


Assessment of Health Vulnerability and Adaptation to Climate Change




TheBhutanese

One of three samples confirmed first Chikungunya case in Bhutan

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The World Health Organization (WHO) along with UN Development Program (UNDP) have been granted a project for Piloting climate change adaptation to protect human health, from the Global Environment Fund (GEF) administered Special Climate Change Fund (SCCF).

The project is being piloted in seven countries namely Barbados, Bhutan, China, Kenya, Fiji and Jordan to design and implement practical measures to protect health under the changing climate.

For Bhutan, the pilot project will assist to define health adaptation measures to meet the anticipated health impacts from Climate Change.

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ACRONYMS

ALM	Adaptive Learning Mechanism
ARI	Acute Respiratory Infection
AR4	Fourth Assessment Report
AWS	Automatic Weather Station
CBA	Community Based Adaptation
CBDR	Community Based Disaster Risk Management
CSD	Climate-Sensitive Disease
CRM	Climate Risk Management
COP	Conference of Parties to the UNFCCC
DDM	Department of Disaster Management
DALYs	Disability Adjusted Life years
DGM	Department of Geology and Mines
DHMS	Department of Hydro met Services
DoE	Department of Energy
DoFPS	Department of Forest and Park Services
DoL	Department of Livestock
DoR	Department of Roads
EFRC	Environment friendly Road Construction
EMS	Emergency Medical Services
EWS	Early Warning System
GEF	Global Environment Facility
GLOFs	Glacial Lake Outburst Floods
GNHC	Gross National Happiness Commission
GRRH	Gelephu Regional Referral Hospital
HMIS	Health Management and Information System
IPCC	Inter- Governmental Panel on Climate Change
JDWNRH	Jigme Dorji Wangchuck National Referral Hospital
LDCF	Least Developed Countries Fund
MoAF	Ministry of Agriculture and Forest
MoH	Ministry of Health
MoWHS	Ministry of Work and Human Settlement
MRRH	Monger Regional Referral Hospital
MSTCCC	Multi-Sectoral Technical Committee on Climate Change
NAPA	National Adaptation Programme of Action
NDRMF	National Disaster Risk Management Framework
NEC	National Environment Commission
NGOs	Non- Governmental Organizations
NWFFWC	National Weather and Flood Forecasting and Warning Centre
RIHS	Royal Institute of Health Science
RWHTs	Rain Water Harvesting Techniques
SAR	Search and Rescue
SNC	Second National Communication
UNFCCC	United Nation Framework Convention on Climate Change
UNDP	UN Development Program
WHO	World Health Organization

EXECUTIVE SUMMARY

This V&A assessment was coordinated by WHO, Thimphu with financial support from Global Environment Fund (GEF). The main objective of this assessment is to access the vulnerability of the health sector to the impacts of current and future climate change and identify measures to reduce climate related risks to health. Accordingly, the VAA study focused on Vector Borne Diseases (Malaria, Dengue, JE and Kalazar), Diarrheal diseases and extreme weather events. Such evidence and understanding is a critical step for Ministry of Health, Bhutan to identify appropriate protective measure and justify future requests for support to protect health from climate change.

The assessment process involved framing and scoping the assessment exercise, identify baseline conditions, conduct impact and adaptation assessment. The WHO document "Protecting health from climate change: Vulnerability Assessment and Adaption" was used as the main guiding document for this VAA. The climate data and future estimates were availed from Hydro Met Department, Ministry of Economic Affairs and the Second National Communication of National Environment Commission. Health data was sourced from Ministry of Health and additional data were obtained from community based surveys, stakeholders meetings etc. Statistical analysis was performed in Strata and SPSS.

Change in climatic conditions: SNC downscaled climate models consider changes in temperature and precipitation over a short term period (2010-2039) and long term time period (2040-2069), using SRES A1B scenario. The two climate simulations (ECHAM5 and HadCM3Q0) projects the temperature to increase by about 3.5^{0}C by 2069 and a progressive increase in precipitation from 1980 to 2069, indicating that Bhutan will have warmer and wetter climate which will have an impact on climate sensitive sectors. However, due to significant topographic difference between districts, these expected changes will not be uniform.

Impacts of climate change on diarrheal diseases: Diarrheal diseases continue to burden an estimate of 10% of the total population and 30% children under five years of age (Annex 15). Current trend is indicative that 30% of the children under five will be suffering from diarrheal diseases annually and based on the population projection (National Statistical Bureau), it is estimated that by 2015 and 2030 there will be 24815 and 18698 children at risk of diarrheal diseases respectively.

The central region with seven districts has the highest (120) diarrheal incidence rate while individually, Wangdue, Zhemgang, Punakha and Trongsa has the highest incidence rate. The health facilities located in military centers (Wangdue and Lungtenphu RBA Hospital), industrial areas, mega project and border areas (Gomtu, Gelephu and Phuntsholing Hospitals) are in high incidence rate. The data indicate that maximum temperature has been stable (2003-2011) and the two hottest years (2006 & 2009) doesn't correspond to high diarrhea incidence occurred during 2003 and 2004. However, seasonal analysis indicates that 53% of the total diarrheal cases are reported between April and August, with peak cases occurring predominantly in June (Figure 15). Therefore month of May, June and July are vulnerable period and this is also supported by Time Series analysis (Table 13).

The Time Series analysis using ARIMA (1,1,1) (0,1,1) forecast (Table 13) incidence rate of 82.5 and 80.6 per 1000 diarrhea cases in all age group in 2012 and 2013 respectively (Incidence rate in 2011 is 84.9) in Bhutan. In children under five years of age, the incidence rate will be 181.7 and 130.5 per 1000 diarrhea cases for 2012 and 2013 respectively (incidence rate in children under five years in 2011 is 215) (Table 13). The Random Effect Poisson Regression show that mean temperature is significantly ($p<0.000$) associated with the total diarrhea incidence but not significant for under five diarrhea incidence ($p=0.244$). And the rainfall is not significantly associated with the total diarrhea incidence (p=0.46), however rainfall is associated with under five diarrhea incidence (p=0.032). Therefore, for every increase in mean temperature by 1^0C, the total diarrhea incidence (per 1000) is expected to increase by 5.3% (Table 14). No under-five diarrhea incidence will increase for every unit (mm) of rainfall despite being significantly associated (Annex 8, Annex 9, Annex 16, and Annex 17).

In summary, the diarrheal diseases in Bhutan will continue to remain stable over next few years as there is no significant incremental in cases for next two years despite the association per this analysis. Problem analysis indicate that diarrheal morbidity could be over reported due to double reporting of the same child coming for consecutive days and leniency in defining diarrhea "officially it is three diarrheal episode in a day". An exploratory study (practice) of household level hygiene, sanitation and safe drinking water is recommended.

Impacts of climate change on Vector Borne Diseases: It is estimated that average temperatures will increase an additional 1.1^0C in the period 2010-2039, and 2.4^0 C for the period 2040-2069 from what has been experience in the baseline period 1980-2009. This increase in temperature may increase the likelihood of VBD transmission in new areas, particularly at the geographic margins (both in distance and altitude) of the current suitable temperature range for transmission.

Trend analysis indicates that malaria transmission is declining and since 2007, the total malaria cases were contained below 1000 with only 194 cases in 2011. The annual parasite incidence (API) is below 1 per 1000 population in 2011 (Figure 23) and VDCP is on track for malaria elimination. However, an estimated 76% (521,803) of Bhutanese live in areas of favorable climate for malaria transmission and 42% reside in the 7 districts where malaria has endemic transmission (Annex 25).Within the endemic districts the high risk groups are males (67%) with women and children at 32% and 3% respectively. The most affected occupational group is the farmers (44% 2007) (38% 2009) followed by the students (23% 2007) (26% 2009) who are exposed to outdoor biting (Annex 25 and Annex 26). The assessment shows that if other conditions (such as humidity, health care seeking behavior and preventive and control measures) remain same in the endemic districts; for each 1^0C increase in mean temperature, that malaria incidence will increase by 14.9%. Malaria incidence will decrease by 0.01% for increase in 1mm of total rainfall.

The best model determined by Wangdi et al, ARIMA (2, 1, 1) (0, 1, 1) predict the occurrence of 153 and 215 malaria cases in 2012 and 2013 respectively (Figure 30 and Figure 31). Long term prediction (Random Effect Poisson Regression[1]) indicate that malaria incidence could increase in the endemic districts by 14.9% for each 1^0C in mean temperature lagged at one month and malaria incidence will decrease by 0.01% for increase in 1mm of total rainfall lagged at one month. In conclusion, the malaria forecasting based on time series (short term forecasting) showed that malaria incidence in endemic areas of Bhutan are likely to dwindle over next few years, if current levels of malaria control are maintained over time, and new cases are not introduced from outside Bhutan. The other climate sensitive vector borne diseases like Dengue, Kala-azar, Japanese Encephalitis are reported and vectors are confirmed. However, the available information is still insignificant to make any substantial analysis. An important adaptation option for these VBDs is to coordinate surveillance, monitoring and reporting between the Public Health laboratory, Vector Borne Diseases Control Program and the Health Management Information System to enable proper deduction in near future.

[1] Poisson Regression is a statistical technique used to describe the probability of occurrence of count data (malaria cases) as a result of the value of predictor variables (mean temperature and rainfall).

Impact climate change on extreme weather events and other health risks associated with climate change:

Historical evidence (Table 25) and data from Department of Geology and Mines confirms that Glacial Lake Outburst, cyclone related storms, flash floods, landslides, and windstorms have caused immense damage to infrastructures, crops and livestock. With an estimate of 2674 glacial lakes of which 25 were designated as potentially dangerous (Mines, 2001), the river basins of Bhutan remain at constant risk of GLOF. The 1994 GLOF damaged more than 1700 acres of agriculture land and the 2011 windstorms affected sixteen dzongkhags causing damage to 2,424 rural homes, 81 cultural assets, 57 schools, 21 health facilities and 13 other government buildings (DMIS data, DDM MoHCA). While past affects of these extreme weather conditions are known, the likelihood of such events are difficult to predict. This study has identified the most at risk downstream valleys, towns with estimate population and health facilities at risk (Table 26, 27, Figure 32).

For health sector, the emergency preparedness during extreme weather conditions particularly for GLOF, earthquake, windstorm and fire are critical. Another challenge for health sector is the growing demand for post traumatic services like counseling and ensuring hygiene and sanitation through adequate and safe drinking water and sanitation facilities after the disaster. Identifying alternative water sources in the GLOF risk areas is important. Also as evident from the past events, the rice fields are most affected during the GLOF and flooding which could affect the nutritional status of the people, with one third of children (under five) being affected by chronic under nutrition (37% stunting) under normal condition, the situation could aggravated in extreme weather conditions.

Respiratory allergies, cancers, cardio vascular diseases and mental health are important conditions which are influenced by climate change. Atmospheric pollution causing respiratory allergies, depleting Ozone layer associated with UV induced skin cancer and growing demand for counseling for affected victims are known facts from literature reviews. In Bhutan, the cases of allergies, cancers and cardio vascular diseases are increasing but there is lack of data to associate the pattern with climate change and no system exist to enable such associations in future**.**

In conclusion, the mean annual temperature will increase by 3.5^0C by 2069 (SNC) and climate change will affect the current burden of climate sensitive diseases in Bhutan. The proportion of population at risk of climate sensitive disease will increase as there would be shift in the geographic ranges due to climate change. This VAA study finds positive association between climate variables, malaria and diarrheal diseases indicating change and shift in disease morbidity. It is recommended that present strategies and control programs are sustained, regularly reviewed and the adaptation measure identified in this report be acted upon. Subsequently, the poverty, literacy rate, safe drinking water, hygiene, sanitation, access to health services, child care and health seeking practices would be detrimental in prevention and control of CSD. Particularly the literacy and poverty uplift would greatly affect the control and prevention of these diseases. MOH should identify pockets of areas and communities that require concerted effort to improve these indicators. Extreme weather conditions put all district at risk and the adaptation is beyond the Environmental Health Program in DoPH. EHP can function as a coordinating, monitoring & surveillance program that ensures adaptation means to reduce morbidity and mortality related to climate change. Immediate requirements for MoH is to revisit the National Disaster Management Act of 2011, HM relief Fund 2011 and National Disaster Management Frame work and put in place health approach to CSD and extreme weather conditions.

CHAPTER 1: INTRODUCTION TO CLIMATE RISK IN BHUTAN

1.1 The climate policy context in Bhutan

Relevant Regional, International and Bhutanese Policy on Climate Change

Bhutan signed United Nations Framework Convention on Climate Change (UNFCCC) at Rio de Janeiro in 1992 and ratified the same in August 1995 and the Kyoto Protocol in August 2002. The 2nd National Communication (SNC) was submitted in 2011 and the update of the projects and profiles of the NAPA document has been completed. The project Identification Form (PIF) for the second NAPA project has also been approved by GEF and Project Preparation Grant (PPG) has also been sanctioned. NEC in collaboration with UNDP has initiated the process of preparation of the project proposal for submission to Least Developed Countries Fund (LDCF).

NAPA

The Bhutan National Adaptation Programme of Action (NAPA) was formulated in 2006. The National Adaptation Programme of Action (NAPAs) is the outcome of the decision by the seventh session of the Conference of Parties (COP7) of the United Nations Framework Convention on Climate Change (UNFCCC) on the “Least Developed Countries Work Program”. In Bhutan NAPA 2006, there were nine priority projects, including emergency medical services for emergencies. Due to the urgency of hazard risks posed by Glacial Lake Outburst Floods (GLOFs) three priority projects are currently being implemented via the project ‘Reducing climate change induced risks and vulnerabilities from glacial lake outburst floods in the Punaka, Wangdi and Chamkhar valleys’[2]. In early 2011, update of the projects and profiles of Bhutan NAPA, 2006 was initiated to account for previously un-recognized climate risks in Bhutan (windstorms and cyclones), to update project costing, and to account for related activities that have been undertaken in part or whole since 2006.

MSTCCC

A Multi-Sectoral Technical Committee on Climate Change (MSTCCC) was formed in 2011 through directives of the National Environment Commission (NEC) to serve as a forum for coordinating all climate change issues in the country. The committee comprises of members from various government sectors, non-governmental organizations (NGOs) and private sectors.

Relevant Policy on Climate and Health

The WHO-SEARO has actively supported action for climate change and health. A regional committee resolution signed in 2008, (WHO-SEARO 2008; WHO-SEARO 2010).

- World Health Assembly resolution (WHA 61.19) on climate change and health;
- New Delhi Declaration on climate and health in SEAR (2008)
- Regional Framework for Action to Protect Human Health (2008)
- Regional parliamentarians convened in Bhutan (2010)

Various efforts have been undertaken by national authorities in Member States and by the health sector as well as by WHO in the South-East Asia Region, to prepare and implement national and regional climate action plans.

[2] Bhutan has accessed approximately USD 3.45 million for the three projects from the LDCF, United Nations Development Programme, Austrian Development Agency and World Wildlife Fund (WWF-Bhutan).

Rationale and funding of the Vulnerability and Adaptation assessment

The WHO considers Vulnerability and Adaptation to Climate Change Assessments (V & As) to be a core activity in the protection of populations from the impacts of climate change (Campbell-Lendrum et al. 2009; WHO 2009a; WHO 2009b). This V&A assessment in Bhutan is thus a critical instrument to provide national level evidence of the linkages between climate and health; improve understanding of local and specific health risks, provide the opportunity for capacity building in applied research, and serve as a baseline analysis to monitor how health risks may be influenced by a changing climate overtime. Generation of such evidence and understanding is a critical step for Bhutan to identify the needs of the health sector and communities, identify appropriate protective measures to be implemented, and justify future requests for support to protect health from climate change.

In Bhutan, the need for further studies on the Health impacts of Climate Change has been repeatedly indicated in regional and national level processes since 2006 (WHO-SEARO 2008; WHO/SEARO 2006; WHO-SEARO 2011; K. Ebi et al. 2007). Discussion of climate and health in Bhutan began in 2006, and has since remained limited. Three principle studies exist. Firstly, an exploratory study commissioned by RSPN in 2006, described broad considerations of climate impacts, conducting some temperature and health outcome correlations, but mostly citing analogous studies to suggest climate sensitivity of health conditions in Bhutan. Secondly, as part of the project development phase for a WHO/UNDP/GEF project, WHO and the MoH in 2006 conducted a baseline assessment of climate and health, drawing upon expert opinions of national health experts on local health conditions, and international experts in climate and health. Thirdly, inclusion of health concerns in Bhutan's SNC. Although analysis of impacts of climate change on health was incorporated in the SNC, 2011, analyses conducted by international consultants were data limited, and health outcome coverage and depth of analysis was poor.

Thus programmatic decision-making at the MoH, still calls for improved evidence of climate impacts on health. This V&A was thus prioritized within the MoH led by WHO/UNDP/GEF funded project, Piloting Climate Change Adaptation to Protect Human Health (2010-2014).

1.2 Climate Risk Context in Bhutan

This section described the climatic regions of Bhutan, the current climate conditions, and summarizes what is known and expected for climate change in Bhutan.

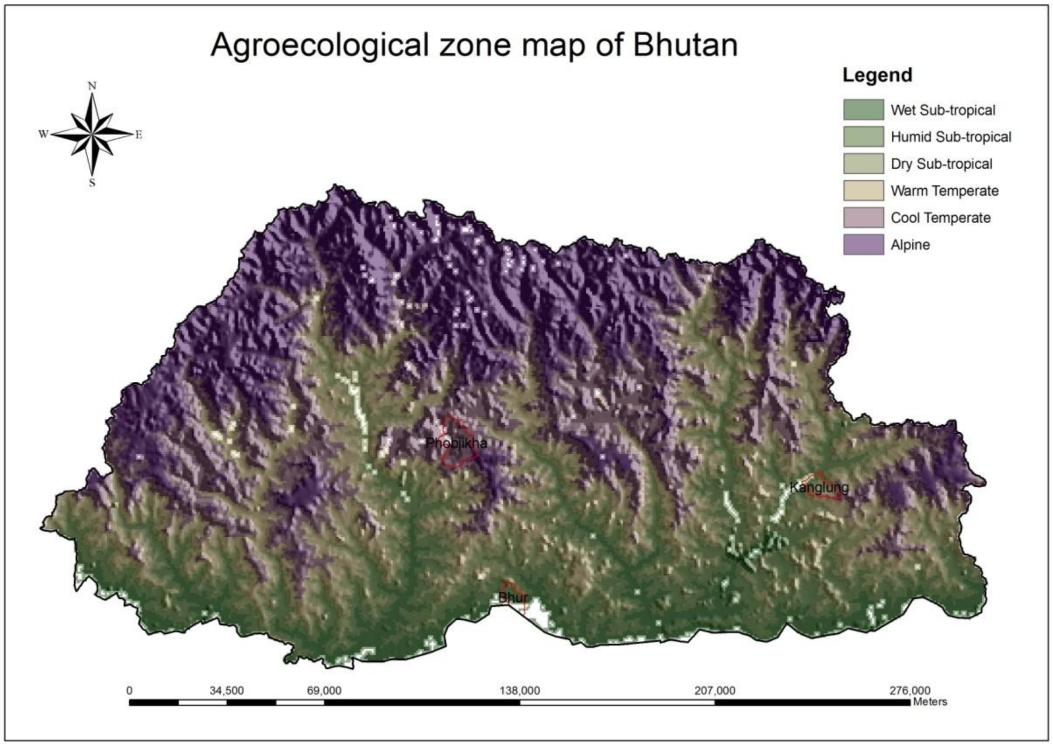
1.2.1 Current Observed Trends of Climate Condition in Bhutan

Bhutan is located on a fragile mountainous ecosystem in the eastern Himalayas between China on the north and India on the west, south, and east. The country is situated between 26°45'N and 28°10N latitudes and 88°45'E and 92°10E longitudes, with a maximum longitudinal distance of 330kms and a latitudinal distance of 180km. The highly rugged terrain rises from an elevation of 100m above sea level in the south to over 7,550m in the north.

Bhutan has a wide range of micro-climatic conditions within its three distinct climatic zones– the humid and sub-tropical southern "belt" of plains and foothills, the temperate inner valleys, and the cold alpine northern regions with year-round glacial and snow cover. Observed climate features in Bhutan include temperature, precipitation, air quality, snow pack melt/glacial retreat, climate variability and extreme weather events that vary by climate zone. Summarized in (Figure 1) the southern belt has a hot, humid climate, with temperatures remaining fairly even throughout the year between 15-30°C, and rainfall between 2,500-5,000mm. The central inner Himalayas have a cool, temperate climate, with annual average rainfall of about 1,000mm.

The higher and more northern region has an alpine climate, with annual rainfall of around 400mm. Most rainfall occurs during the summer, with the Indian southwest monsoon accounting for 60-90% of total rainfall. The winters are relatively dry.

Figure 1: Agroecological zone map of Bhutan



1.2.2 Future Climate in Bhutan

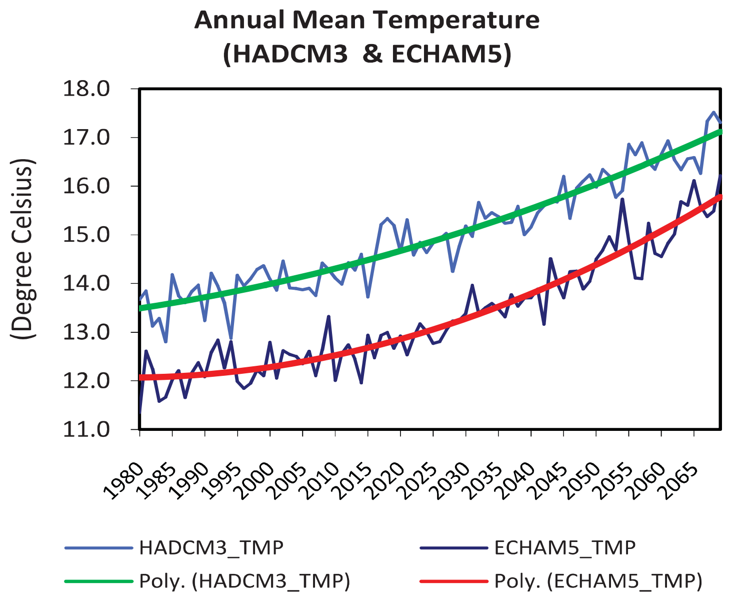
Estimates of the projected future climate conditions in Bhutan generated for the SNC were used. These downscaled climate models[3] consider changes in temperature and precipitation over a short term time period (2010-2039) and a long term time period (2040-2069), using the SRES A1B scenario.

Projected Future Temperature in Bhutan

The two climate simulations (ECHAM5 and HadCM3Q0) project the temperature to increase by about 3.5^{0}C by 2069. This means compared to the average temperature of 12.0 ^{0}C - 13.50 ^{0}C in 1980, the annual average temperatures in 2069 may approximately is between ~ 15.50 ^{0}C to ~ 17.00 ^{0}C. As shown in (Figure 1), the differences in high and low estimates vary according to the model, but show the same magnitude of increase.

[3] Estimates of future climatic conditions in Bhutan are based on downscaled climate change scenarios generated at (22km resolution) covering the period 1979-2069. This prepared in PRECIS and piloted by two GCMs (German ECHAM5 A1B and the British HadCM3Q0 A1B).

Figure 2: Annual trends of annual mean air temperature (0C) from 1980 to 2069 for Bhutan according to the PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios



Future Precipitation patterns in Bhutan

The two climate simulations (ECHAM5 and HadCM3Q0) project a progressive and steady increase in precipitation from 1980 to 2069, indicating on average that Bhutan will get wetter. The two models have a difference of 100mm/year. The ECHAM5 model, shows average precipitation will steadily increase by ~ 600mm/year. Thus by 2069, average annual precipitation in Bhutan averaging ~ 2,400 – 2600 mm/ year as per this model. HadCM3Q0 project precipitation to increase from ~ 1,900 mm/year in 1980 to ~ 2,400 mm/ year by 2069.

Figure 3: Annual trends of mean total annual precipitation (mm) from 1980 to 2069 for Bhutan according to the PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios

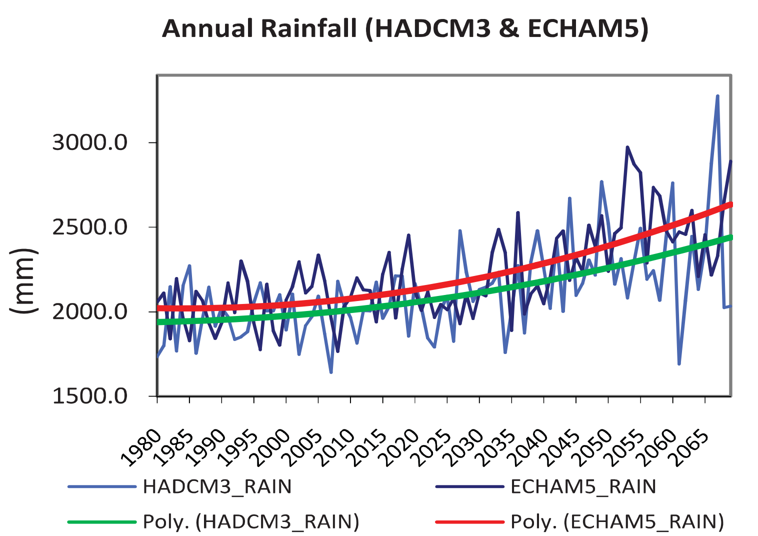
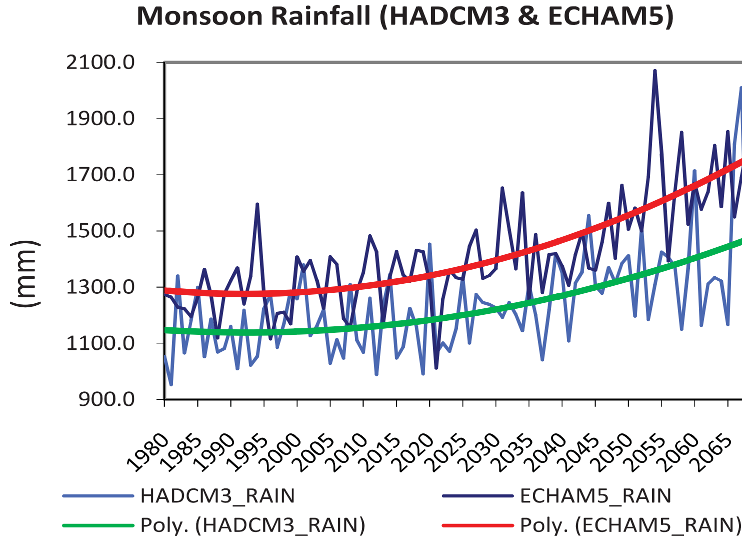


Figure 4: Annual trends of seasonal/monsoon total precipitation (mm) from 1980 to 2069 for Bhutan according to the PRECIS downscaled HadCM3Q0 and ECHAM5 scenarios



A warmer and wetter climate in Bhutan will have certain impacts on climate-sensitive sectors such as agriculture, forestry, water resources, as well as the health sector.

Table 1: Summary Temperature and Precipitation Changes

Climate Indicators	1980	2010	2020	2040	2060
Mean Temperature	12.0*/13.5**	12.5/14.5	12.8/14.8	13.5/15.5	15.5/17.0
Mean Precipitation	N/a				
Number Extreme Rainfall events	N/a				

*Figures reflect *ECHAM5 and **HadCM3Q0*

Given the significant topographic differences between districts in Bhutan, these expected changes will not be uniform. (Table 2) indicates the expected changes in average and seasonal temperatures in each of Bhutan's *Dzongkhags*, over 3 time periods. (Table 2) indicates estimated future precipitation.

Table 2: Summary of Temperature Changes (0C) by Dzongkhags for the periods 1985-2010, 2010-2040 and 2040-2069 according to the downscaled HadCM3Q0 scenario

Dzongkhag	1980-2009			2010-2039			2040-2069		
	Mean Annual Temp (^{0}C)	Mean Monsoon Temp (^{0}C)	Mean Winter Temp (^{0}C)	Mean Annual Temp (^{0}C) Change	Mean Monsoon Temp (^{0}C) Change	Mean Winter Temp (^{0}C) Change	Mean Annual Temp (^{0}C) Change	Mean Monsoon Temp (^{0}C) Change	Mean Winter Temp (^{0}C) Change
Bumthang	8.3	15.2	0.6	1.1	0.9	1.3	2.6	2.2	2.8
Gasa	3.9	11.7	-4.2	1.2	0.9	1.4	2.7	2.4	2.8
Haa	12.6	18.9	5.2	1.1	0.8	1.3	2.5	2.1	2.9
Paro	7.6	14.8	-0.2	1.2	0.9	1.4	2.6	2.3	2.8
Thimphu	7	13.9	-0.3	1.1	0.9	1.4	2.6	2.3	2.7
Lhuentse	10.3	17.1	2.8	1	0.8	1.2	2.5	2.1	2.9
Yangtse	11.4	17.7	4.5	1	0.8	1.1	2.4	2.1	2.8
Trongsa	12.9	18.8	6.1	1	0.8	1.1	2.3	2	2.6
Zhemgang	20.4	25	14.9	0.9	0.8	1.1	2.3	1.9	2.6
Dagana	19.3	24.1	13.4	1	0.8	1.2	2.4	1.9	2.8
Chhukha	19.5	24.2	13.7	1	0.8	1.2	2.3	1.9	2.8
Monggar	17.5	22.6	11.6	0.9	0.8	1	2.3	1.9	2.7
Punakha	10	16.7	2.5	1	0.8	1.1	2.5	2.2	2.7
Trashigang	15.1	20.5	8.8	1	0.8	1.1	2.4	1.9	2.7
Wangduephodrang	10.6	17	3.2	1	0.8	1.2	2.5	2.1	2.7
Tsirang	20.7	25.4	15	0.9	0.8	1	2.3	1.9	2.6
Samdrupjongkhar	22	26.4	16.8	1	0.8	1.1	2.3	1.9	2.7
Samtse	21.1	25.5	15.4	1	0.8	1.1	2.3	1.8	2.7
Sarpang	21.8	26.2	16.4	0.9	0.8	1.1	2.3	1.8	2.6
Pemagatshel	22.2	26.7	16.8	0.9	0.8	1	2.3	1.9	2.7

Table 3: Summary of Precipitation Changes (mm) by Dzongkhags for the periods 1985 2010, 2010 2040 and 2040 2069 according to the downscaled HadCM3Q0 scenario

Dzongkhag	1985-2010			2010-2039			2040-2069		
	Mean Annual Precip. (mm)	Mean Monsoon Precip. (mm)	Mean Winter Precip. (mm)	Mean Annual Precip. Change (mm)	Mean Monsoon Precip. Change (mm)	Mean Winter Precip. Change (mm)	Mean Annual Precip. Change (mm)	Mean Monsoon Precip. Change (mm)	Mean Winter Precip. Change (mm)
Bumthang	1117.7	668.8	59.8	125.3	71.6	-0.3	355.1	244.8	26.1
Gasa	678.8	471.1	6.8	134.1	91.4	1.6	403	326.5	9.5
Haa	2084.9	1271.1	98.3	200.2	79.7	-2.7	480.1	272.5	42.5
Lhuentse	1224.3	692.2	81.2	87.8	42.6	0.1	355.9	236.9	35.5
Paro	1226.3	860.5	24.3	124	48.9	3.6	381.8	252.7	22.5
Yangtse	1296.8	713.2	101.4	72.6	19.3	1.2	328.1	176.2	41.4
Thimphu	1112.9	848.5	14.8	112.4	58	2.2	365	292.1	11.1
Trashigang	1776.3	931.2	144.5	122.9	46.1	-11.7	345.2	161.3	24.5
Trongsa	1988.4	1151.8	148.2	125.9	66	-13.5	450.5	316.3	28.4
Tsirang	3480.6	2028.9	195.8	23.3	-59.6	-20.5	318.6	198.6	5.6
Wangduephodrang	1673.6	1060.9	85.8	123.5	73.8	-6.5	389.4	280.5	21.2
Chhukha	3397.7	1978.5	164.6	119.7	-2.5	-7.4	421.5	244.9	38.4
Dagana	3290.8	2012.1	152.8	67.6	-29.9	-11.2	351.8	183.3	20
Monggar	2431.7	1379.4	174.2	60.3	-2.5	-11.5	325.7	183.3	12.1
Punakha	1422.3	954	37.6	136.5	84.3	3.1	412.5	344.5	16.2
Zhemgang	2969.2	1591.7	215.6	78.1	-2.9	-14.9	307.4	168.1	11.2
Pemagatshel	2713.7	1369	209.5	58.2	-21.4	-13.7	260.1	109.8	13.2
Samdrupjongkhar	2187.1	1097.5	170.8	77.1	-3.1	-15.3	262.1	99.6	17.1
Samtse	3280.5	1942.2	178.1	158.8	37.3	-18	308.9	155.4	27.2
Sarpang	3394.1	1829.7	213.8	22.1	-53.2	-11.3	232	114.4	14.1

Summary of climate scenarios

Compared to the current (1980-2009) climate, by 2010-2039 the mean annual temperature might increase by ~ 0.8 ^{0}C according to ECHAM5/A1B scenario and by ~ 1.0 ^{0}C as per HadCM3Q0/A1B scenario. During the period 2040-2069, the mean annual temperature increases by ~ 2.00 C in the ECHAM5/A1B scenario and by ~ 2.4 ^{0}C in the HadCM3Q0/A1B scenario.

HadCM3Q0/A1B scenario projects a slightly higher increase in mean winter seasonal temperature (~ 1.2 ^{0}C) and a slightly lower increase in mean monsoon seasonal temperature (~ 0.8 ^{0}C) for the period 2010-2039. HadCM3Q0/A1B also scenario projects a slightly higher increase in mean winter seasonal temperature (~ 2.8 ^{0}C) and a slightly lower increase in mean monsoon seasonal temperature (~ 2.1 ^{0}C) for the period 2040-2069. However, ECHAM5/A1B scenario shows little or no difference between the annual and seasonal (monsoon and winter) temperature changes for the period 2040-2069.

Both the scenarios project a slight increase in mean total annual precipitation of ~ 6% in the 2010-2039 periods. On the other hand there is a slight decrease in winter precipitation (~2%) and increase between 4-8% in the monsoon season for the period 2010-2039 on a seasonal basis. Finally, for the 2040-2069 period, the HadCM3Q0/A1B projects a moderate increase in mean total annual precipitation of ~ 21 %, but with generally higher increases in the monsoon season compared to the winter season for Bhutan on the whole (11%). Similarly, the ECHAM5/A1B scenario also projects an increase in mean total annual precipitation of ~ 25 % for the 2040-2069 period, also with generally higher increases in the monsoon season compared to the winter season for all Dzongkhags together.

Therefore, for changes in precipitation both the HadCM3Q0/A1B and ECHAM5/A1B scenarios project moderate increases in mean total annual rainfall for the 2040-2069 period, but with the wet monsoon becoming wetter season and the dry winter season becoming drier. These more extreme precipitation changes between seasons conform to the findings of the (IPCC 2007) report for the Himalayan region of Southeast Asia.

Existing Recommendations for Climate Adaptation of the Health Sector (2011)

Based on limited analysis and multi-sectoral committee judgment, the SNC of Bhutan identified the following priorities for the Health sector in Bhutan.

- Ensure adequate drinking water during the dry period
- Control and reduce spread of vector borne diseases
- Build disaster response management preparedness
- To educate and enhance the level of awareness to cope with health risks of climate change
- Strengthening the surveillance, research, monitoring, review and supervisory system and feedback mechanism for climate related diseases
- Build and improve program and research capacity to monitor climate change impacts on human health
- Reduce nutritional impacts of climate change

CHAPTER 2: HEALTH CONTEXT IN BHUTAN

2.1 Development Context

Bhutan is small country located between China (Tibetan Region) in the north and India in south. It covers an approximate area of 38,294 km^2, spanning roughly 150 km North to South and about 300 km East to West. The country's terrain is mountainous and rugged with elevation ranging from about 180 meters above sea level in the south to more than 7,550 meters above sea level in the North. 70.5 % of the land mass is covered by forest and only 2.9% is under cultivation (Bhutan 2011). Glaciers in the northern Bhutan covers about 10% of the total surface area. Bhutan is the youngest democratic country in the world with its first democratic election held in March 2008. The country is administratively divided into twenty units called Dzongkhag which are further divided into 205 sub-units called Geogs.

Bhutan's is a least developed country and its socioeconomic development philosophy is guided by four principles of Gross National Happiness (GNH) which seeks to institute development with values. The development philosophy recognizes that there are more dimensions to development, which are equally, if not more important than GDP. The goal is to balance between material satisfaction and spiritual wellbeing of both individual and society. Ranked the happiest country in south Asia (World Happiness Report 2012), the Bhutanese economy is primarily driven by the agriculture sector and 69% are dependent on subsistence farming.

The GDP per capita income is USD 1851 (MTR 2011). Average life expectancy is 66.3 years, with females on average living to be 66.9 years and males 65.7 years (PHCB 2005). The average household family size is 5.0 persons (BLSS 2007). Literacy rate is 59.5% (Urban – 76% and Rural – 52%). Unemployment rate in 2011 was 3.1% (LFS, 2011, NSB) with average inflation rate of 9.1% in 2010 (NSB 2011, SYoB).

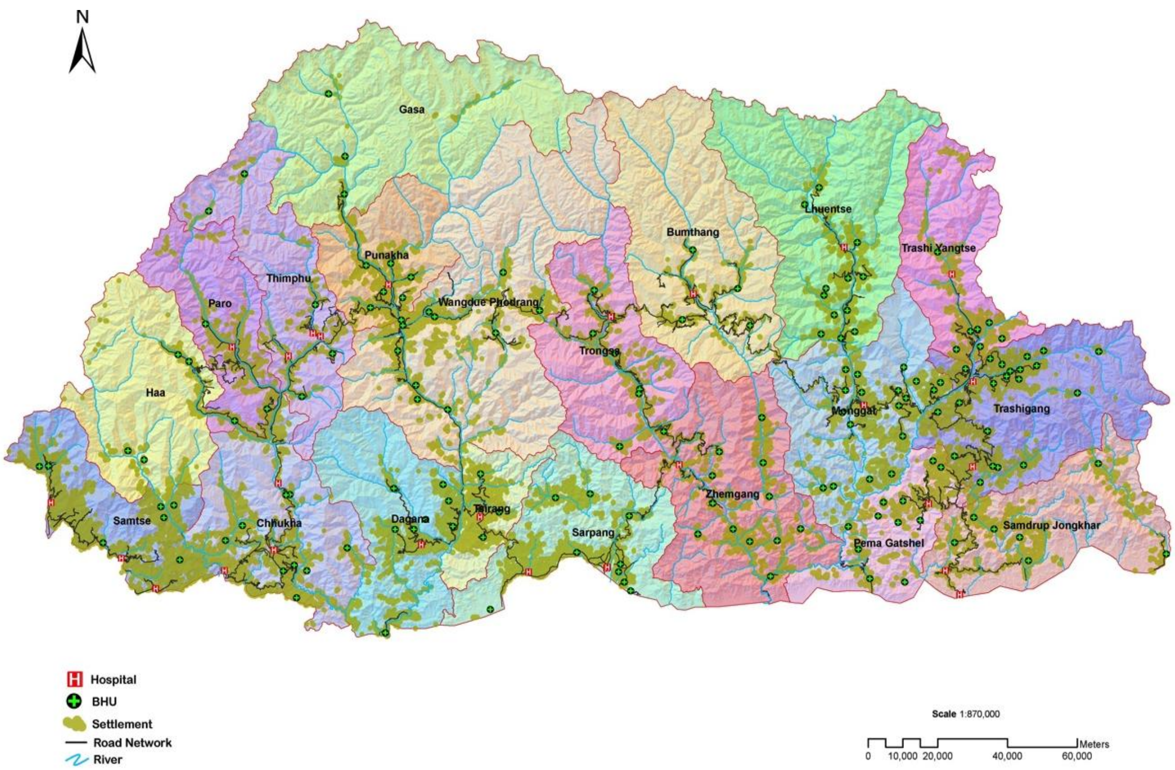
Approximately 23% of the population belongs to households with per capita consumption below the total poverty line and the rate of subsistence poverty is estimated at 5.9% (PAR 2007). 69% of Bhutan's population is rural and depend primarily on subsistence farming. In 2005, 31% of Bhutan's total population lived in 61 towns, 40 % of which resided in Thimphu, the capital. It is estimated that 73% of the total population of Bhutan will live in urban areas by 2020, if growth rates in urban centers estimated at 7.3% persist (NAP, 2009). Poverty is pre-dominantly a rural phenomenon with forty nine out of every fifty and practically all the extremely poor persons residing in the rural areas (PAR 2007).

2.2 Overview of Health Services

The Royal Government of Bhutan finances and provides free healthcare to its citizens ('NHS model') since embarking on an ambitious socio-economic development programmed more than five decades ago. The Government is mandated under the Constitution (promulgated in 2008) to "provide free access to basic public health services in both modern and traditional medicines" and "endeavor to provide security in the event of sickness." The health system framework in Bhutan is embedded in the country's overall development philosophy of Gross National Happiness and to achieve the national goals of equity, social justice, sustainability and efficiency. Bhutan adopted the Alma Ata Declaration on Primary Health Care in 1979, and its developmental strategies in the health sector largely advocate Primary Health Care approaches.

Since the first Five year plan, in 1961, health sector has established a network of closely inter-linked health service facilities and maintains healthcare coverage at over 90%. Shown in (Figure 5) the Bhutan health system includes 31 hospitals providing both allopathic and indigenous medical care, 181 Basic Health Units (BHU), 38 Indigenous Units and 518 Out Reach Clinics (ORC) spread over 205 goes (blocks) providing primary health care services.

Figure 5: GIS Map showing health services distribution in Bhutan in 2010



The primary design of health services in Bhutan focuses on provision of primary care, preventive care and health promotion and outreach services backed by a multiple tiered referral system BHUs serve primarily to carry out public health functions, and operate as primary care facilities. Out-reach clinics are mobile clinics providing preventive and minor curative services to the community at periodic intervals. The secondary and tertiary care services are supported by a network of Primary Health Care Centres (Basic Health Units (BHU) and out-reach clinics) distributed throughout the country.

Secondary level heath care services are delivered through Dzongkhag general hospitals, Dungkhag (Sub-district) hospitals and Grade I BHUs. These facilities have medical doctors with basic diagnostic facilities (laboratory and radiology) along with both in-patient and out-patient services. There are 28 such facilities in the country which includes 1 independent indigenous hospital in Thimphu, the capital city. The 2 regional referral hospitals and the National referral hospital(s) provide secondary as well as tertiary health care services.

(Table 4) describes that health personnel include approximately 187 medical doctors, 579 health workers, 556 nurses, 710 technicians, and 106 drungtshos and menpas (Indigenous Physicians).

In addition to formal health service providers, there are 1200 active village health volunteer workers (VHWs) continuously assisting the health workers in delivering the primary care and outreach services. Currently, there are 3 doctors per 10,000 populations, and 18 hospital beds per 10,000 populations. Healthcare seeking behavior in Bhutan is high, given the coverage and free service, BMICS 2010 reported 77% Antenatal Care Attendance and 63% institutional deliveries.

Table 4: Health Facilities and Personnel in Bhutan

Health Facilities (Number)	1984	1994	2000	2005	2011
Hospitals	27	27	29	29	31
Basic Health Units (BHU)	67	84	163	176	181
Indigenous health units	5	9	19	21	38
Outreach clinics	NA	472	445	485	518
Health Professionals (Number)					
Doctors (MBBS/Specialists)	134	112	114	145	187
Nurses (AN/GNM/B. Sc. Nurse)	252	340	596	524	556
Health Assistants	85	105	163	210	366
Basic Health Workers	NA	137	176	171	169
Drungtshos (Indigenous Physicians)	11	22	31	30	43
sMenpas (Sowa Menpas)	NA	14	23	36	63
Pharmacists	119	40	62	83	11
Technicians	NA	NA	NA	114	679

2.3 Public Health Context

Since the inception of the health system in Bhutan, the primary objective is to prevent and reduce morbidity and mortality in the population. To this end, the health system has striven to cater quality care and treatment through different stages of life cycles of the people – 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 from malaria, leprosy and HIV/AIDS, etc.

The Total Fertility Rate (TFR) is 2.8, population growth rate is 1.8, Infant mortality rate per 1000 live birth is 40 (PHCB), Maternal Mortality Rate is 250 per 100,000 live births, achieved Universal Child Immunization (UCI) in 1991, Eradicated small pox and achieved leprosy elimination goal in 1997 and eliminated IDD in 2003. The last Neonatal tetanus case was reported in 1994 and the last clinical case of Polio was reported in 1986.

Table 5: Summary of key indicators, national health surveys, 1984, 1994 & 2000, and data from census 2005 and AHB 2010

Indicators			**Rate**		
Population	1984	1994	2000	2005	2011
Male	27,747	30,440	33,489	333,595	363,383
Female	28,458	33,450	35,358	301,387	332,439
Total	**56,205**	**63,890**	**68,847**	**634,982**	**695,822**
Sex ratio, males per 100 females	97.5	91	94.7	110.7	109
Overall dependency ratio (percent)	80	91.7	77.4	60.6	61.7
Sex ratio, at birth (males per 100 females)	102	105.1	106.6	101	NA
Gender fertility rate	169.6	172.7	142.7	NA	NA
Total fertility rate	NA	5.6	4.7	3.6	3.1
Crude birth rate (per 1000 population)	39.1	39.9	34.0	20	19.7
Crude death rate (per 1000 population)	13.4	9	8.64	7	7.1
Population growth rate (percent)	2.6	3.1	2.5	1.3	1.8(AHB)
Infant Mortality Rate (per 1000 live births)	102.8	70.7	60.5	40	47 (BMICS)
U5MR (per 1000 live births)	162.4	96.9	84	61.5	69 (BMICS)
Maternal mortality ratio (per 100,000 live births)	770	380	255	NA	NA
Contraceptive prevalence rate (percent)	NA	18.8	30.7	NA	65.6
Access to safe drinking water (percent)	NA	NA	77.8	84.2	96 (BMICS)
Sanitation (latrine) coverage (percent)	NA	NA	88	89.2	93
Immunization Coverage (%)	NA	NA	NA	NA	94.4
Trained birth attendance %	NA	10.9	23.6	49.1	64.5 (BMICS)

2.4 Disease Prevalence

Dramatic progress has been made to improve rates of life expectancy at birth and the overall health status of the population of Bhutan over the past decades. The country is on track to achieve most of the health-related Millennium Development Goals during the Tenth Five Year Plan. However, the present disease burden (Table 6) continues to project the traditional morbidity pattern. Sanitation, hygiene and water related diseases still feature prominently in the morbidity list[4].

Table 6: Morbidity of common diseases for past five years

Sl.#	Indicators	Year					Source
		2007	2008	2009	2010	2011	
1	Alcohol Liver Diseases incidence (per 10,000 population)	22	20	23	28	29	HMIS, MoH
2	Cancer incidence (per 10,000 population)	13	10	17	15	14	HMIS, MoH
3	Conjunctivitis incidence (per 10,000 population)	700	555	542	948	487	HMIS, MoH
4	Diabetes incidence (per 10,000 population)	26	38	38	47	53	HMIS, MoH
5	Diarrhoea incidence (per 10,000 under 5 children)	3296	2690	2892	2428	2257	HMIS, MoH
6	Depression incidence (per 10,000 population)	11	11	9	11	7	HMIS, MoH
7	Hypertension incidence per 10,000 population	294	303	310	343	325	HMIS, MoH
8	Intestinal Worms incidence (per 10,000 under 5 children)	686	503	397	219	186	HMIS, MoH
9	Malaria incidence (per 10,000 population at risk)	16	8	18	7	5	HMIS, MoH
10	Pneumonia incidence (per 10,000 under 5 children)	1311	1479	1031	1135	974	HMIS, MoH
11	Skin infections (per 10,000 population)	1707	1453	1322	1323	1463	HMIS, MoH
12	STD/STI incidence (per 10,000 population)	20	19	26	10	12	HMIS, MoH
13	Tuberculosis prevalence rate (per 10,000 population)	13	14	15	15	15	HMIS, MoH

4 http://www.health.gov.bt/reports/June%202012%20update%20report.pdf

Table 7: Environmental burden by disease category [DALYs/1000 capita], per year[5]

Disease Group	Lowest Country Rate	BHUTAN	Highest Country rate
Diarrhoea	0.2	15	107
Respiratory infections	0.1	6.8	71
Malaria	0.0	0.5	34
Other vector-borne diseases	0.0	1.3	4.9
Lung cancer	0.0	0.2	2.6
Other cancers	0.3	1.0	4.1
Neuropsychiatric disorders	1.4	2.4	3.0
Cardiovascular disease	1.4	3.6	14
Asthma	.3	1.3	2.8
Musculoskeletal diseases	0.5	0.6	1.5
Road traffic injuries	0.3	2.0	15
Other unintentional injuries	0.6	7.3	30
Intentional injuries	0.0	1.1	7.5
Malnutrition Proportion <5stunting		33.5%	
Proportion <5 underweight		12.7%	

Table 8: Environmental burden of disease for selected risk factors, per year

Risk Factor	Exposure	Deaths /year	DALYs/ 1000 cap /year
Water, sanitation and hygiene (diarrhoea only)	Improved sanitation: 70% Improved water: 62%	300	14
Indoor air	SFU% households: 67%	200	7
Outdoor air	Mean urban PM10: 13 ug/m3	-	-
Main malaria vectors	A. minimus; A. maculatus	-	-
Main other vectors	None	-	-

Estimates based on national exposure and WHO country health statistics 2004

Malaria: There has been a consistent decrease in malaria burden over the years. However, the decreasing trend of malaria cases could not be sustained in 2009 with 972 positive cases and an increase in the Annual Parasite Incidence from 0.7 (in 2008) to 2 (in 2009) per 1000 risk population. The abnormal rainfall patterns associated with early rains and some dry spell led to numerous localized outbreaks. This is further compounded by high infection rates across the border and cross-border mosquito movements. The coverage and utilization of Long Lasting Insecticidal Net as well as Indoor Residual Spraying has remained above 90 percent. (Source AHB for various years and Malaria Programme, Ministry of Health)

Non Communicable Diseases (NCD) has established their stronghold in Bhutan with an increasingly urban and sedentary lifestyle, traditionally high-fat based diet, and consumption of alcohol and tobacco. Consequently, as seen in (Table 9) diabetes, hypertension, cancers and traffic injuries are already seeing growing incidence.

[5] Country profiles of Environmental Burden of Disease, Bhutan, World Health Organization, Public Health and Environment, Geneva 2009.

Table 9: Non-communicable diseases in Bhutan

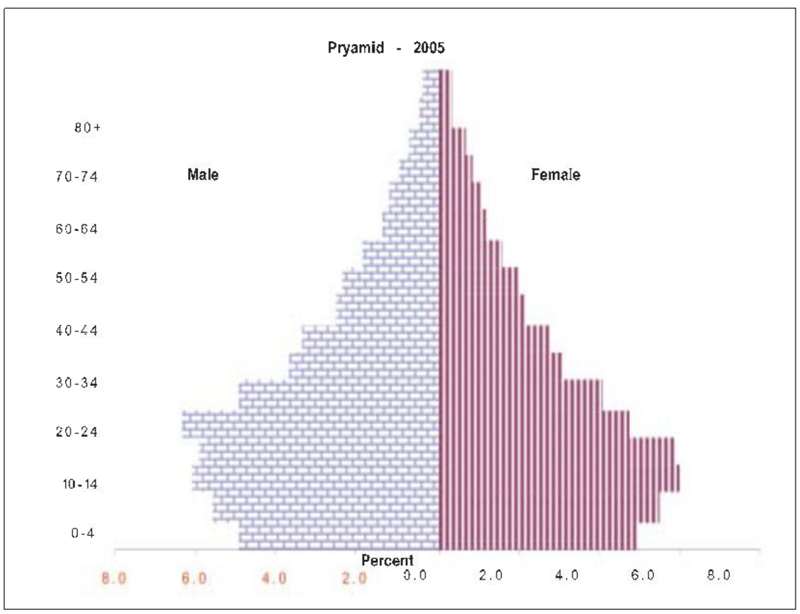
Indicators	2007	2008	2009	2010	2011
Diabetes Incidence per 10,000 population	26	38	38	47	53
Cancer Incidence per 10,000 population	13	10	17	15	14
Alcohol Liver Disease Incidence per 10,000 Population	22	20	23	28	29
Hypertension Incidence per 10,000 population	294	303	310	343	325
Depression Incidence per 10,000	11	11	9	11	7

Source: AHB 2012

2.5 Population Trends

In 2011 the estimated population of Bhutan was 708,265 (projected) with 369,476 persons (52.2%) male and 338,789 persons (47.8%) female (Bhutan, 2011). The estimated annual population growth rate is 1.3% and the present population density is low at 18.4 person/km. Seen in (Figure 6), as of the most recent census in 2005, the population structure had 33.1% under age 15, 62.3% between 15-64, and only 4.7% over the age of 65. More people live in rural areas (69.1%) than urban (30.9%)

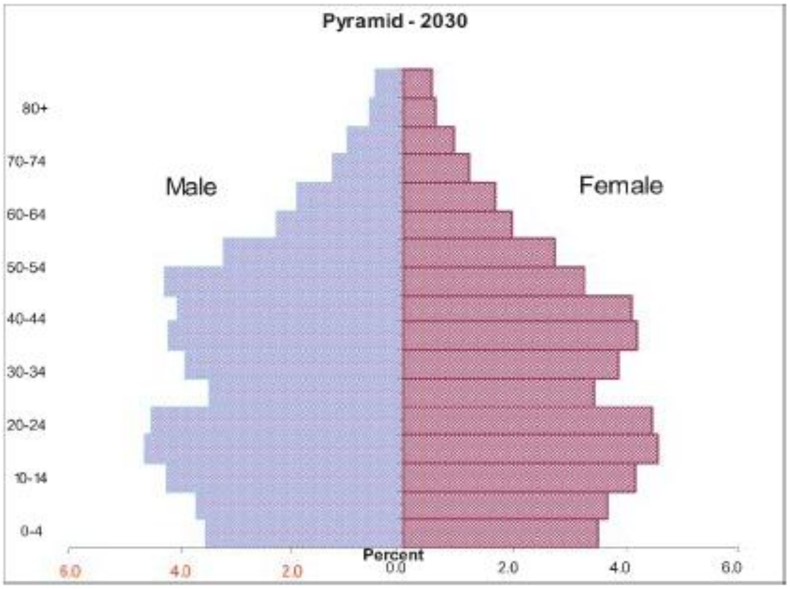
Figure 6: Population distribution as of 2005



Source: Population and Housing Census of Bhutan (PHCB 2005)

However, by 2030 (in the next 18 years) the population structure in Bhutan is expected to change and is projected to grow by 40% with an increase in population density from 16 persons (2005) to 23 person by 2030 (Annex 1). Two important shifts in the population distribution are expected, and are visible in (Figure 7). First, the number of older persons (over 65) will double by 2030, from 29,745 persons to 58,110 persons due to declining fertility and consistent increase in life expectancy. Secondly, because of the declining fertility rate, the proportion of population aged less than 15 years is projected to decline from 33.1% to 22.8% of the population. The population in the school-going age of 5-14 years is expected to decline from 147,406 persons in 2005 (23.2% population) to 15.8% of the population or 140,037 children in 2030.

Figure 7: Projected Age Sex Distribution 2030



Source: Population and Housing Census of Bhutan (PHCB 2005)

2.6 Public health priorities in Bhutan

Bhutan has made significant progress in improving the health of its citizens. However, the following new challenges have been recognized by the health sector in Bhutan (MoH, 2012 National Health Policy)

1) Rising health care expenditure;
2) Changing life style and disease pattern;
3) Inadequate human resources;
4) Changing political environment;
5) Increasingly evolving health care needs of the population;
6) International health obligations and
7) New health technologies.

Priorities for the health sector in Bhutan include:

- Achieve the Millennium Development Goals and SAARC Development Goals beyond the set targets;
- Improve quality and accessibility of health services;
- Improve promotive, preventive, curative and rehabilitative capacity;
- Enhance traditional medicine services at all levels, promote traditional medicine services as a centre of excellence in the region and facilitate health tourism; and
- Promote sustainability and equity in health care delivery system

CHAPTER 3: VULNERABILITY, HEALTH DETERMINANTS, AND CLIMATE SENSITIVITY

3.1 Vulnerability

Vulnerability is the susceptibility to harm, defined in terms of a population or a location. Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change(IPCC 2007).

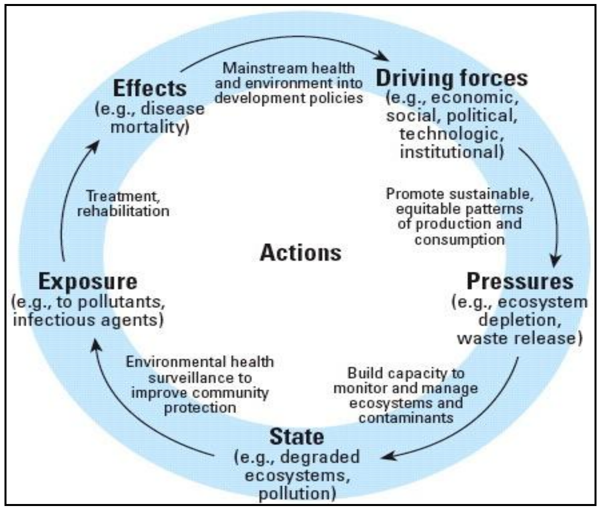
Vulnerability is a dynamic state and may itself be influenced by climate change (e.g., extreme weather events affecting health infrastructure). From a health perspective, vulnerability can be defined as the summation of all risk and protective factors that ultimately determine whether a sub population or region experiences adverse health outcomes due to climate change(Balbus and Malina 2009) of a region, such as baseline climate, abundance of natural resources (i.e., access to freshwater), elevation, infrastructure, and other factors can alter vulnerability.

3.2 Determinants of Health

Good or bad human health status is the result of a complex set of biological, social and environmental circumstances. Often referred to as the environmental and social determinants of health these underlying conditions in a country, to which people are exposed, and to which health outcomes can be attributed are critical considerations for health policy. For example, food security is an underlying determinant of nutritional status. Social indicators such as poverty, literacy, equity, access to health and other social services are important social determinants of health status in a country. Equally, issues such as the level of air and water pollution, access and use of sanitation, deforestation, productivity of agriculture, presence or absence of disease vectors dependent upon favorable ecological conditions for breeding and transmission, are critical environmental determinants of human health. Weather and climate conditions such as temperature, precipitation, and humidity are environmental determinants of health. This study uses a holistic framework to understand how health is determined and how these determining risk factors will themselves be affected by climate.

The D-P-S-E-E-A framework describes links between health, environment and development issues (Corvalán, Kjellström, and Smith 1999) in terms of: (D) driving forces, (P) pressures, (S)states, (E) exposures, (E) health effects of environmental risk factors and (A) actions which can be taken to mitigate these environmental health risks at different levels. From this model, shown in (Figure 8) we recognize that various driving forces generate pressures that influence the state of the environment and ultimately human health, through a range of exposure pathways by which people are exposed to adverse environmental conditions.

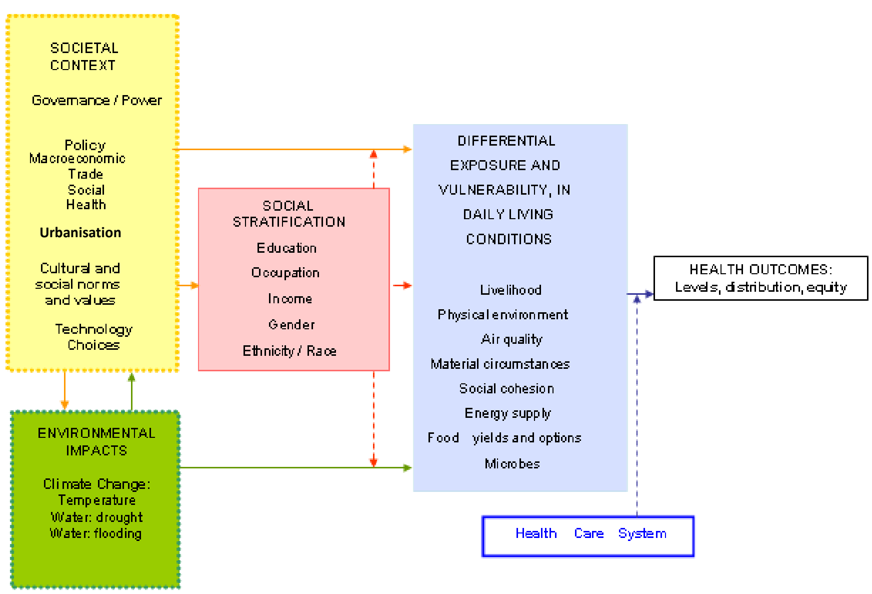
Figure 8: DPSEEA Model of Environmental health



The environmental determinants of health drive the exposures a person or community is likely to encounter. These environmental determinants such as agricultural production and food security, water resources, land use and forest cover, glacial lakes, energy, and air quality are recognized to be sensitive to changing climate conditions,

The societal context of vulnerability is shaped by existing governance structures, cultural norms, and macroeconomic policies. These conditions in turn influence social conditions and opportunities such as education, occupation, income, along with population characteristics of gender and ethnicity which determining factors for differential exposure and vulnerability in daily living conditions to shocks, stresses, and health impacts (Figure 9) (Bowen, Friel et al. 2011).

Figure 9: Conceptual model of Social determinants and Climate Change



3.3 Climate sensitivity of environmental determinants of health in Bhutan

Changing environmental conditions often result in changing and increasing health risks for people. Dry forests are at risk for fire, negative climate-impacts on food production increase risks for nutritional deficiencies. Five environmental conditions important for maintaining human health, biodiversity, air quality, food security, water security, and natural disasters are recognized in the SNC (2011) to be sensitive to climate changes in Bhutan and likely to be affected in the following ways.

1. Biodiversity and Forestry (SNC)

Bhutan is ranked amongst the top ten countries with the highest species density in the world, and has the highest fraction of land (42.7%) in Protected Areas (NCD 2009) and the highest proportion of forest cover (70.6%) than any Asian country (NCD 2002). Current threats to forests and biodiversity include direct pressures like urbanization, industrialization and other development and human activities, and indirect pressures like population growth, changing consumption patterns and climate change. For the forestry and biodiversity sector, both the HadCM3Q0/AIB and ECHAM5/A1B climate models, when coupled with the Holdridge Forest Classification System, show a general northward migration of the major forest classes of Bhutan in the future (2010-2039 and 2040- 2069), with subtropical species invading the southern margins and alpine species decreasing on the northern margins. Climate change will accelerate and exacerbate threats to biodiversity through loss of species, spread of invasive, pests and diseases, increased risk of forest fire, loss of agro diversity and loss of livelihood, traditional knowledge and practices.

2. Air quality

The quality of air in Bhutan is still pristine but a rapid economic development is placing pressure on air quality particularly in urban cities. The emission from vehicles, industries and domestic activities are the main causes of air pollutant, apart from seasonal dryness, wind and cold being factors that influences air quality in Bhutan including the heating season (November to March), when wood is used for space heating. Therefore, the foremost air pollutant of concern in Bhutan is particulate matter.

Between 2004 and 2010, stations were installed to measure particulate matter concentration in Thimphu, Kanglung, Gomtu, Rinchending, Pasakha, and Bajo town. Since then NECS has been carrying out daily monitoring of an ambient particulate matter concentration of less than 10µm (PM10) for 24 hours. The stations are categorized as industrial, mixed, and sensitive area each having maximum permissible limits of particulate matter in ug/m^3 set according to Ambient Air Quality Standards (Annex 43). Thimphu data till 2008, revealed that PM10 concentration level is significantly lower than the EU and US guideline standards, however the most recent data from NEC (Jan-Mar, 2011) showed that out of 3 months monitoring days of air quality, Gomtu has exceeded the limits for mixed area under the ambient air quality standards by 78% of monitoring days, Rinchending by 40%, Pasakha by 33%(industrial area), Thimphu by 5%(sensitive area) and kanglung by 1% (sensitive area) of the 90 monitoring days. According to 2012 Annual Health Bulletin the occurrence of respiratory diseases morbidity is very high at 1.6 million but there is no national study assessing the correlation between air pollution and the occurrence of respiratory diseases.

3. Water Security and Quality (SNC)

Bhutan has one of the highest per capita availability of water. Rivers constitute the main source of available water. Per capita consumption is estimated at 665 m3 (2002), with 93% consumed for irrigation and 2.3% for municipal uses. Per capita consumption is projected to increase to 7% by 2022 (NEC 2008).

V & A assessment of water indicates no climate affect on total water flow in the Wang Chhu River Basin which includes Thimphu, Haa, Paro, and Chukha. However, the majority of population settlements are located on hillsides and dependent on natural springs and smaller streams. Reported cases of water scarcity had been reported from several districts like Pemagatshel, Dagana etc (Namgyal 2011) (Pelden 2008) which presents a potential area of vulnerability, with projected drier and warmer winters in the future. Sub catchments areas with heavy population concentration are vulnerable. Access to safe drinking water is 96.1% (National Statistical Bureau 2010).

Table 10: Projection of Worst case scenario gross national consumptive and non-consumptive water

Demand Category	2002 (million m^3/year)	2012 (million m^3/year)	2022 (million m^3/year)
Municipal Demand	10	19	37
Irrigation Demand	393	472	472
Rural Demand	11	15	20
Industrial Demand	0.6	0.9	1.5
Livestock Demand	7.5	8.8	10.2
Sum of maximum consumptive demand	422	516	541
Sum of water supply demands	29.1	43.7	68.7
Add-on irrigation demand	15	-	26
Non-consumptive hydropower demand	6,700	16,600	26,900

Source: Final Water Resources Management Plan (WRMP) report, 2003

4. Agriculture and Food security (SNC)

2.9% of the total land area is used for agriculture (NSSC 2010) and 69% of Bhutan's population depends on it for their livelihood. Agriculture accounts for 18.5% of GDP in 2008. Therefore, a significant segment of the Bhutanese population is vulnerable to the impacts of climate change as crop irrigation is dependent on perennial streams and the monsoons. In addition, the rugged and steep terrain makes it difficult to both expand productions and market any surplus that may be produced. The main cash crops of the farmers (rice, potatoes, chillies, apples, maize and oranges) are all highly sensitive to water and temperature variations (DoA 2005). Dry land crops such as wheat, buckwheat, maize and barley are the major food source for the farmers; both for family consumption and for rearing livestock. Dry land crops are however entirely dependent on rainfall thus making the farmers even more vulnerable to climate hazards. Concerns are raised about the potential impacts of climate change on land use and soil fertility as well as adaptation to climate change risks in crop management and seed varieties.

5. Glaciers and GLOF

The northern region of Bhutan has numerous snow-clad mountains and glaciers. The glacier retraction and creation of glacial lakes with potential outburst floods is a major concern in Bhutan. Bhutan has 677 glaciers and 2674 glacial lakes. According to a study conducted by the Department of Geology and Mines, glaciers covered with debris are retreating at an average of 30-35 meters annually forming huge glacial lakes (YUTAKA AGETA 2000) while debris free glaciers show an average retreat of 27m per year on a horizontal scale (KARMA 2003).

Due to the rapid melting, 25 glacial lakes are considered potentially dangerous with the threat of glacial lake outburst floods (GLOFs). Based on rates of glacial retreat, temperature trends in the area and trends in GLOF in the region, threats from GLOF are expected to increase in the future. 18 years back (October 2004) the Luggye Tsho (glacial) moraine broke and released 18 million cubic meters of water killing 17 people and razing fields and settlements downstream (RSPN 2006). Bhutan has implemented GLOF risk mitigation measures at a couple of lakes. The possible significant impacts of glacial lake outbursts in the context of Bhutan include perturbation in the quantity of river water used for hydropower generation, destruction of settlements, infrastructure and agricultural lands and loss of biodiversity and even human lives downstream.

Table 11: Primary and Secondary Climate Sensitive Diseases

Climate Sensitive Health Outcome	Risk Factor	Scenarios of Health Risk Changes due to Climatic Changes
Vector Borne Diseases	Transmission of: Malaria P. Vivax Malaria P. Falciparum Dengue/DHF Japanese Encephalitis Emergent VBD: Kalazar, Chickungunya, Filariasis	Potential expansion of transmission zones due to: Warmer temperatures Population movement Increased rainfall dilutes chemical control methods
Diarrheal Diseases	Transmission of: Water borne diseases: (typhoid, cholera, dysentery, leptospirosis, polio, norovirusetc) Water-Washed (Hygiene) Lack of Water Food borne diseases (salmonellosis, e-coli, etc) Parasitosis/Helminthosis	Potential increased incidence due to: Reduced water for hygiene in some areas Contamination of water sources from flooding Use of compromised water sources in insecure highland areas Warmer temperatures conducive to food spoilage Concentration of migrants in urban areas with poor quality WATSAN
Injury, Losses and Damages to infrastructure and life	Occurrence of: GLOFs Flash flooding Windstorms Landslides Extreme temperatures	Potential increased losses and damages due to: BHU or Hospital facility or vehicle damage Interruption of regular services during emergencies Road blockages delay care-seeking or supply delivery Injury Drowning and death Mental Health Compromised water/san services
Secondary Impacts of climate change on Health in Bhutan		
Morbidity and Mortality of other CSDs	Nutrition & Nutritional Deficiency Mental Health Respiratory Diseases Allergens Cardiovascular diseases Rodent-borne diseases (Leptospirosis/Plague) Zoonosis	Potential increased incidence due to: Food insecurity – disruption of production Loss of productive land to flooding/erosion Foodstuff losses to flooding/storage Shocks and losses of disasters Increased allergens Reduced air quality from forest fires

CHAPTER 4: RESEARCH AIMS &METHODS

4.1 Objectives of the assessment

Broad objective

To access the vulnerability of the Health Sector in Bhutan to the impacts of current and future climate change; and identify effective measures to reduce climate-related risks to health in Bhutan.

Specific objectives

1. To assess the country's vulnerability including the populations and regions that are most vulnerable to different kinds of health effects.
2. To establish baseline conditions of climate sensitive diseases by describing the sensitivity and human health risks introduced by current climate variability and recent climate change
3. To describe the current capacity of health and other sectors to currently manage the risks of climate sensitive health outcomes.
4. To describe and estimate the risk of climate sensitive health outcomes which may change over decades due to social and environmental conditions, irrespective of climate change.
5. To estimate the possible additional burden of climate-sensitive diseases (future risk) attributable to climate change which may occur over the coming decades?
6. To identify and recommend adaptation options to address current and projected health risks.

4.2 Methods

4.2.1 Process for conducting the assessment

The World Health Organization (WHO) along with UN Development Program (UNDP) have been granted a project for Piloting climate change adaptation to protect human health, from the Global Environment Fund (GEF) administered Special Climate Change Fund (SCCF). The project is intended to assist the Ministry of Health, Royal Government of Bhutan to define health adaptation measures to meet the anticipated health impacts from Climate Change. As a part of the project, the Ministry of Health, Bhutan has awarded the Center for Research Initiatives, Thimphu (local consultancy firm) the task of conducting the National Health Vulnerability and Adaptation Assessment to Climate Change. Joy Guillemot, Technical Expert for Climate Change and Health was recruited by WHO to support CRI. The national and the international consultants were supported by the Technical Working Group (Annex 2) for health and climate change through series of consultations.

4.2.2 Methods of the assessment

Health and climate change is relatively new concept. Country like Bhutan has not internalized the change in climate variables and its effect on diseases. There is a dire lack of professional capacity in Ministry of Health. In such circumstance, the study needs to be properly coordinated to optimize the benefits and needs of the country. A variety of methodologies were discussed for assessing the potential health effects of climate variability and change in Bhutan. Both qualitative and quantitative approaches were used, as appropriate, depending on the data availability, level and type of knowledge. World Health Organization (WHO) "Protecting health from climate change: Vulnerability Assessment and Adaption was used as the main guiding document for the VAA.

4.2.3 Assessment Scope

Frame & Scope the Assessment			Vulnerability Assessment	Impact Assessment	Adaptation Assessment
What to collect	**Where to Collect (Source)**	**How to Collect (Tools)**	**Exposure: Current human health risks & burden & capacity of sectors to address it.**	**Sensitivity: Project future health risk & impact under climate change.**	**Health Capacity to adjust, to moderate the potential damage from Vector borne diseases it and to cope with the consequences.**
Burden of diseases, **Area affected.** **Population at risk.** **Morbidity and mortality**	VBDC Program, Respective Malaria centers, MoH	Annual Malaria Reports, National Malaria survey & review reports. Field visits and consultations using checklist and questionnaires	Diseases incidence & trend analysis Population at risk, endemic areas Morbidity and mortality Current VBDCP policies, interventions & capacity	Risk estimates due to climate variability (regions, populations, incidences) Estimate possible additional burden due to CC. Gap analysis & recommendations in policies and strategies to reduce the potential health risks due to climate change.	Effectiveness of VBDC Program. Health capacity to deal with future VBD incidences due to Climate change. Gap Analysis and recommendations

Vulnerability and Adaptation Assessment Process

Step 1: Frame and Scope the Assessment exercise

Step 2: Conduct Vulnerability Assessment (to identify baseline conditions).

(2.1) Describe Current Risks of Climate-Sensitive Health Outcomes, Including the Most Vulnerable Populations and Regions

(2.2) Describe the Current Capacity of Health and Other Sectors to Manage the Risks of Climate-Sensitive Health Outcomes

Step 3: Conduct Impact Assessment (to identify future impacts of climate change on health).

(3.1) Describe How the Risks of Climate-Sensitive Health Outcomes, Including the Most Vulnerable Populations and Regions, May Change over Coming Decades, Irrespective of Climate Change

(3.2) Estimate the Possible Additional Burden of Adverse Health Outcomes due to Climate Change

Step 4: Conduct Adaptation assessment (to identify and prioritize policies and programs to address current and projected health risks.)

(4.1) Identify additional public health and health-care policies and programs to prevent likely future health burdens

(4.2)Prioritize public health and health-care policies and programs to reduce likely future health burdens

(4.3)Estimate the costs of action and of inaction

4.2.4 Thematic Scope

Many public health priorities in Bhutan are climate sensitive and may be impacted by future climate change. Resources and information constrain lead to prioritization of following three categories of health impacts which are the focus of this study:

1. Losses and damages, including morbidity and mortality related to extreme weather events and GLOF flooding
2. Diarrheal diseases, including water-borne, water-washed, and food-borne transmission.
3. Malaria incidences including other vector borne diseases like dengue/DHF, JE, and Kalazar

20 districts (Dzongkhags) are the geographic basis of analysis, where possible disaggregated information at block (geog) or health facility was used for case studies. This study also reflects health concerns across the 3 climatic zones 1) the Northern Alpine regions 2) Central inner valleys and 3) southern low lands. Secondary climate sensitive's diseases which may be impacted are also preliminarily described, as the basis for future studies. These include nutrition, mental health, respiratory infections, cancer and etc.

4.3 Data Collection and Methods

Vulnerability is a function of the exposure to hazard, sensitivity to harm and adaptive capacity of the population or health system to not be negatively affected by or recover from climate-related risks. These three factors will be assessed and described in detail, using secondary data to support primary data collected in field surveys, as available.

Baseline climatic conditions will be derived from the Bhutan SNC, and figures provided by the Department of Hydromet Services. Baseline conditions of climate sensitive health outcomes will be obtained primarily through an in-depth literature review of existing government reports, peer-reviewed literature, and existing secondary data from the MoH HMIS, VBDCP, and others. Population and Health System vulnerability by district will be determined though a combination of sources.

(a) Exposure Data: Historical data on exposure to climatic-related hazards and variables such as, average temperature, precipitation, and extreme weather from 1990 to 2010 at the district level; will be collected from the Meteorological division. Historical incidence of extreme weather events such as flash floods, windstorms, and related hazards such as landslides will be correlated with health outcomes, to estimate health burdens associated with extreme events in Bhutan.

Future climate exposure will use downscaled GCMs elaborated for the SNC.

Sensitivity: Data describing population sensitivity. Demographic pattern of the population and its health characteristics will be studied and mapped using GIS. GIS will be used extensively to gather and correlate health, socio-demographic data, environmental and climatic data. Important sensitivity data include:

- Population with age and sex breakdown
- Mapping of population according to area of residence – rural, urban, river basin etc
- Socio-economic status of the population
- Health status in terms of prevalence of disease, nutritional status
- Access to health care and availability of services
- Communication facilities available
- Distribution of other sector services and availability, i.e. education

Adaptive capacity: The ability to change behavior and adjust practices to respond to climate change so as to moderate or offset the potential damages will be assessed. Factors to be considered here will be on the educational level of the population, awareness on climate change, preparedness for disaster, community actions taken to mitigate climate change and activities initiated by stakeholders. Key information to be collected will be on type of technologies used by other sectors for early warning systems, availability of resources, collaboration and current status of NAPA (National Adaptation Programme of Action)

Focus will be given on assessing the adaptive capability of the health sector to respond to the challenges of climate change in Bhutan. Towards this end surveys of the capacity and vulnerability of health facilities and programmes will be undertaken both at the local and national levels.

Field Survey of Adaptive Capacity and Readiness of the Health Sector

As part of the assessment, selected health facilities were visited for consulting with the health workers, program officers, district health officers and the communities to ascertain the ongoing strategies, programs and discuss the future requirements and challenges. The methods employed were in-depth consultations, focus group discussion and observations:

Questionnaire guide for capacity adaptation Refer (Assessment tool 1: Inter sector - National Context Assessment), (Assessment tool 2: Environmental Health Program, Ministry of Health Assessment), (Assessment tool 3: Vector Borne Disease Control Program (VDCP) Assessment), (Assessment tool 4: Health Facility Level Assessment)

Focus Group Discussions: This is held with district administrators, focal persons, health workers and local communities from different areas and the main theme for discussion will be on vulnerability, climate change, awareness and risks from climate change events. Inter sector -National Context Assessment

Study Sites

Taking into view the health outcomes of interest for the present assessment, we propose the following sites for field survey.

- Sites for Diarrheal study: Gelephu & Paro hospital, Khamdang BHU and Chamgang BHU
- Site for Malaria study: Gelephu Hospital, Damphu Hospital, Bajothang BHU, Tongtonphey BHU, Lhamiozingkha BHU, Nganglam BHU, Khehi BHU
- Study sites for extreme weather sites: Punakha, Wangdue, Bumthang GLOF valley and Pemagatsel district for windstorm and earthquake.

Figure 10: Study sites for the study

Site selection was determined by the retrospective analysis of CSD burden (high incidence areas), coupled with the risk assessment of population which are most exposed to climate sensitive environmental risk conditions. Therefore the hospitals and BHUs with highest malaria and diarrheal cases for last two years (Annex 2) and (Annex 39) were selected. Due consideration were also given to non endemic district, project areas and areas with potential for outbreaks. Pemagatshel was specifically selected to represent the extreme weather events as it was the most affected in 2011 windstorm.

4.4 Secondary data analyses

a) Climate data

The National Environment Commission has constructed two future climate scenarios (HadCM3Q0/A1B and ECHAM5/A1B), to estimate future mean precipitation and temperature for covering the periods for 2010-2039 and 2040-2069 downscaling in PRECIS. National climatic variables (1996-2011) were provided by Hydro-Met Department, MoEA.

b) Health data

10 years diarrhea and dysentery incidences segregated by health facility were obtained from Health Information Unit, MoH. Vector borne related incidences were obtained from VDCP, Gelephu and the damages to properties and infrastructure due to extreme weather conditions were availed from Department of Disaster Management, MoHCA.

Statistical Analyses

Using regression analysis and ANOVA statistics, time-series trend analysis of baseline climate conditions (1980-2009) will be correlated with the incidence of selected CSD at the district level. The results will indicate the sensitivity of these CSD to changes to variables of precipitation and temperature, if at all. The correlation coefficients can then be used to extrapolate potential changes in diseases incidence attributable to the estimate degree of change in these two variables alone, at the district level.

Qualitative Scenarios

Given data limitations in the historical climate and disease record, qualitative scenarios can be used to estimate potential changes in disease and health outcome risks. The current trend of the selected health outcomes and related conditions will also be studied and using expert judgment of stakeholders, literature review and consultants experience, inputs will be used to describe future trend irrespective of climate change. Storylines will be used to gather and construct future health impacts following climate change.

4.5 Study Protocol for Capacity Assessment

Health facilities depending on risk and vulnerable population were identified and visited. Program Manger and the senior medical entomologist of VDCP, and malaria technicians in health facilities and the health in charges and District medical officers of the identified health facilities were met and interviewed. At the national level the Program Officer of Environmental Health, NEC, DDM and others were also consulted.

CHAPTER 5: IMPACTS OF CLIMATE CHANGE ON DIARRHEAL DISEASES IN BHUTAN

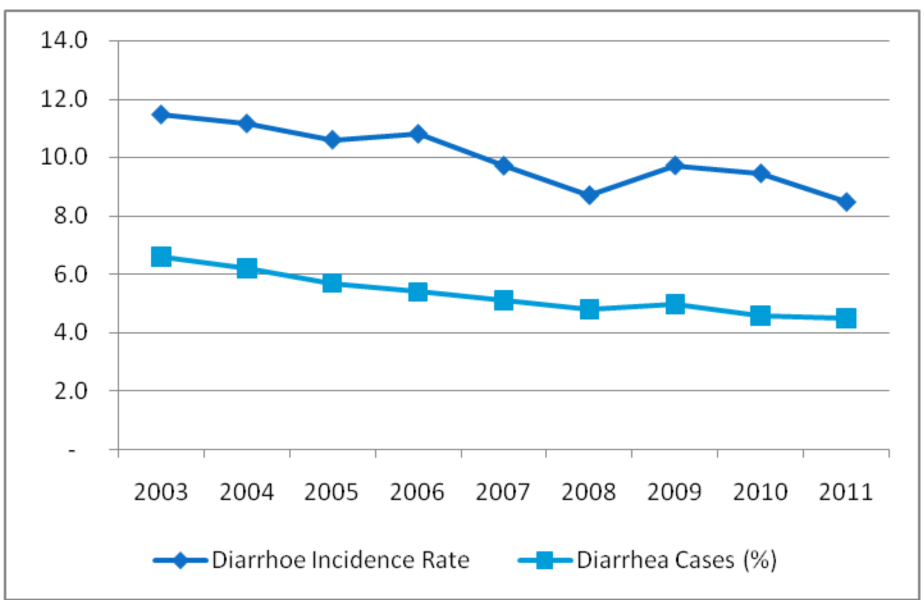
5.1 Global Overview

Diarrhea is one of the leading causes of mortality and morbidity (Kosek M 2003) and about two million children die each year (Umesh D. Parashar 2003) from it. In Bhutan annually it affects about 30% children under five years of age (Annex 15). Water and food contaminated with bacteria, viruses, and protozoa cause infectious diarrhea often locking the victims into a vicious cycle of undernourishment, susceptibility to other infectious diseases, and eventually death. The risk factors constitute accessibility to safe drinking water & improved sanitation (Ravallion 2001) infant and young child care and feeding practices and climatic change. The access to safe drinking in Bhutan is 96% with 55% of the households with improved latrine and climatic conditions in Bhutan have been stable over the past 10 years. WHO estimates that there will be 10% more diarrheal diseases by 2030 than there would have been with no climate change (Shuman 2011). The disease burden from water, sanitation, and hygiene is estimated to be 4.0% of all deaths and 5.7% of the total disease burden in DALYs (Annette Prüss 2002).

5.2 Vulnerability and Baseline Conditions of Diarrheal Disease

Diarrheal diseases are in the top ten causes of morbidity (Table 6) and the number of diarrhea cases has remain same over the last five years while the incident rate has been fluctuating since 2008 with slight decrease in 2011 (Figure 11).

Figure 11: Diarrhea cases & diarrhea incidence rate, 2003-2011



Annually, diarrheal cases continue to burden an estimate of 10% of the total population and 30% children under five years of age (Annex 15).The central region with seven districts (Bumthang, Dagana, Sarpang, Trongsa, Tsirang, Zhemgang, Wangduephodrang) has the highest (120) diarrhea incidence rate (Table 12). Regional classification of climate variables is not available for tabulating climatic risk.

Table 12: Average diarrheal incidence rate by region

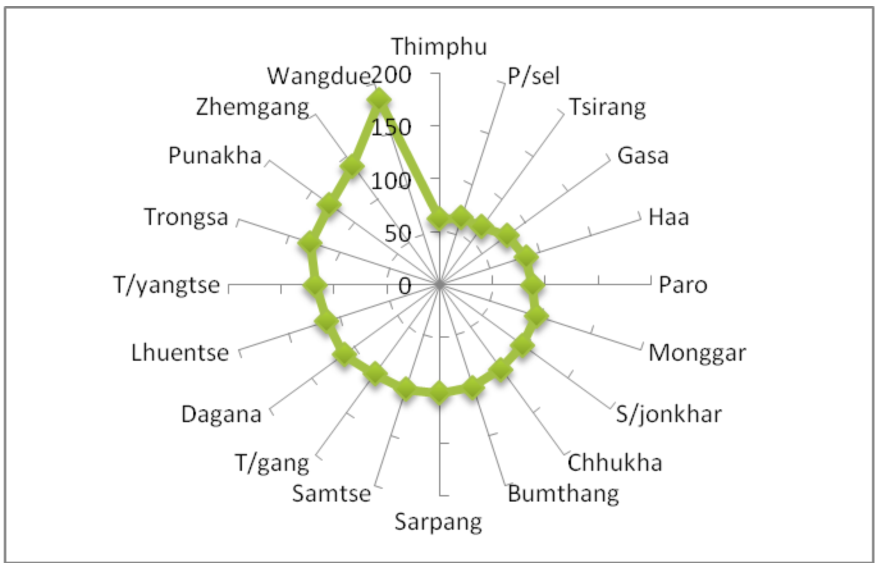
Region	Diarrhea Incident Rate	Access to H_2O (BMIS 2010)
Central Region	120	95%
Eastern Region	99	98%
Western Region	93	96%

Diarrheal disease caused by pathogenic organisms such as Salmonellosis, Helminthesis, Shigellosis, leptospirosis and cholera are reported. However, the number of cases diagnosed and reported by causal agent is negligible. In 2010 and 2011 reported only 41 cases of shigellosis and 1 leptospirosis (NDS, PHL, DoPH, MoH) case for the whole country. The last known cholera outbreak was in 1998. Systematic collection of data on notifiable diseases such as Shigellosis, Leptospirosis and cholera commenced in 2010 (Wangchuk 2010; Wangchuk 2011).

Vulnerable Districts

The incidence rates indicate that Wangdue, Zhemgang, Punakha and Trongsa are most vulnerable to diarrheal disease (Figure 12). Further, the incident rates have been increasing in Gasa, Paro and Samdrupjongkhar in 2010 and 2011 (Annex 5).

Figure 12: District wise average diarrheal incidence, 2003-2010

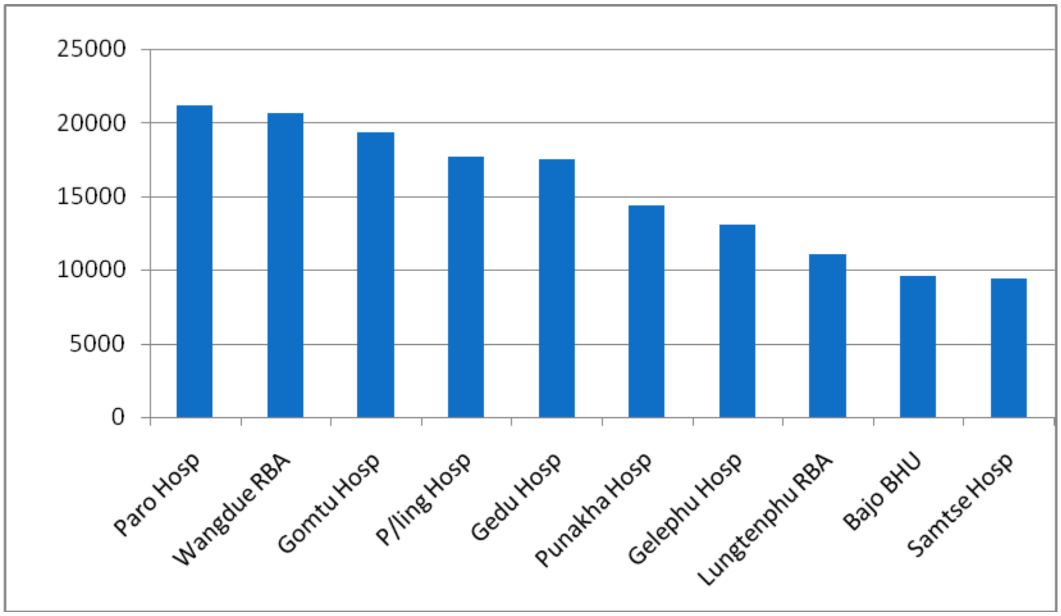


However, when considering the diarrheal cases, 48% of the total diarrheal cases are reported from 5 districts of Chukha (12%), Samtse (10%), Thimphu and Wangdue (9% each) and Trashigang (8%) (Annex 6) and the common characteristic of these five districts are large catchment areas, clustered urban population, existence of referral hospitals and mega hydro power projects, industrial factories and open border with India. While Gasa and Haa district reported the least diarrheal cases and both are northern most district with least population and highly migratory.

Vulnerable health facilities

Similarly, it is observed that health facilities located in military centers (Wangdi and Lungtenphu RBA Hospital), industrial areas and border areas (Gomtu, Gelephu and Phuntsholing Hospitals) are most vulnerable Figure 13 and Annex 7. On the other hand the health facilities with low catchment and situated in northern district have the lowest diarrheal incidence. Incidence rate is not available as population by health facilities is not reliable. Regionally, the western region has the highest diarrheal incidence followed by eastern and southern region and least in the central region (Table 12).

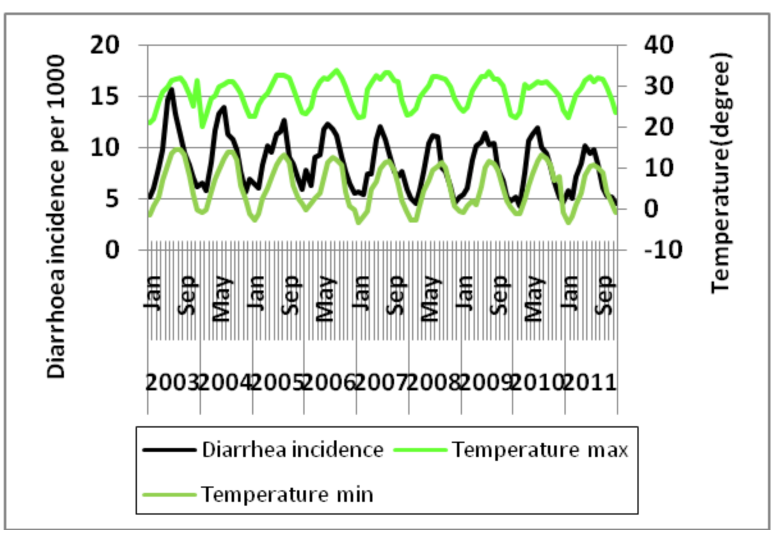
Figure 13: Ten health facilities with highest number of Diarrhea cases



Vulnerable season

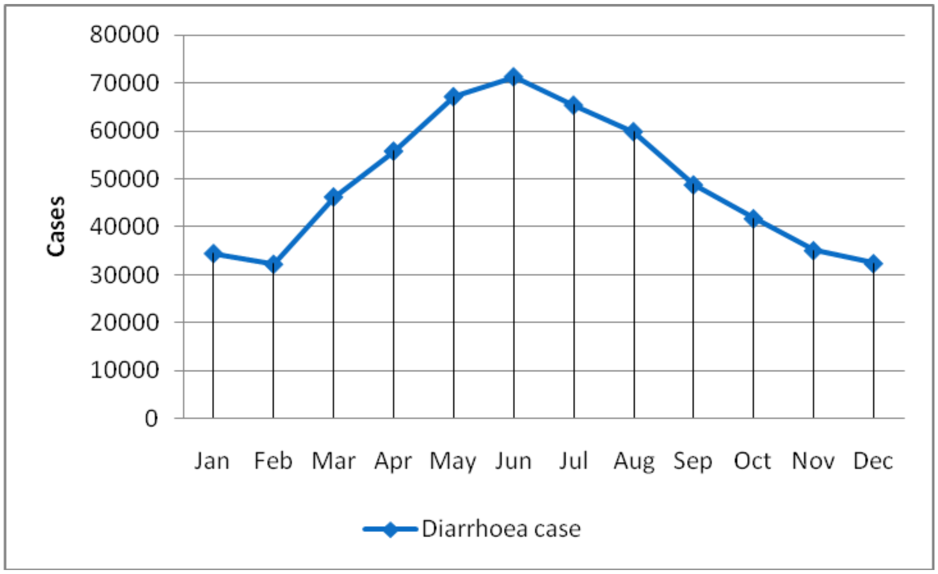
Figure 14 reveal that maximum temperature has been stable (2003-2011) and the two hottest years (2006 & 2009) doesn't correspond to high diarrhea incidence occurred during 2003 and 2004. However, seasonal analysis indicates that 53% of the total diarrheal cases are reported between April and August, with peak cases occurring predominantly in June (Figure 15) with the exception of 2005 and 2011 when caseload peaked during July. Therefore month of May, June and July are vulnerable period and this is also supported by time series analysis (Table 13).

Figure 14: Comparisons of total diarrheal incidence and temperature (degree) over the analysis period (2003 to 2011)



(Note: black arrows show the highest temperature while red arrows show the highest diarrhea incidence)

Figure 15: Diarrheal caseload by month, 2003-2011



5.3 Future Impacts (vulnerability) of Climate Change on Diarrheal Disease in Bhutan

Globally the relationship between climate change and health is now unequivocal and time series analysis (ARIMAX) from Peru, Fiji, China, India and Bangladesh indicate increase in diarrhea incidence due to change in climate (Sarkar 2007) Similarly, the time series analysis using ARIMA (1,1,1) (0,1,1) forecast (Table 13) incidence rate of 82.5 and 80.6 per 1000 diarrhea cases in all age group in 2012 and 2013 respectively (Incidence rate in 2011 is 84.9) in Bhutan. In children under five years of age, the incidence rate will be 181.7 and 130.5 per 1000 diarrhea cases for 2012 and 2013 respectively (incidence rate in children under five years in 2011 is 215) (Table 13).

Table 13: Monthly forecasted diarrhea incidence (total and under five) per 1000 for 2012 and 2013

Months	**2012**		**2013**	
	Total diarrhea	Under five diarrhea	Total diarrhea	Under five diarrhea
January	5.5	20.2	5.5	16.6
February	4.8	17.3	4.8	13.5
March	6.9	19.6	6.9	15.8
April	8.2	18.5	8.2	14.6
May	10.0	20.4	10.0	16.3
June	9.2	18.8	9.2	14.6
July	9.5	16.8	9.5	12.5
August	5.8	8.7	5.8	4.1
September	5.0	8.5	5.0	3.8
October	4.9	9.7	4.9	4.8
November	4.3	9.5	4.3	4.6
December	5.3	20.2	5.3	16.6
Total	82.5	181.7	80.6	130.5

Also the Random Effect Poisson Regression was performed on longitudinal data (2003-2011) of all 20 districts and three district with highest diarrhea incidence rate. The analysis show that mean temperature is significantly ($p<0.000$) associated with the total diarrhea incidence but not significant for under five diarrhea incidence ($p=0.244$). And the rainfall is not significantly associated with the total diarrhea incidence ($p=0.46$), however rainfall is associated with under five diarrhea incidence ($p=0.032$). Therefore, for every increase in mean temperature by 1^0C, the total diarrhea incidence (per 1000) is expected to increase by 5.3% (Table 14). No under-five diarrhea incidence will increase for every unit (mm) of rainfall despite being significantly associated (Annex 8, Annex 9, Annex 16, and Annex 17).

For the three vulnerable districts of Zhemgang, Wangdue & Punakha with highest reported diarrhea incidence, Poisson Random Regression was carried out to find the association and change in diarrhea incidence. The analysis indicates that:

- In Wangdue, for every increase of mean temperature by 1^0C, the total and under five diarrhea incidence will increase by 5.1% and 1.3% respectively (Annex 10)
- In Zhemgang district, diarrhea incidence (total and under five) will increase by 6.8% and 2.0% for 1^0C increase of mean temperature (Annex 11)
- Phunakha district will see an increase of 4.7% of total diarrhea but no increase in incidence of under five diarrhea incidence (Annex 12)

Further, using the projected climatic variables of these three districts from SNC (Annex 13 &Annex 14), the highest and lowest increase in the diarrhea incidence will be seen in Zhemgang and Wangdue respectively for both the time frame (2010-2039 and 2040-2069) based on project increase in temperature for both the models (Table 14 & Table 15). However, change in precipitation has no affect on the overall diarrhea incidence but it does affect the diarrheal incidence in children under five years of age (Table 16 and Table 17). The forecast shows significant increase in diarrhea incidence for Punakha (111.8%) based on the projected rainfall from the HADCM3/A1B MODEL.

Table 14: Forecasted increase in diarrheal incidence for three districts based on projected increase in temperature based on HADCM3/A1B Model

	HADCM3/A1B MODEL	Wangdue	Zhemgang	Punakha
Total diarrhea incidence increase	2010-2039	5.1%	6.1%	4.7%
	2040-2069	12.8%	15.6%	11.8%
Under five diarrheal incidence	2010-2039	1.3%	1.8%	0.8%
	2040-2069	3.3%	4.6%	1.8%

Table 15: Forecasted increase in diarrheal incidence for three districts based on projected increase in temperature based on ECHAM3/A1B Model

	ECHAM5/A1B MODEL	Wangdue	Zhemgang	Punakha
Total diarrhea incidence increase	2010-2039	4.1%	5.4%	3.3%
	2040-2069	12.2%	15.0%	11.8%
Under five diarrheal incidence	2010-2039	1.0%	1.6%	0.6%
	2040-2069	3.1%	4.4%	1.8%

Table 16: Forecasted increase in diarrheal incidence for three districts based on projected increase in rainfall based on HADCM3/A1B Model

	HADCM3/A1B MODEL	Wangdue	Zhemgang	Punakha
Total diarrhea incidence increase	2010-2039			
	2040-2069			
Under five diarrheal incidence	2010-2039	12.4%		27.3%
	2040-2069	38.9%		82.5%

Table 17: Forecasted increase in diarrheal incidence for three districts based on projected increase in rainfall based on ECHAM3/A1B Model

	HADCM3/A1B MODEL	Wangdue	Zhemgang	Punakha
Total diarrhea incidence increase	2010-2039			
	2040-2069			
Under five diarrheal incidence	2010-2039	11.9%		21.4%
	2040-2069	52.5%		111.8%

Diarrheal diseases in Bhutan will continue to remain stable over next few years as there is no significant incremental in cases for next two years despite the association per this analysis. This could be possibly due to effective primary health care services with 90% of the population having access to health services (AHB 2012) and 96% of the households with access to safe drinking water supply.

In addition to risks attributed to climate change, some of the immediate risk factor for diarrheal incidence include the Hydro power project sites (Punatshangchu and Tala Hydro Power Project), industrial areas of Pasakha and Gomtu, Military wings and growing urban areas (Thimphu, Phuntsholing, Mongar, Samdrupjonkhar).

Current trend is indicative that 30% of the children under five years of age will be suffering from diarrheal diseases annually and based on the population project (National Statistical Bureau), we estimate that by 2015 and 2030 there will be 24815 and 18698 children at risk of diarrheal diseases respectively.

5.4 Gap Analysis of Diarrheal Diseases Control Program

The Diarrheal Control Program currently operates as CDD/ARI under the Communicable Diseases Division, Department of Public Health. It is manned by two persons and the main function of the program is policy planning, resource mobilization and allocation, coordination and disseminating information, plan and develop control strategies based on information, regular monitoring and surveillance. The actual implementations of activities are decentralized to district health services where medical doctors and different categories of health workers are available in adequate numbers.

Human resources at the BHU and Hospital level are adequate in terms of skills and number to deal with current and future diarrheal morbidity. Health workers are adequately trained on diagnosis, treatment and management of diarrhea in the Royal Institute of Health Sciences through minimum two years of training. Periodic in-service training for health workers are conducted regularly.

Problem analysis indicate that diarrheal morbidity could be over reported due to double reporting of the same child coming for consecutive days and leniency in defining diarrhea "officially it is three diarrheal episode in a day"

5.5 Adaptation Needs and Options to Manage Climate Risks to Diarrheal Disease

As the baseline illustrated, annually in Bhutan diarrheal disease affects about 30% of Bhutanese children under five, rising to 35% in high risk zones (those identified with high incidence). Despite significant improvements in water and sanitation infrastructure, current burden of diarrheal disease is still very high and indicates additional action is needed to reduce transmission of waterborne diseases.

The vulnerable areas include hydro power project, resettlement and industrial areas, and military centers and borders areas. The risk can be escalated in the month of June, July and August. These risk factors are likely to be affected by climate change, which predicts increased rainfall and higher temperatures. Available data allows to categories vulnerability by Region, district and by health facilities.

- Districts: Wangdue, Punakha, Trongsa, Zhemgang and Trashiyangtse.
- Health Facilities: Paro Hospital, Wangdue RBA BHU, Gomtu Hospital, Phuntsholing Hospital, Gedu Hospital, Punakha Hospital, Gelephu Hospital, Lungtenphu Amy Hospital, Bajo BHU and Samtse Hospital (Figure 13)
- Regionally the Central region is most vulnerable (Table 12)

Since 1997 the coverage of water and sanitation has been over 70% reaching 96% in 2011. However, high access to safe drinking water and sanitation seems to have little effect on the reduction of diarrheal incidences in Bhutan. It is most likely that a significant portion of current diarrheal morbidity is related to hygiene and sanitation practices rather than absence of access to piped water. Poor household hygiene may be maintaining high levels of diarrheal disease transmission despite increased Wat/San infrastructure. Also children under five are most vulnerable and correspondingly the malnutrition is also high in children under five (NNS 2009). Various adaptation options are outlined in the Recommendation chapter

Case Study: Realities of Water and Sanitation Risks for Diarrhea

The Case Analysis of Linzhi BHU: We found that 82% of the houses have latrine but majority of them are not usable, some have never been used and most villagers still use open defecation in nature. At the time of the field survey, access to piped water was only 6%, despite official statistics for the same year reporting 74% in this area have access to piped water (2012 AHB). Community sanitation like foot path and drainage system is lacking.

For example, in Chabesa, Lingzhi gewog there are 24 households with a total population of 110, including 12 children under five. The nearest health facility (Lingshi BHU) is two hours walk. Neither of the two available water posts are functional (shown below), and according to villagers they have been without a safe drinking water source for many months. Community members access surface water from a nearby running stream 15-20 meters from the furthest household. As shown in the picture, there is neither stone path nor drainage system in the community resulting in water logging and muddy foot path contributing to poor household/personal hygiene and sanitation. Thus, although officially 82% have access to improved sanitation, and 74% improved water source in this community, the true conditions are far from these figures. It is not surprising that diarrheal incidence reported at the BHU for these communities is 37 per 1000 population which is very high.

Non-functional water post in Chabesa village, Lingshi gewog

This case study demonstrates the importance for the MoH to institute a stringent data quality and validation system particularly on use and access of water and sanitation services. In the context of climate change, poor reporting contributes to increased vulnerability both of communities and the health system. When communities are much more vulnerable than official records imply, a range of deteriorating conditions and even outbreaks can occur, which will result in strain on the health system and avoidable disease and deaths.

A provision was made in the 2012 Annual Health Bulletin to collect and report the non functional water post. An innovative system to collect real-time data from community health workers through SMS, could improve the reliability of the administrative data on piped water and latrine coverage. Access to safe drinking water and sanitation coverage has increased from 78% in 1996 to 96% in 2011 (Bhutan, 2011) though the diarrhea cases has not decreased in Bhutan. This is despite strong evidence that improved access to safe drinking water is known to reduce diarrheal incidence (Ravallion 2001).

CHAPTER 6: IMPACTS OF CLIMATE CHANGE ON VECTOR-BORNE DISEASES IN BHUTAN

6.1 Overview

Climate change and increased climatic variability could significantly affect vector borne disease in Bhutan (Table 1). All vector-borne diseases are climate sensitive. It is established in the scientific literature that temperature, precipitation, humidity, and other environmental and climatic factors affect the reproduction, development, behavior, and population dynamics of arthropod vectors temperatures directly affect the spread of vector-borne diseases in three ways: it expands the geographic range of the vector, decreases the time required for the pathogen to replicate inside the mosquito and become infectious to another human, known as the extrinsic incubation period (EIP)finally increases the biting rate of female mosquitoes (contact rate) (Brunkard, Cifuentes, and Rothenberg 2008). Climate also influences the population dynamics and ranges of nonhuman vertebrate reservoirs (eg. bats, rats, pigs, birds) of vector borne diseases.

In Bhutan, it is estimated that average temperatures will increase an additional 1.1^0C in the period 2010-2039 and by a total of 2.4 ^{0}C for the period 2040-2069 from what has been experience in the baseline period 1980-2009 (SNC, NEC). These increases in temperature may increase the likelihood of VBD transmission in new areas, particularly at the geographic margins (both in distance and altitude) of the current suitable temperature range for transmission. These margins will expand as temperatures rise. For many diseases these margins lie in the range 14–18 Degree Celsius at the lower end and about 35–40 Degree Celsius the upper end (Githeko, Lindsay et al. 2000).

While Bhutan has successfully controlled malaria and is working toward elimination it has recently experienced the emergence of other important vector borne diseases which may be affected by climate change. These include outbreaks and sporadic cases of Dengue (2004) Kalazaar (2006) Japanese Encephilitis (2009), Scrub Typhus, Filariasis and most recently Chikungunya (2012). However, existing data is limited regarding these other diseases and therefore this analysis considers the climate sensitivity as an example of how the transmission of other VBDs may be influenced by climate change. Similarly, findings regarding malaria may be transferrable to other VBDs, with regards to diagnosis and treatment of fevers and use of bed nets.

6.2 Baseline Conditions of VBDs in Bhutan

This section describes the baseline conditions Dengue fever, Japanese encephalitis, kalazaar, and malaria which are the most important climate sensitive vector-borne diseases in Bhutan. Scrub Typhus, Filiariasis, and Chickungunya are also climate-sensitive and present in Bhutan, but not considered. Baseline conditions include current disease burden and distribution, risk factors for transmission, known sensitivity to climate, and current control capacity.

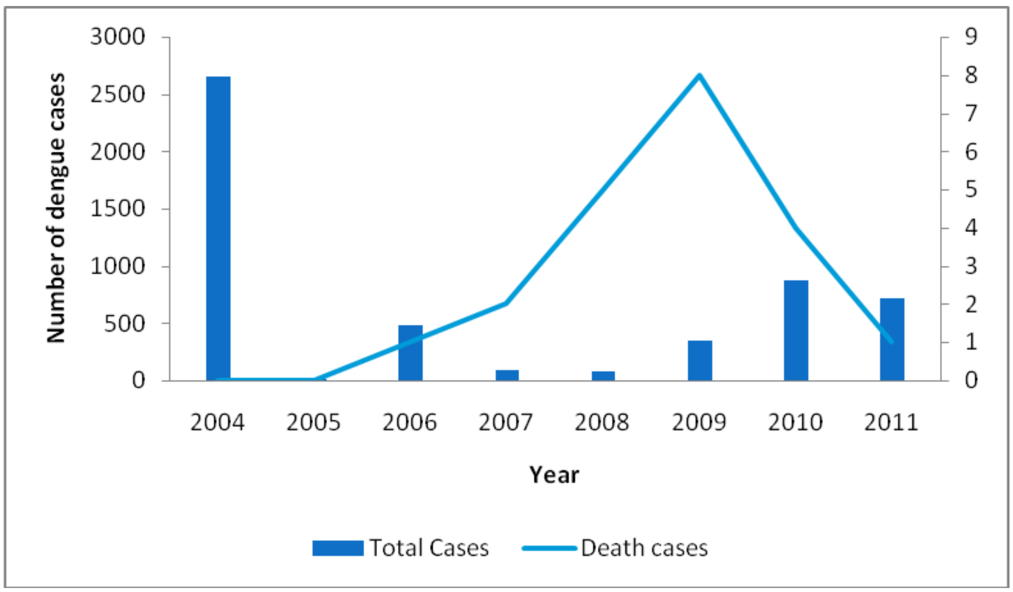
6.2.1 Dengue

Dengue is the fastest emerging arborviral infection. Its epidemiology is evolving rapidly, with increased frequency of outbreaks and expansion to new geographical areas that were previously unaffected. The mortality is highest during the initial period of the outbreak/epidemic.

The progressive worsening of dengue is attributed to unplanned urban development, poor water storage and unsatisfactory sanitary conditions. It is an integral part of urbanization because of the creation of breeding habitats. It is a domesticated species that breeds in artificial containers. The high population density of the vector increases the opportunities for transmission of dengue.

Burden of Disease: Despite the known presence of Aedesaegypti and Aedesalbopictus in the southern region of Bhutan, cases of dengue fever were not reported until July 2004 when an epidemic in Phuntsholing reported 2616 cases.

Figure 16: Reported dengue cases and mortality, 2004-2011. (Source DSB 2011, PHL)

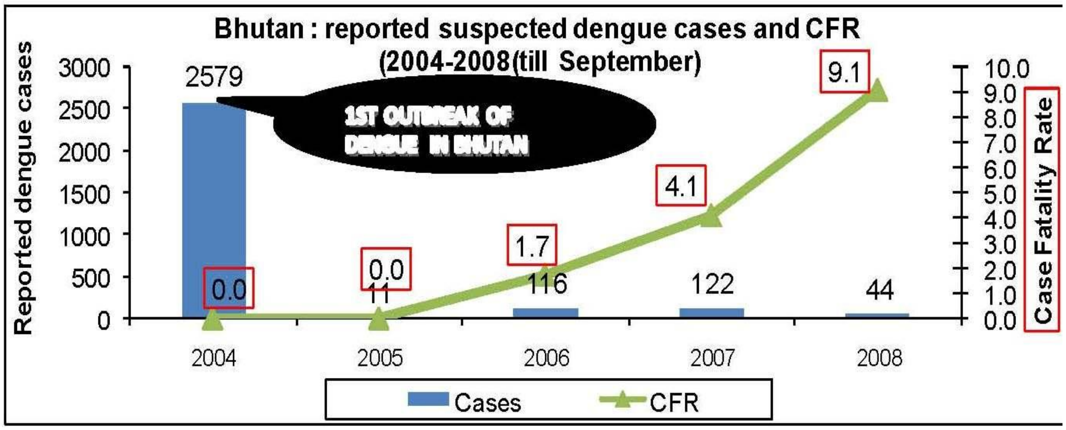


Since 2004, dengue has remained a problem during the monsoon period with transmission occurring July-September[6]. However total dengue burden and trend is still unknown especially of severe dengue cases (DHF and DSS). However, outbreaks have occurred every few years in Bhutan (Figure 19) mostly affecting the age group of 20-49 years. The dengue virus strains circulating in Bhutan are similar to those circulating regionally and may have been introduced or reintroduced from these neighboring areas (Dorji et al. 2009). Cross-border transmission risks persist.

Since 2004 the CFR has increased from 0.0 (2004-2005) to 1.7 (2006) to 9.1 (2008) (Figure 17). Previous researchers have noted the increasing CFR and suggest that it is the same individuals who are becoming infected and re-infected, thus producing more deadly immune responses (Timothy 2010). Bouley suggests areas with higher CFRs are thus target populations to educate about mosquito control and protection

6 http://www.searo.who.int/LinkFiles/Dengue_dengue_Bhutan.pdf

Figure 17: Bhutan reported suspected dengue cases and CFR 2004-2008 (source: VDCP program profile document, 2008)



Source: VDCP, Program profile 2008, MoH

Aedes vectors have now been reported in 80% of the districts of Bhutan (Figure 18).The Aedes surveillance in 2010 confirmed that Aedesaegypti, a domestic species occupying indoor water containers and bathrooms, was found to be prevalent only in Phuentsholing town. However, Aedesalbopictus which is found in domestic, peri-domestic and as well as breeding in natural containers, shows widespread distribution in both urban and rural areas and shows geographical expansion towards north from the southern plains in Bhutan. Aedesalbopictus has been detected during summer season in 17 districts; the three districts free of A.Albopictus are from Bumthang, Paro and Gasa. (Record of VDCP 2004-2010).

Figure 18: Prevalence of Dengue vector in Bhutan, 2011

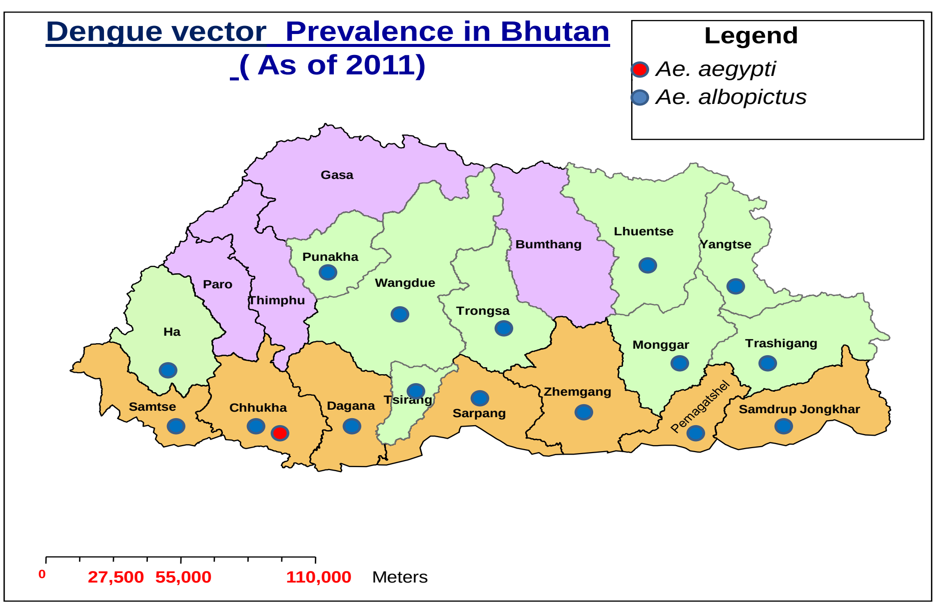
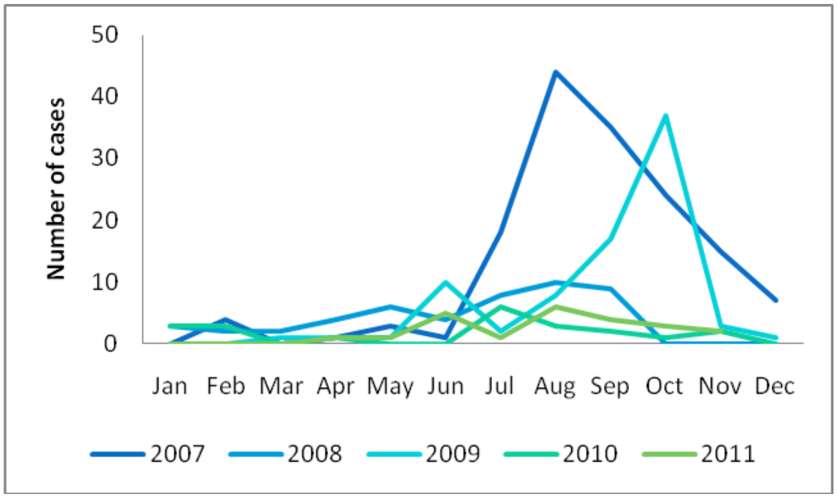


Figure 19: Dengue cases by month of occurrence based on serology (2007-2008). (Source: DSB 2011, PHL)



Sensitivity to climate: A wide-body of international research has reported positive influences of climatic variability on the occurrence of dengue, (Hales et al. 2002; Wu et al. 2009; Depradine and Lovell 2004). Climate change is projected to expand the latitudinal and altitudinal range of dengue as well as extend its transmission duration in both the tropics and the temperate zones bordering areas where dengue is currently endemic (Brunkard, Cifuentes, and Rothenberg 2008).

Gap Analysis and Adaptation options: Dengue is an emergent disease in Bhutan and the VBDCP (2008) reports numerous challenges with regards to dengue control. Globally, dengue surveillance is a major challenge since clinical signs are non-specific and diagnosis requires specialized laboratory support. Population awareness of dengue risks is considered generally low given the new nature of the disease and limited IEC campaigns. Dengue control requires a high level of sustained government and public commitment, strengthening of the public health infrastructure, inter-sectoral and international collaboration and community mobilization. However, because dengue in Bhutan currently occurs mostly in epidemics, commitment to dengue control post-epidemic is limited. Cross-border transmission of dengue in Bhutan is a persistent threat, requiring international collaboration for control.

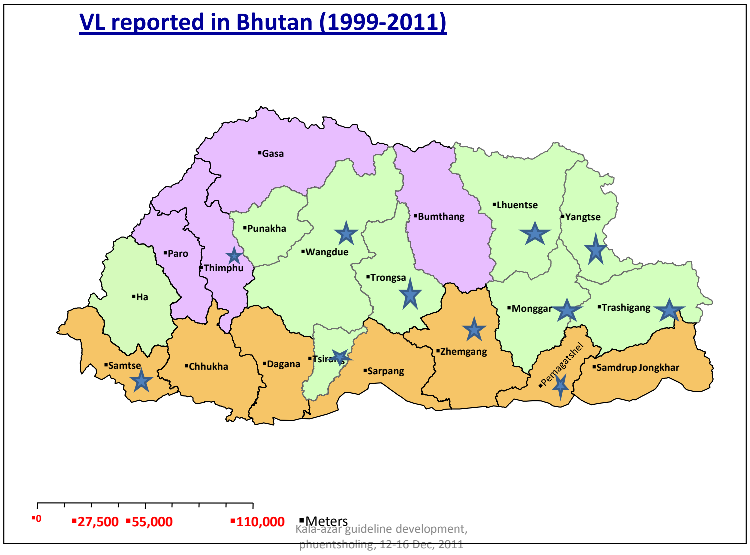
6.2.2 Visceral Leishmaniasis (Kala-azar)

Visceral Leishmaniasis/Kalaazar[7] is a notifiable disease and first detected in Bhutan in 2006. Regionally, kala-azar is endemic in India, Bangladesh, and re-emergent in Nepal. For example, identified in Nepal in the 1960-1970's, it declined with the intensified malarial control use of DDT, until DDT was phased out and kala-azar began to re-emerge (Dahal 2008). This may or may not be the case in Bhutan where DDT was used for IRS until 1994; however the VBDCP switched to deltamethrine which is also known to be effective for kala-azar vectors (Dinesh et al. 2010).

Burden of Disease: In Bhutan as of 2011, 11 districts have reported prevalence of kala-azar (Figure 20). In 2010, a total of 6 new cases of kala-azar from Dorokha in Samtse district, Tsirang district, Zhemgang, Trashiyangtse and Mongar were reported to regional hospitals, JDWNRH and MRRH. To date the highest number of cases comes from Mongar district with 47% of total cases reported since 2006/19cases (Bhattacharya et al. 2010).

7 Kala-azar lowers immunity, causes persistent fever, anemia, liver and spleen enlargement, and if left untreated death

Figure 20: Visceral Leishmaniasis/Kala-azar reported districts



Presence of the vector Phlebotomusargentipes and P. chinensis (sandflies) has not only been confirmed in 7 districts (Thimphu, Wangdue, Dagana, Tsirang, Mongar, Trashigang, Trashiyangtse) but captured above 2000 meters. The presence of sand flies permits transmission of both L. donovani and L .infantum in the valleys but also in the hills (Annex 20). The sand flies are not encountered in the southern belt of malaria endemic districts where malaria control interventions are regular and intensive. It often affects the poorest households who often reside in mud-plastered houses, with presence of heaps of cow dung or rat burrows where the vector thrives, and in bushes and vegetation's around houses where spraying for malaria may not be done.

Sensitivity to Climate: Bhutan does not have enough data to perform any statistical analysis and no research has been conducted on kala-azar sensitivity to climatic variables in Bhutan. In Nepal, found a positive correlation between kala-azar cases annual mean temperature and mean precipitation (Dahal 2008).

Gap Analysis and Adaptation options: Lack of knowledge of the incidence of the disease constrains the planning of elimination. Proper surveillance, early diagnosis and treatment with effective vector control are needed. Bhutan may benefit from partnership in the WHO-SEARO Regional Strategic Framework for Elimination of Kala-azar from the South-East Asia Region (2005-2015)[8] the border districts in Bhutan are also at risk due to movement of people from neighboring countries.

- To develop a strategic plan for control of kala-azar in the country and move towards elimination of this disease
- To develop a guideline on diagnosis and treatment of kala-azar so as to update all the health workers in the country

8 http://www.searo.who.int/LinkFiles/Kala_azar_VBC-85_Rev_1.pdf

Bhutan Kala-azar update

In Bhutan kala-azar was not a priority public health problem until the findings of Dr. S.K. Bhattacharya and VDCP team in July 2007 where a dozen cases from 6 districts having an estimated population of two hundred fifty two thousand, were found to have received treatment since 1999. Kala-azar was first reported in the country in 1999 and there are no records prior to this. In 2007, with support from WHO SEARO, Dr. S.K.Bhattacharya carried out an investigation on Kala-azar in Bhutan assisted by Deputy Chief Entomologist Rinzin Namgay. During the investigation, a case study for all the 12 cases recorded in Mongar regional referral hospital and JDWNRH were carried out and it was found that the 5 of the cases were from Mongar district while the rest of the cases were from Thimphu, Wangdiphodrang, Lhuentse , Trashiyangtse and Trashigang. Vector surveillance could not be carried out because of heavy rains. The doctors and staff of MRRH and JDWNRH were informed about the prevalence of Kala-azar in the country and a seminar on the diagnosis and treatment of Kala-azar was conducted. The new test kit rK39 was also demonstrated.

In 2008, vector surveillance was carried out and the sandfly vector identified as phlebotomus argentipes and p.longiductus.

In September 2010, a team from the VDCP visited the affected areas in Mongar district to carry out active case surveillance using rK39 test kits, vector surveillance, follow up of old patients and to create awareness about Kala-azar in these communities. No new cases were detected and most of the old patients were doing well except for one who had to be referred to MRRH for specialist consultation.

In 2010, a total of 6 new cases of Kala-azar were reported from JDWNRH and MRRH. The cases were from Dorokha in Samtse district, Tsirang district, Zhemgang, Trashi Yangtse and Mongar.

To date the maximum numbers of cases have been reported from Mongar district with 9 cases out of a total of 19 cases reported since 1999.

6.2.3 Japanese encephalitis

Japanese encephalitis virus (JEV)[9] is an arbovirus transmitted by mosquitoes Culextritaeniorhynchus and C. Vishnu. JEV is transmitted by Culex mosquitoes among wading water birds, with pigs as amplifying reservoirs, and humans as dead-end hosts (Miller et al. 2012).

Burden of Disease: Till date only three JE cases has been reported positive and that was in 2011. Of the three cases of JE the two confirmed were of children age 5 years, 6 years & 14 years. The cases were detected from sentinel sites of Mongar, Gelephu and JDWNRH.

Transmission Risk: The risk for JE is very high in Bhutan with rice cultivation as a major agricultural practice and common presence of piggeries as backyard live stock in all rural communities. JE distribution is very significantly linked to irrigated rice production combined with pigs (Miller et al. 2012)[10]. Though many Culex species are nuisance mosquitoes, species such as Culexquinquefasciatus is a very important vector for filariasis and abundantly found in the urban areas of Bhutan. Cx. triataeniorhynchus, Cx. bitaeniorhynchus andCx. Vishnuiare the vectors of Japanese encephalitis found to breed in the paddy fields.

9 In human, 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.

10 The transmission cycle is recognized to be: viral replication in pigs, mosquitos become infected during blood meals, and the mosquito transmits onward to humans.

Sensitivity to Climate: No research has been conducted on JE sensitivity to climatic variables in Bhutan. However, JE epidemics are highly seasonal, occurring during monsoon season when temperature reaches 30 ^{0}C or above (Mellor &Leake, 2000) and in India the JE cases peaked as temperature and rainfall increased (Rao et al. 2000). In China the epidemics have been associated with particular phases of the rice cultivation cycle (Okuno et al. 1975).

Management Capacity: Acute encephalitis syndrome (AES) surveillance started in March 2011 to monitor the trend of AES and etiology agents causing AES[11]. Currently Public Health Laboratory (PHL) MoH, is monitoring the AES surveillance. Since the JE has been noticed in very small numbers and only once, no separate control programs has been established. However the existing vector management strategies and public health measures of the VDCP is adequate to cover JE epidemics supported by PHL.

6.2.4 Chikungunya

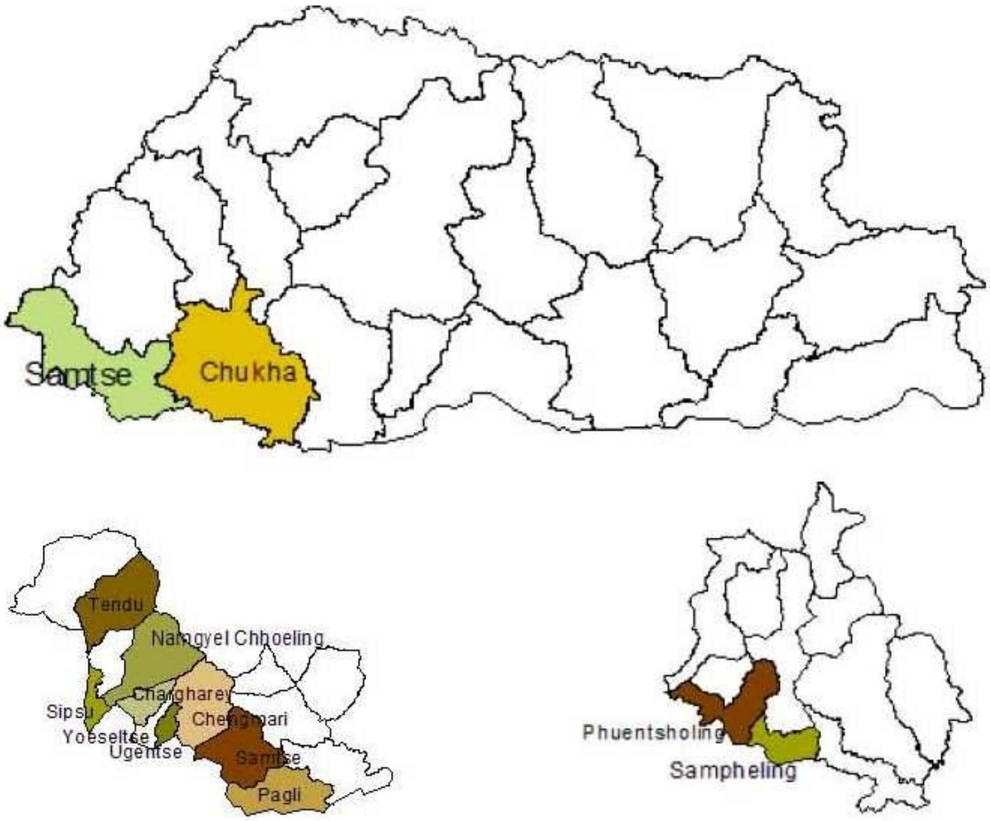
Chikungunya fever is caused by a mosquito transmitted alphavirus (chikungunya virus) belonging to family of Tagoviridae. Chikungunya virus (CHIKV) was first isolated from man and mosquito during an epidemic of fever in Newala, Tanzania between 1952 and 1953 (Ross 1956). CHIKV is transmitted to human primarily by Aedes aegypti and Aedes albopictus and both this vectors are prevalent in Bhutan since 2004.

Chikungunya fever is rarely life-threatening and milder than dengue infection. It has no severe hemorrhage manifestation or shock (Nimmannitya and Mansuwan, 1966). The first chikungunya outbreak in Asia was reported in Bangkok, Thailand in 1958 and the first outbreak in India was reported in Kolkata in 1963-64. It remerged again in India between 1999-2003 and 2005-2006 respectively. In India, more than 1.3 million cases were recorded in 13 states during outbreaks in 2005-2006.

Chikungunya fever outbreak was documented for the first time in the Bhutan in July 2012. Prior to this outbreak, there was no history of chikungunya fever cases or outbreaks reported in the past and also from nearby Indian (West Bengal) border towns. On 19th July 2012, the Public Health Laboratory (PHL) received three samples collected from suspected cases from Samtse hospital and later one sample was confirmed positive for CHIKV. In August 2012 another 11 samples were tested positive for CHIKV (six from P/ling hospital and five from Samtse hospital). Till date (31st August), the Public Health Laboratory has tested a total 215 samples out of which 64 were laboratory confirmed either by ELISA or PCR. All the cases are from southern Bhutan of Samtse and Chukha Dzonkgkhags.

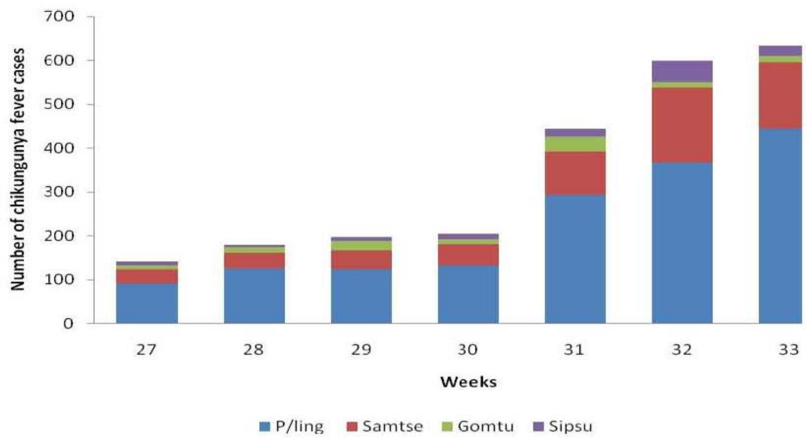
11 Controversy surrounded the death of 8 infants exposed to the pentavalant vaccine in 2009, resulting in the suspension of vaccination.

Figure 21: Affected districts and blocks: (Source: Report on CHIKV, Bhutan, PHL, MoH)



In a comprehensive study conducted by Public Health Laboratory, Thimphu, Chikungunya was presumed to be introduced in the second week of July 2012. The confirmed cases from Gomtu and Samtse had travel history to Charmachi, West Bengal but an index case of Phuntsholing had no travel history to border town prior to onset of illness. A total of 2515 fever cases were documented between 27-33 week from four hospitals (Figure 22); Phuntsholing (62%), Samtse (23%), Sipsu (5%) and Gomtu (4%).

Figure 22: Fever cases for 2012 (1-33 week). Source: Report on CHIKV, Bhutan, PHL, MoH



The most common age group affected was 15-44 years (54%) and 5-14 years (Table 1). The transmission was confirmed imported from nearby bordering town (Birpara and Chamarchi) after a test confirmed CHIKV on 14th July 2012 in these areas.

Table 18: Frequency distribution by age (N=2515): Source: Report on CHIKV, Bhutan, PHL, MoH

	Age (Year)						Hospitals
	<1	1-4	5-14	15-44	45-64	65>	
Proportion (%)	2.62	11.42	11.99	58.05	12.55	3.37	Samtse
	2.40	11.88	20.14	54.18	9.38	2.02	P/ling
	1.63	8.94	22.76	53.66	8.94	4.07	Gomtu
	0	8.33	36.36	46.21	8.33	3.03	Sipsu
	2.00	11.00	19.00	54.00	10.00	2.00	Total

It is recommended that fever surveillance instituted in malaria endemic areas be extended to all health facilities to monitor unusual public health events and an online reporting system be instituted to monitor real time fever incidences serving as early warning.

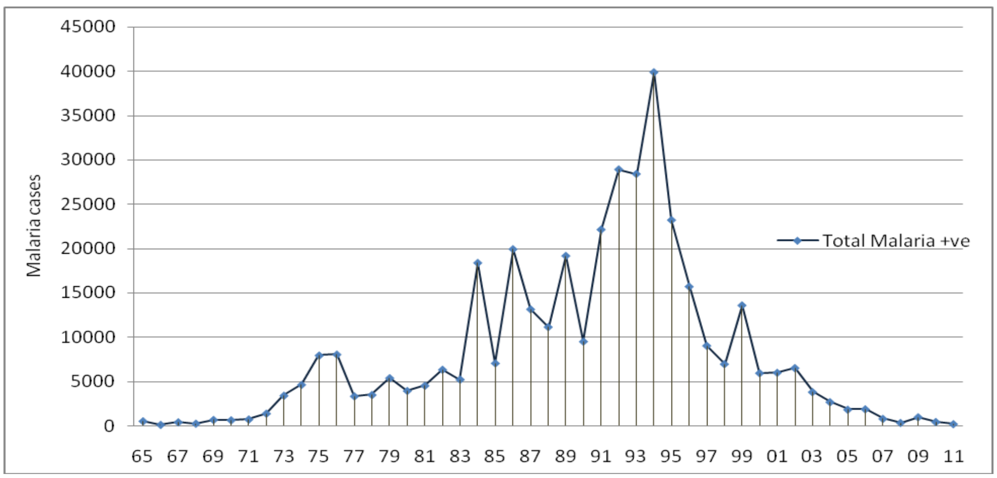
6.3 Malaria

Burden of Disease: How big of a problem is Malaria in Bhutan?

Two types of malaria are prevalent in Bhutan: Plasmodium falciparum (30-60% of cases) and Plasmodium vivax (Annex 24)[12]. Morbidity due to malaria has been greatly reduced and the control program is gearing for elimination (Yangzom, Gueye et al. 2012). Epidemiological situation of malaria in Bhutan for the past 10 years (2000- 2009) revealed that the disease transmission trends are declining due to sustained interventions including (i) additional provisions for Long-lasting Insecticidal Nets (LLINs) for vector control and (ii) effective treatments by Artemisinin-based Combination Therapy (ACTs) are strongly advocated for achieving further reduction in malaria receptivity.

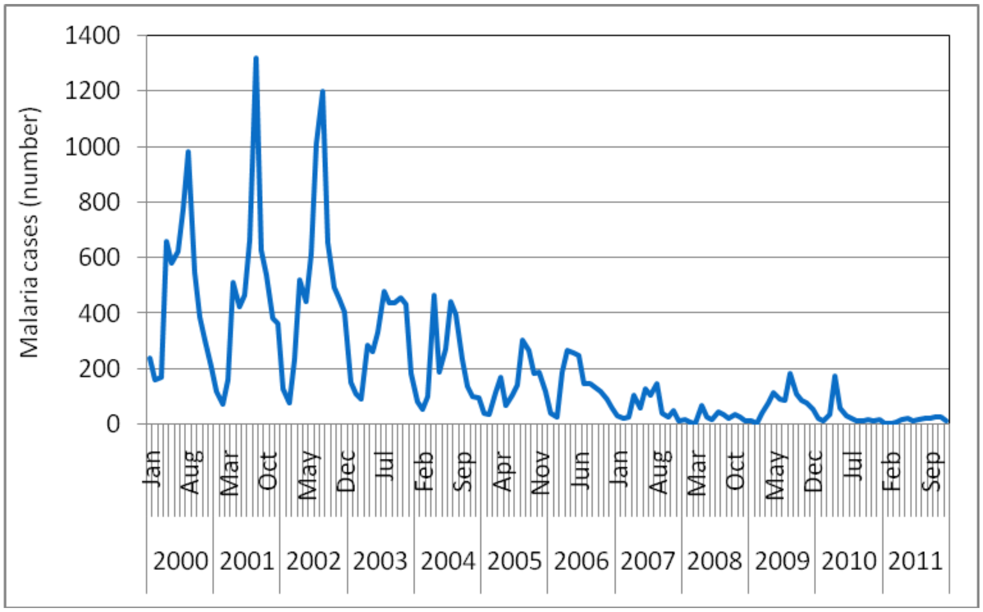
The number of cases increased from 518 in 1964 to a maximum of 39,852 in 1994 (Annex 19). From 1984-1994, there was a progressive increase in malaria cases with increasing prevalence of falciparum malaria. With the institution of surveillance, treatment and strategies, the morbidity and mortality due to malaria was drastically reduced. Since 2007, the total malaria cases were contained below 1000 with only 194 cases in 2011 (Figure 23). The annual parasite incidence (API) is below 1 per 1000 population in 2011 and VDCP is gearing towards malaria elimination phase. The reduction in the morbidity and mortality is mainly attributed to the effectiveness of the new insecticides treated bed nets to all at risk population in the country.

Figure 23: Malaria incidence from 1965 to 2011 in Bhutan



12 P. falciparum causes a more severe form of malaria, with higher mortality, while P. vivax remains in the body longer, causing a more gradual health deterioration.

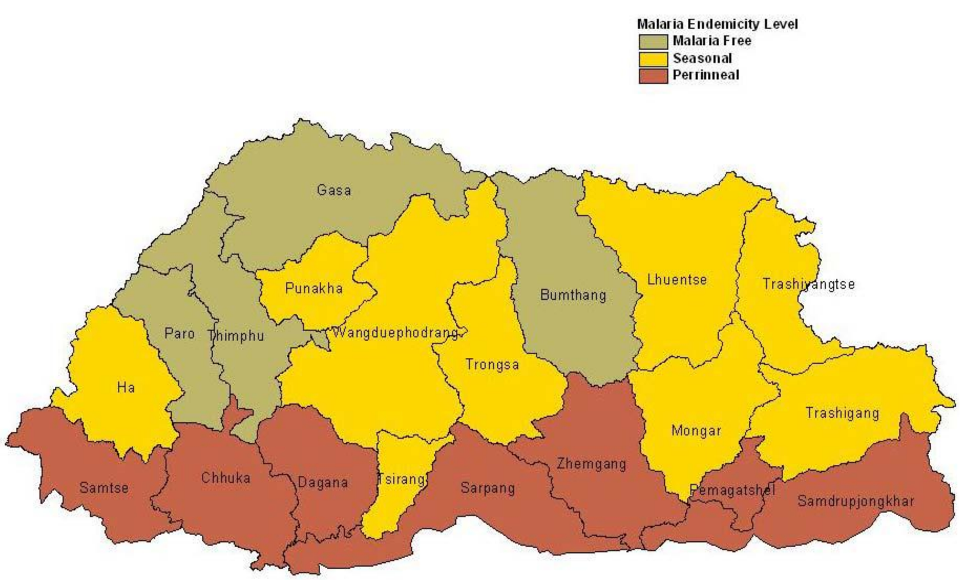
Figure 24: Malaria trend from 2000 to 2011



Geographic Distribution: Where does Malaria Occur?

In 2011, 93% of the malaria cases had been contained to the seven perennial transmission districts of Chukha, Dagana, Pemagatsel, Sarpang, Samtse, Samdrupjhonkhar and Zhemgang. In 2009, two districts carried the major burden of disease, Sarpang district accounted for 63.4% of total cases, followed by Samdrupjhonkhar district at 9.5% (WHO-SEARO 2011). Both districts share a long relatively porous border with India(Annex 22). Shown in Annex 23 seasonal transmission occurs in the riverine valleys of nine districts Haa, Lhuntse, Mongar, Punakha, Trashigang, Trashiyangtse, Trongsa, Tsirang, Wangdue. Local malaria transmission does not occur in four districts, Paro, Thimphu, Gasa, and Bumthang.

Figure 25: Map of Malaria Endemicity in Bhutan 2011



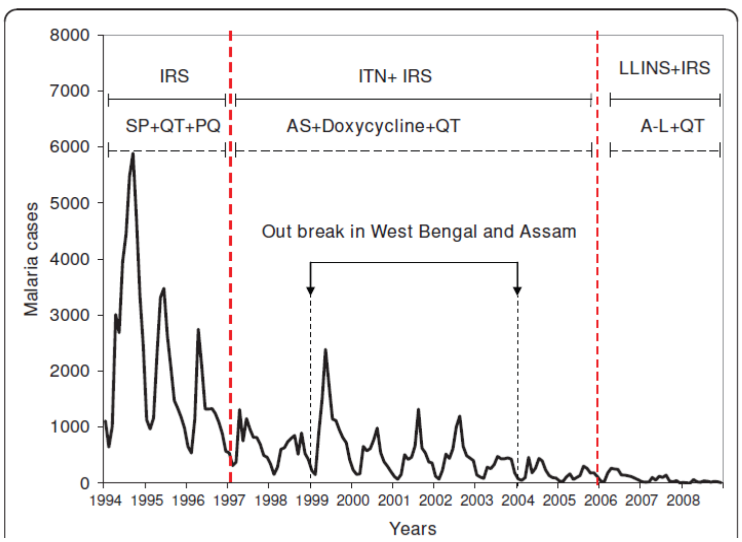
Current at risk populations: Who is at risk of Malaria?

An estimated 76% (521,803) of Bhutanese live in areas of favorable climate for malaria transmission and 42% reside in the 7 districts where malaria has endemic transmission (Annex 25). Within the endemic districts the high risk groups are males (67%) with women and children at 32% and 3% respectively. The most affected occupational group is the farmers (44% 2007) (38% 2009) followed by the students (23% 2007) (26% 2009) who are exposed to outdoor biting (Annex 25 and Annex 26). However, within the endemic districts some geogs (blocks) do not have local transmission but the population is still at risk of travel related or imported malaria as most of the population from the higher communities travel regularly to the border towns for shopping or business Annex 30. Travelers and commerce from malaria free districts who visit the southern districts and southern border towns are also at risk of malaria.

The cross-border nature of malaria transmission deserves focused interventions on both sides of the border to check the focal disease outbreak and spread of drug-resistant P. falciparum. There was only one death in 2011 due to malaria (Annex 37).

Malaria Epidemics have occurred periodically across Bhutan from 1999 till 2003, this was attributed to the increased malaria cases in Assam and West Bengal Figure 26 (Wangdi, Kaewkungwal et al. 2011).

Figure 26: Malaria trends of the endemic districts of Bhutan with control and treatment measures[13] adapted from Wangdi et al., 2011.



In 2009, there was nearly threefold increase in cases due to series of outbreaks with 80% of cases from Sarpang (Annex 28). The outbreak was attributed to loss of residual efficacy of Long Lasting Insecticide Bed Nets (LLINs) distributed in 2006.

13 Treatment protocol changes during the study period SP = sulphadoxine-pyrimethamine; QT: quinine; PQ: primaquine; AS: Artesunate; A-L: artemether and lumefantrine.

Burden of Epidemic Malaria

In areas stable malaria transmission, such as the 7 endemic malaria districts in Bhutan, the probability of dying from an untreated case of malaria is approximately 2-3%.

However, in areas of unstable transmission, such as the 13 non-endemic districts immunity to malaria in the population is non-existent or poorly developed. When an epidemic occurs in such areas the case fatality rates can be up to 20-30%, severe diseases can affect all age groups. When adults are severely affected or die, the impacts of an epidemic are amplified on families and society.

It is estimated that epidemic malaria causes 12-25% of estimated annual worldwide malaria deaths, including up to 50% of the estimated annual malaria mortality in persons less than 15 years of age (Worrall, Rietveld, and Delacollette 2004).

Transmission Risk for Malaria

The risk of being infected by malaria depends on the number of infected mosquitoes, the number of vulnerable people and the contact rate of the two. The VBDCP has successfully reduced malaria morbidity and mortality and overall the risk of malaria is low with annual parasite incidence (API) is below 1 per 1000 population in 2011. Risks do increase for locals and visitors to concentrated areas of the endemic districts (i.e. border geogs of Sarpang and Samdrupjhonkhar), the risk is higher during particular times of the year (i.e. April – August), and the risk goes up for specific groups, such as male farmers and students who have greater contact opportunities.

However, it is recognized that emerging social and environmental conditions, present new challenges for maintaining and eliminating malaria, even in the absence of climate change. These conditions which may increases the risk of transmission and need further research are related to (1) industrial development, (2) intensification of agriculture and fisheries, (3) population movement from highlands to lowlands (4) cross-border trade, commerce, and labor migration, and (5) urbanization (WHO-SEARO 2011).

1. The first risk factor occurs in areas where large industrial projects and Hydro Power project with huge immigrant workers are being stationed. At present there are three mega hydro power projects underway Wangdue (Punatsangchu Hydro Power Project), in Trongsa (Mangdechu project), and Dagana (Dagachu project) which collectively house an apprimate of 11,614 labourers. Another 11 hydro power projects are being proposed in next few years across additional 8 districts (Annex 30 and Annex 31. Also, these ongoing and proposed projects are located in malaria transmission zones with confirmed vector prevalence. These projects may increase local VBD risks by creating new breeding sites and opportunities for vector proliferation, due to importation of a significant number of migrant workers, who remain in residence in Bhutan for a period up to 18 – 24 months and whose health status (e.g. parasitimia) are not thoroughly checked on entry to Bhutan. These potential risk factors require further investigation for verification.
2. Intensification of agriculture has resulted in an increasing number of fishery ponds and irrigation canals, which create additional breeding sites. These particularly in malaria endemic and non endemic districts, such as Sarpang and Samdrupjongkhar.
3. Urbanisation: A third risk factor is the rural to urban migration pattern. At 6% internal migration it is highest in South Asia and 72% of urban dwellers are migrants(UNDP Human Development Report 2009 & Rural urban survey, MoA 2005) resulting in culmination low income families living at compromised livings standards, with inadequate hygiene and sanitation facilities.

4. Highland to low-land population movement: The temporary population movement from highland (non endemic areas) to lowlands within Bhutan for trade, economic and vacation places people at risk for exposure to VBD. These includes the resettlement of landless people from non-malarious districts to malaria endemic districts and thus have low immunity and limited or no knowledge on prevention and treatment seeking practices. In 2011, 44 households have been resettled in Pemagatsel (a malaria endemic district). Future plans to relocate people to Tareythang in Pemagashel, Jomotshangkha and Nganglam in Pemagatsel.
5. The fourth risk factor is cross-border transmission from India[14]. The open border with India in the south, and greater trade and population movement with the constant influx of "carrier" populations. Already a significant proportion of cases treated in Bhutanese clinics in the border areas live in India, or have contracted in India. The degree of future risk posed by cross-border transmission will depend on the success of cross-border control strategies.

6.3.1 Malaria Sensitivity to Climate

The seasonality of endemic malaria in Bhutan is sharply defined by temperatures suitable for sporogony and propagation of vector mosquitoes. This occurs between mid-March and November with incidence peaking in July (June- August), with smaller peak just before the onset of the summer, although it may differ from district to district (WHO-SEARO 2011). This seasonality is attributed to the increased in temperature that favors multiplication of vectors and enhancement of the vector host interaction as the population engage in agricultural activities (Wangdi, Kaewkungwal et al. 2011). Temperature lower than 16 ^{0}C or higher than 30 ^{0}C have negative impact on the growth of the mosquitoes, also, at these temperature the propagation rate of plasmodium is reduced (Rahman, Roytman et al. 2010).

14 The number of Bhutanese and foreigners treated in clinics are recorded separately. This study only considers the Bhutanese cases reported.

Sensitivity of malaria transmission to climate

Meteorological factors are important drivers of malaria transmission by affecting both malaria parasites and vectors directly or indirectly. Changes in temperature, rainfall, and relative humidity due to climate change are expected to influence malaria directly by modifying the behavior and geographical distribution of malaria vectors and by changing the length of the life cycle of the parasite. An increase in temperature accelerates the insect metabolic rate, increasing egg production and making blood feeding more frequent (e.g. Mellor and Leake 2000). Small changes in precipitation or temperature may cause previously inhospitable areas to become conducive to transmission by rendering hospitable higher altitudes that were formerly too cold for mosquito populations to develop.

Extrinsic factors such as environment (climate), social, behavioral, economic conditions (poverty), political factors, and control and preventive efforts play an important role in the transmission of malaria (Berman, 2001). Climate variability that impacts on the incubation rate of *plasmodium* and the breeding activity of *Anopheles* is an important environmental contributor.

Temperature plays a very important role in the transmission and prevalence of malaria. Temperatures lower than 16°C or higher than 30°C have a negative impact on the growth of the mosquitoes; also, at low temperatures the propagation rate of *Plasmodium* is reduced in the body of the mosquitoes. In addition, there is a decline in the transmission of malaria when the relative humidity is below 60%. This could be due to reduction of vector lifespan. The transmission rate increases with the increase in relative humidity; at 80% humidity, the transmission is as twice that at 60% (Bi *et al.*, 2003; Ye *et al.*, 2007). Other climatic factors like rainfall play a very important role in providing the medium for the aquatic stages of the mosquito's life cycle and *Anopheline* population and density. The rainfall also causes an increase in the relative humidity there by increasing the longevity of the adult mosquito. However, if the rainfall is heavy and continuous, it washes off the breeding sites and flushes out the mosquito larvae, so have a negative affect (Bi *et al.*, 2003; Mabaso*et al.*, 2007).

Therefore, if global temperatures increase by 2–3 ^{0}C, as they are expected to, it is estimated that the population at risk for malaria will increase by 3%–5% (Shuman 2011) which means that millions of additional people would likely develop malaria each year.

Climatic Conditions Relevant to Malaria transmission

In Bhutan, the mean maximum temperature of the seven endemic districts varied from 25^{0}C to 27^{0}C during the study period (2000-2011) and the mean minimum temperature varied from 12^{0}C to 13^{0}C. The average annual temperature in the endemic districts is around 19^{0}C. Total rainfall varied from 1500 mm to 1900 mm over the study period and humidity remained above 80% in most years with the exception of 2011 at 74.3% shown in (Figure 28 and Figure 19) although the monthly key climatic factors (minimum temperature, maximum temperature rainfall and humidity) have been relatively stable over the 12 year study period, the incidence of malaria has been steadily reducing over the study period due to intensive control measures.

Figure 27: Malaria cases and temperature-maximum of the seven endemic districts over the analysis period (2000 to 2011)

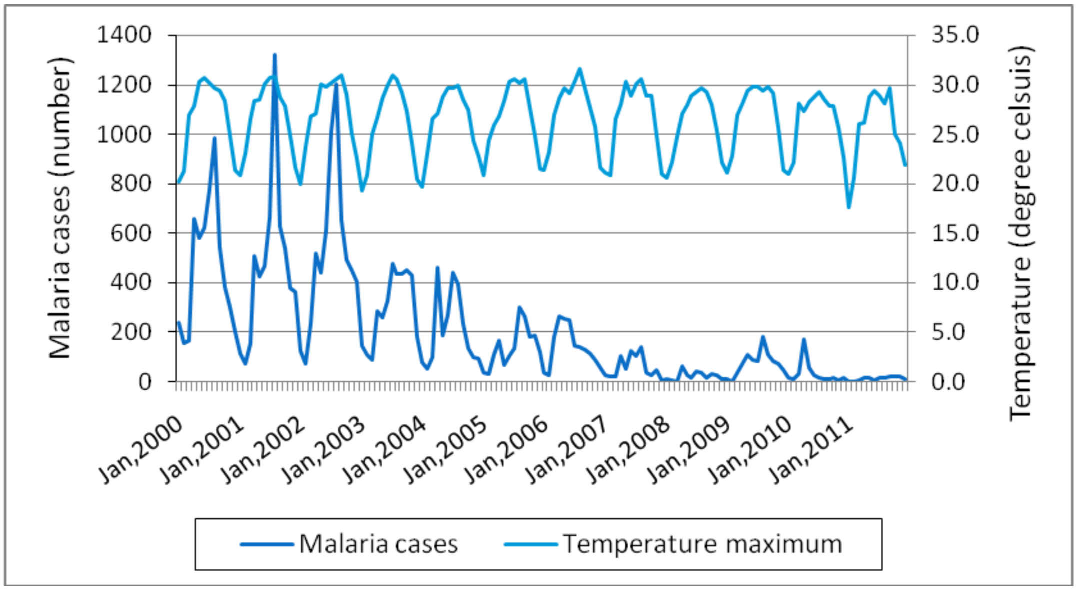


Figure 28: Monthly Malaria cases and humidity of the seven endemic districts over the analysis period (2000 to 2011)

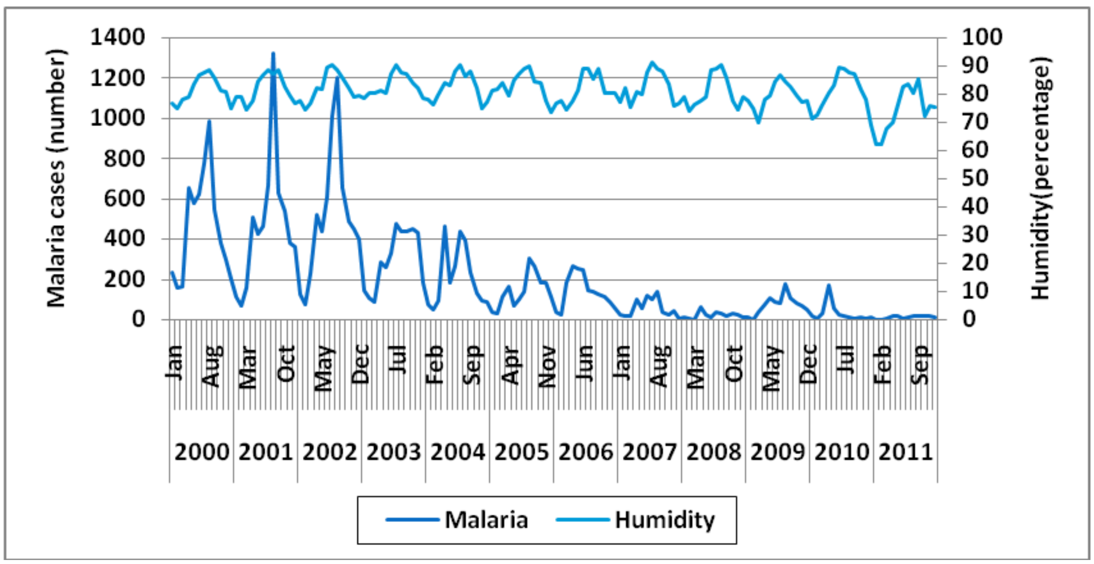
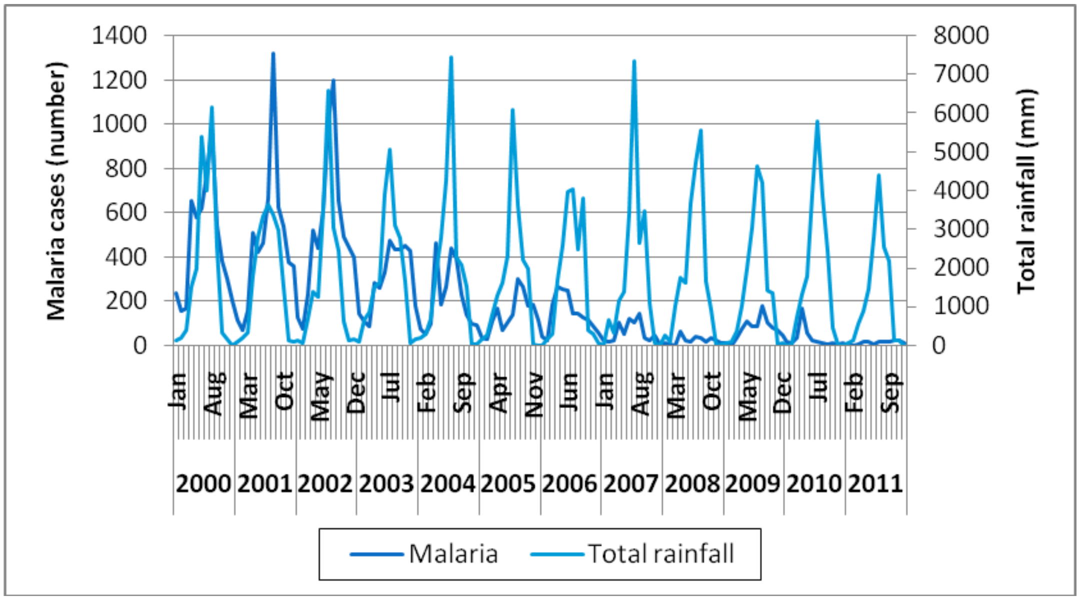


Figure 29: Monthly malaria cases and total rainfall of the seven endemic districts over the analysis period (2000 to 2011)



Sensitivity of malaria incidence and climatic factors in Bhutan

Two separate methods were used to estimate the sensitivity of malarial incidence with climatic conditions. The analysis was confined to the seven endemic districts of Bhutan, where the majority of cases are reported.

First, we relied upon previous studies conducted in Bhutan sought to identify the predictive conditions for malaria incidence (Wangdi, et al., 2011). Wangdi et al found statistically significant predictors for individual districts, but there was no consistency in the predictor variables of malaria across seven endemic districts. Mean maximum temperature was a significant driver of malaria cases one month later, in four of the seven endemic districts. No single variable could be used to predict malaria cases in more than two districts.

Secondly, we used Random Effect Poisson Regression[15] to analyse the strength of the influence of extrinsic climatic variables such as mean temperature and total rainfall on monthly malarial incidence in the endemic zones. This analysis was carried out with longitudinal data (2000-2011) for malaria cases (n = 29500) occurring in the seven malaria endemic districts. The cases of malaria were time-lagged to the extrinsic climate conditions by 1-month to allow for the adequate time period for the development of the mosquitoes and transmission of the parasites to the new host and manifestations of the malaria.

Each variable was regressed (mean temperature and rainfall) independently with malaria cases, while controlling out the effects of other three variables, to see the strength of association. Shown in (Table 19) only two of the four climatic variables had statistically significant relationships with the incidence of malaria, mean temperature (p=0.000) and total rainfall (p=0.001).

15 Poisson Regression is a statistical technique used to describe the probability of occurrence of count data (malaria cases) as a result of the value of predictor variables (mean temperature and rainfall).

Table 19: Random Poisson Regression for combined malaria cases in 7 districts and climatic factors (mean temperature and total rainfall) lagged at one month.

Climatic Variables	Incidence Rate Ratio	SE	*p-value*	*95% CI*
Monthly Mean Temperature	1.149	0.012	0.000	0000000
Monthly Mean Temperature Maximum	1.078	0.023	0.000	0000000
Monthly Mean Temperature Minimum	1.021	0.020	0.306	0000000
Monthly Total Rainfall	0.9999	0.000	0.001	0000000
Monthly Mean Humidity	1.090	0.010	0.000	0000000

Therefore, based on this analysis, it could be expected with all other conditions such as humidity, health care seeking behavior and preventive and control measures remaining the same in the endemic districts; that for each 1^0C increase in mean temperature, that malaria incidence will increase in the endemic districts by 14.9%. Malaria incidence will decrease by 0.01% for increase in 1mm of total rainfall.

6.3.2 Baseline Health System Vulnerability to Manage VBDs

Malarial surveillance in Bhutan began in 1964 with the establishment of the National Malaria Control Programme; this programme was renamed the National Vector Borne Disease Control Programme (VDCP) in 2003. In 2010, a review of the VBDCP by WHO SEARO showed significant improvement in national capacity for monitoring and evaluation, research capacity and cross-border collaboration as well as an increase in well trained staff (WHO-SEARO 2011). Currently the program has a total of 41 staffs which includes 1 Medical Doctor (Chief Program Officer), 4 program officers, 4 entomologist, 9 technicians, 1 data manager, 7 Finance and admin and 15 support staffs (Annex 32). Vulnerability lies not in number but as a knowledge gap between climate change and its effect on VBDs. VBDCP has no information and no future plans to incorporate metrological information in their routine data collection. Program need to update its data base (Excel) to incorporate population denominator and the information officer requires skill enhancement to enable handling of standard data package like SPSS or STATA etc.

Another baseline vulnerability occurs in the surveillance component. Information flow and response to outbreak is not clear between PHL and VBDCP. While the malaria reporting/surveillance is clear, other VBDs diseases like JE, Kala-Azar and Dengue has no systematic reporting system and no central agency responsible for reliable information. Functionally PHL is responsible for diagnostic and VBDCP for vector surveillance, identification of breeding sites, control and management. But in between the two divisions, no one has the valid data on these three diseases. This needs to be streamlined. Also assuming that malaria control is the most significant activity and capacity of the VBDCP, it can be inferred that observations and recommendations for malaria control are superior to, and transferrable to capacity to manage the emergence of other VBDs, such as dengue, kala-azar, JE, and chikungunya.

Although malaria has declined, cross-border transmission and migration, along with additional risk issues significant maintenance and investment is needed to eliminate the disease. The malaria control programme has a weekly fever and malaria reporting system in place for epidemic detection. The malaria control programme intends to initiate an epidemiological surveillance system for epidemic prediction on the basis of meteorological variables, morbidity and mortality, and entomological and socioeconomic variables. Epidemic response includes: provision of adequate relief to the affected population, containment of transmission, prevention of further spread and emergency preparedness.

6.3.3 Future Impacts of climate change on VBDs

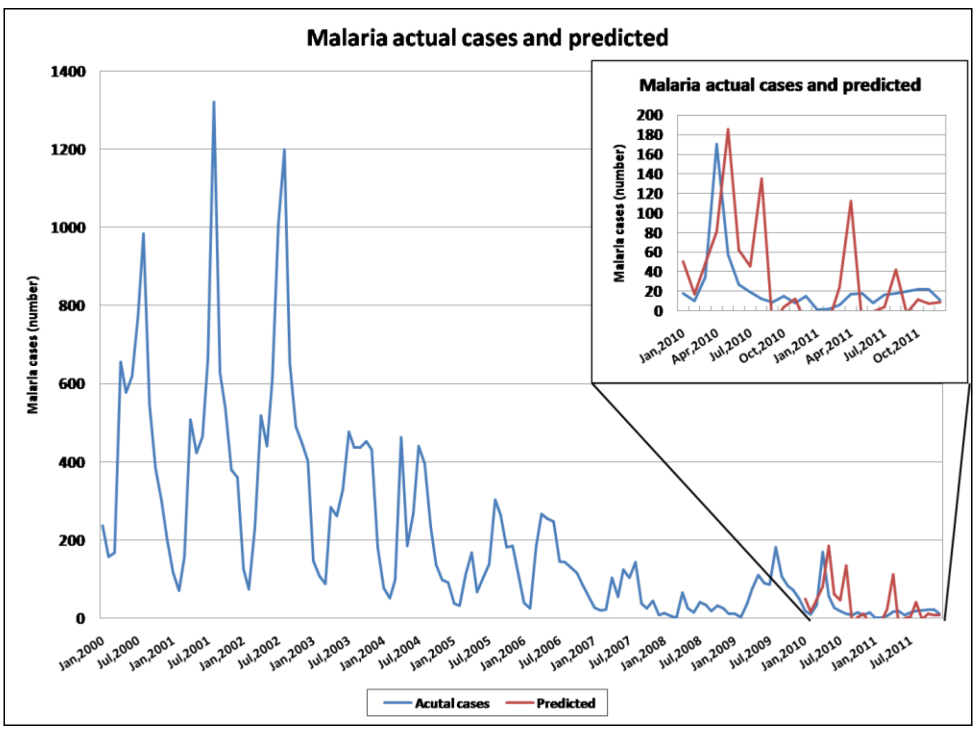
Two different methods were used to forecast the expansion of malaria in the current endemic areas over time. First, for short-term forecasting, an existing predictive model for malaria and climatic conditions (Wangdi et al., 2010), was replicated to estimate expected case loads for an additional 2 years. Secondly, for longer-term estimates the sensitivity analysis was extrapolated using the regional climate models, and accounting for population growth.

Short-Term Forecasting future cases of malaria driven by climate changes

Wangdi et al., established that for understanding and short-term prediction of malarial incidence in Bhutan's epidemic districts that a multiplicative seasonal Auto-regressive Integrated Moving Average (ARIMA) is best suited[16]. They predicted cases for 2009 and 2010 and identified that no single model is applicable to use for predictive modeling of malaria in Bhutan, because of the district level heterogeneity in malaria transmission patterns. However, the model ARIMA (2,1,1) (0, 1, 1) was most applicable across endemic districts and used in the present study to further predict the malaria cases for 2010 and 2011, and then plotted against the actual incidence to see how closely these malaria cases match (Figure 30 and Figure 31)

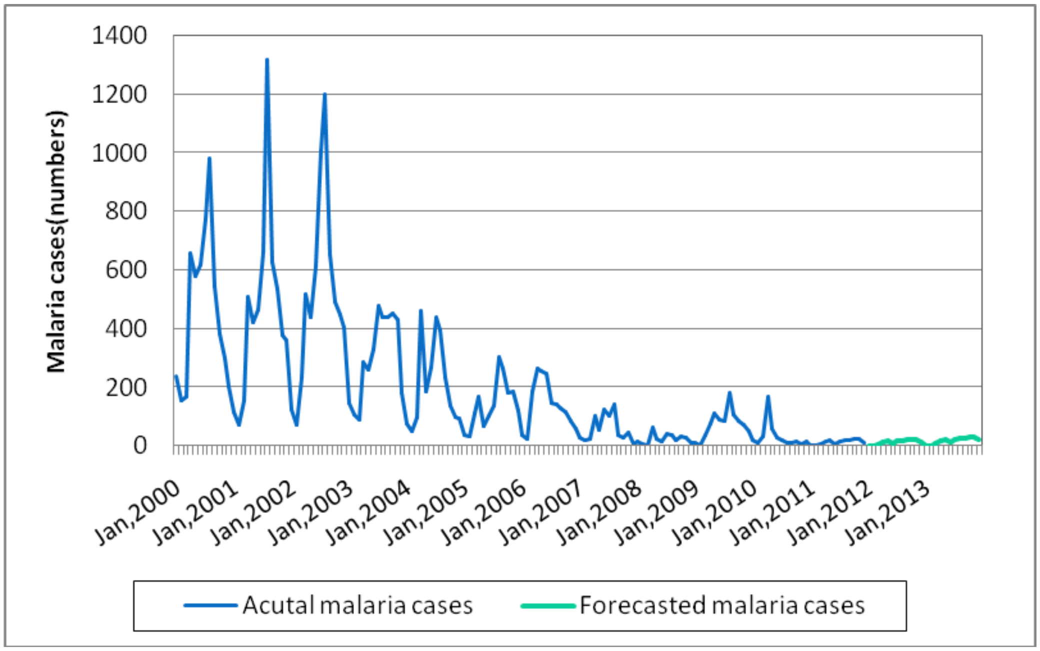
In this study, the best model determined by Wangdi et al, ARIMA (2, 1, 1) (0, 1, 1) was used to forecast malarial incidence for the years 2012 and 2013, respectively. Results predict the occurrence of 153 and 215 malaria cases in 2012 and 2013 respectively (Figure 30 and Figure 31)

Figure 30: Graph showing actual malaria cases (2000-2011) and predicted malaria cases (2010-2011)



16 A SARIMA model can be described as ARIMA (p, d, q) multiplied by (P, D, Q) where (p and P representing the auto regressive and seasonal autoregressive; d and D representing the non-seasonal difference and seasonal differencing; and q and Q the moving average parameters and seasonal moving average parameters, respectively and s representing the length of the seasonal period). ARIMA involves the estimation of a series of parameters to account for the inherent dynamics in the time series (Tianetal., 2008).

Figure 31: Actual malaria cases from 2000-2011 and predicted malaria cases in 2012 -2013 for the endemic districts of Bhutan



Long-Term Forecasting Malaria in Endemic Zone

During the study period (2000-2011) the mean maximum temperature of the seven endemic districts is between 25 ^{0}C to 27 ^{0}C and the mean minimum temperature varied from 12 ^{0}C to 13 ^{0}C. An analysis with longitudinal data (2000-2011) for malaria cases occurring in the seven malaria endemic districts using Random Effect Poisson Regression[17] indicates a relationship between incidence of malaria, mean temperature lagged at one month (p=0.000) and total rainfall lagged at one month (p=0.001) shown in (Table 20). Therefore, based on this analysis it could be expected with all other conditions such as humidity, health care seeking behavior, API, and preventive and control measures remaining the same; malaria incidence could increase in the endemic districts by 14.9% for each 1^{0}C in mean temperature lagged at one month. Malaria incidence will decrease by 0.01% for increase in 1mm of total rainfall lagged at one month.

Table 20: Random Poisson Regression for combined malaria cases in 7 endemic districts & climate factors lagged at one month

	Incidence Rate Ratio	**SE**	***p-value***	***CI (95%)***
Mean Temperature	1.149	0.012	0.000	1.125 1.173
Total Rainfall	0.9999	0.000	0.001	0.9998 0.99997

Shown in (Table 21) the baseline temperatures (1980-2009) are expected to increase by 1^{0}C (annual) and 0.8 ^{0}C monsoon within the next 30 years - bringing annual mean temperature to 21.9 ^{0}C (Monsoon 26.2 ^{0}C) and 23.2 ^{0}C (Monsoon 27.3 ^{0}C) in the endemic zones.

17 Poisson Regression is a statistical technique used to describe the probability of occurrence of count data (malaria cases) as a result of the value of predictor variables (mean temperature and rainfall).

Notably, two districts in particular (Tsirang and Monggar) currently with seasonal malaria transmission will warm in the next 30 years to have a similar temperature range as today's endemic districts. Tsirang currently with a mean annual temperature of 20.7 ^{0}C (Monsoon 25.4 ^{0}C) during 2010-2039, will increase to 21.6 ^{0}C (Monsoon 26.2 ^{0}C) and in the period 2040-2069 on to 23 ^{0}C mean (Monsoon 27.3 ^{0}C). Monggar currently with a mean annual temperature of 17.5 ^{0}C (Monsoon 22.6 ^{0}C) will warm into the range of a mean 18.4 ^{0}C (Monsoon 23.4 ^{0}C) during 2010-2039, and in the period 2040-2069 warm to a mean 19.8 ^{0}C (Monsoon 24.5 ^{0}C).

Table 21: Average future temperatures per malaria transmission zone

Malaria Zone	Baseline 1980-2009 Annual Mean Temperature	Baseline 1980-2009 Monsoon Mean Temperature	FUTURE 2010-2039 Annual Mean Temp	FUTURE 2010-2039 Monsoon Mean Temp	FUTURE 2040-2069 Annual Mean Temp	FUTURE 2040-2069 Monsoon Mean Temp
Endemic	20.9 (19.5-22.2)	25.4 (24.1-26.7)	21.9 (20.5 - 23.1)	26.2 (24.9-27.5)	23.2 (21.7-24.5)	27.3 (26-28.6)
Seasonal	13.5 (10-20.7)	19.4 (16.7-25.4)	14.4 (11-21.6)	20.2n (17.5-26.2)	15.9 (12.8-23)	21.4 (18.9-27.3)
None	6.7 (3.9-8.3)	13.9 (11.7-15.2)	7.9 (5.1-9.4)	14.8 (12.6-16.1)	9.3 (6.6-10.9)	16.2 (14.1-17.4)

Long-Term Forecasting Malaria in Sarpang

Forecasting was done for Sarpang district as it contributes the greatest proportion of cases in Bhutan, by using the projected increase in mean temperature and rainfall for two future time periods according to two regional climate models established for Bhutan (SNC, 2010). For the period of 2010-2039, based on projected increase in mean temperature the malaria incidence in Sarpang district will increase between 26.91% (95% CI (25.92, 27.99). (HADCM3/A1B MODEL) and 23.92% (95% CI (66.24, 71.53) (ECHAM5/A1B MODEL). This represents a case load increase of approximately 78 and 75 cases respectively for the time period of 2010-2039 and 2040-2069.

For the time frame of 2040-2069 malaria incidence is expected to increase from today's levels by 68.77% (95% CI (23.04, 24.88). (HADCM3/A1B MODEL) and 65.78% (95% CI (63.36, 68.42). (ECHAM5/A1B MODEL). This represents a case load increase of approximately 78 and 75 cases respectively for the time period of 2010-2039 and 2040-2069. However, no increase in malaria incidence will be observed based on the rainfall from either models.

Table 22: Projected increase in the mean annual temperature and mean annual precipitation change for 2010-2039 and 2040-2069 for Sarpang district

	Mean Annual Temperature Change Degree Celcius as per		Mean Annual Temperature Change Degree Celcius as per	
	HADCM3/A1B MODEL		ECHAM5/A1B MODEL	
	2010-2039	2040-2069	2010-2039	2040-2069
Mean temperature	0.9	2.3	0.8	2.2
Mean Annual Precipitation change	22.1 (mm)	232 (mm)	100.6 (mm)	412.3 (mm)

Table 23: Random Poisson Regression of Sarpang district and climatic factors (mean temperature and humidity) lagged at one month

Climatic variables	IRR	SE	*p*-value	Confidence Interval (95%)
Mean temperature	1.299	0.007	0.000	1.288 1.311
Rainfall	1.000	0.000	0.000	0.966 0.973

Limitations

The analysis using the time series ARIMA is subjected to a number of limitations; factors that would result in increase of malaria are disease outbreaks, unusual climatic factors with resultant increase in malaria incidence, migration of people to the malaria endemic area from non-malarious area would result in increased incidence of malaria as a result of introduction of non-immune population. Whereas, factors such as improved preventive and control would prevent mosquito-man contact thereby reduction in the incidence of malaria cases, unusual climatic factors such as drought would also result in decreased incidence of malaria.

Another limitation is that this study does not account for the total burden of malaria circulating within Bhutan. This is because Bhutanese and foreigner cases treated in clinics are recorded separately, and this study only considers the Bhutanese cases reported.

Future Malaria in Bhutan - Conclusions

Malaria forecasting based on time series (short term forecasting) showed that malaria incidence in endemic areas of Bhutan are likely to dwindle over next few years, if current levels of malaria control are maintained over time, and new cases are not introduced from outside Bhutan. However, effect of different climatic variables on malaria cases for the seven endemic districts showed that the mean temperature was a significant driver of malaria occurrence with every 1^0C increase in mean temperature with respect to the annual average, the incidence rate is expected to increase by 14.9% while malaria incidence rate will decrease by 0.01% for 1mm increase in rainfall.

Based on the projected increase in mean temperature, malaria incidence in Sarpang district will increase by 23.92%- 26.91% for the time frame of 2010-2039 and 65.78%-68.77% during 2040-2069 according to two models. However, no increase in malaria incidence will be observed based on the rainfall from either models.

Vector Case Study

Bhutan's first malaria survey was conducted in 1962 and in 1964 the National Malaria Eradication (NMEP) was established in 1964 which was later renamed as Vector Borne Disease Control Program (VBDCP) in 2003. Over the period, there has been a consistent decrease in the malaria burden between 2000 and 2011 and currently the API has declined from 14 in 2000 to 0.4 in 2011, slide positivity rate (SPR) decreased from 8 in 2000 to 0.4 in 2010 and the number of malaria deaths decreased from 15 in 2000 to 1 in 2011.

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One of three samples confirmed first Chikungunya case in Bhutan

By Tashi Deki | 01 August 2012

Out of three clinically confirmed samples in Samtse, one sample confirmed the mosquito-borne disease Chikungunya after the laboratory test conducted in Bangkok.

This is the first-ever confirmed case of the disease in the country.

Public Health Laboratory's (PHL) head Sonam Wangchuk said all the 14 samples received from Phuentsholing and Samtse had been sent to Bangkok yesterday forPolymerase chain reaction (PRC) tests including the samples found negative after Enzyme-linked immunosorbent assay (ELISA) test done is PHL.

"The tests done in the PHL may miss a diagnosis, therefore test results of the samples which were negative has also been sent out," he said. It would take a week to know the results.

With the recent outbreak in India particularly in West Bengal, cases symptomatic of the disease was observed at the same time, in the South around the area. A health team is already on-site to look over the situation.

"Following this outbreak, to avoid it we have alerted all the border hospitals to collect the samples and find out whether this virus is circulating among population," said the PHL head.

Since the disease is a viral infection, no antibodies are available for the treatment of Chikungunya, which is why the symptoms treated are only for fever, joint pains and body aches.

It is said that timely medical attention will help avoid complications. The symptoms of the disease usually lasts for a week but joint pain can go on for several weeks or months.

Malaria is now considered a problem only in the 7 perennial transmission districts and in the rest of the district's the level of infection has been reduced to less than one infection per 1000 population at risk. However, the effect of climate change on malaria has not been seriously considered. Vulnerability assessment and adaptation to climate change component is missing in their 2011 annual malaria review and strategy. The predominant reason cited is lack of information on climate change and technical expertise to guide the program on the issue.

With predicted raise in temperature and rainfall (SNC), places earlier not conducive for malaria vectors, now may become conducive in coming 10-20 years. For example, malaria in early 90's were confined to southern districts but now indigenous cases were reported from higher altitude areas such as Gongdara (500-1500m) in Sarpang, Pataley (700-1900m) in Tsirang, Decheling (500-1699m) in Pemagatshel and Wangduephodrang (1350m) areas.

Similarly, Dengue has been reported from areas of Dagapela (1355m) in Dagana district and even Thimphu (3800m). Also, mosquito surveillance in the past revealed existence of common higher altitude species such as *An. lindesayi*, *An. baileyiAn. bengalensis*, *An. willmori*, *Culexmimeticus*, *Aedesdesmotes*etc but now *Anopheles, Aedes* and *Culex* species responsible for malaria, dengue and JE are also found in those areas.

Currently a total of 24 species of Anopheles have been recorded, of which 18 were encountered only in 2009 vector surveillance. Likewise Sand Flies were detected in Langjophaka and Mothithang areas of Thimphu for the first time in 2000 (ANR 2008), and dengue in 2004. Very recently in August 2012, chikungunya outbreak was confirmed in Samtse and Phuentsholing.

The coherent elucidation of relation between VBDs and climate change require spatial recordings of climate variables as well as zones potentially occupied by mosquitoes (ZPOM) and epidemiological data records for comparison; which they do not have now.

6.4 Adaptation needs and options for VBD control

The VBDCP has built its core service delivery structure based on deployment of malaria/medical technicians[18] to BHUs and hospitals. This work is supported in malaria treatment by the health assistants, nurse and doctors and supplemented in IEC and community mobilization by village health workers and in IRS by spray operators.

In changing scenario of malaria transmission, broad adaptation option includes inclusion of VBDs diagnosis, treatment and prevention in the Royal Institute of Health Sciences (RIHS) for all categories of health workers. Policy interventions that is inclusive of other sectors, improving reporting, surveillance, and development of population based data base etc. Also, sustained interventions including (i) additional provisions for long-lasting

18 A malaria/medical technician is a multipurpose health worker providing microscopy, RDT, recording and reporting, IEC materials, case follow-up, supporting LLIN and IRS delivery and entomological surveillance and supporting delivery of LLIN, IRS and larval source control.

insecticidal nets (LLINs) for vector control and (ii) effective treatments by artemisinin-based combination therapy (ACTs) needs to be continued for achieving further reduction in malaria receptivity coupled with ongoing preventions adaptation like ditching stagnant water, reclamation of marshy areas and land depressions, proper container disposal, fishery pond management, proper gradient drainage and irrigation system must be continued.

In reference to cross border transmission, among seven bordering districts with India, Sarpang adjoining to Tsirang and Kokrajhar districts of Assam consistently contributed most cases in the country (30 – 60%), and deserves focused interventions on both sides of the border to check the focal disease outbreak and spread of drug-resistant varieties of P. falciparum cases. It was revealing that 10 – 20% of patients treated in health centers near the border were from India, most of which were consistently recorded in Sarpang district (57 – 95%) that call for prioritizing interventions on both sides of the border to avert disease outbreaks in place and time.

Border health check up post to monitor the magnitude of population migration and prevalence of fever/malaria in such groups is non-existent and is required urgently. High-rise in cases in such groups would implicate the possible disease onslaught which would call for concerted control efforts. In making provision for case detection and treatment with laboratory back up facility would prevent the entry and dissemination of new parasite strains/ drug-resistant varieties. In mega-developmental projects, built in health check facility should be mandatory to prevent possible disease outbreaks due to congregation of migratory labor force and associated risks. These locations provide ideal breeding habitats for vector proliferation permitting disease transmission. In 2009, there was nearly threefold increase in cases due to series of focal disease outbreaks with majority cases from Sarpang (80%). It was attributed to loss of residual efficacy of LLINs earlier distributed in 2006. It is imperative that residual bio-efficacy should be monitored periodically to replace those worn-out preventing escalation of cases.

Strategically, VBDCP is working alone in prevention and control of VBDs. A systematic policy approach needs to be framed for effective adaptation to sudden malaria outbreaks in least expected areas. For instance, currently there is no mechanism for malaria prevention and diagnosis in mega hydro power project constructions areas. Only when cases are suspected the VDCP is informed. Now with many power plants in pipeline and with more than 5000 Indian labourers already in Punatsangchu Project it is critical to liaise with Druk Green Power Corporation (DGPC) for preparedness and coordinated action for early detection, diagnosis, treatment and prevention.

Also, development of linkages with other participating agencies for decisive action to overcome disease outbreaks and spread, and saving lives is critical. For instance, urban planners and architects (Department of Urban Development & Engineering Services and respective Thromdeys) to plan better to deal with extreme temperatures, extreme events, and increase in vectors; and the agricultural sector, since certain agricultural practices that provide breeding grounds for vectors will need to be altered.

Adaption strategy	Description of Adaptation activities
International and cross border cooperation	Coordination of vector control efforts at borders.
	Screening of migrant workers particularly for big projects.
	Sharing of research, expertise on vector control, surveillance and mapping.
Inter sector coordination and cooperation	Coordinate with Druk Green Power Cooperation to systematise the screening of the migrant workers, Standardize housing, water, sanitation and drainage in the labour camps of mega power projects.
	Similar standardization in all industrial areas and urban towns by coordinating with Bhutan Chamber of Commerce and Industries and with Thromde (Municipal) respectively.
	Coordinate with Hydro Met Division, MoEA for meteorological data of relevance to health.
Surveillance & Research	Surveillance of Anopheles &Aedes Sp Mosquitoes & examining their relationship with climatic and weather.
	Mapping of vectors & resistance pattern (to insecticide & treatment)
	Incorporation of meteorological data in Health Information System.
Vector Control	Targeted larvicidal & insecticidal spraying
	Reducing areas conducive or covering of domestic water containers.
Epidemic Preparedness	Continue IEC activities on VBDs, particularly use of LLIN bed net, good drainage, proper disposal of containers, illness, awareness & treatment.
	Institute communication system between health centers & VDCP to allow prompt response to epidemics.
Early Diagnosis & treatment	Ensure that health facilities can make prompt, accurate diagnosis of VBD
	Ensure that health facilities can treat illnesses with appropriate level of care

CHAPTER 7: IMPACTS OF FLOODING & GLOFS ON HEALTH & HEALTH SERVICES IN BHUTAN

7.1 Overview

Bhutan is already observing the impacts of climate change. The most significant impact witnessed is the accelerated formation of supra-glacial lakes due to the accelerated retreat of glaciers with increasing temperatures (UNDP 2009). These glacial lakes naturally form are known to break their natural dams, causing glacial lake outburst floods or GLOFs, major GLOFs occurred in 1957, 1960, and 1994. Climate change is now accelerating the formation and increasing the risk of subsequent flooding.

However, other extreme weather events are also being observed. Although rivers and streams are known to swell and flood during the monsoons, Bhutan in recent years has experienced more frequent extreme weather events including cyclone related storms, flash floods, landslides, and windstorms. In May 2009, for the first time the land-locked country was severely affected by coastal cyclones. Heavy nation-wide flooding was experienced due to heavy precipitation from Cyclone Aila in the Bay of Bengal. Water levels recorded in Punatsangchhu were even higher than during the 1994 GLOF event.

As a mountainous country, the majority of Bhutan's settlements, agriculture and infrastructure is concentrated in the river valleys, and thus highly vulnerable to riverine and flash flooding, erosion and landslides. These disasters can have significant impacts on community health and health services and infrastructure. This chapter discusses the potential risks to health posed by climate change in coming decades.

7.2 Baseline Conditions of Extreme Events in Bhutan

This section describes the baseline conditions of the impacts of three types of extreme events (GLOFs, riverine and flash flooding, and windstorms) on health and the health system in Bhutan. This includes the burden of disease and losses/damages from extreme events risk factors, sensitivity of risk factors to climate, and capacity of the health sector to manage impacts of extreme events.

Table 24: Summary of climate related disasters and health sector losses &damages (2009-2012) (Source DMIS database)

Year	Disaster event	Death	Injuries	Private Homes	Govt. Infrastructure
2009	Flood	12	0	11	1
2009	Wind Storm	0	0	3	0
2010	Fire	2	1	58	NA
2011	Wind Storm	1	0	2424	91 (21 health facilities)
2011	Flood	0	0	11	0
2011	Fire	1	6	55	0
2011	Landslide	1	1	2	0
2012	Wind Storm			30	4

1. Windstorms

Severe windstorms have been recorded in Bhutan since 1994, however are considered a relatively new hazard in Bhutan. Reports have mostly been recorded in local newspapers rather than official statistics until recently. However, in recent years windstorms seem to be increasing in severity and frequency, causing damages to thousands of private houses, government facilities, and agricultural crops. In 2011 alone, successive windstorms affected sixteen dzongkhags causing damage to 2,424 rural homes, 81 cultural assets, 57 schools, 21 health facilities and 13 other government buildings (DMIS data, DDM MoHCA).

Burden of Disease from windstorms

Windstorms can have a range of consequences for health, including death. Traumatic injuries are the primary health outcome associated with road traffic accidents, individual accidents and building failure. Windstorms can increase the risk of a number of other health effects, including mental stress. In Bhutan windstorm related mortality and injuries have been recorded since 2009.

The primary risk factor for traumatic injury and death is being outside during the windstorm's peak activity. It has therefore been recognized that windstorms peaking in the early hours of the morning have a smaller impact than those peaking during working hours.

Those most vulnerable to being hurt or killed by windstorms include (but are not limited to):

- Neighborhoods with poor quality buildings, work camps, and squatter settlements
- Low income households
- The elderly and children
- Farmers, drivers, vendors with outdoor occupations

Sensitivity to climate change

Surface wind speed and direction are affected by a range of climatic conditions, which are changing in the Eastern Himalayan region. More information is needed on available climate research in the region and Regional Climate Models to understand the influence of climate change on windstorms.

Capacity: Given that no forecasting for severe winds are available in Bhutan, preparedness for events is limited.

2. Glacial Lake Outburst Floods

Bhutan has 677 glaciers and 2674 glacial lakes of which 25 were previously designated as potentially dangerous (Mines, 2001). All major river systems in Bhutan originate from glaciers and glacial lakes in the higher Himalayas. The recent "Study on Glacial Lake Outburst Floods in the Bhutan Himalayas" conducted in 2009-2012 with international support[19] developed a new satellite-based glacial lake inventory and reviewed the threat levels of "potentially dangerous" lakes with new data. The majority of glacial lakes previously labeled as "potentially dangerous", have been reclassified to not pose immediate danger of flooding, apart from the "Lunana complex"[20]. However, this research advises close monitoring of all glacial lakes as circumstances could change rapidly due to the rapid change in climatic conditions.

19 http://www.eorc.jaxa.jp/ALOS/bhutan_gli/gli-readme120330.pdf. Supported by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA) in collaboration with the Department of Geology and Mines (DGM)

20 The three lakes -Luggye, Raphstreng and Thorthormi that exist adjacent to each other in Lunana.

Table 25: Past GLOF events in Bhutan ((DDM/ADPC 2010, DMIS)

Event	Areas/Dzongkhags Affected	Loss and Damages	Remarks
1957 GLOF	Pho-chu sub basin		Caused by burst of TarinaTsho
1960 GLOF	Pho-chu sub basin		
1994 GLOF	Pho-chu sub basin (Gasa, Punakha, Wangdue, Tsirang, Sarpang)	Damaged more than 1,700 acres of agriculture and pasture lands, a dozen houses, 6 tonnes of food grains and washed away five water mills and 16 yaks	Caused by partial burst of Luggye Tsho in Lunana
August 2000 Floods	Phuentsholing		Flooding caused by Dotengchu
2005 Floods	Phuentsholing/ Pasakha	More than 200 people lost their properties	Caused due to heavy rainfall
2004 Floods	Six eastern Dzongkhags	9 lives lost; 29 houses completely washed away, 26 collapsed and 107 partially damaged; 161 acres of wetland and 503 acres of dry land washed away; 350 mt maize, 126 mt paddy, 2000 orange trees and 21 mt potatoes estimated as lost affecting 1437 households; 39 irrigations channels damaged; 22 bridges damaged or washed away; Farm and feeder roads damaged.	Caused due to heavy monsoon
May 2009 Floods	Almost all 20 dzongkhags affected	12 people died and properties worth Nu.766 million damaged	Caused due to heavy rains precipitated by Cyclone Aila
June 2009 Floods	Thimphu, Chukhha, Bumthang, Wangdue, Haa, Gasa, Punakha, Trongsa	12 deaths 11 homes damaged	Caused due to incessant rainfall
March 2011 Floods	Thimphu	11 homes damaged	Caused due to incessant rainfall
2012 (landslides and flash floods)		More than 2000 acres of agricultural land damaged, 4165 households affected, farm roads and irrigation channels affecting 529 households damaged	

In the event of a GLOF flood the primary risk factor for traumatic injury and death is being in the path of the floodwaters and incurring injury or drowning in the floodwaters. Those most vulnerable to being hurt or killed by a GLOF include (but are not limited to) children, elderly, and those who cannot swim.

However, if a GLOF is highly destructive resulting in the loss of homes, family members, or livelihoods it may also increase the risk of mental health issues, such as anxiety, post-traumatic stress disorder, and depression. Losses in public health infrastructure such as water posts, wells, sanitation facilities and latrines. If sanitation is compromised in a GLOF the risks of post-event outbreaks will increase.

Geographic Distribution of communities and health services at risk

All major rivers in Bhutan originate from glaciers or glacial lakes and all major human settlement and development occur along river valleys, exposing majority of Bhutan's population to direct or indirect risks from GLOFs and flooding events.

However, communities with the highest vulnerability to GLOFs are located in the 5 River basins downstream from the 25 potentially dangerous glacial lakes. Even within these river basins, the level of vulnerability and risk could be differentiated based on past events and recent research conducted on the status/stability of the lake.

Greatest concern are the 9 lakes in Pho chhu basin where there have been four GLOF events in recent times (Table 25) and especially the risk of GLOF from the combined waters of Thorthormi and Raphstreng lakes, which together could release a flow of over 53 million cubic meters of water (NEC 2011 and UNDP-LDCF/GEF, 2009)

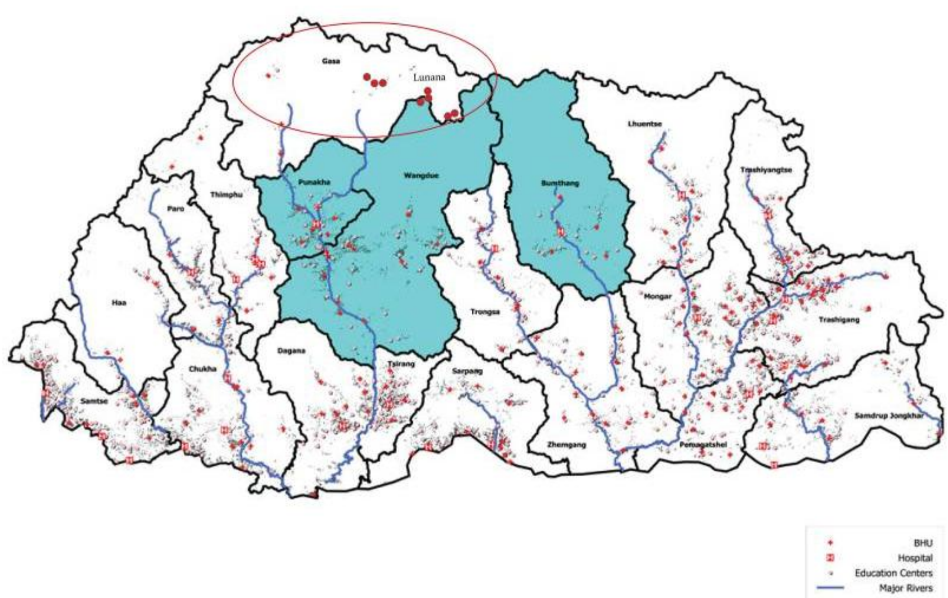
The 25 potentially dangerous glacial lakes are distributed across the northern highlands, 7 are in the head waters of Mangdechhu, 9 (including Thorthormi Tsho) in the headwaters of Phochhu, 3 in the Chamkharchu basin, 1 in Kurichhu basin and 5 in the Mochhu basin (ICCIMOD and DGM-Inventory of Glaciers, Glacial Lakes and GLOF, 2001).

Table 26: Summary of glaciers and glacial lakes (Source: Karma et al, 2008; ICIMOD, 2010; SCN)

	River Basin	Glaciers	Glacial lakes	Potentially Dangerous	Most at risk Downstream Towns/Populations
1	AmoChhu	0	71	0	Phuntshholing Town
2	Wang Chhu	36	221	0	Haa, Paro & Thimphu Valley
3	Puna Tsang Chhu	272	980	14*	Punakha and Wangdue Valley
4	Manas Chhu	310	1383	11	Chamkhar Valley
6	Northern Basins	59	10	0	All of Above
	Total	677	2674	25	

*Including Thorthormi Lake in Lunana

Figure 32: Health Facilities and settlements located in river basin



Sensitivity of GLOFS to Climate

Rate of glacier retreat is affected by increasing temperature and rainfall, which is evidenced by the greater loss of glacier mass during the warmer months. Under current conditions of an average temperature change of 0.6 degrees/year, current glacial retreat rates for debris covered glacier (35m/year) and debris free glaciers (9m/year). Glacial retreat rates for the period 2010-2039 are estimated to be78.2m to 168m/ year for debris covered glaciers and 20.1m to 43.2 m/year for the period 2040-2069 for debris free glaciers (Commission 2011). In addition to the increasing temperatures, projections for precipitation levels for the two future periods of 2010-2039 and 2040-2069, indicate significant increase in the northern regions of Bhutan. Based on rates of glacial retreat and increasing temperature trends in the region, glacial lake formation is expected to continue resulting in continued high risk of GLOF events in the future.

Capacity and Management

Hazard maps have been developed for the Chamkhar, Punakha and Wangdue Valleys at risk of GLOF flooding. For Mangdechu hazard demarcations and mapping were developed only in 2012 and is still not available for public viewing. A GLOF hazard zonation and vulnerability mapping exercise was done for the upper Punakha-Wangdi valley in 2002 and has been extended for the whole basin and for Chamkhar valley and completed under the ongoing "Reducing Vulnerability from Climate Change-Induced GLOF's in Bhutan" project (UNDP – LDCF/GEF, 2009). As per the hazard maps over 20 communities in the Chamkhar valley and more than 25 communities that have been identified as most vulnerable and in the high-risk (red) zone area.

Table 27: Vulnerable communities in Punakha-Wangdue and Chamkhar valleys identified in the GLOF hazard zonation map (this does not include vulnerable areas in Gasa, Tsirang and Lhamoizingkha)

Affected Units	Punakha	Wangdue	Bumthang	Total
No. of Geogs /blocks	4	1	1	6
No. of villages/Communities	9	4	8	21
No. of Household	90	4	307	401
No. of Schools	5	2	2	7
Students/Monks Population	2012	622	1111	3745
Teachers Population	103	39	39	181
BHU	1	0	1	2
Hospitals	1	1	0	2
	66 evacuation sites have been demarcated			

The major hospitals and BHUs included in high risk zones are Punakha and Wangdue Hospital, Samdingkha BHU and Damphel BHU in Bumthang.

3. Riverine and Flash Flooding

The occasional GLOF event and recurrent flooding events have continuously taken lives and caused huge loss and damages to private property/assets (including agricultural land, corps, livestock), development infrastructure (schools, health facilities, bridges, roads, local government and other office buildings, RNR centers) and cultural assets (lhakhangs, chortens).

Table 28: Past Flooding Events ((DDM/ADPC 2010, DMIS

Event	Date	Areas/Dzongkhags Affected	Loss and Damages	Remarks
Flood	2000 (August)	Phuentsholing	NA	Flooding caused by Dotengchu
Flood	2005	Phuentsholing/ Pasakha	Property damage: 200	Caused due to heavy rainfall
Flood	2004	Six eastern Dzongkhags	9 deaths Property damage: homes washed away (29); collapsed (26); partially damaged (107) Land lost: 161 acres of wetland and 503 acres of dry land; Agricultural Loss: 350 mt maize, 126 mt paddy, 2000 orange trees and 21 mt potatoes - affecting 1437 households; 39 irrigations channels damaged; 22 bridges damaged or washed away; Farm and feeder roads damaged	Caused due to heavy monsoon
Floods	2009 (May)	Almost all 20 dzongkhags affected	12 deaths Property damage worth Nu.766 million	Caused due to heavy rains precipitated by Cyclone Aila
Floods	2009 (June)	Thimphu, Chukhha, Bumthang, Wangdue, Haa, Gasa, Punakha, Trongsa	12 deaths 11 homes damaged	Caused due to incessant rainfall
Floods	2011 (March)	Thimphu	11 homes damaged	Caused due to incessant rainfall

7.3 Sensitivity of extreme precipitation to climate change

The timing and intensity of precipitation is affected by a range of climatic conditions which are changing in the Eastern Himalayan region due to increased sea surface temperatures, winds, and glacial melt. More information is needed on available climate research in the region and Regional Climate Models to understand precipitation changes and predictions in Bhutan.

7.4 Capacity

Baseline Health System Preparedness for Extreme Events

Due to past disaster and emergency events, there has been an increase in the level of awareness and more urgency attached to enhance preparedness levels in all sectors. The Department of Disaster Management (DDM) under the Ministry of Home and Cultural Affairs (MoHCA) has been working to raise awareness and capacities at national and local levels and advocating for mainstreaming disaster risk concerns in key sectors such as Health. Since 2008 there are designated disaster management focal persons in each government ministry and relevant agencies and each Dzongkhag administration is in the process of establishing Dzongkhag Disaster Management Committees (DDMCs), which will have a representative from the Health Sector as a member.

The National Health Policy (NHP) 2011 of Bhutan has a specific section on Emergency Health Service and spells out that – "All health facilities shall institute appropriate system of care to deal with emergencies, disasters, epidemics and outbreaks" and "shall provide a system of emergency for (a) disasters (b) epidemic outbreaks (c) mass casualty (d) routine emergencies". It further states the need to build capacities in terms of material as well as human resources.

In addition, Ministry of Health, with support from the World Health Organization (WHO) has formulated the Health Sector Disaster Management and Contingency Plan 2012 to plan for and respond to various natural disasters and emergency events. This is primarily in compliance to the National Disaster Management Act, 2012. A number of simulation and table top exercises have been conducted at the national and in district hospitals. The plan includes the delivery of emergency response and risk assessment capacity building activities, communication plans and procedures and the conduct of evacuation drills in all health facilities. Complementary to this effort, the DDM with support from the Global Facility for Disaster Reduction and Recovery (GFDRR) and the Geo Hazards International (GHI) is currently facilitating a technical working group to formulate a comprehensive action plan to enhance the safety of all health facilities in the country. Also, under the Building Bhutanese Seismic Resilience Project implemented by the DDM and GHI, vulnerability assessment checklists are being developed specifically for health facilities in Bhutan and training of engineers on the use of the same is expected to happen before the end of 2012.

In terms of emergency medical care, the Ministry of Health established the Health Help Center (HHC) in Thimphu within the Jigme Dorji Wangchuck National Referral Hospital complex, under the Department of Medical Services (DMS). Services from the HHC can be availed across Bhutan by dialing a toll free number 112. HHC's emergency medical response services includes using GPS technology for the deployment of the nearest available ambulance and paramedics to the site of incident. Besides emergency medical response, the centre also provides medical advice and counseling services.

The Ministry of Health is still in the process of finalizing its sector contingency plan. There is still the need to enhance disaster and emergency preparedness and capacities at all levels and to increase understanding of climate change associated risks and its impacts on the health sector and the delivery of health services. The implementation of the Health sector emergency/disaster contingency plan would enable the human resource gap analysis for MoH to deal with different types of disasters in all the health centers. The existing number of health workers in the health centers of GLOF risk areas of Punakha, Wangdue and Bumthang are inadequate in number to deal with GLOF or any other Natural disaster.

Specifically for GLOF, the Department of Disaster Management (DDM), the Department of Geology and Mines (DGM) and the Department of Hydro-met Services (DHS) are jointly implementing a GLOF mitigation and preparedness project to physically reduce water levels of Thorthormi lake in Lunana, establish an end to end automatic early warning system in the Punatsangchhu river basin and raise awareness and capacities of at risk communities in the GLOF red zone areas. Currently Thorthormi water levels have been manually decreased by1.45 meters.

An automatic early warning system has been established in (14 sirens/areas) with loud sirens that will alert communities of GLOF coming, and provide approximately 1-6 hours advance warning. Awareness activities in vulnerable communities and respective local governments are being carried out on a continuous basis.

7.5 Future Impacts of CC on Extreme Events

Irrespective of climate change, given population trends (eg. Wangdue, Punakha) human settlement, number and density of people in the vulnerable areas will continue to grow. Due to existing urban areas (such as the planned township of Khuruthang) and development facilities and institutions (roads, schools, vocational training institutes etc.), rapid development and urbanization can be expected. This would in turn increase exposure of people and all other elements at risk not only to natural hazards related to climate change but also to earthquakes as Bhutan located in high risk seismic zone.

In addition, due to the lack of hazard zonation maps and limited information for other district than Punakha, Wangdue and Chamkhar valley, the urban planners may not take disaster risks and vulnerabilities into account during the land use planning and development process. Therefore, strengthening of public health and medical delivery system and enhancing preparedness levels of the health sector is of urgent necessity even without climate change, though climate change makes the requirement more immediate and critical.

For Bhutan there is an increasing trend for both maximum and minimum temperatures and annual temperature is projected to increase by 0.8 – 1.0 degrees centigrade in 2010-2039 and by 2.0 – 2.4 degrees centigrade by 2040-2069. Similarly, changes in mean annual precipitation are projected to increase 10% by 2010-2039 and 20% by 2040-2069, with wetter monsoons and drier winters (NEC, 2011). These changing conditions may would logically result in more climate related extreme events such as windstorms, flooding and landslide events, which would further increase the exposure risk of vulnerable communities to extreme events.

Increasing temperatures and precipitation levels are linked to increasing rate of glacial retreat. At present glaciers in Bhutan are retreating rapidly at approximately 8-10 m/year for debris free glaciers and 30-40 m/year for debris covered glaciers. But with changing climate conditions, glacier melt rate may rapidly increase, meaning increased risk of GLOF events, especially from the identified 25 potentially dangerous glacial lakes and more so in the Pho chhu basin with the history of four GLOF incidents.

Possible future losses and damages in the health sector and other health impacts due to increase in frequency and intensity of extreme events could be:

- Deaths and injuries in GLOF and flood risk areas
- Post-disaster mental health issues
- Loss and damages of health facilities and equipment, incurring replacement costs and disruption of services
- Loss and damage to, drinking water sources and supply systems, compromising water quality
- Loss and damage of sanitation infrastructure (latrines, reclaimed water)
- Loss of accessibility to health services due to damage to roads and bridges necessary to reach health services and disruption of public services such as communication, transportation needed for health service delivery.

Table 29: Loss and Damage estimates in the case of May 2009 Floods precipitated by Cyclone Aila (Source: DDM)

Sl no	Loss and Damages	Estimate
1	Lives lost	13
2	Government Infrastructure	Nu. 544 Million
3	Farm and Feeder Roads	Nu. 47 Million
4	Agricultural Property	Nu. 7.5 Million
5	Drinking Water/ Irrigation	Nu. 45 Million
6	Livestock	Nu. 15 Million
7	Private	Nu. 7 Million
	Total	Nu. 766 Million

7.6 Adaptation needs and options of Extreme Events

Strategy	Description of Adaptation activities
Enhancing preparedness for extreme weather conditions and other emergencies	Legislative and institutional strengthening – National Disaster Management Bill, the DM institutions and mechanisms to be put in place, strengthen provisions for Climate Change Build emergency management and response capacities – Develop Standard procedures for response, communication, search and rescue, assessments etc. Financial mechanisms for preparedness and mitigation activities – this should also include extreme events Mechanisms to restrict further development in high risk areas – Ministerial or government directives, local government by laws, insurance mechanisms etc. Develop and implement comprehensive awareness and education strategy – at various levels, various hazards, risk communication, climate change information etc. Institute risk transfer/insurance mechanisms , especially for crop and livestock Continue community based capacity building activities to build disaster resilient communities Work towards development of a multi-hazard atlas, including mapping of extreme events Develop disaster management plans at national, sector and local levels – risk identification including extreme events, risk reduction and mitigation and adaptation activities, preparedness and response activities
GLOF	Mitigation of potential dangerous lakes – similar to the lake lowering at Thorthomi, would be expensive but may be required to mitigate few potentially dangerous lakes Establish early warning systems – both automatic and community based, clear protocols and channels of communication Conduct end to end evacuation drills for Punatsangchu and Chamkhar basin as the hazard zonation is complete and evacuation areas have been identified. Assess level of awareness and adaptation capacities Carry out awareness and capacity building activities regularly, especially in vulnerable communities and special consideration may be made for vulnerable groups (children, women persons with special needs, elderly) Establish system of monitoring glacial lakes, especially the 25 potentially dangerous glacial lakes Work towards the establishment of seismic stations as seismic activity may trigger GLOF events Strengthen meteorological network to provide accurate and efficient information to forecast extreme events and record weather information Continue assessment and hazard zonation in other river basins
Other adaptation measures	Water resource management Climate observation and forecasting/ early warning Measures to prevent siltation from floods and loss of agricultural lands Resilient drinking water and irrigation facilities
Health specific interventions	Review and implement the health Sector Disaster Management and Contingency Plan Ensure safe drinking water and emergency water treatment options Strengthen medical emergency response capacities Assess all health facilities for safety and enhance preparedness in all health facilities Create awareness on health risks due to climate change effects and conduct more research into climate related diseases and impacts of climate change on human health

CHAPTER 8: OTHER EMERGENT HEALTH RISKS IN BHUTAN ASSOCIATED WITH CLIMATIC CHANGES

8.1 Health Vulnerability & Baseline Conditions of other Climate Sensitive health outcomes in Bhutan

Overview

In addition to the primary health conditions of interest to this study, a secondary range of important morbidities in Bhutan are also climate sensitive, and may see increased prevalence due to climate change in the future. The Ministry of Health should remain vigilant to monitor changes in these conditions in coming years, and conduct further studies on the climate sensitivity.

8.1.1 Nutrition

Climate change will have major impact on the nutritional status of the population because the determinants are related to food, health, sanitation, water and care practices, which can be directly affected by climate change. Cyclone Aila in May 2009 caused massive floods, landslides and windstorms affecting the 17 of the 20 districts. However, the impact of natural disaster on nutritional status has never been assed or recorded except for those with injuries reporting to health for treatment.

With one third of Bhutanese children less than five years of age being affected by chronic under nutrition (33.5% stunting) and one in every eight children (13% underweight) being under weight (Annex 41), climate change induced conditions can escalated the situation.

GLOF risk areas of Bumthang, Punakha and Wangdue with high malnutrition and diarrhea incidence rate (

Annex 42) can be severely affected due to extreme weather conditions.

Table 30: Nutritional status of the eastern region

Indicator	1988	1999	2009	2009
	NCHS	NCHS	NCHS	WHO
Wasting	4.1%	2.6%	4.6%	4.6%
Stunting	56.1%	40%	30.2%	37%
Underweight	37.9%	18.7%	15.2%	11.1%

Source: http://www.foodsecurityatlas.org/btn/country/utilization/childrens-nutritional-status

Geographic disparities regarding nutritional status are notable, with communities from the eastern and rural regions of Bhutan experiencing notably higher levels of malnutrition and food poverty than other regions and urban areas (WFP, 2012). Eastern districts average of 43% of children affected by stunting and 15% under weight (Table 31).Three eastern districts are having particularly high vulnerability to malnutrition where close to 50% of the children affected by chronic malnutrition: Lhuntse (59%), Trashigang (47.2%) and Pemagatshel (45%). Hence any disruption in water, sanitation, access to health services etc can have serious impact on an already fragile health and nutritional status.

Table 31: GLOF Risk District with Diarrhea incidence rate and nutrition status: BMIS 2010

Diarrheal incidence rate from 2002 to 2011per 1000 population	
National	111.2
East	99.0
Central	119.6
West	113.1

Adaptation

1. Helping farmers adapt to changing climate by finding new crop varieties or species that are more resistant to climate change conditions, pests and diseases.
2. Setting up and/or strengthening nutrition early warning and surveillance systems, integrating (further) the climate dimension.
3. Include nutrition prevention as part of the strategies of climate change adaptation measures.

8.1.2 Food security and safety

Although only 7.8 % of Bhutan's land is arable[21], the country has a predominantly agrarian based economy with 69% of the total populations being dependent on substance farming. However, there is already shortage of food production in Bhutan (10 FYP Vol. II) and Bhutan is not self-sufficient in grain food production, and imports addition products to supplement national production. The impacts of climate change on food production and safety in Bhutan will be different in different geographical regions. However, food production today is vulnerable to a range of threats which may intensify with a changing climate in coming decades, including flooding, fires, pests, and drought.

However, food security in Bhutan is an issue of access to resources and economic opportunities, more than lack of availability of food. For rural households (69%), difficulties arise from a inconsistent lack of access to land and water, preventing them from growing their own food. For urban (39%), non-farming rural and the landless populations, vulnerability stems largely from unpredictable employment opportunities.

The food insecurity in Bhutan is a combined outcome of access to food, utilization of food and availability of food and natural hazards that challenging the overall food security situation. These components negatively interact most in the eastern and southern districts causing both chronic and transitory food insecurity (WFP and Ministry of Agriculture 2005).

Vulnerable Populations

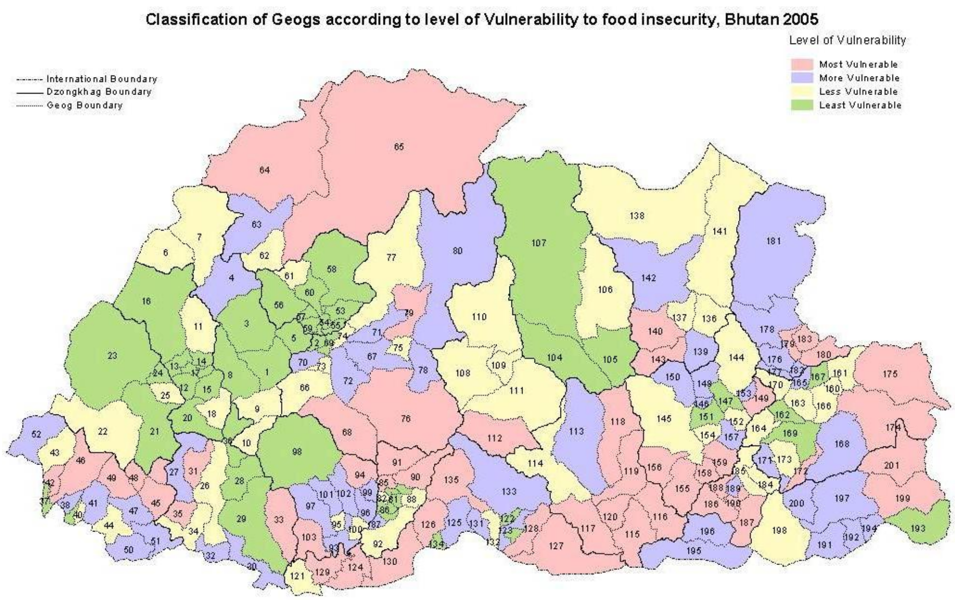
Chronic, transitory (periodic) and seasonal food insecurity is experienced in Bhutan. Chronic food insecurity is not widespread but particularly seen in pockets and among particular groups. The most vulnerable populations include landless farmers who work as farm labour, the labourers who live on daily wages, farmers without sufficient land or livestock holdings, women headed households who either lack sufficient landholdings or work force to generate income. Transitory food insecurity with seasonal food crisis is more common for the rural farmers with small land holdings, farmers producing crops completely for their own consumption, and households with low income in the informal sectors and peri-urban areas. One of the major causes of transitory food insecurity is the postharvest crop loss due to wildlife destruction or by other natural disasters. Seasonal food insecurity worsens as the food deficit months coincide with the periods of intensive agricultural operations, including tilling and planting when the food need of the workers are higher than in normal times.

21 Agriculture diversification in Bhutan , 2005, SonamTobgay

54.5% of the households have grain production enough to last nine months and an estimated 30.9% of the population are living under national poverty line. Poverty and food insecurity prevail predominantly in Lhuntse, Samtse, Zhemgang and Monggar districts (PAR 2007). Therefore the valleys along the river basin, food insecure districts and districts with highest poverty rates are most vulnerable to climate changed induced food insecurity.

Climate change mostly threatens to increase risks of transitory food insecurity, with shocks coming to farmers due to natural disasters and pest infestations. Warmer temperatures and altered seasonality due to climate change, affects not only disease vectors but also agricultural pests. Pemagatshel and Zhemgang are two dzongkhags where all the geogs are experiencing frequent crop damage by pests, and the severity of such attacks are increasing over the years(WFP and Ministry of Agriculture 2005). Mongar, Tashigang and Trashiyangtse are also vulnerable dzongkhags as more than 50 percent of their geogs are hit by wildlife attacks and landslides that are frequent and severe. Thirteen percent of the geogs in Mongar have frequent but less severe landslides. Samste is another dzongkhag that is suffering from pest attacks and landslides of varying frequency and severity. A projected increase in climate variability and extreme events may further introduce favorable conditions for crop pests threatening local production capacity and livelihoods.

Figure 33: Food insecurity by Geog in Bhutan



Source: Ministry of Agriculture and WFP, 2005

In terms of food safety and human health, increases in ambient air temperature accelerate the rate of microbial growth in raw and prepared food products. Thus in light of warmer future temperatures in Bhutan extra precautions will be needed to maintain commercial and domestic food hygiene so as to prevent food spoilage and additional cases of food poisoning from pathogens such as Campylobacter spp., Salmonella spp., hepatitis A virus and Escherichia coli (E. coli). Though access to water coverage and latrine is high, the actual behavior practice in food handling and preparation is still poor. Food transport distances from field-to-market can be significant in Bhutan, particularly of raw fruits and vegetables. Lengthy and unhygienic transport under warm and moist conditions is common to due lack of proper transportation facilities. In addition, the growth of aflatoxin in grains such as maize has been recently reported (Kuensel). However, there is no adequate data on food contamination in health.

Adaptation

1. Ministry of Health and Ministry of Agriculture need to revisit the National Food Safety Act.
2. Clear programmatic approach needs to be drafted between the two ministries.
3. National Nutrition Program needs to incorporate the Health food safety issues in its program strategy and work closely with MoA and BAFRA.
4. Improve or upgrade storage facilities to store and have access to food grains as an insurance against crop loss or damage

8.1.3 Respiratory diseases

Respiratory allergies and diseases may become more prevalent because of increased human exposure to pollen (due to altered growing seasons), molds (from extreme or more frequent precipitation), air pollution and aerosolized marine toxins (due to increased temperature, coastal runoff, and humidity) and dust (from droughts). For example, climate change will affect air quality through several pathways including production and allergen city of aeroallergens. Earlier flower blooming resulting from temperature increases. According to WHO global estimates, 300 million people have asthma, 210 million people have COPD while millions more have allergic rhinitis etc. For every one degree celsius rise in temperature, the risk of premature death among respiratory patients is up to six times higher than in the rest of the population. Climate change and respiratory disease by European Respiratory Society 2010[22].

In Bhutan respiratory diseases are showing an increasing trend over the last couple of years like common cold cases was 29,2142 in 2006 and increased to 32,3709 in 2010, similarly acute tonsillitis and pharangitis increased from 63,669 to 74,432 over the same period and other respiratory and nose diseases increased from 43,023 in 2006 to 51,861 in 2010 .

Respiratory illness is among the top ten causes of consultation reported from health centers, this might increase further because climate change affects people with existing respiratory illnesses as well as cause respiratory illnesses in normal populations.

The key risk factors known globally to influence respiratory disease which may change in frequency or intensity due to climate change include extreme temperature events (both hot and cold), changes in chemical composition of air pollution with heat, flooding, damp housing, thunderstorms, aeroallergens such as pollen and mould spores and consequent allergies, asthma and allergic rhinitis., and incidence of forest fires and dust storms.

In Bhutan, limited diagnostic facilities exist to identify the causes of respiratory illness. No documents are available for analysis.

Adaptation

1. Adjustments of diagnostic tools and clinical treatments in the health care settings with time
2. Awareness among the clinicians on the changing patterns of disease that will occur response to changing environmental conditions.
3. Improve disease surveillance and warning systems.
4. Actions to be designed to reduce the impact of already established climate change on patients with respiratory disease and to protect the public from related exposures known to adversely affect lung health
5. Health care providers to become involved in adaptation and mitigation strategies to help minimize the ultimate disease burden related to climate change.

22 http://dev.ersnet.org/uploads/Document/cc/WEB_CHEMIN_5568_1260432234.pdf)

8.1.4 Cancer and Cardiovascular Disease

Direct effect of climate change is depletion of stratospheric ozone which will result in increased ultraviolet (UV) radiation exposure. UV radiation exposure increases the risk of skin cancers and cata-racts. In Bhutan, over the last five years an average of 977 cataract cases were observed (1079 cases in 2011) but none were suspected to climate change. A total of 4694 cancer cases were registered since 2007 categorized as cervical, neoplasm and others. On confirmation with the Department of Dermatology, JDWNRH that handles all skin cancers, it has been revealed that there were no cases of squamous and basal cell carcinomas (both related to environment). There were three cases of Melanoma of the foot reported during the same period, however, the etiology of which is unknown.

Coming to cardio vascular diseases, there is evidence of climate sensitivity for several cardiovascular diseases, with both extreme cold and extreme heat directly affecting the incidence of hospital admissions for chest pain, acute coronary syndrome, and stroke. And cardiovascular disease refers to a class of diseases that pertain to the heart of blood vessels, such as hypertension, coronary artery disease, heart attack, and stroke. Thus climate change may exacerbate existing cardiovascular disease by increasing heat stress, increasing the body burden of airborne particulates, and changing the distribution of zoonotic vectors that cause infectious diseases linked with cardiovascular disease.

The incidence of cardiovascular diseases is increasing in Bhutan. Hypertension cases have increased from 2050 to 23,853cases between 2006 and 2010. Ischemic heart disease has increased from 94 cases to 268, and cerebrovascular diseases have increased from 184 to 354 and other circulatory diseases from 4267 to 5803 (AHB 2011).

The increased number of cardiovascular patients may experience exacerbated symptoms, due particularly in the event of extreme cold and hot temperatures, which have been noted in other countries to affect the incidence of hospital admissions for chest pain, stroke, cardiac dysrhythmia (irregular heart beat), and other cardiovascular diseases. This is particularly the case in urban setting with high rates of air pollution. The elderly and isolated individuals are at the greatest risk for cardiovascular disease and stroke when triggered by temperature extremes. There is also evidence of increased heart attacks due to increased ozone concentrations which increases stress on heart and stress and anxiety as a result of extreme weather conditions.

There is a lack of evidence in Bhutan on the specific risks that climate change induced conditions poses for cardiovascular diseases, due to the lack of research capacity.

Mitigation and Adaptation

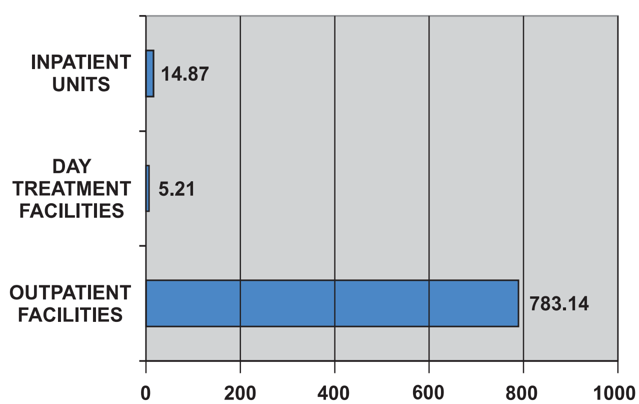
- Research on the incidence of cardiovascular diseases and its associations with temperature and other environmental exposures
- Awareness among clinicians and health care providers on the impact that weather conditions may have on cardiovascular diseases, in order to better care for at risk patients.

8.1.5 Mental Health

By causing or contributing to extreme weather events, climate change may result in geographic displacement of populations, damage to property, loss of loved ones, and chronic stress, all of which can negatively affect mental health. The baseline of the burden of mental health disorders in Bhutan is not well known. However, in the last few years the number of patients with mental disorders seeking help from the health care system has grown significantly throughout the country. However, it is recognized there are many psychiatric patients not receiving adequate treatment or rehabilitation, many of whom have been disowned by their families or chose to live on their own.

The majority mental health patients seeking care in Bhutan are treated in outpatient facilities, while the rate of user's treated in inpatient units and day treatment facilities is significantly lower and capacity is limited. Outpatient facilities treat 5,266 people or 783 users per100,000 population primarily for mood (affective) disorders (22%) and neurotic, stress-related and somatoform disorders(17%)schizophrenia (5%), substance abuse (3%). Diagnoses of patients admitted to community-based psychiatric inpatient units primarily suffer from mood disorders (32%), mental and behavior disorders due to psychoactive substance use including alcohol (27%), and schizophrenia (19%).

Figure 34: Patients treated in mental health facilities in Bhutan (rate per 100.000 population



The burden of mental disorders is underappreciated although it contributes significantly to disability and limit's flexibility and resilience at the household level to cope with other stresses and pressures. Mental health patients are a highly vulnerable special needs group, whose well-being and safety can be severely compromised by traumatic events such as disasters. Persons suffering from mental health disorders such as schizophrenia, anxiety, autism may not respond to emergency alerts and need special care during and after such a traumatic event. Additionally patients taking psychotropic drugs are extremely vulnerable to heat stress during heat waves, as these drugs act as thermode regulators.

In addition, Bhutan experiences a range of natural disasters every year which often result in geographic displacement of populations; damage to property, and loss of loved ones etc. These traumatic event scan negatively affect mental state of all people young and old. Although disasters regularly occur in Bhutan, no assessment of impacts on mental health of affected populations has ever been conducted. No mental health counseling has been mobilized and rendered following any natural disasters in Bhutan. Recent efforts to scale-up disaster preparedness do not include a separate mental health and psychosocial support (MHPS) component (Dorji 2006).

Capacity

Modern mental health care services only arrived in Bhutan in the late 1990s, and although still relatively underdeveloped have seen significant investments to scale up appropriate services. The mental health care system is community oriented, however, it is reported that due to a lack of trained health workers at the primary health care level patients have been treated mainly in the district and referral hospitals during the last few years (SEARO, 2006). Extended training of all non-physician health workers in the next few years will improve the coverage of mental care services at the community. However, overall, resources for the mental health system are very scarce, and the only way to improve and sustain mental health services is to integrate mental health care with general health care services.

A disaster/emergency preparedness plan for mental health is not present (SEARO, 2006). In June of 2006, Bhutan was present at a WHO sponsored meeting in Thailand on psychosocial aspects of risk management. Following this meeting, a framework on disaster risk management including preparedness for mental health in Bhutan was proposed to the government for implementation (SEARO, 2006).In light of potentially increasing natural disasters, the MoH should consider the special needs of mental health patients and prepare the mental health program to assess and respond to post-traumatic mental health impacts.

Adaptation

Mental health component is not addressed adequately in the Health Sector Emergency/Disaster Contingency Plan 2012. With increasing natural calamities the requirement for mental health program intervention for post traumatic counseling and management is critical. Current health workers have no skills in this aspect. Therefore the need to reassess the HSECP 2012 from Mental Health perspective is urgent.

CHAPTER 9: CONCLUSION AND RECOMMENDATIONS

Climate change will affect the current burden of climate sensitive diseases in Bhutan. It transpired from the Second National Communication to UNFCC 2011 that the mean annual temperature will increase by 3.5 ^{0}C by 2069. The proportion of population at risk of climate sensitive disease will increase as there would be shift in the geographic ranges due to climate change.

This VAA study finds positive association between climate variables, malaria and diarrheal diseases indicating change and shift in disease morbidity. It is recommended that present strategies and control programs are maintained, regularly reviewed and the adaptation measure identified in this report be acted upon. Malaria program is already going for elimination while Diarrheal cases will decrease as economic, health and social factors improves. Therefore the risk of climate variables on disease morbidity and mortality will be controlled by the ongoing program interventions if appropriate reviews and recommendations are implemented.

Subsequently, the poverty, literacy rate, safe drinking water, hygiene, sanitation, access to health services, child care and health seeking practices would be detrimental in prevention and control of CSD. Fortunately, many of these parameters have reached a very high level in Bhutan; water coverage is 96%, health seeking practices and knowledge about malaria symptoms is above 90% (MICS 2010), access to health services >90, EPI coverage >90%, >90% primary enrolment rate, under poverty to be reduced below 15% by 2012 and GDP growth rate is between 9-11 percent. Particularly the literacy and poverty uplift would greatly affect the control and prevention of these diseases. Effort must be to continue to identify pockets of areas and communities that require concerted effort to improve these indicators. Critical intervention at this point is to sensitize the communities and health workers of non endemic districts that will be affected by climate change. Early warning system and vector surveillance is important for detection of outbreaks.

Extreme weather conditions put all district at risk. The 2011 earth quake and windstorm damaged 6937 private homes and 581 government infrastructures. Seasonal landslides and flash flood affects high ways disrupting the transportation of main good and services within and outside Bhutan and presence of glacial lakes in the northern region of Bhutan puts the valley of Punakha, Wangdue and Bumthang most at risk of Glacial Lake Outburst Flood. Health care system requires taking stock of the vulnerability and approach the adaptation from policy intervention that outlines immediate strategies and long term strategies. The adaptation is beyond the Environmental Health Program in DoPH. EHP can function as a coordinating, monitoring, surveillance program that ensures adaptation means to reduce morbidity and mortality related to climate change. Immediate requirements for MoH is to revisits the National Disaster Management Act of 2011, HM relief Fund 2011 and National Disaster management Frame work and put in place health approach to CSD and extreme weather conditions. This is expected to give MoH a clear outline of immediate and future vulnerability and the national/sectoral approach to emergency and disaster preparedness. Second important and expected intervention is providing effective life saving emergency services in case of extreme weather conditions like flash floods, landslides, GLOF, earth quake, wind storm and fire. Third aspect is to mitigate post emergency morbidity by advising and facilitating access to safe drinking water, sanitation facilities and food supplementary programs in affected areas and identified safe evacuation areas. Third is to prepare and render counseling services to affected victims and families. These components need to comprehended and incorporated into the health policies for specific programs to address it effectively and EHP will monitor.

1. Recommendation: Control of Diarrheal Diseases

Program and Policy Recommendation:

- The current number of people (2) is adequate. However, it would enhance if the head of the Unit has a public health degree. Presently, the unit is functionally compartmentalized into ARI and CDD. It is recommended that one of the two persons be overall in-charge to extend the professional skills to both the diseases.
- Program is recommended to extensively use the quarterly diarrhea morbidity data from HIMS as proxy real time data and closely monitor the districts health facilities. These information be used for strategizing, resource allocation and targeted reduction of diseases burden. There is urgent need for CDD to capitalize on the existing diarrheal/Dysentery data from HIMS.
- Policy consultation (MoH-DUDH-Thromdey-MoEF, MoLHR) to develop and endorse minimum health, hygiene and sanitation provisions for the following categories similar to occupation safety requirements would help to reduce the burden diarrheal and VBD.
    - Labour camp in urban/ semi urban areas, hydro project sites, industrial areas and private construction companies.
    - Low income settlers in urban areas.
    - National Labour Force along high ways.

Recommendation for ensuring regular water supply:

- Sustain the functionality of the current water infrastructures by improving the validity of the district data & lasing with the Public Health Engineering Unit of Department of Public health.
- To follow up with National Environment Commission (NEC) and PHE to identify areas/communities with perennial and seasonal water scarcity.
- The definition of “access to safe drinking water, sanitation and hygiene” requires revisit including the validity of BHU level data on these parameters. Distinction is recommended between safe drinking water and piped water. Also the physical evidence of toilet should not be taken in totality as the definition of hygiene and sanitation. This area requires further consultation at the ministerial level.

Research and Information:

- Development of simple database for use at program, district and BHU level to monitor, report and analyze diarrhea incidence, water, sanitation and hygiene coverage and for cross tabulation and self pointer.
- Water storage and management at the rural households, semi urban low income groups, arm forces and in industrial areas requires assessment to determine storage and consumption practices.
- A study on drainage system in the rural community is recommended because existence or lack of community drainage system affects the household level hygiene and sanitation.
- Follow up on the NEC/PHE water scarcity mapping.

Behaviour Change for improved sanitation & Epidemic preparedness.

- Poor household hygiene may be maintaining high levels of diarrheal disease transmission despite increased Wat/San infrastructure: Therefore develop strategy to advocate household level Safe

Water Management (storage and treatment). Rural people need to understand that piped water is not safe all the time.

- Diarrheal cases peaks in Monsoon season (June July August) during which the water sources even in urban areas get contaminated with sediments. Public notice and early warning be disseminated before the onset & during the monsoon season.
- Liaising with Nutrition Unit for behavior change pertaining to infant and young child feeding, hand washing, food preparation and storage.

2. Recommendation: Control of VBDs (Malaria, Japanese Encephalitis, Dengue and Kala-Azar)

Policy and Program Recommendation

1. VBDCP to extend its intervention policies beyond MoH in context to emerging environmental changes brought about by rapid urbanization, rural urban migration, mushrooming industrial and power projects and influx of immigrant workers from endemic malaria areas. These locations provide ideal breeding habitats for vector proliferation permitting disease transmission. Therefore VBDCP is recommended to develop a multi-sectoral policy or Memorandum of Understanding for prevention and control of Malaria, Dengue, Japanese Encephalitis and Leishmaniasis (Kala azar).
   - Concern Sectors:

i. Department of Urban Developing and Housing (DUDH), Thromdeys, Ministry of Economic Affairs (MoEF) and Ministry of Labour and Human Resources (MoLHR)

- Output:

i. Minimum health, hygiene and sanitation provisions in development projects and new settlements be drafted and adopted

ii. Systematic screening, monitoring and surveillance of immigrant workers

iii. Mandatory provision for LLIN/ or ITNs in project areas.

- Target Groups:

i. Labour camp in urban/ semi urban areas

ii. Hydro power project sites

iii. Industrial areas and private construction companies.

iv. Low income settlers in urban areas.

v. National Labour Force along high ways.

2. With climate change VBDs are expected to emerge in non seasonal/endemic districts. It is recommended that Royal Institute of Health Sciences (RIHS) to incorporate VBDs prevention, case detection, control, treatments and surveillance in health workers curriculum and VBDCP to concentrate on refresher training.
3. Review and continue with case detection (active and passive) in all identified health centres. However focus on reducing vector survival, vector density aimed to reduce vector-human contact. Universal LLIN coverage with at least 2 LLIN per household, two rounds of focal IRS based on micro-stratification at village level using appropriate criteria based on local situation. Focal IRS within 1 Km radius of index case for interruption of further transmission in areas that don’t qualify for focal IRS based on existing micro-stratification criteria.

Research and Information:

- Research component is weak and almost none existence. Strengthening the epidemiological capacity of the national VDCP is strongly suggested as an urgent measure. Staff requirements for up-gradation of VDCP to include at least one epidemiologist should be considered as priority.

4. VDCP to liaise with Hydro Met Division of MoEA for regular information on precipitation, rainfall and humidity and use it as simple transmission risk indicators such as excess rainfall.
5. Installation of metrological instruments (Rain gauge and Hygrometric instruments) is cheap and taking readings and reporting are also easy. Therefore it is recommended that all health facilities be provided with metrological instruments and institute the readings in HIMS. This recommendation has been made in 2006 in a RSPN sponsored study entitled "Health and Climate Change: An exploratory study on climate change and diseases sensitive to climate change.
6. More user friendly data base needs to be adopted, which considers metrological and population figures for determining rates and trends by region, district, health facility, age, gender, etc. Current excel system is cumbersome for analysis and not complete for meaningful analysis.

Epidemic and outbreak preparedness

- Between PHL and VBDCP, one has to be designated as the central authority for overall information collection and record for JE, Kala-Azar and Dengue.
- As the country is in an epidemic-prone situation, focal epidemics are common and may lead to a huge outbreak without proper preparedness. Therefore, Early Warning System be developed and capacity should be built up at the district level for local response to VBDS/malaria outbreaks.

3. Recommendation: Glacial Lake Outburst, Flooding and other Emergencies

National Disaster Bill 2012 and the Health Sector Emergency/Disaster Contingency Plan (HSECP) have covered all important aspect of the health emergency and disaster requirements.

- Draft Health Sector Emergency/Disaster Contingency Plan needs to be simplified. In current state it appears to be checklist, work plan and reporting format, all in one. A conceptual framework on the overall HSECP will help the health workers to follow the plan. Also it is recommended that PLANS be organised into three tier system (Ministerial level, Hospital Level and BHU level). Chapter2 "planning process adopted for outlining HSECP" to be in annex.
- To immediately establish clear line of communication and coordination procedures for emergency in three GLOF risk valleys of Punakha, Wangdue and Bumthang. District Health officers to maintain updated information of the health centres catchment and vulnerable population.
- With increasing natural disasters and calamities, the need and demand for Post Traumatic Stress Counselling and Management is on the rise. Therefore this component needs to be addressed on priority in the MoH Human Resource Plan and in the HSECP.

4. Recommendation: Other emergent health risk associated with climate change

- Identifying and mapping populations and communities at increased risk of climate-related disease, which will also help to identify populations at risk for other climate-related health impacts as many environmentally mediated diseases share common risk factors.
- Promote alerts on any increasing susceptibility to infections that may be due to climate change.

- Systems to monitor changes in allergen concentrations in the air and how they might affect susceptibility.
- The need for long-term data sets on the incidence of cataract, cardio vascular diseases and mental health cases related to displacement and trauma arising from climate change related events.
- To revisit the Health Sector Emergency/Disaster Contingency Plan 2012 to incorporate the mental health components for post traumatic care is recommended. Mental Health Program needs to reassess their capacity for extension of mental health support in case of natural disasters.
- Identifying and incorporating key mental health outcomes in health impact assessments, under a range of climate change scenarios and develop mental health promotion and communication programs related to climate change mitigation and adaptation strategies.
- Awareness among the clinicians on the changing patterns of disease that will occur in response to changing environmental conditions.
- In case of national disaster, the immediate requirements are food, water, shelter and cloth and maintaining hygiene, sanitation and food safety. Therefore Food and Nutrition Unit must be involved in the HSECP. Nutrition program be assessed its readiness to cope with natural disaster in terms of Emergency food and nutrition guideline, vitamin supplements, de-worming tablets, assessment tools and nutritional supplements.
- Scale-up coverage of and increase access to interventions to treat acute malnutrition, especially at community level.

5. Outline Indicators to monitor CC related health risks

Vulnerability Indicators	Population Indicator	Risk Factor Indicator	Adaptation Indicator
Extreme Weather Events (Floods, Windstorms)	Number of injuries/infectious/ mortality due to floods, windstorms, or extreme temperatures	Damages to health facilities	Number of hospitals with emergency response plans and regular drills and training
	Number of extreme weather events reported	Number of “safe-hospitals” in flood risk zones	Number of CB action plans
VBD	Number of cases of VBD Malaria Dengue JE Kalazar Emergent VBD	Positive detection of disease agent in vectors, sentinel species, or reservoirs.	Cases adequately monitored and controlled.
	Number of people at-risk for transmission	Seasonal incidence, i.e. First and last reported cases seasonally	Transmission mapping kept up to date
Diarrheal Disease	Number of cases of diarrheal and dysentery reported	Reported incidence of water infrastructure failures	Cases adequately monitored and controlled.
	Number of surveillance systems accurately identifying and reporting outbreaks	Number of water sources controlled and found unsafe	Water sources monitored and improved
Health System Preparedness for Climate	Engagement of health in national climate planning		Public health workforce available/trained in the use of climate information

6. Limitations of the Study

First the scope of the study was ambitious for the quality of data that was available with Health Information Management System (HMIS) and Vector Borne Diseases Control Program. Secondly, given the mere negligible Vector Borne diseases incidence, it would have been more practical and relevant to have approach the study from a programmatic point than prediction and estimates. Time was drained on the testing the statistical models and presenting it in context. It is strongly recommended that countries proposing to conduct similar studies should have a clear understanding of what they want from the study in their own national context. In case the countries opt to do advance level of analysis (prediction and estimates), it is vital to check the availability of metrological data alongside the diseases morbidity in consultation with the medical epidemiologist. Finally, the local capacity to perform and understand the statistical analysis is critical.

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ANNEXES

Annex 1: Population projection 2005-2030, NSB, Bhutan

Year	Number			Percent		
	Total	Male	Female	Total	Male	Female
2005	634982	333595	301387	100.0	52.5	47.5
2006	646851	339403	307448	100.0	52.5	47.5
2007	658888	345298	313590	100.0	52.4	47.6
2008	671083	351269	319814	100.0	52.3	47.7
2009	683407	357305	326102	100.0	52.3	47.7
2010	695822	363383	332439	100.0	52.2	47.8
2011	708265	369476	338789	100.0	52.2	47.8
2012	720679	375554	345125	100.0	52.1	47.9
2013	733004	381582	351422	100.0	52.1	47.9
2014	745153	387520	357633	100.0	52.0	48.0
2015	757042	393324	363718	100.0	52.0	48.0
2016	768577	398948	369629	100.0	51.9	48.1
2017	779666	404347	375319	100.0	51.9	48.1
2018	790215	409474	380741	100.0	51.8	48.2
2019	800154	414293	385861	100.0	51.8	48.2
2020	809397	418760	390637	100.0	51.7	48.3
2021	818370	423085	395285	100.0	51.7	48.3
2022	827038	427250	395285	99.5	51.7	47.8
2023	835379	431247	414132	101.2	51.6	49.6
2024	843363	435058	408305	100.0	51.6	48.4
2025	850976	438679	412297	100.0	51.6	48.4
2026	858410	442200	416210	100.0	51.5	48.5
2027	865662	445626	420036	100.0	51.5	48.5
2028	872759	448965	423794	100.0	51.4	48.6
2029	879707	452224	427483	100.0	51.4	48.6
2030	886523	455409	431114	100.0	51.4	48.6

Annex 2: The Technical Working Group (TWG) for VAA

1. Chief Program Officer, NCD, Department of Public Health
2. Chief Program Officer, HCDD, Department of Medical Services
3. Chief Program Officer, VBDCP, Department of Public Health
4. Chief Program Officer, ICB, Department of Public Health
5. Head, PHED, Department of Public Health
6. Head, Epidemiology and Research Unit, Ministry of Health
7. Planning Officer, Policy and Planning Division, Ministry of Health
8. Representative, National Environment Commission
9. Representative, Division of Meteorology, Department of Energy
10. Representative, Royal Institute of Health Sciences
11. Program Officer (EHP) as member Secretary

Annex 3: Year wise morbidity of water borne diseases in Bhutan (2003-2011)

Year	Diarrhoea Cases (1)	Dysentery Cases (2)	Skin infection Cases (3)	Total Water borne disease (Cases=1+2+3)	Total morbidity	% of diarrhoea disease of total morbidity	% of dysentry disease of total morbidity	% of skin disease of total morbidity	% of water borne disease of total morbidity
2003	70145	35018	99771	204934	553538	12.7	6.3	18.0	37.0
2004	69539	31110	111201	211850	1130126	6.2	2.8	9.8	18.7
2005	67301	31404	118591	217296	1180270	5.7	2.7	10.0	18.4
2006	69925	31234	30086	131245	1307166	5.3	2.4	2.3	10.0
2007	64100	26601	129845	220546	1263378	5.1	2.1	10.3	17.5
2008	58537	24411	109247	192195	1225006	4.8	2.0	8.9	15.7
2009	65495	27265	99077	191837	1306245	5.0	2.1	7.6	14.7
2010	65869	22289	99274	187432	1418817	4.6	1.6	7.0	13.2
2011	60188	18281	110098	188567	1352243	4.5	1.4	8.1	13.9
Total	860105	389622	1136924	2386651	12893043	6.7	3.0	8.8	18.5

Source AHB

Annex 4: District wise diarrhea cases, 2003-2011

Dzongkhag	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total	%
Chukha	9012	7707	7204	8481	8554	8419	6798	6213	5939	68327	11.6
Samtse	6362	6380	6063	6903	6444	6272	7361	6458	5412	57655	9.8
Thimphu	6891	4692	6801	7394	6761	5041	4205	7003	6461	55249	9.3
Wangdue	6715	10425	5679	6268	3509	4427	6664	5026	4475	53188	9.0
Trashigang	4958	5479	4795	5601	5527	4728	5363	5732	4835	47018	8.0
Sarpang	4063	3940	3955	3410	3630	3073	4107	5145	4590	35913	6.1
Mongar	3340	3416	3842	4725	4443	3230	3549	3483	3339	33367	5.6
Samdrup jongkhar	3342	3245	3740	4238	3268	2490	3415	3390	3682	30810	5.2
Paro	2662	3214	4680	3097	3777	2886	2844	2976	3360	29496	5.0
Punakha	3415	3271	3551	2781	2772	2736	3014	3396	3262	28198	4.8
Zhemgang	2956	2979	2769	2637	2710	2572	2669	2594	2597	24483	4.1
Dagana	2906	2735	2678	2724	2073	2047	2812	2880	2700	23555	4.0
Trashiyangtse	2146	2227	2052	2465	2013	2283	2147	2357	1617	19307	3.3
Lhuntse	1942	1858	2073	2153	1554	1271	1544	2017	1450	15862	2.7
Trongsa	2142	2214	2115	2167	1813	1184	1408	1560	1342	15945	2.7
Bumthang	3142	1783	1903	1577	1376	1269	1533	1275	1214	15072	2.5
Pemagatshel	2055	1977	1329	812	1572	1334	1509	1629	1557	13774	2.3
Tsirang	1089	1072	793	1104	1152	1947	2069	1460	1264	11950	2.0
Haa	837	754	1051	1075	958	1071	2023	1029	798	9596	1.6
Gasa	170	171	228	313	194	257	461	246	294	2334	0.4
Total	**70145**	**69539**	**67301**	**69925**	**64100**	**58537**	**65495**	**65869**	**60188**	**591099**	100.0

Annex 5: District and year wise diarrhea incidence rate (all age group)

Dzongkhag	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg/district
Bumthang	202.1	112.6	118.1	96.2	82.5	74.8	88.8	72.7	68.1	101.8
Dagana	134.6	124.5	119.7	117.7	87.8	85	114.4	114.9	105.6	111.6
Sarpang	113.3	107.9	106.3	89.9	93.7	77.6	101.6	124.6	108.8	102.6
Trongsa	166.4	168.9	158.5	158.5	130.2	83.5	97.5	106	89.6	128.8
Tsirang	60.5	58.5	42.5	58.2	59.7	99.3	103.8	72.1	61.4	68.4
Zhemgang	164.4	162.8	148.6	135.2	136.9	128	130.9	125.5	123.9	139.6
Wangdue	223.7	341.1	182.5	197.4	108.4	134.1	197.9	146.4	128	184.4
Thimphu	75.9	50.8	72.3	77.7	69.5	50.6	41.3	67.2	60.6	62.9
Chhukha	125.1	105.1	96.5	112	110.9	107.2	85	76.4	71.7	98.9
Gasa	56.6	55.9	73.2	98.7	60.1	78.2	137.8	72.3	84.9	79.7
Haa	68	60.1	82.3	90.8	79.7	87.7	163.2	81.8	62.5	86.2
Paro	78.3	92.8	132.7	83.5	100	75.1	72.7	74.8	83	88.1
Punakha	150.9	142	151.4	116.4	114	110.5	119.6	132.4	125	129.1
Samtse	111.8	110.1	102.8	112.9	103.6	99.2	114.5	98.8	81.4	103.9
Lhuentse	130.8	122.9	134.7	137.8	98.1	79.1	94.7	122	86.5	111.8
Monggar	93.4	93.8	103.6	125.1	115.5	82.4	88.9	85.7	80.7	96.6
Pemagatshel	95.6	90.3	59.6	36	68.7	57.6	64.3	68.5	64.7	67.2
S/Jonkhar	102.2	97.5	110.4	122.6	92.8	69.3	93.3	90.9	96.9	97.3
Trashigang	105.4	114.4	98.3	113.1	109.9	92.7	103.6	109.1	90.7	104.1
Trashiyangtse	125.4	127.8	115.7	136.6	109.6	122.2	113	122	82.4	117.2
Total	114.5	111.5	106.0	108.0	97.2	87.2	97.3	94.6	84.9	104.01

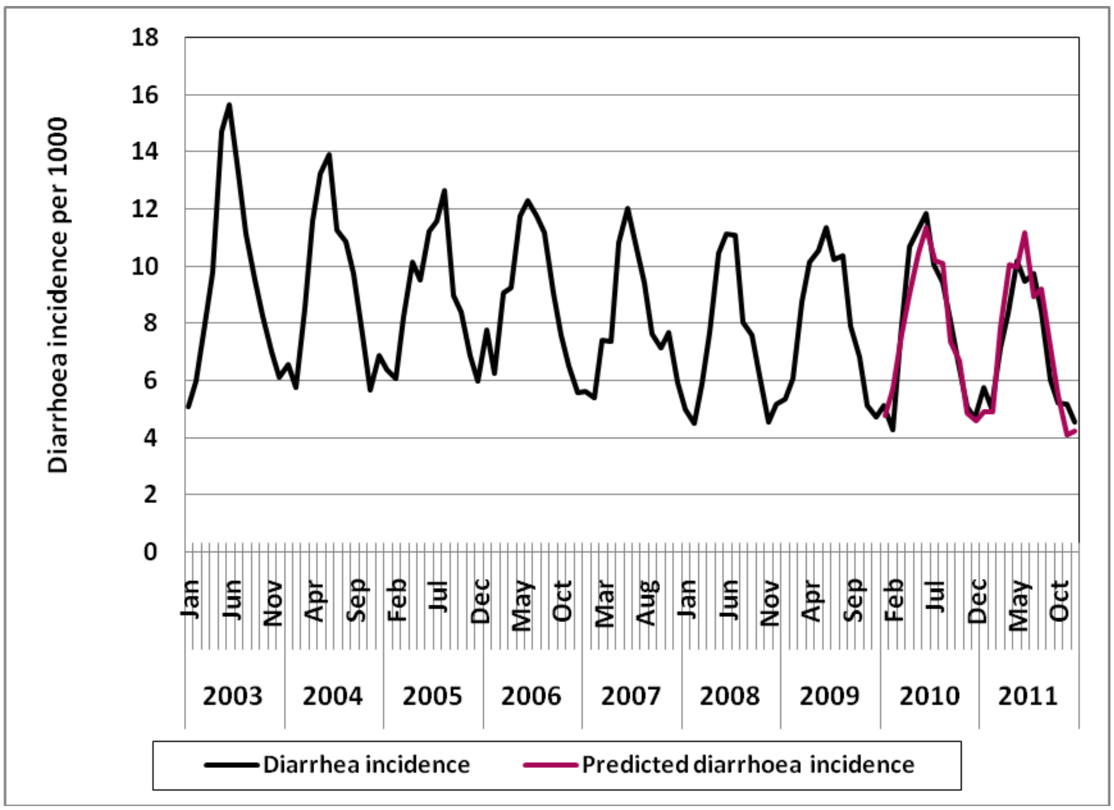
Annex 6: District wise average (2003-2011) and 2011 diarrhea IR alongside % population & access to safe drinking water

Districts	Diarrhea Incidence rate in all age group	Diarrhea Incidence rate in children Under Five	% Total Population (2011)	Access to Improved Drinking water
Wangdue	184	645	5 %	90%
Punakha	129	378	4%	91%
Zhemgang	140	414	3%	91%
Sarpang	103	347	6%	97%
Dagana	112	304	4%	94%
Sjongkhar	97	318	5%	97%
T/gang	104	298	8%	99%
Trongsa	129	369	2%	96%
Lhuentse	112	323	2%	98%
Gasa	80	118	0%	70%
Paro	88	306	6%	96%
T/yangtse	117	310	3%	97%
Monggar	97	299	6%	99%
Samtse	104	301	9%	95%
Chhukha	99	349	12%	94%
Bumthang	102	261	3%	100%
Pemagatshel	67	206	3%	96%
Haa	86	250	2%	100%
Thimphu	63	242	15%	100%
Tsirang	68	206	3%	96%

Annex 7: Ten health facilities with highest number of diarrhea cases

	Health Facility	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
1	Paro Hospital	1683	2249	3934	2159	2988	2008	1934	1907	2332	21194
2	WangdiRba Hospital	1935	6089	2512	1617	279	2072	3338	1528	1298	20668
3	Gomtu Hospital	2366	2636	2243	2050	1932	2123	2101	1967	1908	19326
4	Phuntsholing Hospital	1626	1512	1241	2722	2586	2368	2004	1670	1913	17642
5	Gedu Hospital	3284	1892	2300	2312	2615	2582	1157	871	484	17497
6	Punakha Hospital	1770	1811	1543	1342	1295	1300	1494	1845	1995	14395
7	Gaylegphug Hospital	1342	1213	1335	941	1027	1039	1725	2398	2037	13057
8	LungtenphuRba Hospital	2023	759	651	1055	1187	1181	516	1981	1737	11090
9	BajoBHU I	1440	1084	687	746	931	718	1309	1276	1389	9580
10	Samtse Hospital	1005	947	875	1145	1274	1107	1129	1029	861	9372
	Total	70145	69539	67301	69925	64100	58537	65495	65869	60188	591099

Annex 8: Actual (2003-2011) and predicted diarrhoea incidence (2010-2011)



Annex 9: Poisson Regression of the climatic variable on diarrhea incidence for all 20 districts

	Total diarrhoeal incidence			Under five incidence		
	IRR	SE	*P*	IRR	SE	*P*
Mean temperature	1.053	0.016	0.000	1.01	0.008	0.244
Rainfall	1.000	0.000	0.46	1.000	0.000	0.032

Annex 10: Total diarrhea incidence and under five incidences for Wangdue district

	Total diarrhoeal incidence			Under five incidence		
	IRR	**SE**	***P***	**IRR**	**SE**	***P***
Mean temperature	1.051	0.016	0.000	1.013	0.005	0.01
Rainfall	1.000	0.001	0.48	1.001	0.000	0.000

Annex 11: Total diarrhea incidence and under five incidences for Zhemgang district

	Total diarrhoeal incidence			Under five incidence		
	IRR	**SE**	***P***	**IRR**	**SE**	***P***
Mean temperature	1.068	0.011	0.000	1.02	0.006	0.001
Rainfall	1.000	0.000	0.57	1.000	0.000	0.747

Annex 12: Total diarrhea incidence and under five incidence for Punakha district.

	Total diarrhoeal incidence			Under five incidence		
	IRR	**SE**	***P***	**IRR**	**SE**	***P***
Mean temperature	1.047	0.01	0.000	1.008	0.005	0.148
Rainfall	1.000	0.002	0.002	1.002	0.000	0.000

Annex 13: Projected temperature change (○C) for Wangdue, Zhemgang&Punakha for the time period of 2010-2039 and 2040-2069

Districts with highest Diarrheal incidence rate	Mean Annual Temperature Change Degree Celsius as per		Mean Annual Temperature Change Degree Celsius as per	
	HADCM3/A1B MODEL		**ECHAM5/A1B MODEL**	
	2010-2039	2040-2069	2010-2039	2040-2069
Wangdue	1	2.5	0.8	2.4
Zhemgang	0.9	2.3	0.8	2.2
Punakha	1	2.5	0.7	2.5

Annex 14: Projected precipitation change (mm) for Wangdue, Zhemgang&Punakha for the time period of 2010-2039 and 2040-2069

Districts with highest Diarrheal incidence rate	Mean Annual Precipitation(mm) HADCM3/A1B MODEL		Mean Annual Precipitation (mm) ECHAM5/A1B MODEL	
	2010-2039	2040-2069	2010-2039	2040-2069
Wangdue	123.5 (mm)	389.4 (mm)	119.0 mm	524.9 mm
Zhemgang	78.1 mm	307.4mm	94.9mm	390.4mm
Punakha	136.5mm	412.5mm	107.5 mm	559.0mm

Annex 15: Diarrheal incidence in children under five years of age

Year	Dia. cases in U5	Total U5 Population	% Children affected by Diarrhoea
2003	23608	NA	NA
2004	24311	NA	NA
2005	24774	62553	40
2006	25192	68397	37
2007	22472	72919	31
2008	19326	77414	25
2009	22008	81871	27
2010	19682	86247	23
2011	18492	85918	22

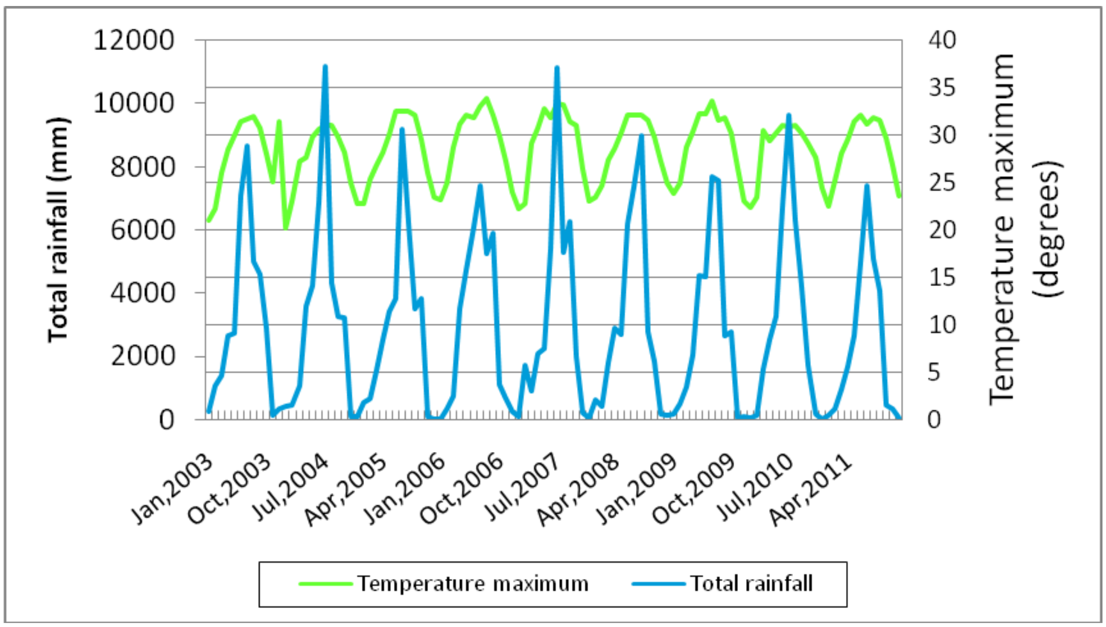
Annex 16: Actual and predicted diarrhea cases for 2010 and 2011

Months	2010		2011	
	Actual cases	Predicted case	Actual cases	Predicted case
January	3564	3295	4059	3490
February	2969	3955	3558	3757
March	5228	5064	5067	5561
April	7438	6222	5920	6820
May	7821	7295	7220	6724
June	8263	7935	6698	7706
July	7003	7165	6889	6128
August	6549	6997	5937	6567
September	5635	5058	4270	4875
October	4614	4724	3700	3758
November	3539	3453	3647	2780
December	3246	3297	3223	3057

Annex 17: Forecasted diarrhea cases for 2012 and 2013

Months	2012	2013
January	4059	3490
February	3558	3757
March	5067	5561
April	5920	6820
May	7220	6724
June	6698	7706
July	6889	6128
August	5937	6567
September	4270	4875
October	3700	3758
November	3647	2780
December	3223	3057
Total	**60188**	**61223**

Annex 18: Total rainfall and temperature maximum over the study period, 2003-2011

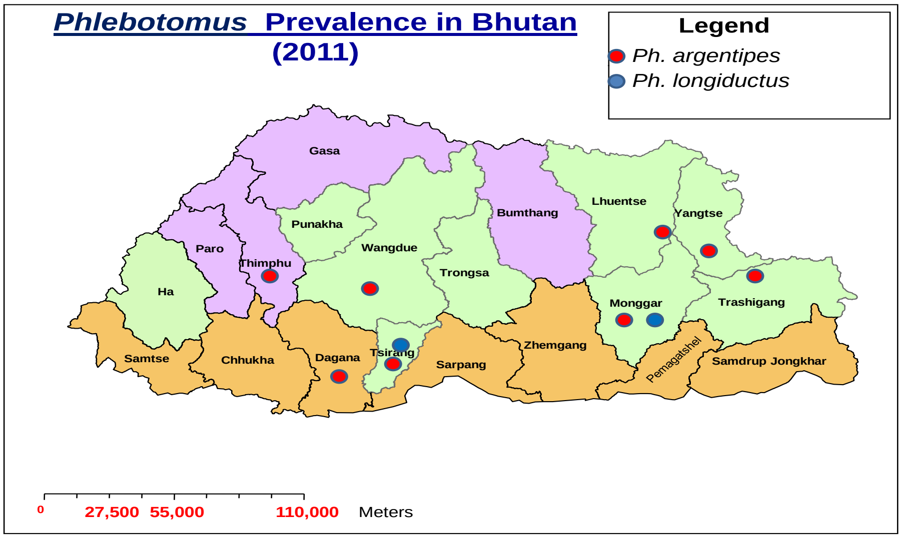


Annex 19: Malaria incidence in Bhutan from 1965-2011

YEAR	Country Pop.	Malaria area pop.	BSC	T+VE	T.PF	ABER	API	SPR	Death	PF%
1965	-	84726	10189	518	85	11	5.5	5.1	-	20.1
1966	-	89746	7148	114	20	7.1	1.5	2	-	15.5
1967	-	139743	15329	405	41	7.6	2	2.6	-	11.2
1968	-	188304	12913	247	26	6.4	1.2	1.9	-	12.3
1969	-	105124	25531	672	181	12.4	3.1	2.6	-	28.8
1970	-	109788	30886	630	147	14	2.9	2	-	24.5
1971	-	111082	31369	720	155	14.2	3.3	2.3	-	22.3
1972	-	113763	38703	1376	337	16.2	5.7	3.6	-	25.3
1973	-	128057	47909	3402	1221	21.5	15.2	7.1	-	37.3
1974	-	104297	47874	4623	2193	21.3	20.5	9.6	-	48.4
1975	-	122772	48170	7929	4459	20.7	33	16.5	-	56.9
1976	-	107662	47699	8035	4271	31.3	50.6	16.9	-	53
1977	-	115656	33619	3328	1597	29	27.5	9.9	-	48
1978	-	130248	39518	3483	1474	30.3	28.7	8.8	-	42
1979	-	111274	41079	5375	3172	43.2	44.3	13.1	-	59
1980	-	127714	45487	3933	2145	41.5	45.9	8.7	-	55.7
1981	-	138346	48361	4522	2722	35	32.7	9.4	-	60.4
1982	-	141058	51939	6328	3043	34.8	42.4	12.2	-	48.2
1983	-	130477	42633	5213	3072	32.6	39.3	12.2	-	59
1984	-	131591	62667	18368	10147	48	140	29.3	-	55.9
1985	-	130375	31763	7043	3951	24.3	53.9	22.2	-	56.3
1986	-	162663	82639	19916	10361	52.5	126.4	24.1	-	52
1987	-	157544	69029	13134	6174	53.9	120.7	19	-	47.3
1988	-	n/a	51164	11134	5169	44.6	97.2	21.7	-	46.8
1989	-	194000	71653	19162	8429	20.4	54.7	27	-	43.9
1990	484650	337959	33973	9497	4126	10	28	28	-	43
1991	493458	364466	67699	22126	12966	19	61	33	-	59
1992	502426	371089	73986	28900	13910	20	78	39	-	48
1993	511558	377830	80980	28392	12779	21	75	35	62	45
1994	520854	384699	97425	39852	15998	25	104	41	48	40
1995	530321	391691	83899	23195	7326	21	59	28	39	32
1996	539959	398709	76019	15696	6026	19	39	21	27	38
1997	549773	406058	68153	9029	3614	17	22	13	14	40
1998	559765	412438	58086	6955	3497	14	17	12	17	50
1999	569938	420952	79859	13579	7600	19	32	17	22	56
2000	580297	428603	76445	5935	2738	18	14	8	15	46
2001	590842	434392	65974	5982	3177	15	14	9	14	53
2002	601582	444324	74696	6511	3496	17	15	9	11	54
2003	612515	452398	61246	3806	1680	14	8	6	15	44
2004	623646	460620	54892	2670	1090	12	6	5	5	41
2005	634982	468993	60152	1825	954	13	4	3	5	52
2006	643237	475089	66079	1868	905	14	4	3	6	48
2007	651599	481265	51446	793	379	11	2	1	2	48
2008	671082	500599	47268	329	180	10	0.7	0.7	2	55
2009	672406	509405	62328	972	559	12	2	2	4	58
2010	695821	518266	54534	436	140	11	1	1	2	40
2011	708265	527134	44481	194	87	9	0.4	0.4	1	45

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

Annex 20: Kala-azar (Leishmaniasis) vector prevalence, 2011



Annex 21: District and total population at risk of Malaria

Districts	Male	Female	Total	% of total pop.
Perennial malaria transmission zone				
Chukha	45415	34528	79943	11.7
Dagana	12408	12171	24579	3.6
Pemagatshel	11647	11831	23478	3.4
Sjongkhar	18782	17826	36608	5.4
Samtse	33283	31030	64313	9.4
Sarpang	20974	19462	40436	5.9
Zhemgang	10012	9786	19798	2.9
Total at risk of perennial malaria	152,521	136,634	289155	42.3
Seasonal malaria transmission zone				
Lhuntse	8156	8145	16301	2.4
Mongar	19996	19926	39922	5.8
Punakha	12793	12411	25204	3.7
Wangdi	17295	16373	33668	4.9
Tashigang	26243	25538	51781	7.6
Tashiyangtse	9431	9564	18995	2.8
Haa	6673	5724	12397	1.8
Tongsa	7360	7088	14448	2.1
Tsirang	10107	9825	19932	2.9
Total at risk of seasonal malaria	118,054	114,594	232,648	34.0
Total population	270,575	251,228	521,803	76.4

Annex 22: Malaria case in Percentage (%) in the 7 malaria risk districts and other 13 districts from 2000 to 2010

Dzongkhag	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sarpang	43	51	49	36	34	36	30	32	41	63	57.1
S/Jongkhar	34	26	23	18	14	28	33	35	26	10	9.6
Samtse	8	14	17	28	38	19	13	7	8	7	6.7
Chukha	4	3	5	12	7	6	11	7	8	6	3.9
Zhemgang	5	2	1	1	1	2	2	0.4	1	1	2.1
Pemagatshel									4	1	3.4
Dagana									3	6	7.6
Other Dzongkhags	6	4	5	5	6	9	11	18	9	6	9.6

Annex 23: Perennial districts showing gewogs and populations at risk

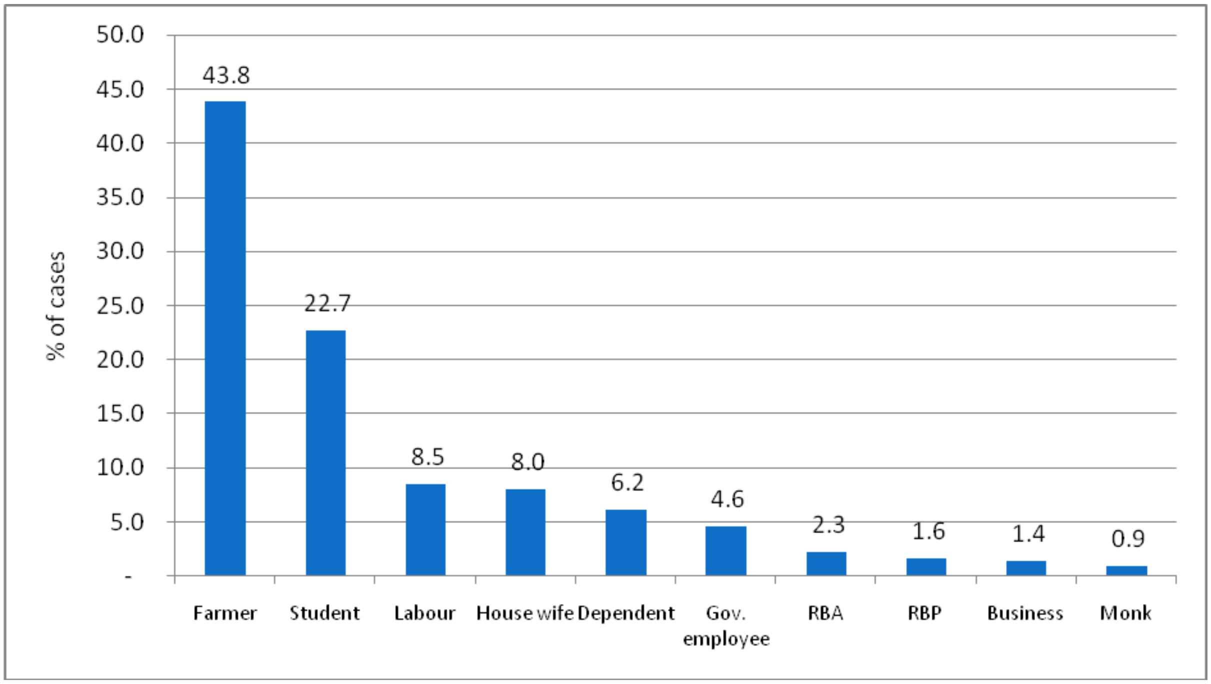
District	Total geogs & towns	Geogs at risk	% of population at risk
Sarpang	12	10	85
Samtse	15	13	88
Samdrup Jongkhar	10	8	85
Pemagatshel	16	10	90
Dagana	16	15	94
Chukha	15	4	57
Zhemgang	10	7	54

**Geog refers to the sub district level*

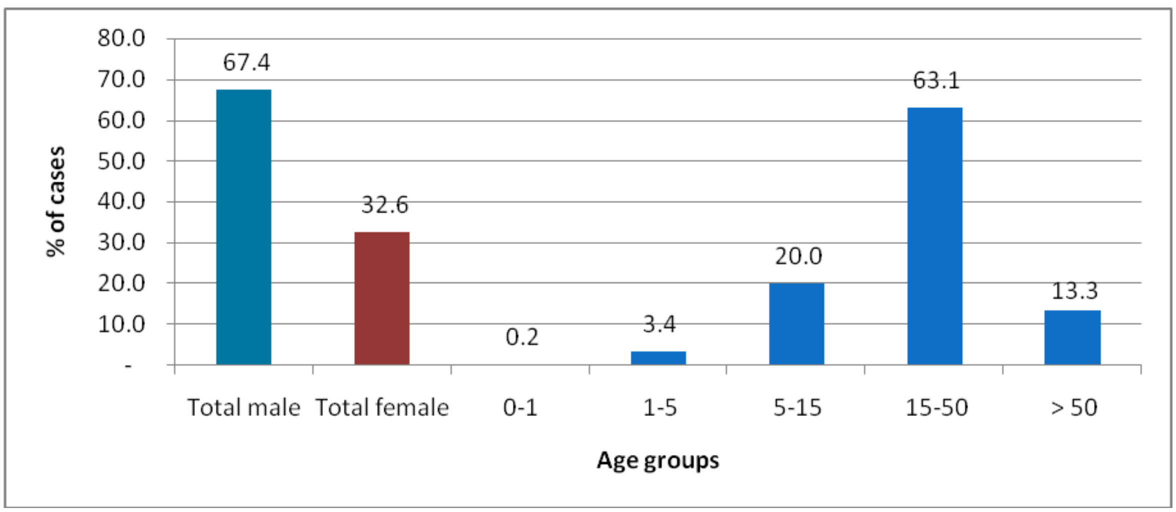
Annex 24: Trend of Plasmodium falciparum and P vivax (AMR 2011)

Stratification according to the transmission risk	Mixed%	Pf%	Pv%
Malaria free districts	11%	2%	5%
Seasonal transmission districts	6%	5%	5%
Malaria transmission districts	83%	93%	90%

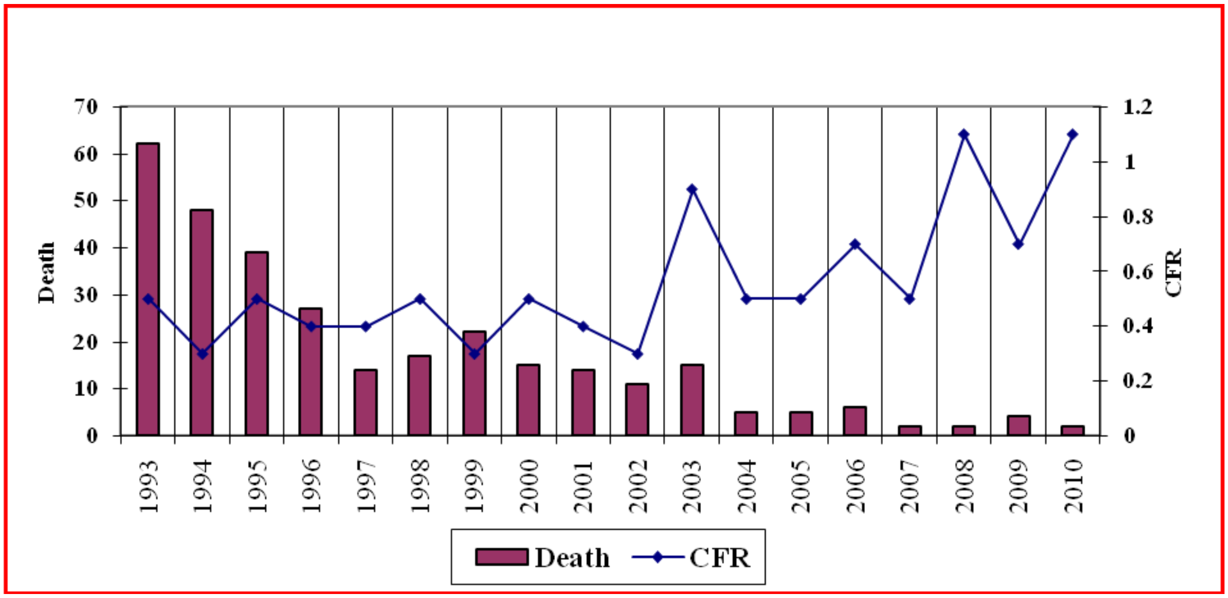
Annex 25: Occupation group of malaria cases in 2010



Annex 26: Malaria incidence in male, female and in different age groups



Annex 27: **Number of reported malaria deaths and case fatality rates in Bhutan from 1993-2010**



Annex 28: Malaria outbreaks reported and investigated in 2009

Place of outbreak (year)	Number of house holds affected	Population affected	Number of cases	Date of outbreak	Time of outbreak investigation	Outbreak investigators	Remarks
Patalay (2009)	97	699	5 cases	18 -22 April 2009	24 April 2009	District & VDCP	**This occurred as the focal IRS was delayed in the stratified area.**
Doban (2009)	362	1875	6 cases		July 2009	District & VDCP	**6 cases had been reported from Jan to July so an investigation was done in this non-transmission villages in Sarpang**
Chepche pi (2009)	6	25	9 cases	May 2nd week	Done on 20 May	District & VDCP	**This area had been the point of transmission to Doban in 2009**
Gelephu Fishery Project (2009)	**10**	**30**	**5 cases**	**First week of August**	**Done on 7 August 2009**	**VDCP**	**Indigenous transmission within the fishery project area.**

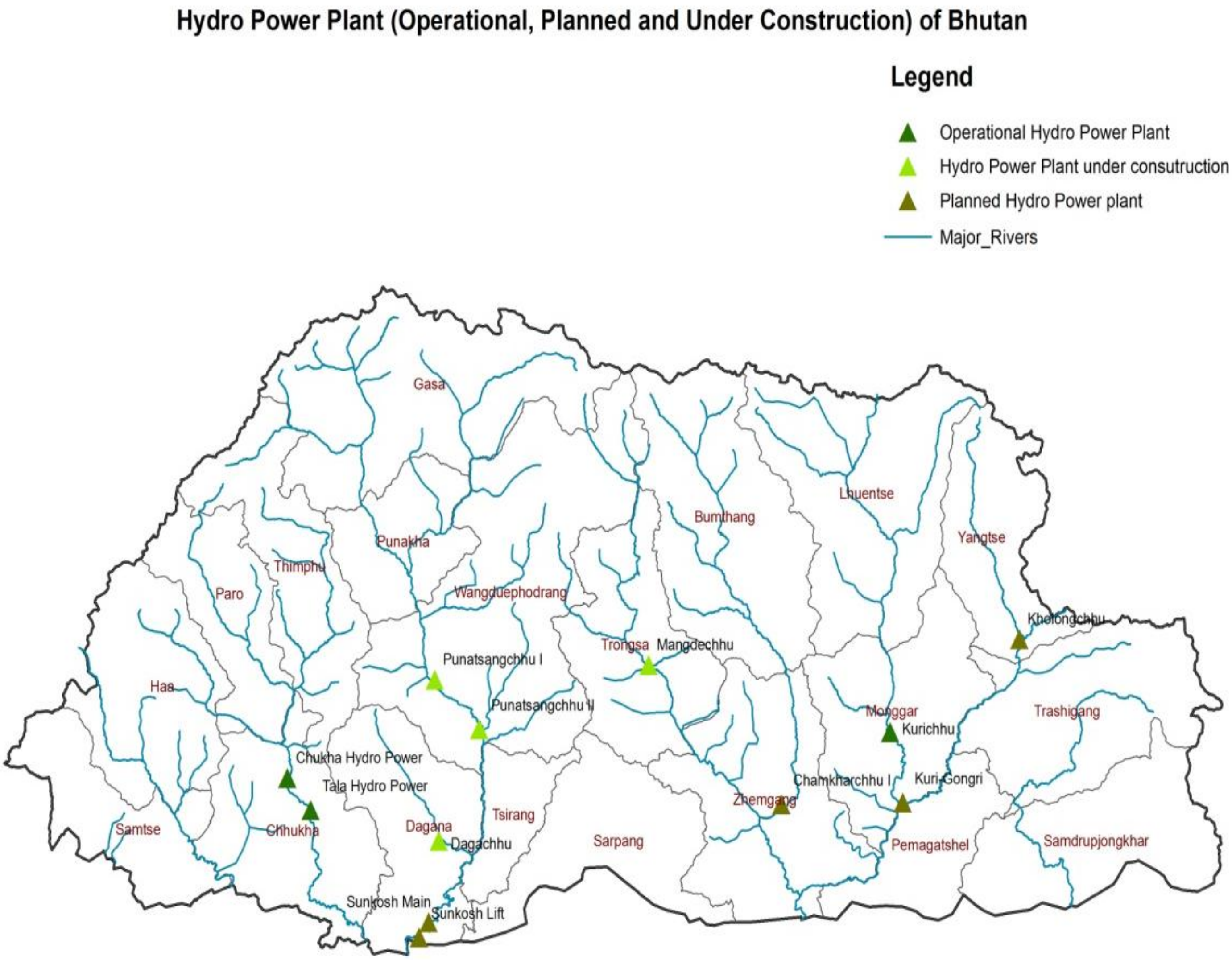
Annex 29: Malaria cases and the mean temperature of the seven endemic districts

Year	Malaria cases	Temperature-maximum (°Celsius)	Temperature-minimum (°Celsius)	Humidity (%)	Total rainfall (mm)
2000	5372	26.8	12.7	81.43	1905.5
2001	5514	26.8	12.9	82.04	1695.0
2002	6080	27.1	12.9	82.21	1677.4
2003	3489	26.1	13.5	83.13	1793.9
2004	2466	26.5	12.9	82.37	1954.8
2005	1675	26.8	12.6	82.98	1701.7
2006	1654	27.1	12.8	81.68	1655.0
2007	688	26.7	12.2	82.24	1803.6
2008	279	26.3	12.2	80.83	1782.7
2009	896	26.9	12.4	79.33	1522.0
2010	376	26.4	12.8	80.42	1701.2
2011	160	25.5	12.0	74.31	1274.1

Annex 30: List of mega hydro power projects in Bhutan with estimates of laborers currently employed (HRD Unit, Respective Projects), 2012

	Project	Mega Watts	Districts	Status	Total Labourer
1	Punatsangchhu-I	1,200	Wangdue	Construction	6067
2	Mangdechhu	720	Trongsa	Construction	301
3	Punatsangchhu-II	990	Wangdue	Construction	3603
4	Sankosh Reservoir	4,060	Dagana	Proposed	NA
5	Kuri-Gongri	1,800	Zhemgang	Proposed	NA
6	Amochhu Reservoir	620	Chukha	Proposed	NA
7	Kholongchhu	650	Tashiyangtse	Proposed	NA
8	Chamkharchhu-I	670	Bumthang	Proposed	NA
9	Wangchhu	600	Chukha	Proposed	NA
10	Bunakha Reservoir	180	Chukha	Proposed	NA
11	Nikachhu	208	Wangdue	Proposed	NA
12	Khomachhu	327	Lhutsi	Proposed	NA
13	Rotpashong	918	Lhuntsi	Proposed	NA
14	Gamri	102	Trashigang	Proposed	NA
15	Dagachhu	114	Dagapela	Construction	1643

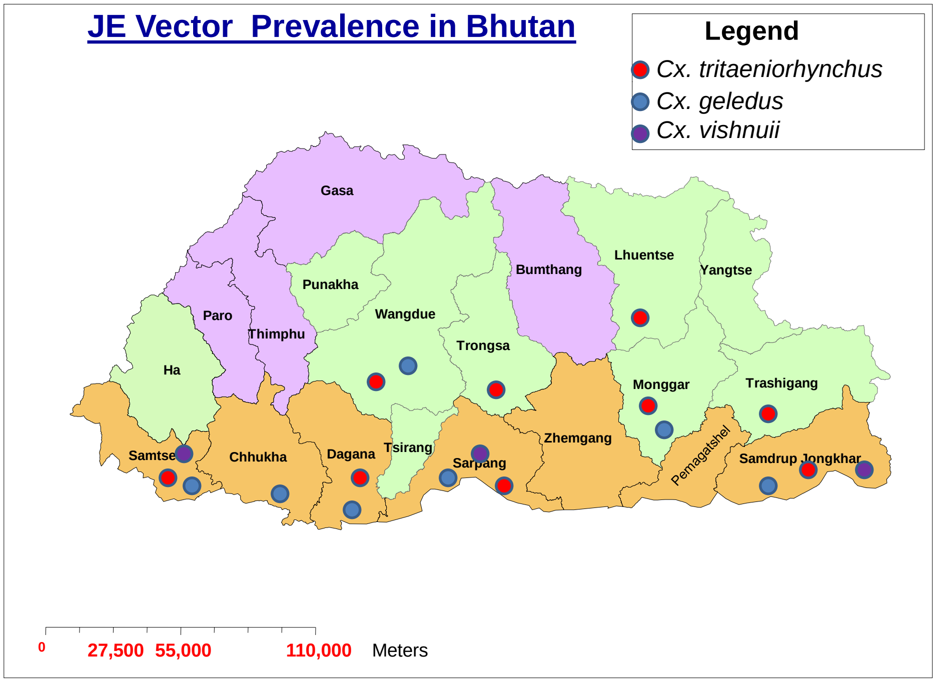
Annex 31: Bhutan map showing operational planned and under construction Hydro Power Projects



Annex 32: Human Resource capacity of VBDCP

Sl.No	Name	Designation
1	Dr. Lobzang Dorji	Chief Program Officer
2	Mr. Tobgyel	Sr. Program Officer
3	Mr. Pema Samdrup	Program Officer
4	Ms. Dechen Pemo	Asst Program Officer
5	Mr. Jigme Thinley	Asst Project Officer
6	Mr. Rinzin Namgay	Chief Entomologist
7	Mr. Nima W. Gyeltshen	Assist. Entomologist
8	Dechen	Assist. Entomologist
9	Tenzin Wangdi	Assist. Entomologist
10	Mr. Dhan Bdr. Giri	Sr. Medical Technician
11	Mr. Singye Dukpa	Sr. Lab. Technician
12	Mr. Tshering Penjor	Malaria Techncian
13	Mr. Kinzang Dorji	Medical Technician-III
14	Mr. Sonam Gyeltshen	Malaria Technician-II
15	Mr. Pema Dorji	Malaria Technician-II
16	Mr. Ugyen	EPI Technician III
17	Mr. Sonam Tashi	Malaria Technician-III
18	Mr. Pema Tshering	Medical Technician-III
19	Mr. Gyeltshen	Asstt. Data Manager
20	Ms. Tshering Deki	Sr. Accounts Officer
21	Mr. Yeshey Dorji	Accounts Officer
22	Mr. Sherab Tenzin	Accounts Asst-IV
23	Ms. Sonam Lhamo	Adm. Asstt.II
24	Ms. Tshering Choden	Adm. Asstt.III
25	Mr.Cheku Wangchuk	Adm. Asstt.III
26	Ms. Gayden Lhamo	Adm. Asstt.III
27	Support Staffs (insect collectors, Drivers, massengers etc)	15

Annex 33: Japanese Encephalitis vector prevalence in Bhutan



Annex 34: Table showing the projected increase in the mean annual temperature and mena annual precipitation change for 201-2039 and 2040-2069Sarpang District

Climate variables	Mean Annual Temperature Change Degree Celcius as per		Mean Annual Temperature Change Degree Celcius as per	
	HADCM3/A1B MODEL		ECHAM5/A1B MODEL	
	2010-2039	2040-2069	2010-2039	2040-2069
Mean temperature	0.9	2.3	0.8	2.2
Mean Annual Precipitation change	22.1 (mm)	232 (mm)	100.6 (mm)	412.3 (mm)

1. Lymphatic filariasis vector (*Culexquinquefasciatus*)
   All urban towns including Thimphu, Wangdi, Punakha, Gelephu, P/ling, Samtse, Tashigang, Mongar, Lingmithang, Jaiposhing

Annex 35: Data Collection and Sources

Data Collected and Used	Source
Metrological and Climate Data	
Observed National Metrological Data for last 10 years (Temperature, Relative Humidity & Rainfall)	Hydro Met Division, MoEA
Location of existing weather stations (lat/long coordinates)	Hydro Met Division, MoEA
Downscaled regional climate Models for Bhutan– HADCM3Q and ECHAM5	NEC, SNC
VBD Data	
Location of Health facilities (lat/long coordinates)	
Malaria incidence by health-facility and districts for endemic and non-endemic districts.	VBDCP
Dengue, Kalazar& JE incidence by district	VBDCP
Entomological Surveys	VBDCP, Malaria Report 2010,
Case-study of vector surveys at higher altitude in Samgang	
Projections of future VBD risk	Original Analysis, based on

Data Collected and Used	Source
	Baseline (NMS) and future climate conditions (HADCM3Q and ECHAM5 plus VBDCP
Health Capacity for VBD	Original Analysis based on Field Visit, + existing reports
Identification of Adaptation options	Existing recommendations = Field Visit/ Consultation
Extreme events weather conditions	
GLOF inventory list (Morbidity & mortality related to GLOF including damage to live stock and health infrastructures)	Hydrology Division and PM for GLOF Early Warning System
Incidence and location of flooding, windstorm, GLOF, landslides	Map NOT AVAILABLE Incidence =
Windstorm and Flash flood inventory list (Morbidity & mortality related to windstorm and flash floods including damage to live stock and infrastructures)	Department of Disaster Management, MoHCA
Health Preparedness and Capacity to prepare and respond to Extreme weather conditions including GLOF, Flash Floods, Landslides, Wind Storm	Field Visits
Identification of Adaptation options to manage extreme events	Existing recommendations =
Water Borne Diseases	
Outbreaks	
Diarrheal disease incidence by health-facility and districts for endemic and non-endemic districts.	HMIS
Projections of future diarrheal disease risk	Original Analysis, based on Baseline (NMS) and future climate conditions (HADCM3Q and ECHAM5 plus HMIS data
Identification of Adaptation options to manage increased DD	
Any other diseases	
Typhoid	PHL but no adequate
Food borne diseases	PHL but limited
Parasitosis	PHL/HMIS but Limited
Dengue, JE, Kalazar	PHL but limited
Respiratory Diseases	NA
Rodent borne diseases (leptospirosis)	NA
Cardio vascular diseases	Medical (limited)
Mental Health	Limited
Key Documents and Reports	Sectors/Divisions
Bhutan National Adaptation Plan for Action	NEC
Second National Communication to UNFCCC (Vol 1 &2)	
Annual Malaria report	VDCP
National Anthropometric (nutrition) Survey, 2009	Nutrition, MoH
Climate change & Health in Bhutan, RSPN, 2008	RSPN
Mid Term Review of Project on Reducing Climate Change-induced Risks and Vulnerabilities from Glacial Lake Outburst Floods in the Punakha-Wangdi and Chamkhar Valleys in Bhutan, 2010	DDM

Data Collected and Used	Source
Assessment of awareness, preparedness and response to GLOF, 2011	DDM
Annual Health Bulletin (2000-2011)	MoH
DANIDA	
Available Maps	
Forest Cover	Soil

Annex 36: Survey Instruments Used to Assess Adaptive Capacity

Environmental Determinants	How determinants can be affected by climate
Air quality	Warmer temperatures combine with higher pollution, wind patterns, and humidity
Water quality	Extreme rainfall (too much or too little) temperatures increase microbial growth
Food Security	Changing precipitation patterns affect production
Water security	Changing precipitation patterns affect availability of surface and ground water
Forestry and Biodiversity	
Glaciers	
Social Determinants	
Poverty	
Access to health care	
Equity	
Literacy	
Gender	

Matrix 1: GLOF and extreme weather events

Frame & Scope the Assessment			Vulnerability Assessment	Impact Assessment	Adaptation Assessment
What to collect	Where to Collect (Source)	How to Collect (Tools)	**Exposure: Current human health risks & burden & capacity of sectors to address it.**	**Sensitivity: Project future health risk & impact under climate change.**	**Health Capacity to adjust, to moderate the potential damage from it and to cope with the consequences of GLOF**
Areas at risk of GLOF **Incidence of GLOF** **Vulnerable Population** **Critical infrastructure and property loss** **Morbidity &Mortality** **Health preparedness, response, recovery and adaptation to future.**	National Focal persons Department of Disaster and Management District environmental offers, Health centers MoH	Consultation with relevant stake holders for GLOF. Consultation, Reports (NDMB, GLOF reports) Via checklist Desk review of M& M reports from DDM and MoH. Field visit to respective Districts and BHUs.	High risk areas for GLOF identified and mapped. Past incidence of GLOF recorded Vulnerable population identified and tabulated M& M related to GLOF recorded (Malnutrition, diarrhoeal diseases, food impact) Health capacity assessed.	Possible regions and areas to be impacted by GLOF. Estimate possible additional burden of adverse health outcomes due to GLOF. Possible impact of GLOF on human health and population Likely impact of GLOF on M& M. Likely burden of GLOF on Health	National Disaster Management Bill and strategies. Sector wise mitigation and preparedness level Artificial lowering of water levels in the potentially dangerous Thorthormi lake in Lunana, Community preparedness and awareness. Early warning system and evacuation plan. Health capacity to response GLOF related calamities. Identification and prioritization of public health and health care intervention to reduce likely future health burden due to GLOF. Health requirements for handling the impact of GLOF

Matrix 2: Vector Borne Diseases

Frame & Scope the Assessment			Vulnerability Assessment Exposure: Current human health risks &burden & capacity of sectors to address it.	Impact Assessment Sensitivity: Project future health risk & impact under climate change.	Adaptation Assessment Health Capacity to adjust, to moderate the potential damage from Vector borne diseases it and to cope with the consequences.
What to collect	Where to Collect (Source)	How to Collect (Tools)			
Burden of diseases, **Area affected.** **Population at risk.** **Morbidity and mortality**	VBDC Program, Respective Malaria centers, MoH	Annual Malaria Reports, National Malaria survey & review reports. Field visits and consultations using checklist and questionnaires	Diseases incidence & trend analysis Population at risk, endemic areas Morbidity and mortality Current VBDCP policies, interventions & capacity	Risk estimates due to climate variability (regions, populations, incidences) Estimate possible additional burden due to CC. Gap analysis & recommendations in policies and strategies to reduce the potential health risks due to climate change.	Effectiveness of VBDC Program. Health capacity to deal with future VBD incidences due to Climate change. Gap Analysis and recommendations

Matrix 3: Water and food borne diseases

Frame & Scope the Assessment			Vulnerability Assessment	Impact Assessment	Adaptation Assessment
What to collect	**Where to Collect (Source)**	**How to Collect (Tools)**	**Exposure: Current human health risks & burden & capacity of sectors to address it.**	**Sensitivity: Project future health risk & impact under climate change.**	**Health Capacity to adjust, to moderate the potential damage from water & food borne diseases and to cope with the consequences of GLOF**
Current burden of diarrhoea and Dysentry **Area affected.** **Population at risk.** **Morbidity and mortality**	Annual CDD report, National Health survey reports, Annual health bulletin. Agencies: Metrological Division- MoA. Control of Diarrhoea Diseases Program. Public health engineering Division, MOH.	Field visits and consultations. Using checklist and questionnaires.	Population and area at risk of water & food borne diseases. Water source scarcity due to environmental changes. Diseases incidence trend analysis of these areas. Effectiveness of ongoing programs and their capacity to deal with future water borne incidences due to Climate change.	Future health risk estimates due to climate variability (regions, populations, incidences) and even otherwise.	Effectiveness of ongoing programs and their capacity to deal with future water borne incidences due to Climate change. Gap Analysis and recommendations

Assessment Tool 1: Inter sector - National Context Assessment

QUESTIONS	ELEMENTS TO LOOK FOR
Has there been a national vulnerability and impacts assessment conducted?	Assessment(s) include(S) exposure to climate impacts, socioeconomic drivers of vulnerability, community-level assessments.
Is there an assessment of climate risks to priorities in major existing national planning documents?	Key documents explicitly address climate change Key documents have been reviewed for climate sensitivity and resilience
Is there a system in place for regularly updating the above assessments in the future?	An institution(S) has (or institutions have)a mandate to produce the above assessments iteratively over time.
Has an authoritative body been tasked with adaptation coordination?	Prioritization processes take into account key documents (FYP) that reflect existing national development priorities.
To what extent have clear coordination processes been established and is it functioning effectively?	A coordination body has been established with clear mandate. Appropriate membership.
To what extent is relevant information reaching key stakeholders who need it?	Staffs serving the coordination body have appropriate skills and knowledge. A description of the coordination process is available. There is a system for monitoring and review of the coordination mechanism. The coordinating body meets regularly. Appropriateness and regularity of the focal persons? The country has climate observation/monitoring systems that are regularly maintained and updated. Raw data is readily available publicly and undergoes regular review. Coordination and data exchange within sectors, data management and utilization in MOH, hospitals, BHU and VDCP. Representatives of key government agencies say they have the information they need, have access to this information. Key stakeholders are using information in decision making and project implementation.

Assessment Tool 2: Environmental Health Program, Ministry of Health Assessment

QUESTIONS	ELEMENTS TO LOOK FOR
Capacity of health sector institutions to respond to climate-sensitive health risks?	Inclusion of Climate change in Health & Public health policy Evidence of long term plans and strategy Integration of climate-DSC in HMIS Existence of specific programs for DSC, Vision, mandate, Structure, function, capacity HCC in Health specific 11 FYP Health component in NAPA Inter-sector coordination, participation and commitment Bilateral and multilateral collaborations, donor support, projects etc Climate-sensitive health risks are identified with sufficient lead-time for effective response Climate-sensitive health risk data are reported in timely and reliable manner to disease control agencies Climate data are reported in timely and reliable manner to disease control agencies.
To what extent are selected adaptation options implemented on the ground?	Climate change-induced changes and drivers of health-risks are determined. Projects/programs/policies are developed to implement selection option(s), as appropriate. Sufficient budget is provided in support of implementation. Mechanism exists for integrating new risk assessment information into projects/programs/policies over time. Coordination between Environmental Health Program, VDCP and DMS. Information exchange, resource allocation. Current capacity of the MoH to deal with diarrheal diseases. How effective are current health policies and programmes in managing climate-sensitive health outcomes, including surveillance, laboratory diagnostics, communications, outbreak response, outreach and community mobilization, and ph measures?

Assessment Tool 3: Vector Borne Disease Control Program (VDCP) Assessment

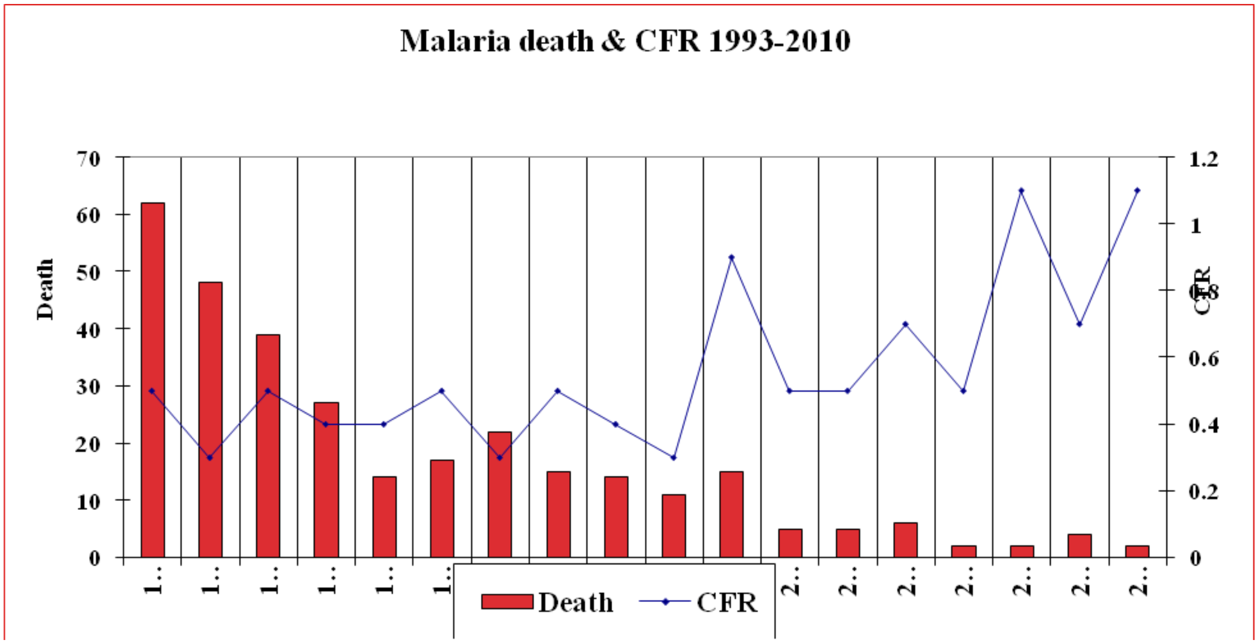
CAPACITY QUESTIONS	ELEMENTS TO LOOK FOR
What strategies & programs interventions are in place for adaptation to climate change	Vector Surveillance and mapping Malaria Early Warning Systems, simple transmission risk indicators such as excess rainfall. Early warning system Integration of meteorological data VBD data collection & utilization Studies on vector borne and climate variables Awareness on CSD, NAPA, UNFCC Screening, monitoring and surveillance in Hydro power Malaria incidences in non endemic areas Future plans Human resources (program level, regional level and health facility level) Equipments and testing reagents Capacity building programs in non endemic districts Budgetary provisions IEC programs on community adaptations Training syllabus and long-term support mechanisms for community and national level health protection from climate change Describe current VBD Control Program Evaluate current capacity of the VDCP. How effective are current health policies and programmes in managing climate-sensitive health outcomes? What kind of outbreak would put stress on the system?

Assessment Tool 4: Health Facility Level Assessment

QUESTIONS	ELEMENTS TO LOOK FOR
General Background and Context	OPD cases, common diseases Seasonal trends in diseases Disease outbreaks, frequency, season, mortality and morbidity. Collect story of outbreak detection, management, and shortcomings: Catchment area and estimate of vulnerable population to CSD Damage to the BHU/Hospital/Transport due to disasters? When: What: In your opinion, could the health services be interrupted or damaged due to any of these?
Health Services Vulnerability to Disasters: Health capacity to mitigate mortality and morbidity due to extreme weather conditions. **Extreme Events**	Is their emergency protocol, drill done, lab services, H1N1 experience, what new risk, preparedness required, staff trained, capacity requirement, line of communication during disaster. Health system capacity in terms of preparedness, response and recovery in case of GLOF Training of health personnel in emergency response, risk assessment Knowledge of risk? Future plans for sitting of health centers and PH infrastructure in these areas?
Water Borne Diseases	Incidents of natural disasters: Flash floods, landslide, thunder storms. Inventory, deaths, preparedness, Current capacity of the Health sector to deal with emergency medical care due to GLOF and extreme events What emergency plans and provision are in place (health policies and programs) for early action, and managing response and recovery after GLOF, or other climate-induced disaster? Water and sanitation, water source, scarcity, quality, water borne diseases Which regions and populations in a country are the most vulnerable to diarrheal diseases? Risk Factor: Map of water sources (municipal, spring, river, wells) Risk Factor: Access to Safe drinking water Risk Factor: Hygiene Total Population at risk by age and vulnerability in GLOF area (children >5 for CDD) Summary: Current burden and distribution of all diarrheal disease, including occurrence of notable epidemics Categorize the blocks/districts by incidence of all diarrheal disease, (morbidity and mortality) including occurrence of epidemics Rank most vulnerable population and region to expanded incidence, or introduction to new areas due to temp/precip, migration, damage to water infrastructure.

Control measures adopted.
1965 to 1994 DDT (IRS)
1995 to 1997 Deltamethrin (IRS)
1998 onwards ITBN
2003 focal IRS
2004 - 1 round IRS selected area,ITBN
2006 onwards 2 round of focal IRS,LLINs,ITBN

Annex 37: Number of reported malaria deaths and case fatality rates in Bhutan from 1993-2010



Annex 38: Malaria outbreaks reported and investigated in 2009

Place of outbreak (year)	Number of house holds affected	Population affected	Number of cases	Date of outbreak	Time of outbreak investigation	Outbreak investigators	Remarks
Patalay (2009)	97	699	5 cases	18 -22 April 2009	24 April 2009	District & VDCP	**This occurred as the focal IRS was delayed in the stratified area.**
Doban (2009)	362	1875	6 cases		July 2009	District & VDCP	**6 cases had been reported from Jan to July so an investigation was done in this non-transmission villages in Sarpang**
Chepchepi (2009)	6	25	9 cases	May 2nd week	Done on 20 May	District & VDCP	**This area had been the point of transmission to Doban in 2009**
Gelephu Fishery Project (2009)	**10**	**30**	**5 cases**	**First week of August**	**Done on 7 August 2009**	**VDCP**	**Indigenous transmission within the fishery project area.**

Annex 39: Malaria cases and the mean temperature of the seven endemic districts

Year	Malaria cases	Temperature-maximum (°Celsius)	Temperature-minimum (°Celsius)	Humidity (%)	Total rainfall (mm)
2000	5372	26.8	12.7	81.43	1905.5
2001	5514	26.8	12.9	82.04	1695.0
2002	6080	27.1	12.9	82.21	1677.4
2003	3489	26.1	13.5	83.13	1793.9
2004	2466	26.5	12.9	82.37	1954.8
2005	1675	26.8	12.6	82.98	1701.7
2006	1654	27.1	12.8	81.68	1655.0
2007	688	26.7	12.2	82.24	1803.6
2008	279	26.3	12.2	80.83	1782.7
2009	896	26.9	12.4	79.33	1522.0
2010	376	26.4	12.8	80.42	1701.2
2011	160	25.5	12.0	74.31	1274.1

Annex 40: List of mega hydro power projects in Bhutan with estimates of laborers currently employed (HRD Unit, Respective Projects), 2012

	Project	Mega Watts	Districts	Status	Total Labourer
1	Punatsangchhu-I	1,200	Wangdue	Construction	6067
2	Mangdechhu	720	trongsa	Construction	301
3	Punatsangchhu-II	990	Wangdue	Construction	3603
4	Sankosh Reservoir	4,060	Kalikhola	Proposed	NA
5	Kuri-Gongri	1,800	Zhemgang	Proposed	NA
6	Amochhu Reservoir	620		Proposed	NA
7	Kholongchhu	650	Tashiyangtse	Proposed	NA
8	Chamkharchhu-I	670	Bumthang	Proposed	NA
9	Wangchhu	600	Chukha	Proposed	NA
10	Bunakha Reservoir	180	Chukha	Proposed	NA
11	Nikachhu	208	Wangdue	Proposed	NA
12	Khomachhu	327	lhutsi	Proposed	NA
13	Rotpashong	918	lhuntsi	Proposed	NA
14	Gamri	102		Proposed	NA
15	Dagachhu	114	Dagapela	Construction	1643

Annex 41: Nutritional status of children under five years of age, BMIS 2011

	Under Weight	Stunting	Wasting
Male	13.3	33.4	6.2
Female	12	33.6	5.5
Urban	10.5	28	6.5
Rural	13.6	35.8	5.6
Bumthang	9.1	21.5	3.3
Chukha	14.1	27.4	10.9
Dagana	12.4	29	5.5
Gasa	3.6	31.8	3.2
Haa	9.8	30.6	3.3
Lhuntse	17.7	58.9	4.3
Mongar	12	39.7	5.5
Paro	7.5	30.1	6.9
Pemagatshel	19.8	44.9	2.6
Punakha	11.4	20.7	4.7
S/jongkhar	11	37.4	3.4
Samtse	13.1	28.4	4.7
Sarpang	10.9	23.2	4.4
Thimphu	11.9	37.8	6.2
Trashigang	17.7	47.2	8.8
Trashiyangtse	13.6	40.3	4.8
Trongsa	10.3	27.2	2.6
Tsirang	12.9	28.4	5.3
Wangdue	11	28.7	3.7
Zhemgang	15.9	42.8	8.8

Annex 42: Diarrhea incidence and Malnutrition in High Risk GLOF Districts

GLOF Risk district	Diarrhea incidence rate	Underweight	Stunting
Bumthang	102	9%	21.5%
Punakha	129	11.4%	20.7 %
Wangude	184	11 %	28.7%

Annex 43: Ambient Air Quality Standards (Maximum permissible Limits in µg/m^3)

Parameter	Industrial Area	Mixed Area*	Sensitive Area**
Total Suspended Particulate Matter			
24 Hour Average	500	200	100
Yearly Average	360	140	70
Respirable Particulate Matter (PM 10)			
24 Hour Average	200	100	75
Yearly Average	120	60	50
Sulfur Dioxide			
24 Hour Average	120	80	30
Yearly Average	80	60	15
Nitrogen Oxides			
24 Hour Average	120	80	30
Yearly Average	80	60	15
Carbon Monoxide			
8 Hour Average	5000	2000	1000
1 hour Average	10,000	4000	2000

* **Mixed Area** means area where residential, commercial or both activities take place,

** **Sensitive Area** means area where sensitive targets are in place like hospitals, schools, sensitive ecosystems.

GLOSSARY OF TERMS

Key terms defined here for a common understanding, based upon the WHO standard usage and based on glossary used for Ebi et al, 2011.[23]

Adaptation is a process by which strategies and measures to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, implemented, and monitored (UNDP, 2003). In public health, the analogous term is prevention. Various types of adaptation exist, including anticipatory and reactive, private and public, autonomous and planned.

Adaptive capacity is the general ability of individuals, communities, and institutions to effectively prepare for and cope with the consequences of climate variability and change; this includes the ability to moderate potential damages and take advantage of opportunities.

Adaptation deficit Failure to adapt adequately to existing climate risks largely accounts for the adaptation deficit. Controlling and eliminating this deficit in the course of development is a necessary, but not sufficient, step in the longer-term project of adapting to climate change. Development decisions that do not properly consider current climate risks add to the costs and increase the deficit. As climate change accelerates, the adaptation deficit has the potential to rise much higher unless a serious adaptation program is implemented (World Bank 2011).

Climate is the 'average weather' in a particular place over a particular time period. It is the statistical description of the mean and variability of weather variables (e.g. temperature, precipitation) over a period of time ranging from months to thousands or millions of years; the typical time period is 30 years.

Climate Change refers to a statistically significant variation in either the mean state of the climate or in is variability, persisting for an extended period (typically decades or longer). Climate change is due to natural internal processes or external forcing, and to persistent anthropogenic changes in the composition of the atmosphere. The United Nations Framework Convention on Climate Change defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

Climate Variability describes variations in the mean state and other statistics (e.g.,standard deviations, the occurrence of extreme events, etc.) of climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system or to variations in natural or anthropogenic external forcing.

Climate-Sensitive Health Outcome is any health outcome whose geographic range, incidence, or intensity of transmission is directly or indirectly associated with weather or climate.

Co-benefits – benefits (often health benefits) associated with reductions in greenhouse gas emissions. For example, reduced emissions of air pollutants can have immediate health benefits. In addition, there can be co-benefits of adaptation measures, such as new surveillance systems that monitor climate-related and non-climate-related infectious diseases.

[23] Based upon standard language used by the WHO. Full glossary of terms found here: http://www.who.int/globalchange/publications/climatechangeglos.pdf

Exposure: Amount of a factor to which a group or individual was exposed; sometimes contrasted with dose (the amount that enters or interacts with the organism). Exposures may be either beneficial or harmful.

Health is astate of complete physical, mental and social well being, and not merely the absence of disease or infirmity.

Health Systems comprises all the organizations, institutions, and resources that are devoted to producing actions principally aimed at improving, maintaining, or restoring health. (World Health Organization. 2007)

Health system strengthening is defined by the WHO in reference to its current framework as, "improving the six building blocks and managing their interactions in ways that achieve more equitable and sustained improvements across health services and health outcomes, requiring both technical and political knowledge and action." (WHO 2007, 4)

Mitigation refers to policies and measures to reduce greenhouse gas emissions and/or enhance sinks.

Resilience is the ability of a natural or human system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk (i.e., climate-related risk) is a product of the likelihood of exposure and the consequence(s) of that exposure. It arises from the interaction of a physically defined hazard (e.g., floods and other extreme weather events, increasing temperature) with the properties of the exposed system, its vulnerability (UNDP, 2003). System vulnerability is a critical determinant of the risk a region or subpopulation faces when exposed to a particular hazard. This means that programs to decrease vulnerability will decrease risk.

Sensitivity: describes an individual's or sub-population increased responsiveness, primarily for biological reasons, to a particular exposure. Biological sensitivity may be related to developmental stage, pre-existing medical conditions, acquired factors (such as immunity), and genetic factors (Balbus and Malina 2009). Socioeconomic factors also play a critical role in altering vulnerability and sensitivity, by interacting with biological factors that mediate risk (such as nutritional status) and/or lead to differences in the ability to adapt or respond to exposures or early phases of illness and injury.

Vulnerability is the susceptibility to harm, which can be defined in terms of a population or a location. Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change (IPCC 2007). Vulnerability is dynamic and may itself be influenced by climate change (e.g., extreme weather events affecting health infrastructure). From a health perspective, vulnerability can be defined as the summation of all risk and protective factors that ultimately determine whether a subpopulation or region experiences adverse health outcomes due to climate change (Balbus and Malina 2009). Characteristics of a region, such as baseline climate, abundance of natural resources (i.e., access to freshwater), elevation, infrastructure, and other factors can alter vulnerability.