

Figure 11: Malaria case load trend from 1965-2005



Malaria endemic districts

More than 90% of the malaria cases are reported from five endemic districts of Sarpang, Samtse, Samdrupjhonkhar, Chukkha and Zhemgang. Beside, the riverine valleys of Trashigang, Trongsa, Tsirang, Dagana, Punakha, Wangdue, Pemgatsel and Thimphu have seasonal transmission. From the endemic districts, Sarpang and Samdrupjonkhat district together contributes to more than 50% of the overall malarias cases in Bhutan (Table 11) followed by Samtse and Samdrupjhonkar. Less than 5% of the malaria cases are contributed by other 15 non endemic districts.

Table 11: Comparative malaria case load (%) in five endemic Dzongkhags

Dzongkhag	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Sarpang	43	51	49	36	34	36
S/Jongkhar	34	26	23	18	14	28
Samtse	8	14	17	28	38	19
Chukha	4	3	5	12	7	6
Zhemgang	5	2	1	1	1	2
Other districts	6	4	5	5	6	9
	100	100	100	100	100	100

Figure 12: Total malaria cases reported from five endemic districts in ten years (1996-2005)

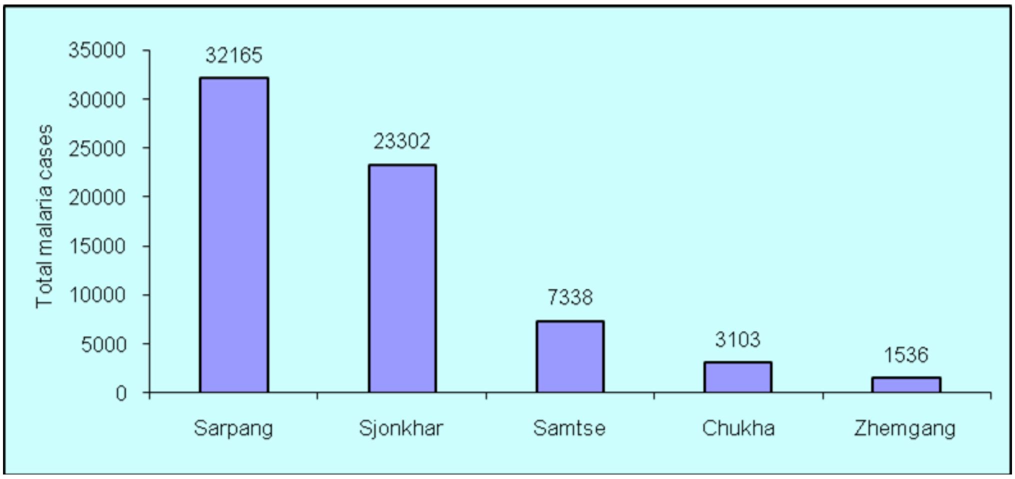
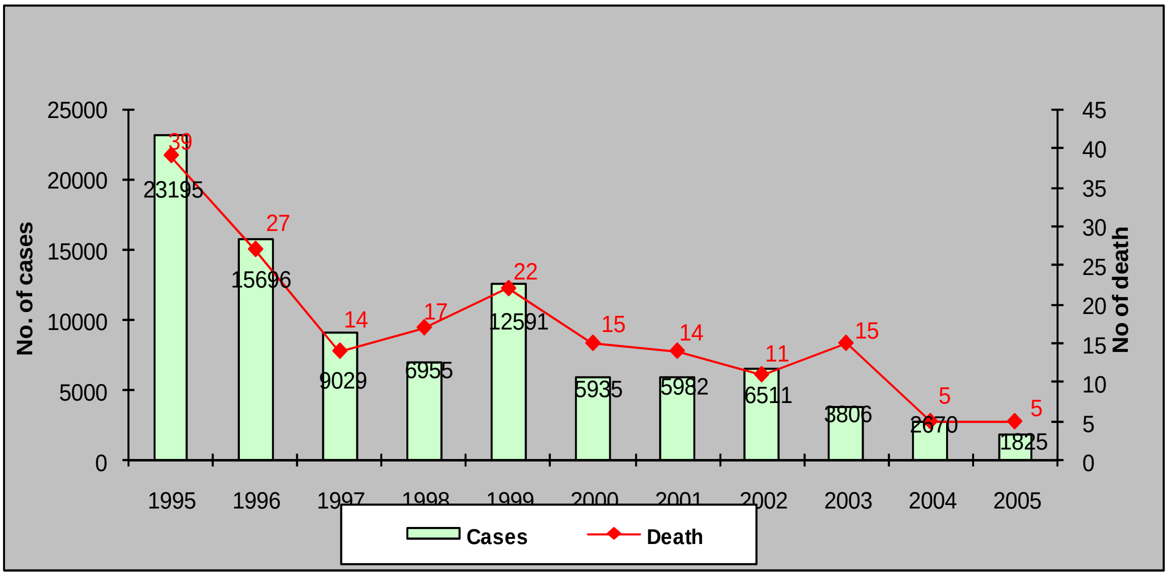


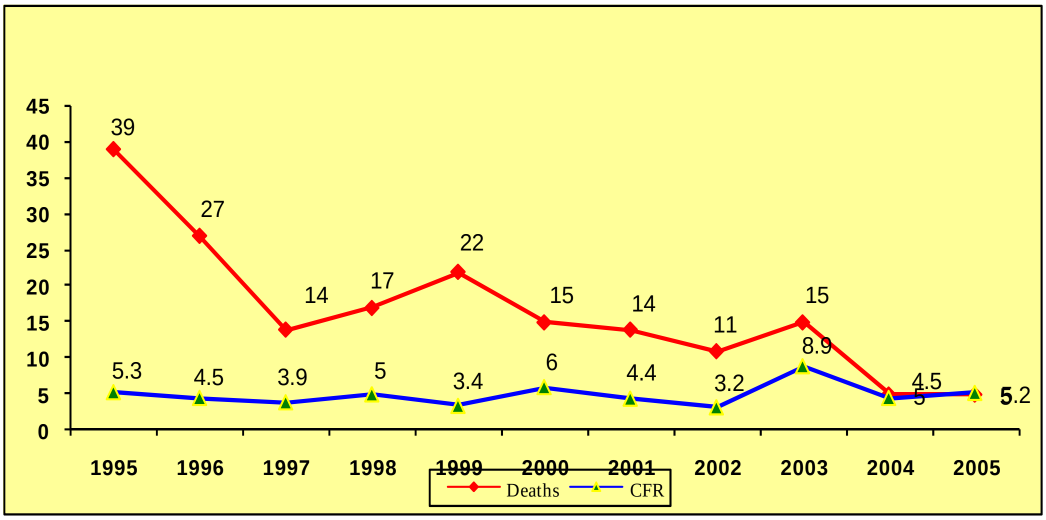
Figure 13: Comparative figure showing year wise malaria morbidity and mortality



Malaria Deaths

Malaria is the second most fatal communicable disease and in Bhutan it has been claiming about 18 lives (average) annually since 1995. The highest number of deaths recorded due to malaria is 62 deaths in 1993 and lowest was 5 deaths in 2004 and 2005. Although there is significant reduction in the malaria case load, the case fatality ratio (CFR) is still high (Figure 14).

Figure 14: Case fatality ratio



3.3 Climate determinants of malaria in Bhutan

Descriptive metrological statistics for five endemic districts

Annual mean temperature for last ten years remained between 20-22.5°C for the five malaria endemic districts. The maximum temperature recorded was 34.85 °C in Chukha (May 1998) and the lowest temperature of 3.55 °C was recorded in Zhemgang in 2000, February. Highest rainfall of 2373mm was recorded in Chukha in June 1998.

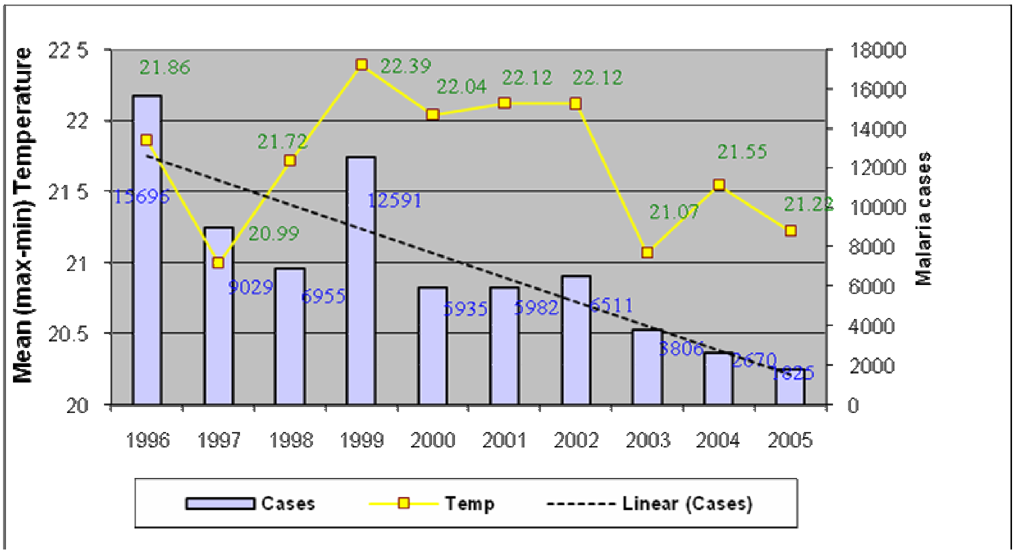
Trend line in Figure 15 indicate a progressive decline in malaria incidence while the annual mean temperature (of maximum and minimum) stays within 20-22.5 °C.

Table 12: Descriptive statistic (meteorological) for five endemic districts.

	Minimum	Maximum	Mean	SD
Temp maximum	9.83°C	34.85 °C (May 1998, Chukha)	25.65	5.05
Temp minimum	3.55°C (February 2000, Zhemgang)	26.65 °C	17.76	5.03
Mean Temperature[3]	6.79 °C	29.71 °C	21.71	4.86
Rainfall	0.00	2373.20 1998 June, Chukha	313.43	391.30

[3] Mean temperature is the mean of the temp minimum and temperature maximum.

Figure 15: Tabulation of annual mean temperature with the total malaria cases.



Correlations of malaria cases with temperature and rainfall

Of the five endemic districts, 82% of the malaria cases are reported from Sarpang and Samdrupjonkhar district. A bivariate test was performed to see if there is correlation or association between temperature, rainfall and malaria cases in these two districts.

The Pearson correlation shows that there is a positive correlation (0.365) between the number of cases and average temperature which is statistically significant as p value is 0.0001 which is less than 0.01 (Table 13). The correlation is significant at 1% significant level. The same is found for malaria cases and rainfall (table 12). This is true for both the districts clubbed together and even when analysed separately (table 13 and 14).

Table 13: Correlation for both the districts:

		TEMAV	RAINF	CASES
TEMAV	Pearson Correlation	1	.565	.365
	Sig. (2-tailed)	.	.000	.000
RAINF	Pearson Correlation	.565	1	.245
	Sig. (2-tailed)	.000	.	.000
CASES	Pearson Correlation	.365	.245	1
	Sig. (2-tailed)	.000	.000	.
	N	240	240	240

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

Table 14: Correlation for individual districts of Sarpang and Samdrupjonkhar:

Dzongkhag			cases
1 Sarpang	temav	Pearson Correlation	.397(**)
		Sig. (2-tailed)	.000
2 Sjonkhar	temav	Pearson Correlation	.275(**)
		Sig. (2-tailed)	.002

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

Partial correlation of malaria cases with temperature and rainfall

Partial correlation shows that both the rainfall and temperature are significantly associated with malaria cases (table 15). However, partial correlations analysis shows that, correlation between cases and temperature is significant even when after controlling for rainfall. However, in the case of correlation between cases and rainfall it is not significant when controlled for temp as shown below. This is true for both the dzongkhags when analyzed separately (table 16)**.**

Table 16: Partial correlations for individual districts of Sarpang and Samdrupjonkhar

Control Variables			cases	temav	rainf
-none-(a)	Temav	Correlation	.408	1.000	.569
		Significance (2-tailed)	.000	.	.000
	Rainf	Correlation	.322	.569	1.000
		Significance (2-tailed)	.000	.000	.
Rainfall	Temav	Correlation	**.289**	1.000	
		Significance (2-tailed)	**.000**		
temav	Rainf	Correlation	.119	1.000	
		Significance (2-tailed)	.068	.	

a Cells contain zero-order (Pearson) correlations.

Hence, there is a statistically significant positive correlation between temperature, rainfall and malaria cases when rainfall and temperature are acting together (not controlled). Further the correlation between cases and temperature is significant even when after controlling for rainfall. However, correlation between cases and rainfall is not significant when controlled for temperature.

Table 16: Partial correlations for both the districts.

Dzongkhag	Control Variables			cases	temav	rainfall
1 Sarpang	-none-(a)	temav	Correlation	.501	1.000	.609
			Significance (2-tailed)	.000	.	.000
		rainf	Correlation	.392	.609	1.000
			Significance (2-tailed)	.000	.000	.
	Rainf	temav	Correlation	.359	1.000	
			Significance (2-tailed)	.000	.	
	temav	rainf	Correlation	.127	1.000	
			Significance (2-tailed)	.175	.	
2 Sjonkhar	-none-(a)	temav	Correlation	.275	1.000	.550
			Significance (2-tailed)	.002	.	.000
		rainf	Correlation	.226	.550	1.000
			Significance (2-tailed)	.013	.000	.
	Rainf	Temav	Correlation	.185	1.000	
			Significance (2-tailed)	.044		
	temav	rainf	Correlation	.093	1.000	
			Significance (2-tailed)	.313	.	

a Cells contain zero-order (Pearson) correlations.

3.4 Results and discussion

The literature review and the malaria data from VDCP for last ten years, indicate that malaria cases are positively associated with change in temperature. However, this needs to be interpreted with caution as other non climatic variables need to be considered to see if there is an effect of temperature on malaria cases. In the current analysis, non-climatic variables were not available and hence the association between temperature and malaria cases may or may not hold true.

The other diseases of concern are seasonal diseases sensitive to climate change like diarrhoea, cholera, dengue and Japanese encephalitis. In this report this comparative analysis were not carried out as data were not adequate for any meaningful analysis.

Limitations of study

- A minimum of 30 years metrological data is required to predict a notable change in climatic conditions. The ten years data can only give the variations.
- There are non-climatic factors such as urbanization, irrigation, agricultural practices (paddy fields, fishery pounds), and most important the malaria prevention program (VDCP) which effect the annual parasitic incidence. Currently there is no data on non-climatic variables so as to perform multivariate and controlled factor analysis.
- Due to lack of population figure of the past years, the malaria incidences could not be accurately determined and hence the malaria cases have been used for the analysis.
- There are other climate sensitive diseases such as Asthma on which the data is still weak.

Section III

4 Key vulnerabilities

The mountainous ecosystems of Bhutan are vulnerable to possible adverse climate change impacts. The six areas considered most vulnerable to climate change are forest and biodiversity, agriculture water resources, glacial lake outbursts, health and landslides. However it is important to note that outcome of climate change on any of these areas are going to be health either in terms of mortality, morbidity, injuries, mental or psychological disorders etc.

Climate change can either directly have an impact on human health in terms of death and injuries as a result of thermal stress, hypothermia, drought etc or indirectly due to spread of vector borne disease like malaria, dengue and JE and infectious diseases like cholera, influenza, leishmaniasis etc.

Therefore health sector's primary role is in emergency preparedness for damage control due to adverse climate change. In this respect, it is imperative to recognize health sectors participation in all areas identified vulnerable to adverse effect of climate change.

5 Recommendations

1. There is a need to sensitize and become aware of the effects of climate change on human health among stakeholders.
2. To integrate metrological data into Health Information Management System (HMIS) for statistical analysis in respect to climate/seasonal diseases and gear towards developing an early warning system for probably outbreaks.
3. Installation of weather stations in all of Bhutan's malaria endemic districts would ensure accurate metrological data.
4. To revisit the Bhutan National Adaptation Programme of Action (NAPA) in the context to health components. Currently health area is confined to emergency medicine and this need to be extended to cover health information and managements for climate sensitive infectious disease.
5. To develop guidelines and indicators for assessing morbidity, mortality & other health information (hygiene, sanitation, mental state etc) of the population suffering from natural calamities. These key health statistics are required for immediate intervention as well as for surveillance and evaluation of the affected community.

6 References

Bhattacharya, S., C. Sharma, et al. (2006). "Climate change and malaria in India." Current Science **90**(3): 369-375.
Burge, H. A. and C. A. Rogers (2000). "Outdoor allergens." Environ Health Perspect **108 Suppl 4**: 653-9.
Gubler, D. J., P. Reiter, et al. (2001). "Climate variability and change in the United States: potential impacts on vector- and rodent-borne diseases." Environ Health Perspect **109 Suppl 2**: 223-33.
Hales, S., P. Weinstein, et al. (1999). "El Nino and the dynamics of vectorborne disease transmission." Environ Health Perspect **107**(2): 99-102.
Hay, S. I., M. F. Myers, et al. (2000). "Etiology of interepidemic periods of mosquito-borne disease." Proc Natl Acad Sci U S A **97**(16): 9335-9.
McMichael, A. J. and A. Haines (1997). "Global climate change: the potential effects on health." BMJ **315**(7111): 805-9.
Mellor, P. S. and C. J. Leake (2000). "Climatic and geographic influences on arboviral infections and vectors." Rev Sci Tech **19**(1): 41-54.
Ministry of Health (1999). National antropometic study.
Ministry of Health (2001). Annual Health Bulletin.
National Environment Commission (2006). Bhuthan National Adaptation Programme of Action. Thimphu, RGoB.
Nolte, H., V. Backer, et al. (2001). "Environmental factors as a cause for the increase in allergic disease." Ann Allergy Asthma Immunol **87**(6 Suppl 3): 7-11.
Office of the Census Commissioner (2005). Population and housing census of Bhutan, RGoB.
Okuno, T., P. T. Tseng, et al. (1975). "Japanese encephalitis surveillance in China (Province of Taiwan) during 1968-1971. I. Geographical and seasonal features of case outbreaks." Jpn J Med Sci Biol **28**(5-6): 235-53.
Pampana, E. (1969). A Textbook of Malaria Eradication. London, Oxford University Press.
Rao, J. S., S. P. Misra, et al. (2000). "Japanese Encephalitis epidemic in Anantapur district, Andhra Pradesh (October-November, 1999)." J Commun Dis **32**(4): 306-12.
RGoB (2005). Population and housing census of Bhutan.
van der Hoek, W., F. Konradsen, et al. (1997). "Correlation between rainfall and malaria in the dry zone of Sri Lanka." Ann Trop Med Parasitol **91**(8): 945-9.
Watson, R. T. and Core Writing Team, Eds. (2001). A contribution of Working Groups I, II and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Cambridge University Press.
WHO/UNICEF (1978). International conference on primary health care, Alma Ata.
World Health Organization (1999). The World Health Report: Making a Difference. Geneva, WHO.
World Health Organization (2002). The World Health Report 2002: Reducing Risks, Promoting Healthy Life. Geneva, WHO.