Government of Malawi

Ministry of Health

VULNERABILITY AND ADAPTATION ASSESSMENT OF THE HEALTH SECTOR IN MALAWI TO IMPACTS OF CLIMATE CHANGE

22nd October, 2015

CONTRIBUTING RESEARCHERS

Dr. B Ngwira	- Principal Investigator
Dr. G M Chavula	- Co-Investigator
Mr. K J Gondwe	- Co-Investigator
Dr. L Kazembe	- Co-Investigator
Dr. T Mzilahowa	- Co-Investigator

Note: Photos on the cover page obtained from ICRISAT, NGONEWS.COM and JUSTGIVING.COM

EXECUTIVE SUMMARY

The study has shown that malaria, diarrhoeal diseases, and malnutrition are among main causes of death in Malawi, a situation which will be exacerbated by climate change. Adaptation measures for malaria include use of insecticide-treated nets (ITNs) and mosquito repellents whereas adaptive strategies for diarrhoea include household water treatment and safe storage (HWTS) such as water filtration and chlorination (using Water Guard), improved sanitation and personal hygiene. For malnutrition, proposed adaptation measures include: income generation through casual labour, crop diversification, growing of drought resistant varieties, winter cropping and irrigation farming to enhance climate change resilience and food security at household level.

The study has also shown that there is inadequate capacity in the MoH to manage key climate change related diseases as well as the ability to apply early warning systems for the prediction of the diseases. Furthermore, it was noted that the ministry does not have adequate financial and human resources to manage the three climate sensitive diseases and condition mentioned above and possibly other climate related diseases.

Under climate change scenario, mean annual temperatures in Malawi are expected to rise by 0.9 to 1.1 degree in 2030, and a further 1.6 to 2.0 degrees in 2050. Mean annual precipitation is projected to change by -1.4% to 3.3% in 2030, while in 2050 this will change by -2.2% to 6.2%.

Vulnerability assessment results show that the incidence of diarrhoea may increase in both Lilongwe and Salima while diarrhoea may decrease with increasing rainfall in Lilongwe, but may increase with rainfall in Salima.

In Lilongwe, both diarrhoea and malaria are projected to increase while malnutrition will decrease by about 5% in 2030 and a further 6% in 2050.

In Chikwawa, diarrhoea incidence will increase by 3.6% in 2030 and 6.4% in 2050. At the same time, malaria incidence will decrease by 4.8% and 8.8% in 2030 and 2050 respectively, while malnutrition will decrease by 1.5% and 2.8% for both 2030 and 2050 respectively.

Four key indicators were selected for use in monitoring and tracking climate change impacts on human health in Malawi, namely: number of cases of the key diseases and their spatial distribution, the frequency and magnitude of floods and droughts, and investment in capacity building, i.e., human, financial, and institutional.

Also, the report has covered issues about information gaps and the need for improved coordination among various organizations that deal with climate change issues in Malawi, the need to address capacity building (human, financial and institutional) in the Ministry of Health, and critical areas of research.

Adaptation strategies for the health sector for the three key diseases have been spelt in the NAPA, NAP, and INDC.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADMARC	Agriculture Development and Marketing Corporation
AIDS	Acquired Immune Deficiency Syndrome
BRACE	Building Resilience Against Climate Effects
CDC	Centre for Disease Control
CHAM	Christian Health Association of Malawi
COP	Conference of the Parties
DHO	District Health Officer
DHS	Demographic and Health Survey
EHP	Essential Health Package
ENSO	El Nino Southern Oscillation
GCM	General Circulation Model
GDP	Gross Domestic Product
GFCS	Global Framework on Climate Services
GHG	Greenhouse Gases
GIS	Geographical Information Systems
GIZ	German Cooperation Agency
GoM	Government of Malawi
HDP	Health Development Partners
HH	Household
HIV	Human Immuno-deficiency Virus
HMIS	Health Management Information System
HSSP	Health Sector Strategic Plan
ICPAC	IGAD Climate Prediction and Application Centre
IGAD	Intergovernmental Authority in Development
INC	Initial National Communication

INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
MDG	Millennium Development Goals
MGDS	Malawi Growth and Development Strategy
MoFEP&D	Ministry of Finance, Economic Planning and Development
MoH	Ministry of Health
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes of Action
NCD	Non-communicable Diseases
NGO	Non-Governmental Organization
NMCP	National Malaria Control Program
NSO	National Statistical Office
NTD	Neglected Tropical Diseases
SNC	Second National Communication
STD	Sexually Transmitted Diseases
SWAp	Sector Wide Approach
TB	Tuberculosis
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
VCT	Voluntary Counselling and Testing
WHO	World Health Organisation

1.0 BACKGROUND

There is ample scientific evidence that climate change is real and that anthropogenic activities, in particular emissions of greenhouse gases (GHGs), are its principal cause (Smith, 2001; Epstein, 2002; Boko *et al*., 2007; IPCC, 2007; World Bank, 2007). Climate change is adversely affecting the world's poorest countries, mainly in sub-Saharan Africa, where most people are at immediate risk because of weak economies and adaptive capacities of these countries. Failure to respond to this phenomenon will stall and reverse efforts to reduce poverty (UNEP, 2002; World Bank, 2007; World Bank, 2008; Tadross *et al*., 2009). The impacts of climate change on human health include altered risk profiles to vector and water borne diseases, and malnutrition. Furthermore, climate change has the potential to cause heat waves, floods, droughts, and storms (Figure 1). Adverse impacts of climate change on human health can be averted by putting in place a combination of strategies such as strengthening key health system functions and improved use of early warning systems for climate and weather information for planning and climate risk management.

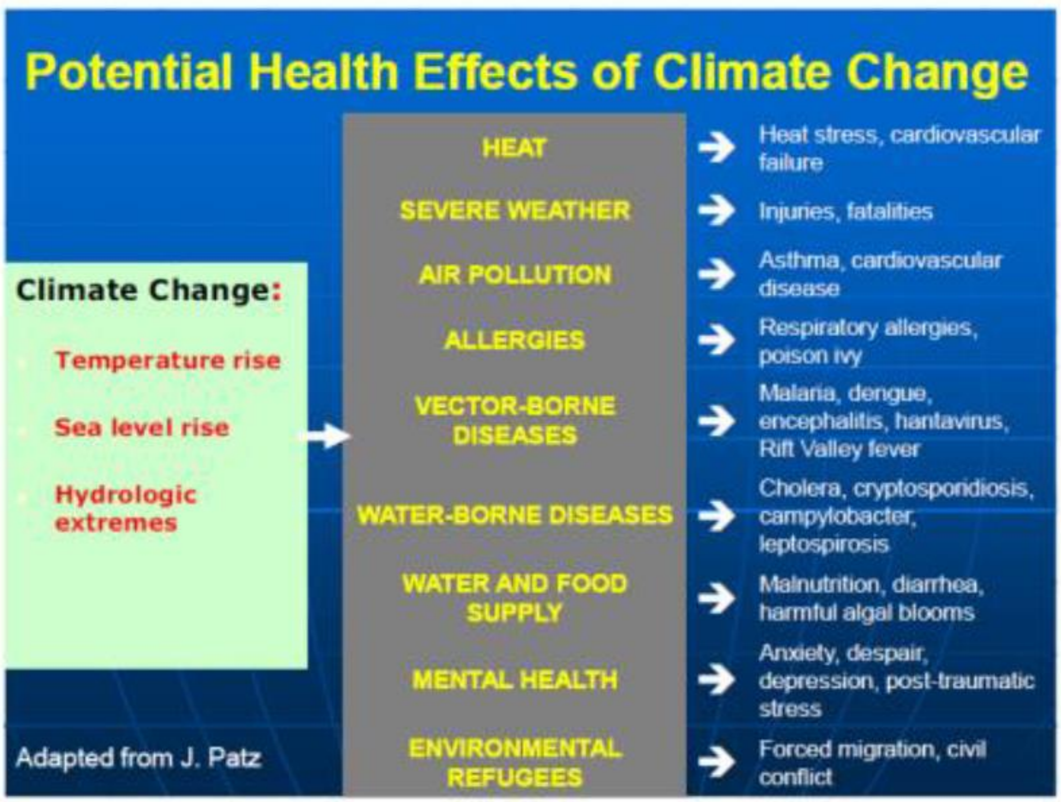

Figure 1: Potential Health Effects of Climate Change (Source: Luber, 2011)

According to the United Nations Country Assessment Report for Malawi of 2010, climate change poses a serious threat to Malawi's development agenda. In the short to medium term, climate change will significantly affect the functioning of natural ecosystems, with serious repercussions on weather-sensitive sectors, such as agriculture, forestry, water resources, energy, fisheries, and wildlife; as well as human health, human settlements, and gender (GoM, 2002; GoM, 2006; GoM, 2007; GoM, 2010; GoM, 2011a; GoM, 2011b; Oxfam, 2009). In the long-term, climate change will undermine the attainment of the Sustainable Development Goals (MDGs), Vision 2020, and the Malawi Growth and Development Strategy (MGDS II), thereby exacerbating poverty in the country.

In view of the above and in line with global efforts, the Government of Malawi signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and April 1994, respectively. In addition to ratifying the UNFCCC, the Government ratified the Kyoto Protocol in October 2001, and submitted the Initial and Second National Communication (INC and SNC) reports to the Conference of the Parties (COP) of the UNFCCC in 2002 and 2011, respectively. In 2006, the Malawi Government developed the National Adaptation Programmes of Action (NAPA) to address short to medium-term impacts of climate change on the country's social and economic sectors. In 2009, the Government recognized Climate Change, Environment and Natural Resources Management as one of the Key Priority Areas (KPA) in the Malawi Growth and Climate Change Learning Strategy. At the moment, the Government is developing the Climate Change Policy and the Nationally Appropriate Mitigation Actions (NAMAs) and National Action Plans (NAPs), and it is also conducting a review of the National Adaptation Programme of Action (NAPA). It is worth noting that the health sector has lagged behind in the implementation of adaptation measures for averting the adverse impacts of climate change in the country.

It is worth noting that the Ministry of Health (MoH) is taking bold steps to address climate change risks to human health and adaptation mechanisms in Malawi as attested by the Ministry's participation in the Africa Adaptation Program of the Global Framework for Climate Services (GFCS). The Ministry plans to work with multiple sectors to improve understanding and readiness for the health risks of climate change and variability. An initial activity of this project involves conducting a nationwide assessment of the potential vulnerabilities and adaptation mechanisms to impacts of climate change. To this end, the MoH commissioned a study on Health and Climate Vulnerability and Adaptation Assessment with financial support from GIZ through the World Health Organization (WHO).

1.1 Vulnerability and Adaptation Assessment of the Health Sector to Climate Change

Vulnerability may be defined as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, the sensitivity and adaptive capacity of that system (IPCC, 2007). An assessment of vulnerability and adaptive capacity is a means of prioritising and directing action where it is needed most urgently by determining which regional areas and natural or human systems are most at risk.

IPCC (2007) further defined *Adaptation* as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation to climate change has the potential to reduce adverse impacts of climate, and enhance the beneficial impacts, and hence enable people to continue to live their lives and participate in developmental issues.

Generally, vulnerability assessments of impacts of climate change on various sectors of the economy begin with the generation of climate change scenarios for temperature and precipitation using General Circulation Models (GCMs), Regional Circulation Models, or Down Scaled GCMs. These data are then used as inputs into sector specific models, e.g. water balance models for water resources, crop models for agriculture, etc. Outputs from sector specific models are then fed into economic models in order to assess potential impacts of climate change on the GDP. The WHO has developed guidelines for assessing the vulnerability of the health sector to climate change as depicted in Figures 2 to 4(b). Statistical modes find wide application in the assessment of the vulnerability of the health sector to adverse impacts of climate change.

There are a number of approaches for establishing climate change scenarios. The common approach is to use General Circulation Models (GCM). Using the GCMs, six global emission scenarios have been developed, namely: A1FI, A1T, A1B, A2, B1 and B2 (IPPC, 2001). According to IGAD and ICPAC (2007), the "A" scenario places more emphasis on economic growth while the "B" scenario emphasizes environmental protection. The "1" scenario assumes more globalization while the "2" scenario assumes more regionalization. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B), where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies. Thus the A1B scenario is ideal for use in generating climate change scenarios for Malawi.

The changing climate is linked to increases in a wide range of non-communicable and infectious diseases (Manangan *et al.*, 2014), and as depicted Figure 1. There are complex ways in which climatic factors can affect the prevalence of diseases or health conditions. Identification of communities and places vulnerable to these changes can help health authorities assess and prevent associated adverse health impacts. The Climate and Health Program at the Centers for Disease Control and Prevention (CDC) has developed the Building Resilience Against Climate Effects (BRACE) framework to help health authorities prepare for and respond to climate change. The BRACE framework is a five-step process that helps to understand how climate has and will affect human health, and enables them to employ a systematic, evidence-based process to customize their response to local circumstances. Listed below are the five steps:

a) Determine the scope of the climate vulnerability assessment by firstly, identifying the area of interest and the projected change in climate exposures at the smallest possible spatial scale, and secondly by identifying the health outcome(s) associated with these climate exposures;
b) For these health outcomes, identify the known risk factors (e.g., socioeconomic factors, environmental factors, infrastructure, pre-existing health conditions);

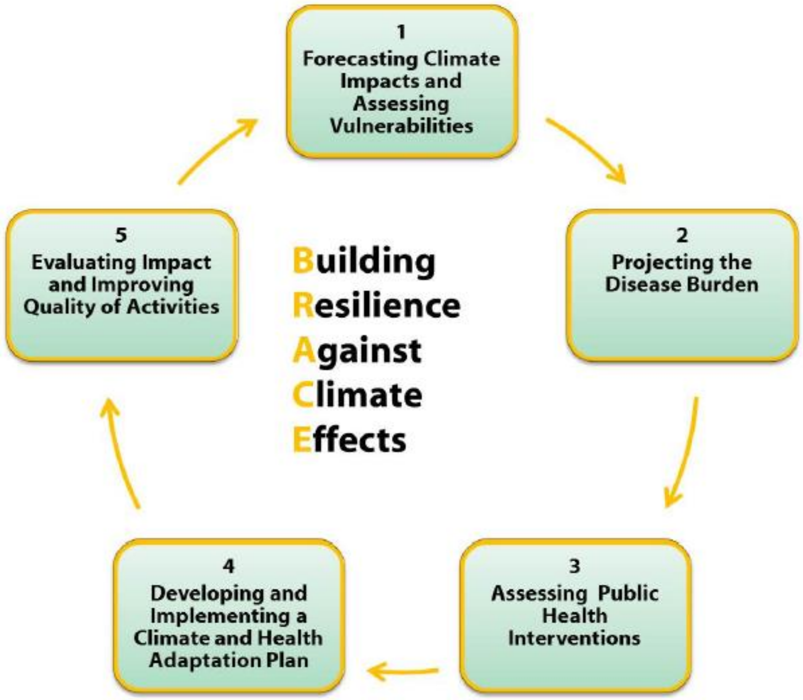

Figure 2: Framework for Building Resilience Against Climate Change Effects (Source: CDC, Undated)

c) Acquire information on health outcomes and associated risk factors at the smallest possible administrative unit (e.g., Enumeration Areas) in accordance with data privacy regulations and availability;
d) Assess adaptive capacity in terms of the system's (e.g., communities, institutions, public services) ability to reduce hazardous exposure and cope with the health consequences resulting from the exposure; and
e) Combine this information in a Geographic Information System (GIS) to identify communities and places that are vulnerable to disease or injury linked to the climate-related exposure.

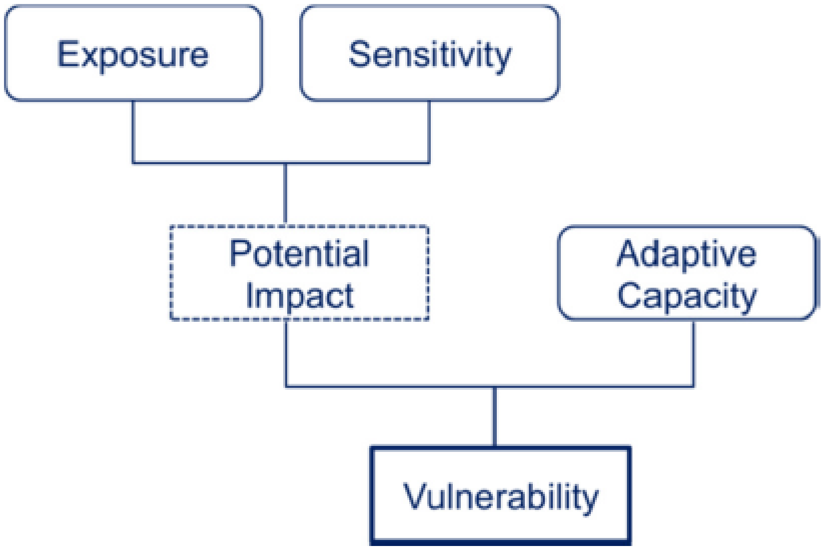

Figure 3: Factors that determine vulnerability (Source: CDC, Undated)

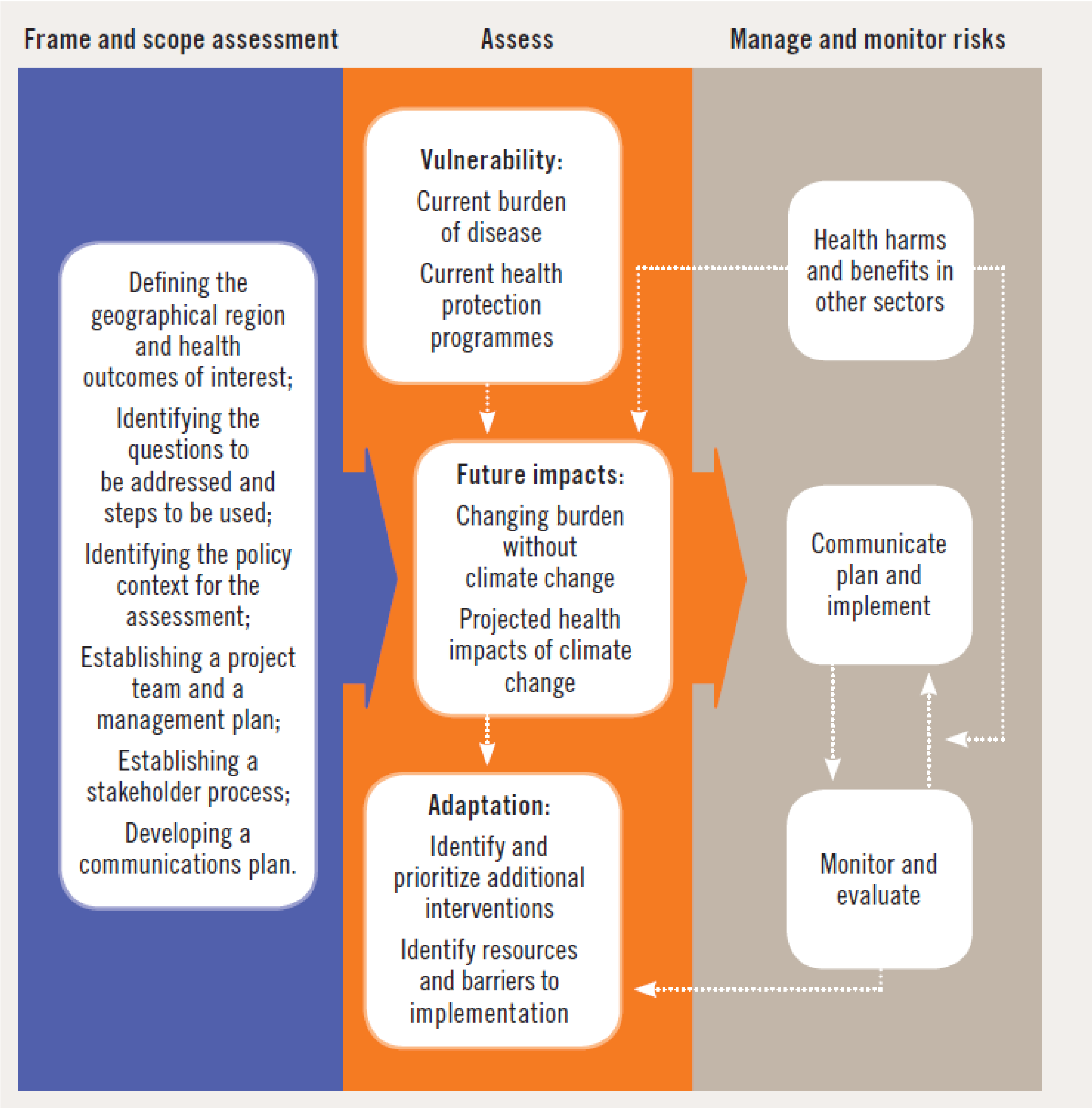

Figure 4 (a): Steps for Assessing Vulnerability and Adaptation of the Health Sector (WHO, 2013)

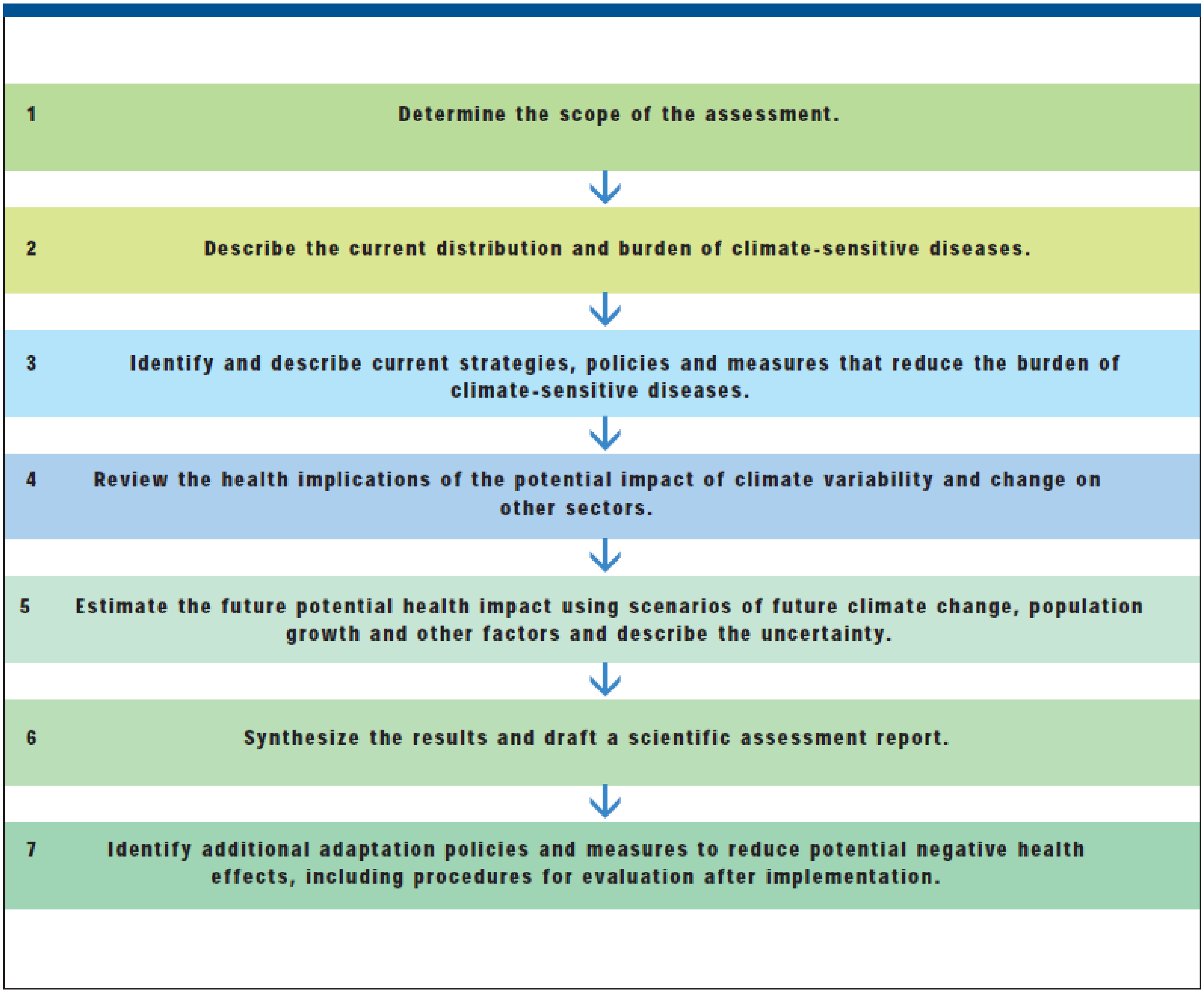

Figure 5 (b): Steps for Assessing Vulnerability and Adaptation of the Health Sector (WMO, 2003)

The main benefit derived from a vulnerability assessment is that it allows health authorities to understand the people and places in their jurisdiction that are more susceptible to adverse health impacts associated with the climate-related exposures modified by climate change. The assessment can thus be used to implement more targeted public health actions to reduce harm to vulnerable communities.

1.2 An Overview of the Health Sector in Malawi

During the implementation of the Malawi Growth and Development Strategy (MGDS), the country registered a number of achievements including a reduction in infant mortality rate from 76 per 1,000 in 2004 to 53 per 1,000 in 2015; under five mortality rate from 133 per 1,000 in 2004 to 85 per 1,000 in 2015; maternal mortality rate from 984 per 100,000 in 2004 to 574 per 100,000 in 2015; and HIV prevalence from 11.8 percent in 2004 to 10.5 percent in 2014 (DHS, 2004, GoM, 2015 and NSO, 2015). Additionally, there has been a decline in malaria prevalence from 43 percent in 2010 to 28 percent in 2012 (GoM 2012). Also, there has been an increase in TB cure rate from 74 percent in 2004 to 86 percent in 2014 (MoFEP&D, 2014) and an increase in the proportion of births attended by skilled health personnel from 38 percent in 2004 to 87.4 percent in 2015 (NSO, 2015).

Notwithstanding the achievement highlighted above, the country still faces a number of challenges, namely: high prevalence of diseases, high mortality rates, high prevalence of HIV, high incidence of malaria cases, limited access to maternal health services, low institutional capacity, inequitable access and utilization of EHP services, inefficiency of health care system, high prevalence of health risk factors, inadequate supply of essential drugs, and inadequate health infrastructure (GoM, 2011a)

In order to adequately address health challenges and to raise the health status of all Malawians, the Government has identified Public Health, Sanitation, Malaria and HIV and AIDS Management as some of the key priority areas. Details of the goals, outcomes and strategies of the health sub-theme are presented in the Malawi Growth and Development Strategy II (GoM, 2011b).

In 2004 the Ministry of Health in conjunction with other government ministries, the private sector, Civil Society Organizations and Health Development Partners (HDP) developed the Sector Wide Approach (SWAp) Program of Work for the period 2004-2010 to guide the implementation of interventions in the health sector. In 2011, the HSSP 2011-2016 was launched which includes the following Essential Health Package (EHP) conditions: HIV/AIDS , ARI, Malaria, Diarrhoeal diseases, Perinatal conditions, Non communicable diseases (NCDs) including trauma, Tuberculosis, Malnutrition, Cancers, Vaccine preventable diseases, Mental illness and epilepsy, Neglected Tropical Diseases (NTDs) and Eye, ear and skin infections.

Malawi's National Adaption Programmes Action (NAPA) of 2006 but revised in 2015 identified the following climate sensitive diseases: malaria, diarrhoea and malnutrition. Malaria is endemic throughout Malawi and continues to be a major public health hazard with an estimated six million cases occurring annually. It is the leading cause of morbidity and mortality in children under five years of age and pregnant women. Under climate change scenario, mosquitos will thrive in areas where prevailing temperatures are now below 15^0C, especially in the cooler mountainous areas (GoM, 2006).

Dehydration from diarrhoea is one of the major causes of death in young children worldwide. The prevalence of diarrhoea overall in Malawi is estimated at 17.5 %, with 38 % in children 6-12 months. The 2010 DHS showed a higher percentage of reported cases without access to improved drinking water and sanitation. In 60% of the cases recorded, treatment was sought from a formal health provider, and 24.2% of children under six months reportedly did not receive any treatment at all. Under climate change scenario, diarrhoeal cases will increase where flooding and drought conditions will prevail, resulting in outbreaks of cholera and dysentery, respectively.

Although there has been some reduction in cases of malnutrition, the incidence of disease remains high, with 47% of children under five stunted and 20% severely stunted. The prevalence of diarrhoea and disease outbreaks such as measles have a significant influence on nutritional status, particularly acute malnutrition, and have to be taken into account when interpreting nutrition surveillance results. Despite the expectation that the MDG target related to nutrition will be reached, high levels of underweight still persist. Thirteen per cent of children under five are underweight and investments in child survival interventions such as vaccines for various diseases, effective treatment of pneumonia at community level, and effective prevention and treatment of malaria and diarrhoeal diseases have contributed significantly to the remarkable decline in infant and under five mortality rates (NSO, 2015). Under climate change scenario, malnutrition cases will increase where flooding will result in loss of crops and droughts will cause reduced yields.

The Government of Malawi through the Ministry of Health (MoH) is the largest provider of formal health services in the country. There are 1060 health facilities in Malawi. These are shown in Table 1, stratified by type and managing authority.

Table 1: Health Facilities (Source: MoH, 2014)

Facility Type	**Managing Authority**				
	Government	**CHAM**	**Private**	**NGO**	**Company**
Hospital	57	44	22	2	0
Health Centre	360	112	5	5	7
Dispensary	46	2	2	0	5
Clinic	25	11	123	52	58
Health Post	27	1	0	0	0
Total	**509**	**170**	**252**	**59**	**70**

In addition, traditional healers and herbalists play an important role in the delivery of health services in the country. The Herbalists Association of Malawi has about 75,000 members. Despite this well- established network of health facilities in the country, the health delivery services have remained poor due to limited financial and human resources. The 2013 Malawi health profile indicated that the ratio of medical personnel to patients is still very low: 0.2 physician to 10,000 patients and 3.4 nurses/midwifes to 10,000 patients. Thus, improvements in health indicators have been rather slow. In addition to the mainstream challenges such as shortage of financial and human resources, as well as poor infrastructure capacity, climate change is exerting an additional strain to the already loaded system. Thus, if appropriate steps are not taken to develop specific strategies to respond to impacts of climate change on human health, the current health interventions will not cope and therefore fail to yield the desired results.

The Malawi Health Sector Strategic Plan (HSSP) 2011-2016 and the accompanying Essential Health Package (EHP) has prioritized public health, including health promotion, disease prevention and community participation. As stated in the preceding discussion, the initial focus of the EHP was on reducing infant and under five mortality and keeping their mothers alive, reducing the risk of HIV to mitigate the enormous impact on human resources and productivity and reducing population growth; all of which are essential for attaining broad based economic growth. The EHP has been expanded to take into account lifestyle diseases (such as diabetes, hypertension), accidents associated with excessive alcohol consumption and drug abuse, mental illness and cancers. The HSSP also lists 10 main risk factors for Malawi and their associated diseases (Table 2).

Table 2: 10 leading factors and diseases or injuries in Malawi

Risk	Risk Factor	% of total	Rank	Disease
1	Unsafe sex	34.1	1	HIV/AIDS
2	Childhood and maternal underweight	16.5	2	Lower Respiratory Infections
3	Unsafe water, sanitation and hygiene	6.7	3	Malaria
4	Zinc deficiency	4.9	4	Diarrheal diseases
5	Vitamin A deficiency	4.8	5	Conditions arising from perinatal conditions
6	Indoor smoke from solid fuels	4.8	6	Cerebrovascular disease
7	High blood pressure	3.5	7	Ischemic heart disease
8	Alcohol	2.0	8	Road Traffic Accidents
9	Tobacco	1.5	9	Tuberculosis
10	Iron deficiency	1.3	10	Protein energy malnutrition

2.0 OBJECTIVES OF THE STUDY

The main objective of the study was to assess the vulnerability of the health sector in Malawi to impacts of climate change and to propose adaptation strategies.

The following were specific objectives of the study:

a) To establish a baseline by determining the magnitude and distribution of the vulnerability of the health sector to climate change and variability, with special focus on the four priority health issues, namely: nutrition, vector-borne diseases, water-borne diseases, and disasters (floods, drought, storms, etc.);
b) To establish a capacity-baseline of the health sector (including the community) to address current and future risks of climate change, including the policy landscape;
c) To explore how the projected future impacts of climate change may impact the four health priorities in Malawi;
d) To identify key indicators and risk factors to be monitored overtime to observe additional future impacts of climate on health;
e) To identify key opportunities to bridge the identified gaps in information and capacity;
f) To identify research needs and information gaps; and
g) To develop recommendations of key national strategies and sectoral programming that can be considered for inclusion under a climate strategy for health

3.0 SCOPE OF WORK

The assessment was done in close collaboration with officials from the Ministry of Health and the Malawi Office of WHO. The consultancy involved the implementation of the following tasks:

a) Developing the vulnerability and adaptation assessment protocol, and administering the same in the selected study areas;
b) Drawing a list of key stakeholders;
c) Conducting the analysis and writing the assessment report;
d) Disseminating the findings of the assessment to key stakeholders;
e) Holding a stakeholder validation workshop to review the findings; and
f) Incorporating comments from stakeholders, and submitting the final report to the Ministry of Health.

4.0 METHOLODY

In order to implement tasks spelt out in Section 2.0, three key data collection approaches were employed, namely: desk/literature review of available information, stakeholder consultations, and field observations. One of the guiding documents for this assessment was the Protecting Health from Climate Change: Vulnerability and Adaptation Assessment (WHO, 2013).

4.1 Baseline Assessment

The NAPA formed the basis for the baseline assessment, complemented by information obtained from the HSSP 2011-2016. Additionally, the MDG Endline Survey 2014 report and the Service Provision Survey of 2014 provided crucial information on the current statutes of the key climate sensitive diseases for Malawi. Baseline data on flood and drought disasters were collected from the Departments of Disaster Management Affairs, Climate Change and Meteorological Services, and Water Resources. Furthermore, a questionnaire was administered to District Health Officers in respect of baseline data on common diseases as well as human, financial and institutional capacity. In addition, consultations with key stakeholders were also carried out. Field observation on existing knowledge on the diseases and the associated adaptation strategies were conducted in Chikwawa and Nsanje districts through Key Informant Interviews and Focus Group Discussions.

4.2 Capacity Assessment

The main focus under this task was to assess capacity to address the current and future risks of climate change, including the policy landscape. In this regard, a semi-structured questionnaire was administered to DHOs, with a view to establishing the existence of capacity to manage the key climate sensitive diseases identified in the NAPA, their understanding of climate change science and related issues, financial and institutional capacity to cope with the adverse impacts of climate change, and the existence as well as application of early warning systems for diseases and extreme climatic weather events, namely floods and droughts.

4.3 Projected Future Impacts of Climate Change on the Health Sector

Data on climatic variables (temperature and rainfall) and number of cases of key diseases were collected from Department of Climate Change and Meteorological Services and MoH (HMIS), respectively. These data were then correlated with a view to exploring exiting relationships.

Furthermore, future projections of climate change scenarios were obtained from the IPCC Fourth Assessment Report of 2007. These were used to determine the future impacts on the key diseases using statistical modelling for the periods 2030 and 2050.

Annual excess incidence of disease attributable to future climate-related changes in temperature and precipitation was estimated by

$$\Delta inc = inc_0(e^{\beta\Delta X} - 1)$$

where Δinc is the expected incidence change due future climatic change ΔX (as provided in Table 5), while inc_0 is the baseline incidence at the present time. Here, the relative risk captures the expected change in disease risk following a 1^{o} Celsius change in temperature or 1% change in rainfall. The average incidence in 2007 was used as a baseline incidence to calculate future incidence.

4.4 Indicators and Risk Factors for Tracking Climate Change Impacts on the Health Sector

This involved the selection of key indicators for use in tracking the disease burden and their spatial distribution, as well as noting the frequency and magnitude of flood and drought disasters, and investments in capacity building.

4.5 Identification of Information Gaps, Capacity Requirements, and Research Needs

This involved synthesising data collected through desk/literature review, stakeholder consultations and field observations.

5.0 STUDY FINDINGS

Discussed in this section are the findings of the study.

5.1 Baseline Assessment.

In this section, profiles of the project districts and disease burden of the key climate sensitive diseases for Malawi have been presented.

5.1.1 Profiles of Selected Project Districts

Four districts were selected for this study according to the existing project areas for WHO, namely: Chikwawa, Zomba, Lilongwe, and Salima was included as a control (See figure 6); with a focus on the three key diseases, namely: malaria, diarrhea (cholera and dysentery), and malnutrition.

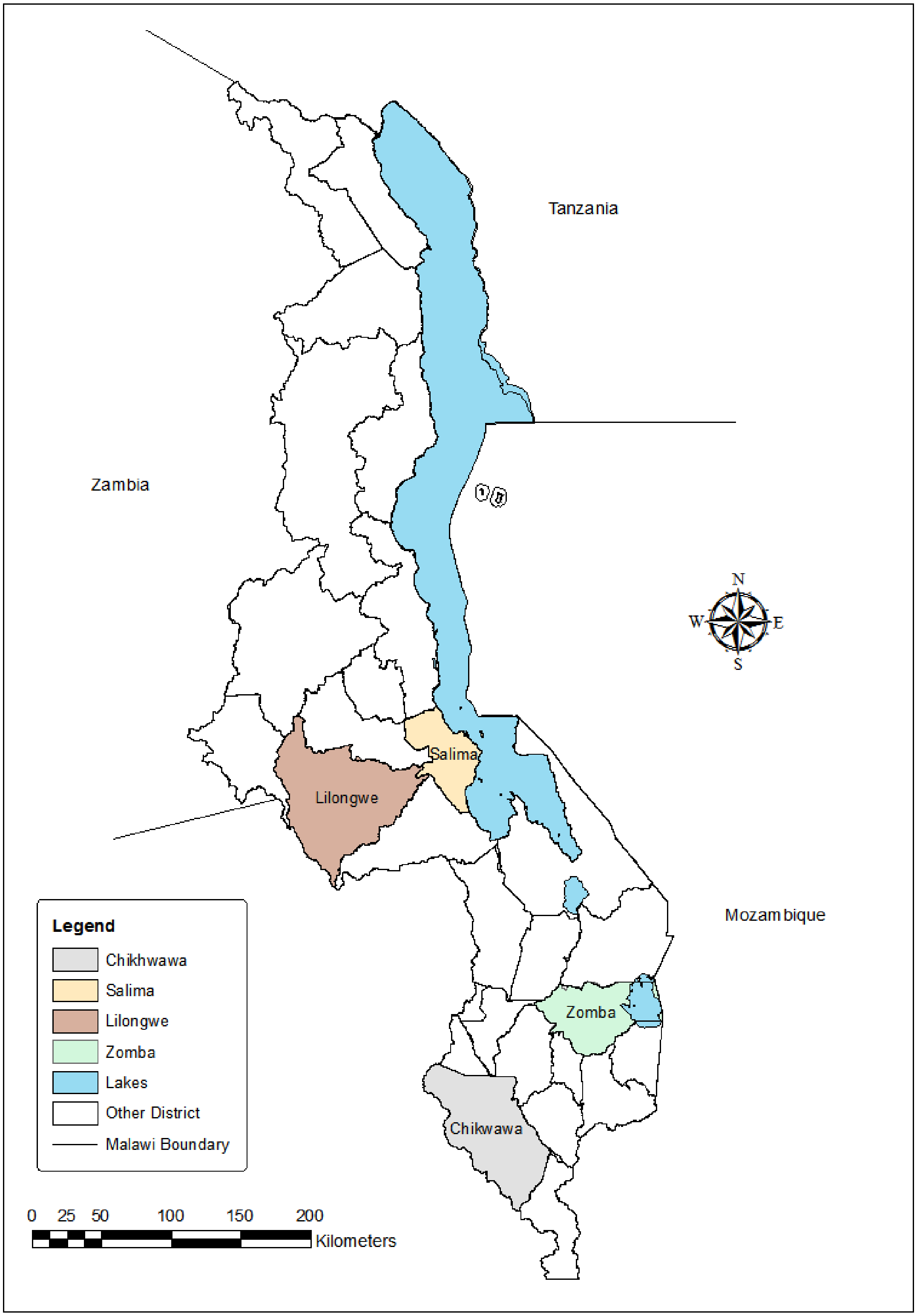

Figure 6: Map of Malawi showing selected districts of study

Additionally, the selected districts represented physiographic zones common in Malawi, i.e., rift valley floor (Salima and Chikwawa Districts), plateau area (Lilongwe District), and mountainous area (Zomba District).

Chikwawa District is located in the Lower Shire Valley in southern Malawi. It is shares boundary with four districts, namely: Mwanza to the north, Blantyre to the northeast, Thyolo to the east and Nsanje to the south. Chikwawa also shares an international border with Mozambique to the west. The district headquarters is approximately 54 km away from Blantyre, the Commercial City of Malawi. The total area of the district is 4,755 sq. km. The district experiences unreliable and variable rainfall ranging from about 170 mm to 967.6 mm minimum and maximum rainfall respectively probably because the district lies in the Shire Highland leeward side. Temperatures are generally high with a maximum of about 37.6 °C usually experienced in November and a minimum of 27.6 °C in July every year whilst the mean monthly temperature is usually 25.7°C.

The 2008 National Population and Housing Census put the estimated total population of Chikwawa at 438,895 of which 220,914 or 50.3% is female and 217,981 or 49.7% is male. Annual Population growth rate is estimated at 2.1% with a district average family size of 4.5. The national population growth is 2.8% while the national average family size is 4.4. The national population density is 139 people/km^2 while the district population density is 92 people/km^2. This translates that the population density at the district level is far much better than at national level. Major diseases in the district are: malaria, eye infections, acute respiratory infections, skin conditions, and diarrhoea. Mortality rates in the district vary from age to age, infant mortality rate in Chikwawa is 157/1,000, and Under 5 mortality rate is 205/1,000, while maternal mortality rate is 1200/100. The national literacy level is 80% for male and 60% for female against district literacy level at 54.9% for males and 32.1% for females (NSO: 1998). The major agricultural outputs of the district are livestock and crops. There are a number of cattle ranches in the district, most of them are in Traditional Authority Ngabu. The major crops grown in the district are maize, cotton, rice, sorghum and millet.

The district has 27 Health Posts, 11 Under Five Clinics, 3 Dispensaries, 12 Health Centres and 3 Hospitals (Chikwawa District Hospital, Ngabu Rural Hospital and Montfort Hospital). In terms of staffing, the district has a medical doctor, nurses, clinicians, Environmental Health Officer and Health Surveillance Assistants. Major diseases for the district are malaria, malnutrition, diarrhoea (cholera), and TB. Malaria is the major cause of Under Five deaths in the district.

Deforestation is one of the major threats to the environment as many people are involved in charcoal production and selling. This has seen most of the natural resource reserve areas deforested. This practice has been extended to the exotic forest reserves. However, people now understand the importance of conserving the environment for their benefits i.e. flood mitigation.

Zomba District is located in southern Malawi, and is surrounded by the districts of Chiradzulu, Blantyre, Mulanje, Phalombe, Machinga, Balaka and the Republic of Mozambique to the east.

The total land area is 2,580 km², with a total population of 583,167 people, more than half (52.6%) of whom are 18 years or younger. The annual population growth rate over the last decade was two percent.

Zomba experiences a tropical climate with three main seasons: cold-dry, hot-dry and hot-wet, ranging respectively from April to July, August to October and November to March. The hottest months are September, October and November, with average temperatures ranging between 28 and 30 degrees Celsius. June and July are the coldest months, with minimum temperatures as low as 10°C. The annual rainfall varies between 600mm and 1500mm (1999-2005). On average, February is the wettest month. More rainfall tends to fall on the windward (eastern) side of Zomba Mountain. Areas to the west of Zomba Plateau experience little rainfall throughout the year, as they are located on the leeward side.

The economy of Zomba District is dominated by agriculture, where individual maize production accounts for the main activity while tobacco is cultivated as the main cash crop. Other crops produced in the district include rice, cassava, sweet potato, groundnuts, beans and pigeon peas. Zomba is one of the few Districts in the country with well-spread distribution of fish ponds. There are around 2,600 farmers engaged in aquaculture, operating more than 5,000 ponds and producing as much as 757 tonnes of fish annually. In addition, Lake Chilwa continues to be the main source of fish in the District, with an annual catchment of more than 5,000 tonnes.

Health services in Zomba are provided mainly at health posts, clinics, health centres and hospitals. In addition, many people get medical treatment from traditional practitioners and traditional birth attendants. The crude birth rate for the District is estimated at 48.1 births per 1,000 Inhabitants. The total fertility rate stands at 5.3 children per woman. The infant mortality rate is 84 deaths per 1,000 live births and child mortality (14.4%) is among the highest in the country. Almost four fifth of all households (79.6%) have access to safe drinking water, while access to sanitation facilities is still at 59%. Methods of refuse disposal include burning, dust bins, rubbish pits, random littering and, mainly for organic waste, integrating into garden and composite pits.

Salima district is located in the Central Region of Malawi, 103 km south of Lilongwe. It has a total land area of 2,196 km^2 or 2.3% of Malawi's land area. It shares boundaries with Nkhotakota to the north, Dowa and Ntchisi to the north-west, Lilongwe to the west, Dedza and Mangochi to the south, and Lake Malawi to the East. The district has a population of about 309,300 based on 2.5% annual growth projections from the 1998 Population and Housing Census, 57.3% of this population is in the poverty bracket of subsisting on MK16,125 per capita /year while 25% is on MK10,029 per capita/ year against the national standards of 52.4% and 22% respectively.

Main source of livelihood, for the majority of the population comprising 93,400 farm families is subsistence agriculture practiced on about 107,400 hectares of customary farm land. This translates into a per capita farm family/land size ratio of 1:1.1 ha. Maize is the major food crop grown in the district followed by sweet potatoes, cassava, and rice. In the 2004/5 growing season,19,700 M/T,16,500M/T, 13,900M/T, and 650M/T of maize, sweet potatoes, cassava and rice were cultivated and produced respectively.

Main landforms range from the rift valley floor to the scattered hilly upland areas lying between 200 and 1000 meters above sea level. Four main rivers: Lifidzi, Lingadzi, Linthipe and Chiluwa provide the drainage system into Lake Malawi. Crop production is mostly done on the well-drained loamy soils and alluvial deposits. The district experiences general warm tropical climate with mean annual temperatures of 22 degrees Celsius. Temperatures are highest between October and November and lowest around June and July.

The district has vast potential for economic growth and expansion through agriculture and tourism. Presently, the irrigation potential from its rivers, the fertile well drained rift valley floor has not been fully utilized. Only 1400 hectares (2%) of private arable land is being utilized for commercial agricultural purposes out of over 56,100 hectares available under this category .The district has also conducive environment in the form of vast unutilized land amounts climate and vegetation for large scale livestock rearing and allied industrial processing projects.

Agriculture remains the pillar and backbone of the district's livelihood strategies being depended on by over 90% of the people for income by offering employment to about 80% of the population.

This has exerted immense pressure however not only on the land suitably available for cultivation, but also on demand for extension methodology services and other technical support services. Only 79 frontline personnel are available to render extension services to 93,400 farm families representing an extension worker/farm family ratio of 1:2278, against standards of 1:900. In addition to this challenge, there are problems related to appropriate production and technological mix, supporting infrastructural networks and marketing-mix, and the need for an overall mindset shift towards agriculture as a business.

The district has a compliment of 1 District Hospital, 12 Health Centers, 4 Dispensaries, and 59 outreach clinics with a total bed occupancy rate of 257. 168 beds out of these are at the district hospital which has equipment for minor and major surgery, dental surgery, diagnostic x-ray, and laboratory and VCT services. It also has facilities for a range of preventive, curative, rehabilitative services as well as and management support. Players in this sector include government's ministry of health, Malawi Defence Force, ADMARC, CHAM, and the private sector. In spite of concerted efforts by stakeholders to improve the delivery of quality services thereby improving the quality of life, access continues to be a challenge. Only 278 medical personnel are available against the required establishment of 358 representing just over 77%. The most substantial critical human resource shortfall however is in the nursing profession where only 70 out of the 152 established positions are filled representing only 46%.

Geographically, all Traditional Authority areas except Pemba and Msosa have health facilities of up to dispensary designation. This translates into only 60% of the district population having access to basic health services. 29% of this population spend almost 1 hour of walking time to access health services. While 42% take more than 2 hours of walking distance to get to the nearest health facility. The impact of this situation is a stagnating life expectancy at 39 years of age which is aggravated by less impressive health indicators in comparison with the national average, viz: Infant Mortality Rate at 132/1000; Under-five Mortality

Rate at 240/1000; Maternal Mortality Rate at 612/100,000 against 113/1000; 204/1000; and 980/100,000 respectively. Major cases of mortality and morbidity for the district continue to be malaria, upper respiratory infections, anaemia, and opportunistic infections as a result of HIV/AIDS. But for children U-5 of age, are malaria, pneumonia, anaemia, and nutritional deficiencies. HIV/AIDS prevalence rate is at 18% against the national average of 12%. The percentage of children less than 1 year of age fully immunized is 56% while the national coverage stands at 70%. Under-5 children suffering effects of malnutrition is unacceptably high at 10% against the national incidence which is 2%.

Lilongwe District is located in the plateau area in the Central Region. Mean temperature ranges from 20-22.5 ^{o}C while the mean rainfall value is estimated to be 800 mm/annum. Agricultural production is the main activity in Lilongwe District, with tobacco as the dominant crop. Health services in the district are provided at three kevels, namely: primary, secondary, and tertiary. At primary level, services are delivered through rural hospitals, health centres, health posts, outreach clinics, and community initiatives. District and CHAM hospitals provide secondary level care while tertiary level care is provided by hospitals similar to those at secondary level but along with specialized surgical and medical facilities. Common diseases include: malaria, acute respiratory infections, diarrhoea, malnutrition, STDs, TB, and HIV/AIDS.

5.1.2 Information on Key Diseases

Information obtained from literature review shows that malaria, diarrhoeal diseases, and malnutrition are among main causes of death in Malawi (GoM, 2015; NSO, 2015). In this regard, changes in climatic patterns such as increases in temperature, floods and droughts are likely to affect the magnitude and distribution of these diseases. At the moment, malaria is known to be endemic in the country. The MDG End-line Survey reported an incidence of malaria in under-five children of 37.2%, with 65.5% of under-five children reported to have slept under an ITN the previous night preceding the survey, with 60.8% of pregnant women using ITN (NSO, 2015). Additionally, the transmission of malaria shows clear seasonal and geographical variation. Therefore, global warming is likely to exacerbate the situation. Pregnant women and children are most vulnerable to malaria. Adaptation measures for malaria include use of insecticide-treated nets (ITNs) and mosquito repellents (including indigenous technologies such as use of blue gum leaves) (GoM, 2006). It is worth noting that 80.2% of households are reported to own an ITN (NSO, 2015).

Diarrhoeal diseases are among the major causes of illness and deaths among children under five years of age. Children are the most vulnerable group, suffering an average of five episodes per year. The MDG End-line survey reported an incidence of 24.1% of children having diarrheal episode in the two weeks preceding the survey (NSO, 2015). Worth of note is the fact that of the children that experienced diarrhoeal episode prior to the survey, 23% received ORS and zinc. According to the NAPA (GoM, 2006), diarrhoea cases are highest during the rainy months of December to April. Adaptation measures applied by households (HH) include boiling of drinking water, filtration and chlorination (using Water Guard), and personal hygiene. The government offers preventive and curative interventions in addition to public awareness campaigns.

Malnutrition is worst during the rainy season when most families have little grain left in storage and parents are busy in their gardens. The MDG End-line Survey (NSO, 2015) reported the following statistics for under-fives: moderate to severe underweight, 16.7%; moderate to severe stunting, 42.4%; and moderate to severe wasting, 3.8%. Over the last ten years, the percentage of malnutrition in children has shown no improvement (GoM, 2006). In times of food shortages, households try to cope by engaging in casual labour in order to boost household income. Other strategies include reducing the number and/or the size meal per day. The government encourages crop diversification, growing of drought resistant varieties, winter cropping and irrigation farming to enhance climate change resilience and food security at household level.

5.1.3 Information on Flood and Drought Disasters

Floods and droughts have been a major source of disruption to the efficient performance of Malawi's agro-based economy, with serious consequences on human health. On one hand, floods have been noted to fuel the spread of malaria, cholera, schistosomiasis, and malnutrition while on the other hand droughts have led to the increased prevalence of malnutrition, dysentery, and scabies.

Flood disasters are attributed to high intensity rainfall that takes place in the country; and that the availability of densely populated river banks with flat topography and degraded catchment areas only exacerbate the severity of flood disasters. Notable flood events that Malawi has experienced so far include the Zomba and Phalombe flash floods of 1946 and 1991, respectively. The Zomba flash floods popularly known as *Napolo* were caused by high intensity rainfall resulting from the joint effect of the ITCZ and the Zomba Cyclone when 711 mm of rainfall fell in 36 hours (Water Department/UNDP, 1986), leaving in its wake severe loss of life and serious damage to property. During the Phalombe flash floods of 1991, 417 mm rainfall fell within a period of three days resulting in the failure of Michesi Hill, causing severe loss of life and extensive damage to property. Severe floods affected 15 out of 28 districts in 2015, casing 176 fatalities and displacing 230,000 people.

Malawi has experienced severe droughts in the past and notable among these occurred in 1948/49 and 1991/92 seasons. Nearly all the droughts that have taken place in the country have been associated with the El Nino and Southern Oscillation (ENSO) phenomena. Recent studies about the ENSO warm phase episode in southern Africa show the existence of two drought cells both of which affect Malawi, mainly the southern part of the country (Eastman *et al*., 1996). The first drought cell shows a path originating from Namibia but covering Botswana, Zimbabwe, southern Zambia, northwest Mozambique and the southern part of Malawi. The second drought cell has its center located near southern Mozambique and southern Zambia and appears to expand outwards. This drought cell too affects Malawi, particularly the southern part of the country. There are no signs at the moment to suggest the abetment of these drought cells and a lull from impacting negatively on the socio-economic development of the country as evidenced by climate change studies done by Chavula and Chirwa (1996).

Disease vectors such as anopheles mosquitoes which cause malaria require minimum ambient temperature of 15^{o}C in order to complete their life cycles. Global warming is therefore making those areas that were malaria free reach those critical temperature thresholds. Literally, mosquitoes and hence malaria seem to be moving up the mountains. Higher temperatures would also be responsible for heat wave related illnesses and health challenges.

5.2 Capacity Assessment

Data obtained from literature review and stakeholder consultations with DHOs show that there is inadequate capacity in the ministry of health to manage key climate change related diseases as well as ability to apply early warning systems for the prediction of the diseases. For example, DHOs indicated that their frontline staff (health Surveillance Assistants) have never had training in climate change science and related issues. Further, it was reported that the ministry does not have adequate financial and human resources to manage the three climate related diseases mentioned above.

5.3 Climate Change Scenarios and Vulnerability Assessment

The A1B scenario was selected since it best describes the energy situation in Malawi as the country has limited technological advances. The future climatic changes in temperature and rainfall are presented in Figures 7 and 8 respectively, for the year 2030 and 2050.

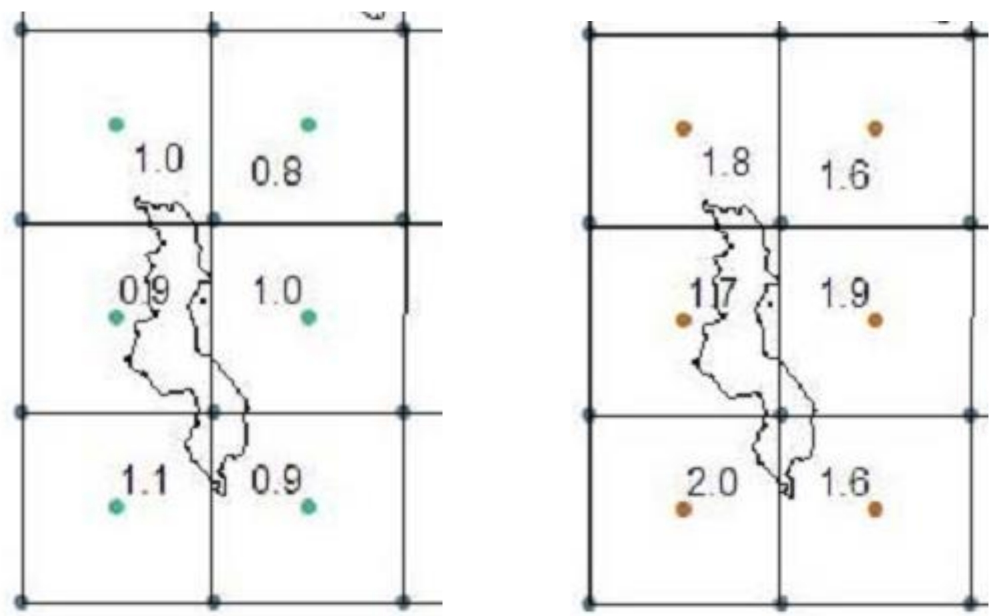

Figure 7: Composite change in mean annual temperature by 2030 (left panel) and 2050 (right panel) in Malawi, using six GCMs (CSM_98, ECH395, ECH498, GFDL90, HAD295, and HAD300). Source: IGAD and ICPAC, 2007.

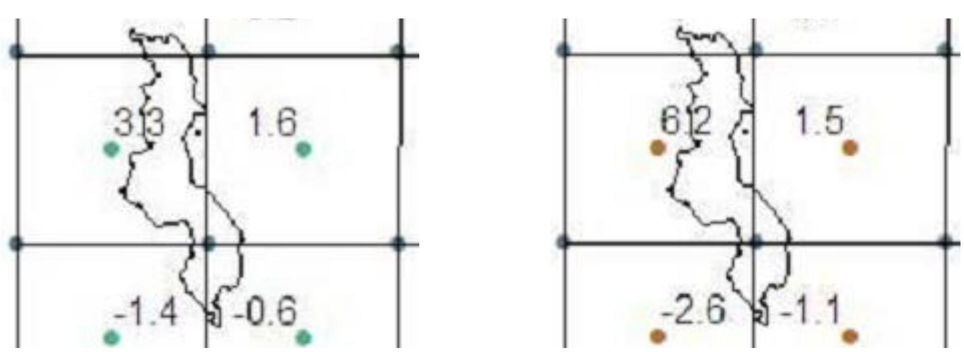

Figure 8: Composite change in mean Annual precipitation by 2030 (left panel) and 2050 (right panel) in Malawi using six GCMs (CSM_98, ECH395, ECH498, GFDL90, HAD295, and HAD300). Source: IGAD and ICPAC, 2007.

In summary, mean annual temperatures are expected to rise by 0.9 to 1.1 degree in 2030, and a further 1.6 to 2.0 degrees in 2050 (Figure 7). Mean annual precipitation is projected to change by -1.4% to 3.3% in 2030, while in 2050 this will change by -2.2% to 6.2% (Figure 8). The respective expected climatic change values for temperature and precipitation for Lilongwe, Salima, Zomba and Chikwawa are presented in Table 3

Table 3: Climate Change Scenarios

	Mean Annual Temperature		Mean Annual Precipitation	
District	2030	2050	2030	2050
Lilongwe	0.9	1.7	3.3	6.2
Salima	0.9	1.7	3.3	6.2
Zomba	0.9	1.6	-0.6	-1.1
Chikwawa	1.1	2.0	-1.4	-2.6

Table 4 shows the summary statistics for the observed disease cases and climate variables. During the period of study, the average number of diarrheal cases in Chikwawa was 1242 while malaria was 7098 and malnutrition was 272.73. The results show that diarrhoea, malaria and malnutrition are weakly correlated with climatic variables (correlation $r<0.2$), except for rainfall and diarrhea ($r=0.54$). In Zomba, the mean number of diarrheal cases of 1096.4 was slightly lower than in Chikwawa district. The mean number of malaria and malnutrition cases were 9825 and 213.7 respectively. The correlation of malaria with rainfall and minimum temperature was moderate ($r=0.5$), but weak for malnutrition and diarrhoea. During the period of study, Lilongwe posted slightly higher number of cases of all disease types. The mean cases of diarrhoea was 3516 while malaria and malnutrition were 22194 and 783.4 respectively. For all diseases, the highest correlation with climatic variables was observed between malaria and rainfall and minimum temperature, otherwise for other diseases this was estimated at $r<0.3$.

In Salima, the mean cases were 585, 5259, and 162.7 for diarrhoea, malaria and malnutrition respectively.

Table 4**:** Summary statistics of disease incidence and climatic variables in Chikwawa, Zomba, Lilongwe and Salima districts.

District	Variable	Number (months)	Mean	Median	Standard deviation	Minimum	Maximum
Chikwawa	Diarrhoea	84	1242.0	1135	400.67	706	2701
	Malaria	84	7098.0	7618	2952.86	1799	14764

	Malnutrition	84	272.7	217	221.33	39	1261
	Rain	84	59.6	22.20	86.87	0	391.60
	Minimum Temperature	84	20.3	21.20	3.50	12.00	25.90
	Maximum Temperature	84	32.9	32.90	3.11	25.20	38.60
Zomba	Diarrhoea	96	1096.4	1078.0	406.01	479.0	2986.0
	Malaria	180	9825.0	9286	4075.68	3260	25893
	Malnutrition	132	213.7	173.0	125.75	100.0	1127.0
	Rain	180	82.3	18.65	110.64	0	439.10
	Minimum Temperature	180	15.9	16.75	2.86	10.40	20.80
	Maximum Temperature	180	26.6	26.80	2.39	21.60	31.60
Lilongwe	Diarrhoea	84	3516.0	3178	1640.02	40	7919
	Malaria	84	22194	20013	12229.1	306	51999
	Malnutrition	84	783.4	781.5	423.68	0	1943.0
	Rain	84	69.77	15.95	98.41	0	407.80
	Minimum Temperature	84	15.14	15.60	3.25	9.00	19.60
	Maximum Temperature	84	27.21	27.00	2.18	22.70	32.00
Salima	Diarrhoea	132	585.8	643.0	491.14	11.0	2760.0
	Malaria	132	5259	5798	3271.64	393	14643
	Malnutrition	132	162.7	127.0	159.14	5.0	945.0
	Rain	132	96.24	8.50	153.95	0	760.70
	Minimum Temperature	132	20.51	20.86	2.34	15.70	24.60
	Maximum Temperature	132	29.56	29.40	2.17	24.60	34.50

5.4 Trends and Seasonality of Disease Incidence

Figures 9 to 12 show boxplots of the observed incidences of diarrhoea, malaria and malnutrition in the four districts under study. These plots display the long-term trend (years) in disease incidence, and seasonality of disease using month. Figure 8 shows monthly variation in disease incidence in Chikwawa district, and provides evidence of strong seasonality of diarrhoea while for malaria, highest incidence are generally in the first months of the year, which coincides with the hot and rainy season. The trend shows the incidence of diarrhoea has been increasing while that of malaria and malnutrition has been decreasing.

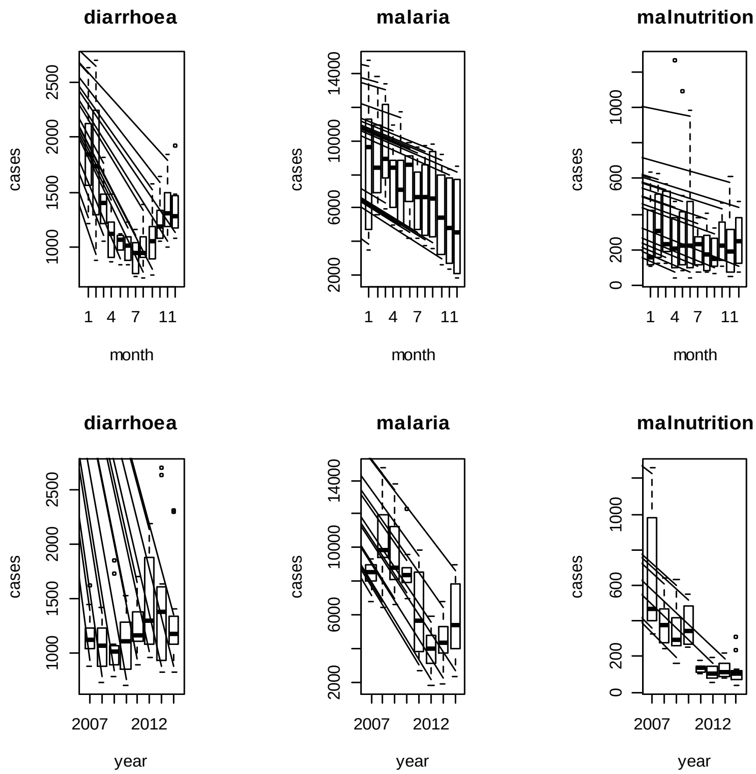

Figure 9: Boxplots for Chikwawa at various years and months

In Zomba, all diseases show a strong seasonality (Figure 10). High number of cases coincide with the hot and rainy season (November-March) while low incidence were recorded in the cold season. The trend presented displays an increasing number of diarrhoea and malaria, but a nearly constant pattern with regards to malnutrition. The variability of malaria within each year is relatively higher than for the other two diseases.

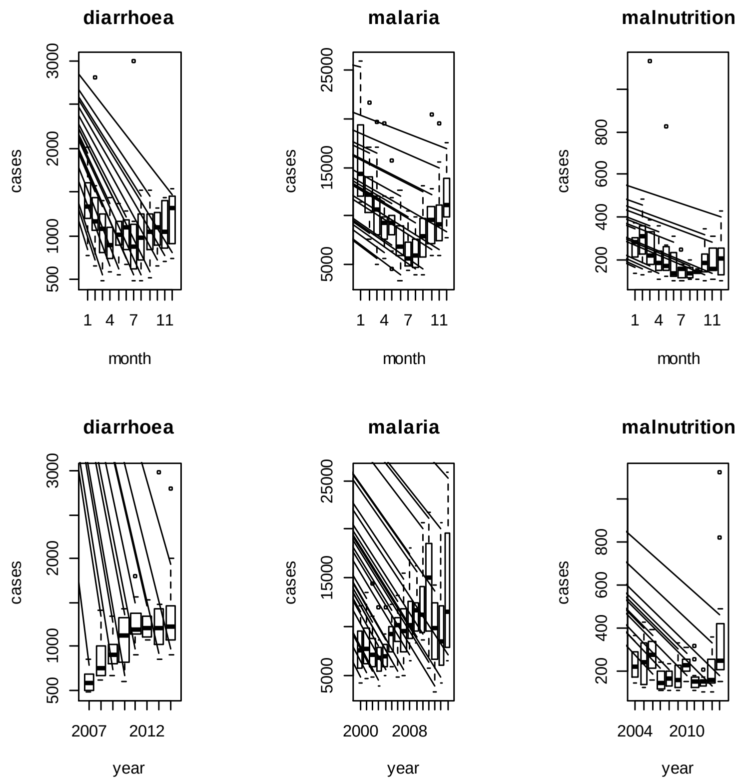

Figure 10: Boxplots showing monthly and yearly pattern in Zomba district

The trends in incidence of diarrhoea, malaria and malnutrition in Lilongwe is presented in Figure 11. The three selected diseases show seasonality. High numbers of reported cases were recorded in January and February, and also in November-December, which is a rainy season, while low incidence was recorded in the second or third quarters of the year. The clear upward trend was visible in diarrhoea incidence while for malaria this increased for four consecutive years (2007-2010), and decreased in subsequent years only to increase again in the year 2014.

Figure 12 shows the distribution of diarrhoea, malaria and malnutrition in Salima. All boxplots show that in general no disease displays any evidence of seasonality, although diarrhoea and malnutrition depict some peaks towards the beginning and end of the year. As in other districts, the incidence of diarrhoea and malnutrition has increased since the year 2007. For malnutrition, the trend of incidence is somewhat constant.

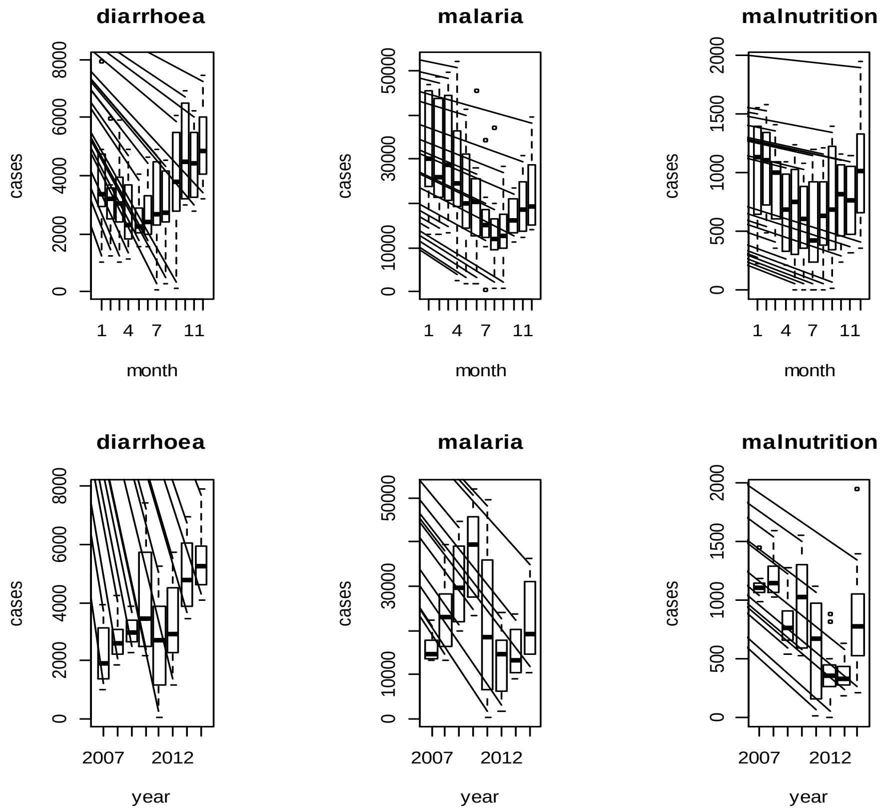

Figure 11: Boxplots of disease data for Lilongwe at different months and years

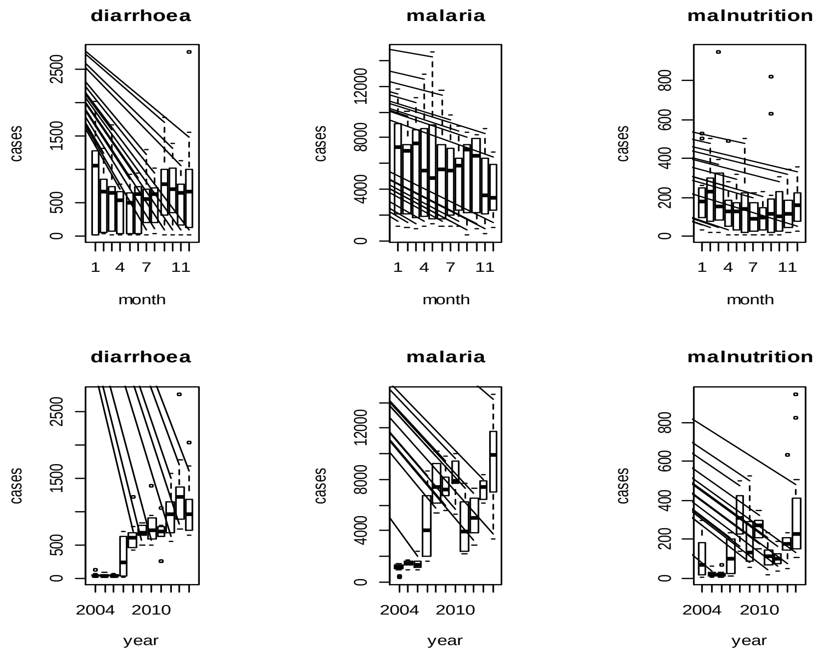

Figure 12: Boxplots of disease data for Salima?? at different months and years

5.5 Relationship between disease and climatic variables

The study investigated the existence of the relationship between disease and climatic variables. Figure 13 to 16 show time plots of each disease and each climatic variable. The top panel shows a plot of diarrhoea against each climatic variable while presented in the middle panel is the relationship between malaria and climatic variables.

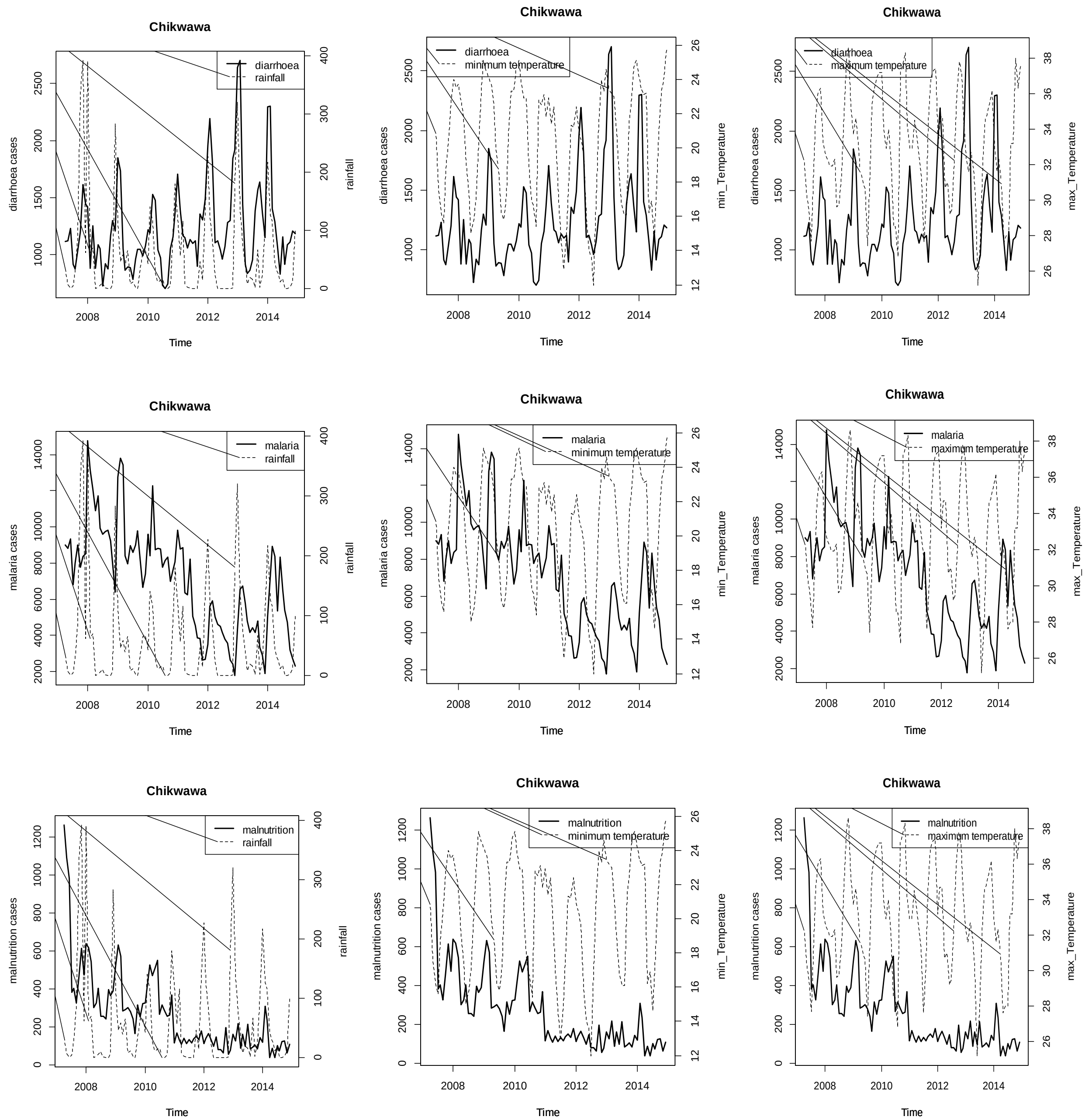

Figure 13: Time series plots of diarrhoea (top panel), malaria (middle panel) and malnutrition (bottom panel) and climatic variables in Chikwawa district.

The bottom panel shows graphs of malnutrition and climatic variables. In general, there was a strong correlation between disease and climatic variables at lags of 1 and 2. For maximum temperature, the lag went as far as 4 months. However, there was lack of plausible epidemiological relationship to extend the models to include lags at month 4.

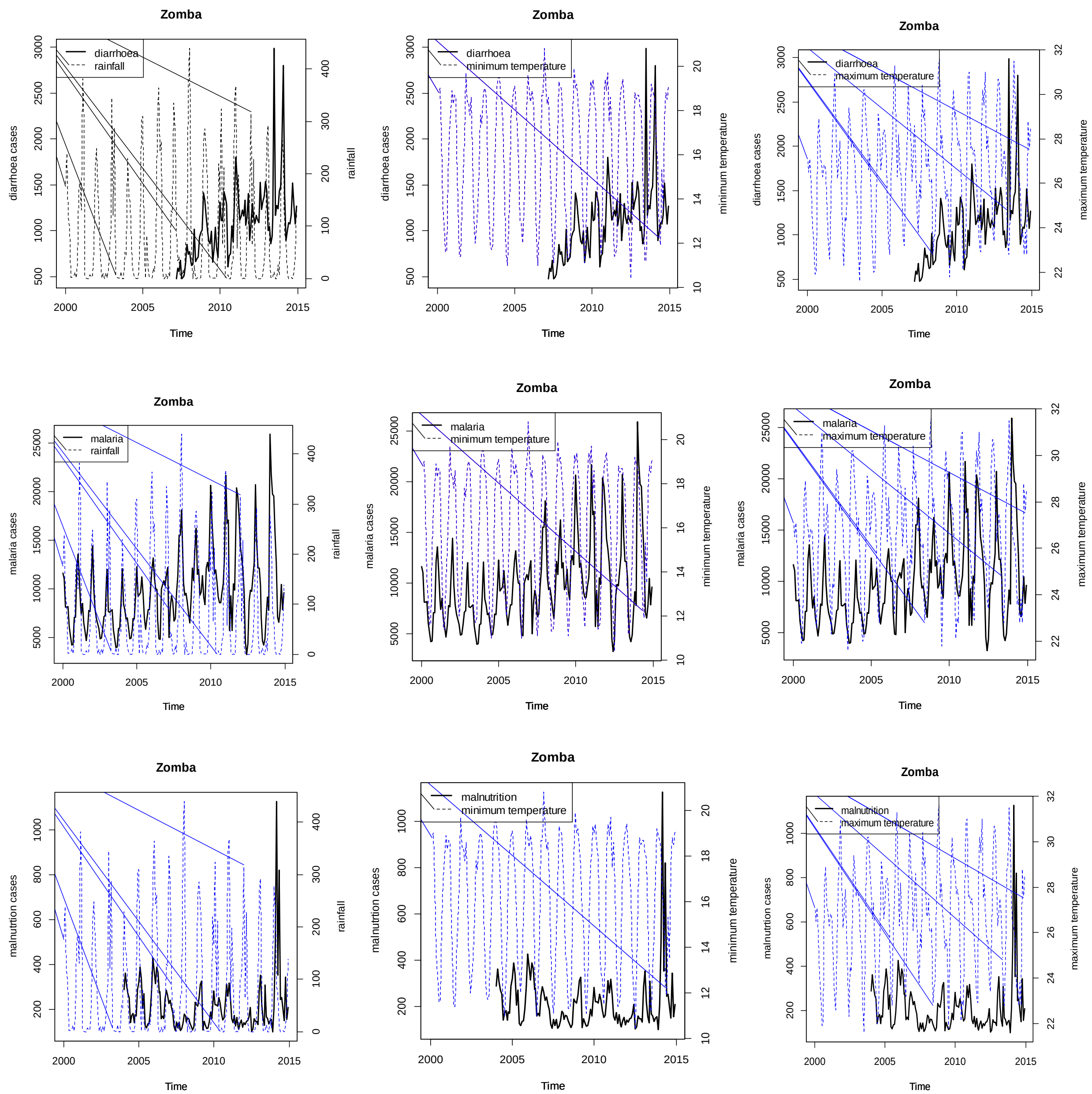

Figure 14: Time series plots of diarrhoea (top panel), malaria (middle panel) and malnutrition (bottom panel) and climatic variables in Zomba district.

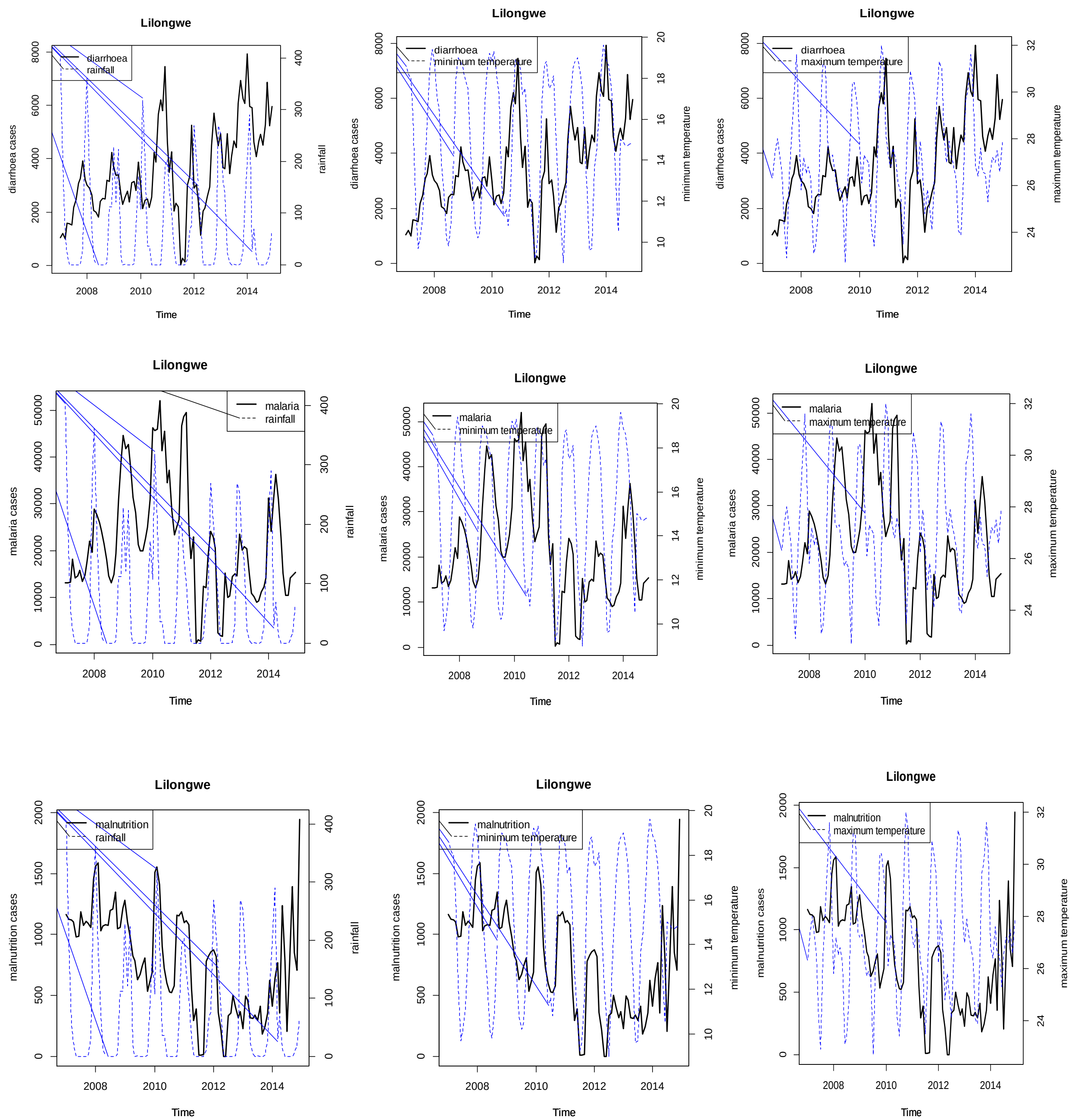

Figure 15: Time series plots of diarrhoea (top panel), malaria (middle panel) and malnutrition (bottom panel) and climatic variables in Lilongwe district.

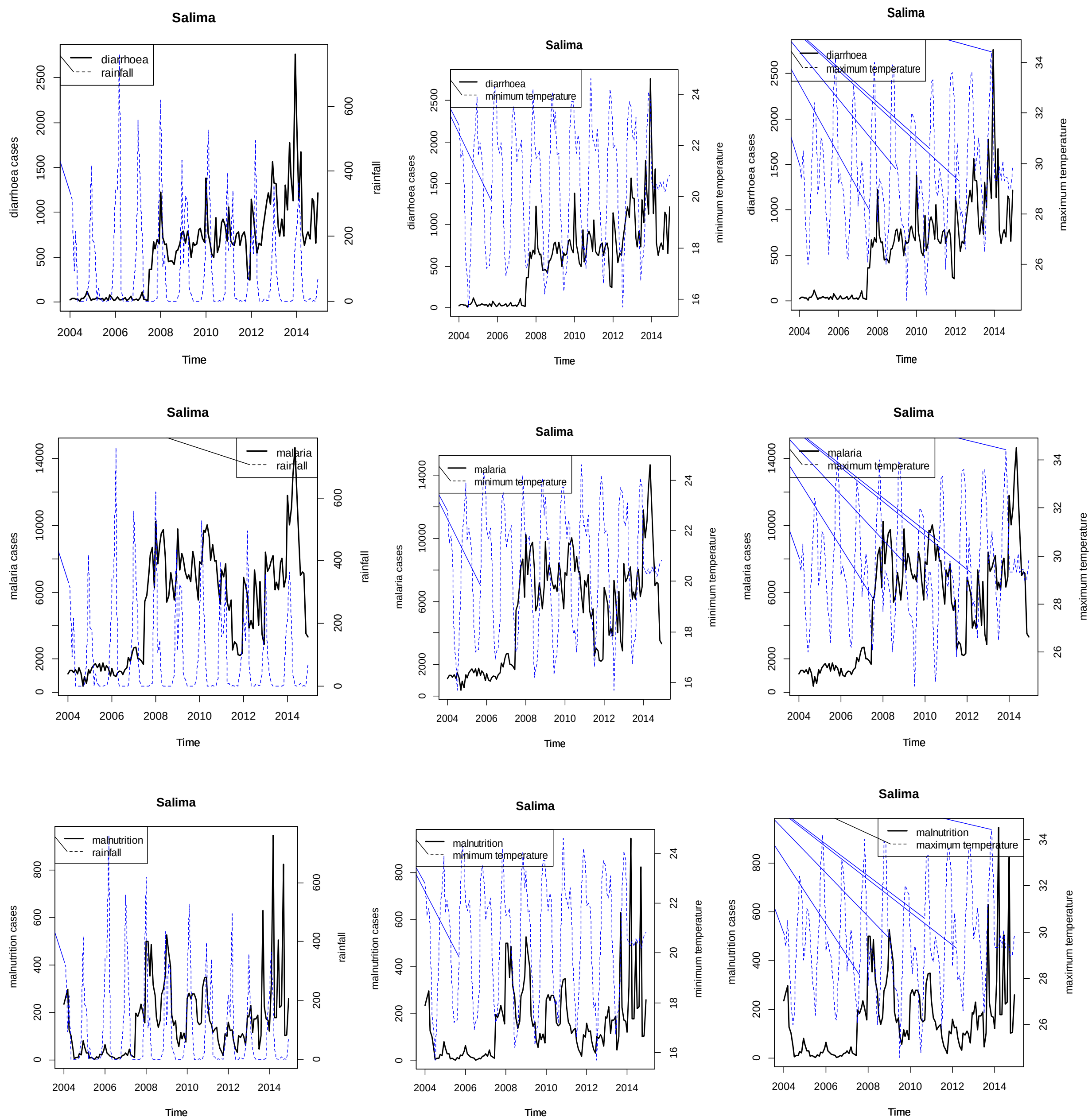

Figure 16:Time series plots of diarrhoea (top panel), malaria (middle panel) and malnutrition (bottom panel) and climatic variables in Salima district.

In order to test the predictive potential of the model, data for the year 2014 for prediction/ forecasting was used. The root mean square error was used to validate the model. The best fitting model was identified and summaries are presented in Tables 5 and 6.

Table 5: Regression coefficients for Chikwawa and Zomba districts

		Chikwawa			Zomba		
Variable		Diarrhoea (95% CI)	Malaria (95% CI)	Malnutrition (95% CI)	Diarrhoea (95% CI)	Malaria (95% CI)	Malnutrition (95% CI)
Climatic	Rainfall (Lag0)	1.001(1.000-1.002)	1.001(1.000-1.001)	1.000 (1.0001-1.0004)	1.0006 (1.0005-1.008)	1.0003 (1.00031-1.00037)	1.001 (1.0004-1.002)
	Rainfall (Lag1)	1.005 (1.004-1.006)	1.001(1.001-1.002)	1.000 (1.0000-1.0003)	1.0005 (1.0004-1.0006)	1.000 (1.0002-1.0003)	1.000 (1.0003-1.0009)
	TMin (Lag1)	1.004 (1.002-1.005)	0.967(0.994-0.999)	1.037(1.01-1.04)	0.988(0.97-0.99)	0.953(0.94-0.97)	1.016(1.01-1.02)
	TMin (Lag2)	1.031(1.001-1.004)	1.027(1.011-1.068)	0.984(0.98-1.01)	1.004(0.99-1.007)	0.935(0.92-0.94)	0.873(0.84-0.89)
	TMax (Lag1)	1.031(1.000-1.004)	1.04 (1.02-1.005)	0.953 (0.94-0.99)	1.042(1.03-1.047)	1.013(1.01-1.03)	0.983(0.93-1.01)
	TMax (Lag2)	1.019(1.000-1.002)	0.987(0.971-0.999)	1.046 (1.03-1.06)	1.076(1.07-1.088)	1.071(1.035-1.11)	1.09(1.02-1.13)
Year	2007	1.000	1.000	1.000	1.000	1.000	1.000
	2008	0.856 (0.822-0.878)	1.150(1.12-1.18)	0.668(0.64-0.72)	1.474(1.44-1.49)	1.047(1.03-1.045)	0.980(0.96-0.99)
	2009	0.873(0.814-0.929)	1.052(1.03-1.08)	0.586(0.55-0.64)	1.586(1.55-1.61)	1.157(1.13-1.19)	1.176(1.15-1.195)
	2010	0.864(0.855-0.877)	0.970(0.96-0.99)	0.643(0.62-0.69)	1.837(1.62-2.01)	1.248(1.21-1.26)	1.457(1.13-1.61)
	2011	1.005(1.002-1.008)	0.647(0.62-0.66)	0.236(0.22-0.25)	2.135(2.08-2.21)	1.380(1.33-1.42)	1.037(1.01-1.05)
	2012	1.163(1.141-1.190)	0.434(0.42-0.44)	0.197(0.18-0.22)	2.028(1.93-2.11)	0.923(0.91-0.95)	0.951(0.89-0.98)
	2013	1.184(1.178-1.197)	0.488(0.47-0.50)	0.214(0.201-0.23)	2.343(2.16-2.55)	0.936(0.91-0.96)	1.186(0.16-1.21)
	2014	1.075(1.057-1.091)	0.624(0.61-0.64)	0.197(0.188-0.22)	2.620(2.51-2.74)	1.488(1.42-1.57)	2.459(2.22-2.64)

For Chikwawa district, it was noted that the effect of rainfall positively related to all diseases at both lag of 0 and 1 month. There was approximately 0.1% increase in diarrhoea, malaria and malnutrition per unit percentage increase in rainfall in the current month, and 0.5% increase in diarrhoea per percentage increase in rainfall in the previous month. Both minimum and maximum temperatures were associated with diarrhoea, malaria and malnutrition. For malaria and minimum temperature, results show a 4% reduction in malaria when temperature increases by 1 degree in the previous month, while malnutrition decreases by 2% in 1 degree increase in temperature in the past 2 months (Table 5). Across all years in Chikwawa, compared to the year 2007, the incidence of diarrhoea has increased, however, a reduced risk of malaria and malnutrition was estimated.

In Zomba district, rainfall was the main driver of all diseases, but the effect was relatively small (0.06%, 0.03% and 0.1% increases for diarrhoea, malaria and malnutrition respectively, for every 1% increase in rainfall). Minimum temperature at a lag of 1 month was negatively associated with the incidence of diarrhoea, and malaria, but positively related to the incidence of malnutrition. However, at lag of 2 months, a positive relationship was noted with the incidence of diarrhoea, at the same time negatively associated with the incidence of malaria and malnutrition. Maximum temperature also positively affected diarrhoea and malaria incidence, but negatively with malnutrition. Overall, the incidence of all diseases has increased since 2007.

Table 6: Regression Coefficients for Lilongwe and Salima Districts

		Lilongwe			Salima		
Variable		Diarrhoea (95% CI)	Malaria (95% CI)	Malnutrition (95% CI)	Diarrhoea (95% CI)	Malaria (95% CI)	Malnutrition (95% CI)
Climatic	Rainfall (Lag0)	0.998 (0.9983-0.9988)	0.99 (0.992-0.994)	0.998 (0.982-0.990)	1.000 (1.0003-1.0005)	0.999 (0.9987-0.9998)	1.001 (1.0008-1.0011)
	Rainfall (Lag1)	0.999 (0.9990-0.9994)	0.98(0.981-0.986)	0.998 (0.980-0.999)	1.000 (0.999-1.0001)	0.999 (0.9986-0.9998)	0.999(0.9985-0.9998)
	TMin (Lag1)	1.000 (0.991-1.002)	1.051(1.02-1.07)	1.105(1.05-1.12)	0.875(0.87-0.89)	0.972 (0.962-0.986)	1.059(1.02-1.071)
	TMin (Lag2)	0.995 (0.991-0.999)	1.136(1.11-1.15)	0.961(0.94-0.98)	1.042(1.03-1.06)	0.948 (0.942-0.952)	0.995(0.96-1.01)
	TMax (Lag1)	1.021 (1.015-1.022)	0.99(0.995-0.996)	0.884(0.85-0.91)	1.120(1.09-1.15)	1.048(1.02-1.06)	1.084(1.04-1.10)
	TMax (Lag2)	1.036 (1.025-1.042)	0.904(0.89-0.91)	0.959(0.94-0.96)	0.987 (0.96-1.001)	1.043(1.02-1.05)	1.033(1.02-1.07)
Year	2007	1.000	1.000	1.000	1.000	1.000	1.000
	2008	1.138(1.12-1.15)	1.350(1.32-1.37)	1.007(1.004-1.10)	2.045(2.02-2.06)	1.62(1.30-1.89)	2.984(2.84-3.14)
	2009	1.268(1.22-1.28)	1.639(1.59-1.67)	0.614(0.59-0.63)	2.409(2.20-2.71)	1.57(1.39-1.78)	1.963(1.81-2.12)
	2010	1.641(1.57-1.72)	1.979(1.97-1.99)	0.817(0.80-0.82)	2.72(2.41-2.92)	1.874(1.84-1.95)	2.343(2.23-2.44)
	2011	1.060(1.03-1.08)	1.234(1.20-1.26)	0.479(0.43-0.51)	2.21(2.20—2.23)	0.968(0.94-0.98)	1.01(1.004-1.012)
	2012	1.324(1.28-1.36)	0.713(0.66-0.75)	0.314(0.28-0.33)	2.98(2.87-3.12)	1.058(1.02-1.07)	0.892(0.74-0.96)
	2013	2.025(2.02-2.03)	0.825(0.80-0.84)	0.301(0.28-0.32)	4.083(4.03-4.11)	1.487(1.34-1.56)	1.742(1.66-1.89)
	2014	2.271(2.24-2.29)	1.056(1.03-1.07)	0.628(0.60-0.64)	3.538(3.31-3.76)	1.947(1.82-2.01)	2.904(2.80-2.98)

Table 6 shows regression estimates for Lilongwe and Salima districts. Results show that the incidence of diarrhoea has been increasing in both Lilongwe and Salima. Diarrhoea was negatively associated with rainfall in Lilongwe, but was positively related to rainfall in Salima. A one degree change in maximum temperature at lag of 1 was associated with a 2% increase in diarrhoea in Lilongwe and 12% increase in Salima. Similarly rainfall was negatively associated with malaria and malnutrition in Lilongwe. A unit increased change in rainfall was associated with about 1% reduction in malaria or malnutrition in Lilongwe. Current rainfall levels were associated with increased malnutrition in Salima, with a 0.1% increase for a 1 unit increase in rainfall. Minimum temperature at lag of 1 month was likely to increase malaria and malnutrition risk by 5% in Lilongwe, and 13% at lag 2 for malaria only in Lilongwe. The same margin of association of 5% was observed between minimum temperature and malnutrition in Salima. Maximum temperature at lag 1 was also associated with a 4.8% and 8.4% increase in malaria and malnutrition respectively.

Table 7: Composite change in mean annual temperature and rainfall by 2030 and 2050 in four districts in Malawi under A1B scenario, using 6 GCMs (CSM_98, ECH395, ECH498, GFDL90, HAD295, and HAD300).

Climatic variable	District	Expected Change in Year 2030	Expected Change in Year 2050
Temperature	Chikwawa	1.1	2.0
	Zomba	0.9	1.6
	Lilongwe	0.9	1.7
	Salima	0.9	1.7
Rain	Chikwawa	-1.4	-2.6
	Zomba	-0.4	-1.1
	Lilongwe	3.3	6.2
	Salima	3.3	6.2

Source: IGAD and ICPAC, 2007.

In summary, mean annual temperatures are expected to rise by 0.9 to 1.1 degree in 2030, and a further 1.6 to 2.0 degrees in 2050 (Table 4). Mean annual precipitation is projected to change by -1.4% to 3.3% in 2030, while in 2050 this will change by -2.2% to 6.2%. The respective expected changes in Lilongwe, Salima, Zomba and Chikwawa are presented in Table 5.

The rising temperatures are likely to create favourable conditions for quick maturing mosquitoes, and may lead to increased heat-related stress. Increasing rainfall in Salima and Lilongwe may lead to flooding, further creating a conducive environment for high transmission of disease pathogens. Reduced rains in the southern region may result in droughts and increased incidence of malnutrition. The projected scenarios of health-outcomes are estimated in the next season.

Figures 17 to 20 show the percentage change in disease incidence for each district under climate change scenario. Table 6 presents a summary of changes induced by each climatic variable and the overall change for all climatic variables.

Table 8: Disease incidence change in 2030 and 2050 based on projected climatic change

District		Diarrhoea		Malaria		Malnutrition	
		Year 2030	Year 2050	Year 2030	Year 2050	Year 2030	Year 2050
Salima	Rain	0.12	0.22	0.01	0.02	0.41	0.76
	Tmin	-9.71	-17.54	-4.20	-7.79	6.65	12.92
	Tmax	9.66	19.21	6.68	12.98	8.95	17.58
	Overall	-0.88	-1.67	2.14	4.02	14.34	25.45
Lilongwe	Rain	-0. 09	-0.17	-0.31	-0.58	-0.49	-0.92
	Tmin	1.29	2.46	6.69	13.02	4.85	9.36
	Tmax	2.21	4.20	-2.46	-4.53	-9.14	-16.57
	Overall	3.32	6.16	3.63	6.73	-5.47	-10.53
Zomba	Rain	-0.02	-0.04	0.01	0.003	-0.04	-0.12
	Tmin	-0.65	-1.14	-6.19	-10.74	-2.33	-4.09
	Tmax	4.04	7.29	2.91	5.24	0.97	1.74
	Overall	3.24	5.68	-3.58	-6.45	-1.44	-2.61
Chikwawa	Rain	-0.08	-0.16	-0.11	-0.18	0.03	0.06
	Tmin	0.41	0.75	-3.34	-5.96	3.50	6.46
	Tmax	0.03	6.24	-1.18	-2.14	-4.85	-8.65
	Overall	3.59	6.41	-4.76	-8.81	-1.51	-2.76

Figure 17 shows the projected change in diarrhoea, malaria and malnutrition for Salima district. The highest increase is estimated in malnutrition, projected at 14.3% in the year 2030 and 25.4% in 2050. Diarrhoea was estimated to decrease by 0.9% and 1.7% in 2030 and 2050 respectively.

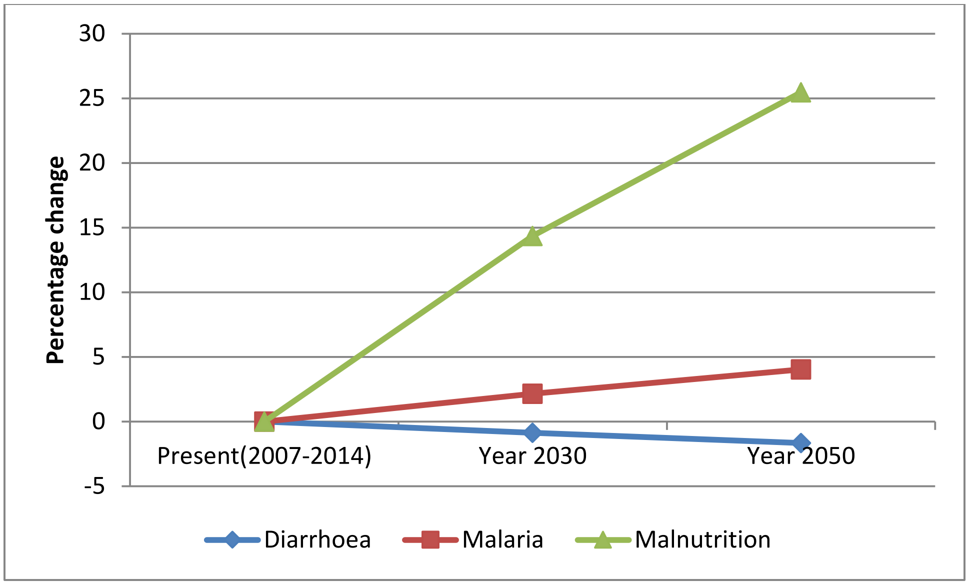

Figure 17:Projected change in diarrhoea, malaria and malnutrition in Salima district.

In Lilongwe, both diarrhoea and malaria are projected to increase (Figure 18). In 2030 diarrhoea increases by 3.32% in 2030 and 6.16% in 2050 while malaria increases by 3.36% and 6.73% in 2030 and 2050 respectively. Malnutrition will decrease by about 5% in 2030 and a further 6% in 2050. Figure 19 shows the anticipated change in Zomba district. Only diarrhoea is estimated to increase by 3.2 times in 2030 and 5.7 times and 2050 respectively compared to the present period (2007-2014). Future malaria incidence will decrease by about 4%, in 2030, and 6.5% in 2050, whereas malnutrition will decline by 1.4% and 2.6% in the two future projected periods.

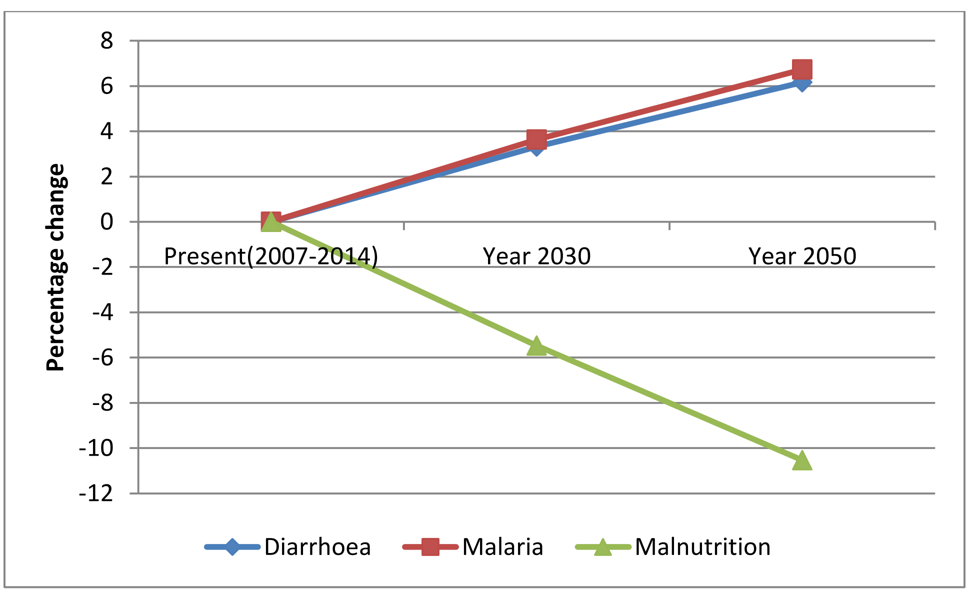

Figure 18: Projected change in diarrhoea, malaria and malnutrition in Lilongwe district

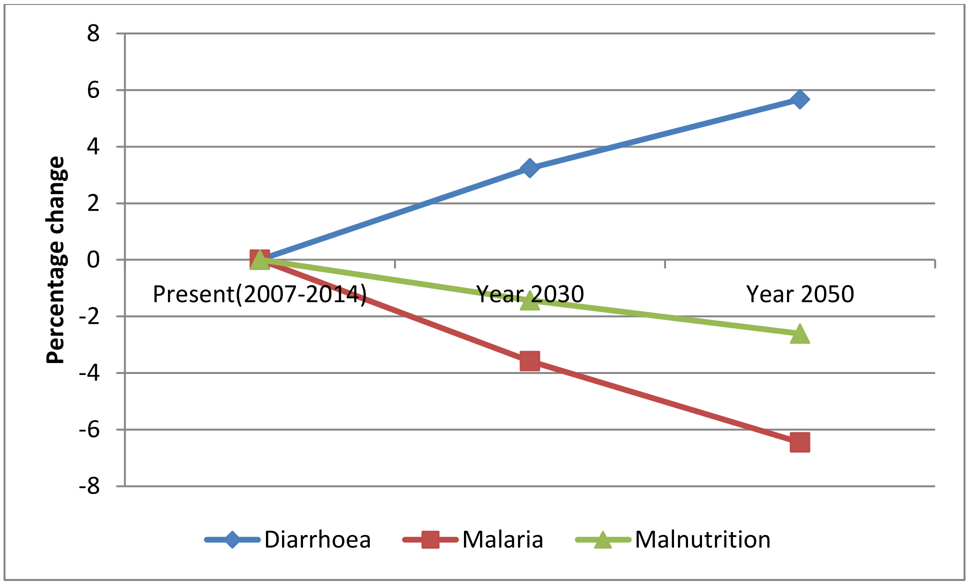

Figure 19: Projected change in diarrhoea, malaria and malnutrition in Zomba district

A similar pattern of change is projected for Chikwawa (Figure 20). Diarrhoea incidence will increase by 3.6% in 2030 and 6.4% in 2050. At the same time, malaria incidence will decrease by 4.8% and 8.8% in 2030 and 2050 respectively, while malnutrition will decrease by 1.5% and 2.8% for both 2030 and 2050 respectively.

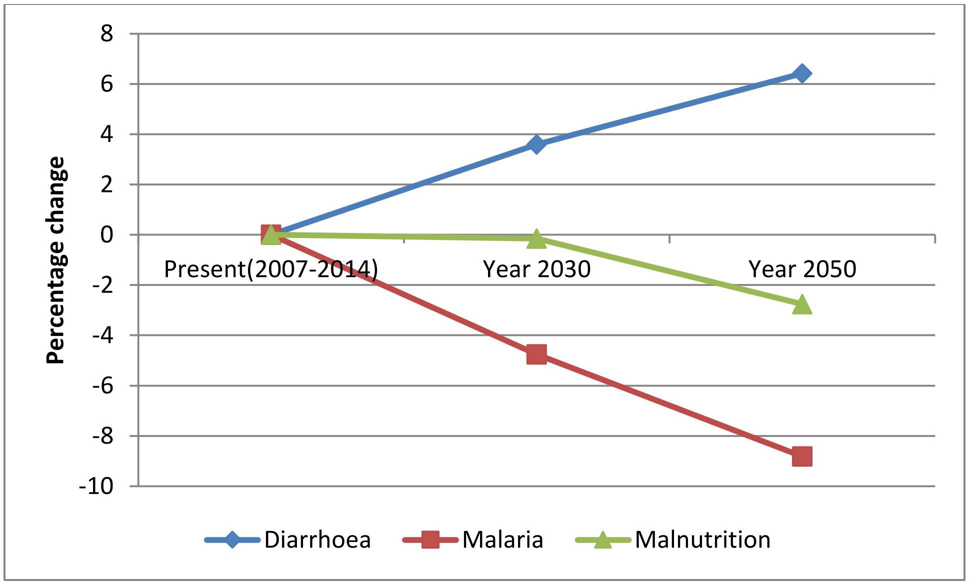

Figure 20:Projected change in diarrhoea, malaria and malnutrition in Chikwawa district

5.6 Indicators and Risk Factors for Tracking Climate Change Impacts on the Health Sector

Four key indicators were selected for use in monitoring and tracking climate change impacts on human health in Malawi, namely: number of cases of the key diseases and their spatial distribution, the frequency and magnitude of floods and droughts, and investment in capacity building, i.e., human, financial, and institutional. What is clear at the moment is that all the four districts are vulnerable to malaria, diarrhoea, and malnutrition. But although the information the number of cases of diseases is being collected and archived in the HMIS, there is at the moment no facility in the software to store spatial data of the same. However, it is envisaged that such a facility will be incorporated the new version of HMIS.

5.7 Identification of Information Gaps, Capacity Requirements, and Research Needs

Views on indigenous knowledge by the local communities on climate change and the causes of the three diseases and their mode of treatment were sought through stakeholder consultations. However, such information is only useful in the diagnosis of the diseases when they have already struck their victims. Therefore there is need to establish a link between LIKSP and science based evidence of climate change impacts and early warning systems. Also, there is very little coordination among organizations that deal with climate change issues in Malawi, more DoDMA, MAIWD, DCCMS, MoH, and various NGOs.

An assessment of the capacity of personnel in the Ministry of Health, local communities and various relevant institutions in addressing the impacts of climate change on human health shows serious shortfalls in trained personnel in the country to address climate change in knowledge, numbers and skills. Very few professionals are conversant with climate change science, vulnerability assessments, and adaptation to climate change.

Two research issues were identified by the study, namely: the need to replicate similar studies in all the remaining districts in Malawi, and the need to identify measures for boosting the country's capacity in implementing climate change related projects and climate change modelling. Additionally, there is need to do the following:

a) Assess current effectiveness of vector control measures;
b) Conduct studies of transmission dynamics, including reservoir host and vector ecology;
c) Develop risk maps of Vector Borne Diseases;
d) Improve epidemic forecasting; and
e) Research into improved treatment and diagnosis of vector-borne diseases.

5.8 Identification of potential adaptation strategies

A wide range of measures have been identified in the health sector to adapt to climate change impacts. Most of these build on well-established public health approaches and are therefore theoretically easy to implement. They include general measures such as:

a) Strengthening effective surveillance and prevention programmes;
b) Sharing lessons learned across countries and sectors;
c) Introducing new prevention measures or increasing existing measures;
d) Developing new policies to address new threats;

e) Institutional mechanisms, including early-warning systems and emergency planning / disaster preparedness schemes, training, communication, monitoring and surveillance, and research;
f) Public education and awareness;
g) Disaster preparedness, including health system surge capacity;
h) Enhanced disease control programme; and
i) Appropriate workforce training and mid-career development

As highlighted in the preceding discussion, Malawi's NAPA (GoM, 2006) mentions three key climate change related diseases, namely: the prevalence of malaria, diarrheal diseases, and chronic malnutrition. Adaptation measures for malaria include use of insecticide-treated nets (ITNs), application of mosquito repellents (including indigenous technologies such as use of blue gum leaves), and draining puddles and ponds containing stagnant water with a view to destroying mosquito breeding areas. At the moment, government programmes such as National Malaria Control Programme (NMCP) and subsidised ITNs for pregnant women and children are helping in combating malaria. Other government programmes involve spraying insecticides in the cities of Blantyre and Lilongwe to kill mosquitos.

Adaptation measures applied by households (HH) for combating diarrheal diseases include boiling and filtering drinking water, chlorination (using Water Guard), and improved hygiene and sanitation. The government offers preventive and curative interventions in addition to public awareness campaigns for diarrheal diseases.

In times of food shortages, households cope by engaging in casual labour in order to boost income for buying food. Other strategies include crop diversification, growing of drought resistant varieties, and practicing irrigated agriculture.

The main thrust of the National Adaptation Plan (NAP) for Malawi in the health sector is to improve disease control systems. Human health is paramount to achieving food and income security and household and national level. Thus, it is envisaged that the actions in this area will decelerate incidences of diseases thereby ensuring an active and healthy community which can effectively contribute to all the sectors outlined above. Key actions include: building capacity in disease prevention and control at community and national levels; and intensifying nutritional and food security education at community level.

Malawi's intended nationally determined contributions (INDCs) in the health sector include the following actions:

a) Improved access to ITN, food, and water and sanitation facilities;
b) Improved access to hospital/health centres within a recommended walking distance of 5 km;
c) Public education and awareness; and

Enhanced capacity at all health centres through training of personnel and provision of resources.

Potential Adaptation Strategies were identified through literature review, stakeholder consultations, and field visits through focus group discussions and key informant interviews

5.9 Monitoring and Evaluation

Monitoring and evaluation of government projects and programmes is the responsibility of the Ministry of Finance, Economic Planning and Development. Although obvious indicators for monitoring impacts of climate change are cases of disease outbreaks and the frequency and magnitude of floods and droughts, it is envisaged that the ministry may use additional indicators and risk factors to consider for monitoring impacts of climate change on human health in Malawi. Risk factors might include the non-availability of drugs for treating the various diseases highlighted in the preceding discussion as well as Malawi's weak economy leading to low adaptive capacity. Additionally, indicators being used in other sectors such as agriculture, forestry and metrological services will be reviewed and where necessary, new indicators identified through this process, will be incorporated to allow for comprehensive tracking of climate change impacts.

6.0 DISCUSSION OF RESULTS

The study has shown that malaria, diarrhoea, and malnutrition continue to be a major public health problem in Malawi as stated in the NAPA; notwithstanding commendable government effort to reduce the disease burden. However, it is worth noting that although the climatic data (i.e., temperature and rainfall) for the selected districts span over a number of years (e.g. from as early as the 1890s), the disease data used in the correlation analysis were for the period 2004 to present. Thus, it was not possible to gain insight into the trend of the diseases over a long period of time, a constraint which may have masked some critical observations about the history of the diseases in the country. This was so because the HMIS only came into existence in 2004. However, it is clear from the graphs of climate variables plotted against the number of cases of diseases that the three climate related diseases exhibit seasonality.

The analysis has shown that the MoH has inadequate capacity in the following areas: management of the three climate change related diseases, climate change science and related issues, availability of financial resources, and the instructional arrangement. Therefore there is need to build capacity in the MoH in the areas highlighted above if the deleterious impacts of climate change on human health are going to be avoided.

In the assessment of the vulnerability of the health sector to climate change, the study relied on the use of climate scenarios obtained from GCMs. While these data are very useful, their area of coverage are generally large. But now that downscaled GCMs are gaining prominence in climate change studies, it may be necessary to conduct similar studies in future using downscaled model results for temperature and rainfall. Also, it is critical that the HMIS incorporates a routine for manipulating spatial data for ease of depicting the spatial distribution of the disease, without necessary using a separate GIS software.

Although the number of cases of diseases and the frequency and magnitude of the occurrence of floods and droughts have been selected as obvious indicators for monitoring impacts of climate change on human health, it is envisaged that the ministry may use additional indicators and risk factors it may deem critical for monitoring the performance of health related projects.

7.0 CONCLUSION

Information obtained from literature review and stakeholder shows that malaria, diarrhoeal diseases, and malnutrition are among main causes of death in Malawi. In this regard, changes in climatic patterns such as increases in temperature, floods and droughts are expected to exacerbate the situation. Adaptation measures for malaria include use of insecticide-treated nets (ITNs) and mosquito repellents. Adaptation measures for diarrhoea include boiling of drinking water or filtration and chlorination (using Water Guard), and personal hygiene. Adaptation measures for malnutrition include: incoming generation for casual labour, crop diversification, growing of drought resistant varieties, winter cropping and irrigation farming to enhance climate change resilience and food security at household level.

The study has shown that there is inadequate capacity in the MoH to manage key climate change related diseases as well as ability to apply early warning systems for the prediction of the diseases. For example, DHOs indicated that their frontline staff (health Surveillance Assistants) have never had training in climate change science and related issues. Further, it was reported that the ministry does not have adequate financial and human resources to manage the three climate related diseases mentioned above.

Under climate change scenario, mean annual temperatures in Malawi are expected to rise by 0.9 to 1.1 degree in 2030, and a further 1.6 to 2.0 degrees in 2050. Mean annual precipitation is projected to change by -1.4% to 3.3% in 2030, while in 2050 this will change by -2.2% to 6.2%.

Vulnerability assessment results show that the incidence of diarrhoea has been increasing in both Lilongwe and Salima. Diarrhoea was negatively associated with rainfall in Lilongwe, but was positively related to rainfall in Salima. Current rainfall levels were associated with increased malnutrition in Salima, with a 0.1% increase for a 1 unit increase in rainfall. Minimum temperature at lag of 1 month was likely to increase malaria and malnutrition risk by 5% in Lilongwe, and 13% at lag 2 for malaria only in Lilongwe. The same margin of association of 5% was observed between minimum temperature and malnutrition in Salima. Maximum temperature at lag 1 was also associated with a 4.8% and 8.4% increase in malaria and malnutrition respectively.

In Lilongwe, both diarrhoea and malaria are projected to increase. In 2030 diarrhoea increases by 3.32% in 2030 and 6.16% in 2050 while malaria increases by 3.36% and 6.73% in 2030 and 2050 respectively. Malnutrition will decrease by about 5% in 2030 and a further 6% in 2050. Only diarrhoea is estimated to increase by 3.2 times in 2030 and 5.7 times and 2050 respectively compared to the present period (2007-2014). Future malaria incidence will decrease by about 4%, in 2030, and 6.5% in 2050, whereas malnutrition will decline by 1.4% and 2.6% in the two future projected periods.

In Chikwawa, diarrhoea incidence will increase by 3.6% in 2030 and 6.4% in 2050. At the same time, malaria incidence will decrease by 4.8% and 8.8% in 2030 and 2050 respectively, while malnutrition will decrease by 1.5% and 2.8% for both 2030 and 2050 respectively.

Four key indicators were selected for use in monitoring and tracking climate change impacts on human health in Malawi, namely: number of cases of the key diseases and their spatial distribution, the frequency and magnitude of floods and droughts, and investment in capacity building, i.e., human, financial, and institutional.

Also, the report has covered issues about information gaps and the need for improved coordination among various organizations that deal with climate change issues in Malawi, the need to address capacity building (human, financial and institutional) in the Ministry of Health, and critical areas of research.

Adaptation strategies for the health sector for the three key diseases have been spelt in the NAPA, NAP, and INDC.

8.0 RECOMMENDATIONS

The following recommendations need urgent attention by the Ministry of Health:

1. Build the capacity in climate change science and related issues in all cadres of staff, i.e., from HSAs to professional staff;
2. Improve coordination with relevant organizations that deal with climate change issues in Malawi;
3. Mainstream climate change in all health planning; and
4. Enhance research in climate change and health.

REFERENCES

1. Action Aid, 2006, Climate Change and Smallholder Farmers in Malawi, Malawi
2. Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, (2007). Africa. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.
3. Chavula G, Chirwa A, 1996, Impacts of climate change on water resources of Malawi, paper presented at the 1996 RPC conference held at Sun and Sand Holiday Resort in Mangochi, Malawi.
4. Eastman J.R., Ayamba A., and Ramachandran M., 1996, The spatial manifestation of ENSO warm phase events in southern Africa, paper presented at the Conference on the Application of Remotely Sensed Data and Geographic Information System (GIS) in Environmental and Natural Resources Assessment in Africa, held in Harare, Zimbabwe, March 15-22, 1996.
5. Epstein, P R (2002). *Climate Change and Infectious Disease: Stormy Weather Ahead?* Epidemiology, July 2002, Vol.13 No. 4.
6. Government of Malawi, 1998, State of the environment report, Malawi
7. Government of Malawi, 2002, Initial National Communication, Malawi
8. Government of Malawi, 2006, National Adaptation Programmes of Action, Malawi
9. Government of Malawi, 2010, Malawi State of Environment and Outlook Report, Malawi
10. Government of Malawi, 2011a, Malawi Health Sector Strategic Plan: moving towards equity and quality, Malawi
11. Government of Malawi, 2011b, Malawi Health Sector Strategic Plan 2011-2016, Malawi
12. Government of Malawi, 2011c, Second National Communication, Malawi
13. Government of Malawi, 2013, National Disaster Risk Management Policy, Malawi
14. Government of Malawi, 2015, Decentralized Early Warning Systems for Malawi, Malawi
15. IPCC (2007a). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning,Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
16. IPCC (2007b). *Climate change 2007: Synthesis Report, Contribution to Fourth Assessment Report*, www.ipcc.ch/meetings/AR4-workshops/uncertainty-guidance-note.pdf
17. Johnson, R. A., and Wichern, D. W. (1998), *Applied Multivariate Statistical Analysis* (4th ed.), Upper Saddle River, NJ: Prentice Hall.
18. Luber George, 2011, Climate change adaptation in the health sector: the BRACE Framework, CDC, USA.
19. McSweeney, C., New, M. and Lizcano, G., 2008, UNDP Climate Change Country Profiles: Malawi, Oxford University, UK.
20. Oxfam, 2009, Winds of change: climate change, poverty, and the environment in Malawi, Malawi

21. Smith, J B (2001). A Summary of Climate Impact Assessments from US Country Studies Program, Climate Change, Springer, Netherland.
22. Tadross M., Suarez P., Lotsch A., Hachigonta S., Mdoka M., Unganai L., Lucio F., Kamdonyo D., Muchinda M. (2009) Growing-season rainfall and scenarios of future change in southeast Africa: implications for cultivating maize. Climate Research. Vol. 40. 147-161. DOI: 10.3354/cr00821
23. WHO, 2013, Protecting health from climate change: vulnerability and adaptation assessment, Switzerland
24. WMO, 2003, Health and environmental change, Canada

APPENDIX

Appendix 1: Questionnaire

University of Malawi - The Polytechnic

Assessment of Vulnerability of the Health Sector in Malawi to the Impacts of Climate Change and Climate Variability

LOCAL INDIGENOUS KNOWLEDGE SYSTEMS AND PRACTICES (LIKSP)

WHO/ MINISTRY OF HEALTH STUDY

Local Indigenous Knowledge Systems and Practices in this particular case, refer to the traditional or local knowledge in terms of the knowledge in general and storage/protection, knowledge dissemination/transfer, technologies applied, innovative materials and delivery of such to predict weather and climate and associated impacts, prevent/avoid negative impacts as well as diagnose, prevent and or/cure diseases such as malaria, cholera, dysentery and malnutrition.

PART 1: PERSONAL DATA

1. Name of the respondent/ Group: ___________________________________
2. Name of the institution/ Village : ___________________________________
3. Contact Person:____
4. Contact details
    a. Phone : ____
    b. Email : ____

PART 2: INDIGENOUS KNOWLEDGE RELATED TO WEATHER AND CLIMATE

5. Have you heard of "climate change"?_____________________________
   (Kodi munamvapo za "kusintha kwa nyengo"?)
6. What do you know about it?_____________________________________
   (Tatilongotselereni zimene munamvapo)
7. How do local people predict weather in terms of short duration ambient condition such as :
   (Kodi mumalosela bwanji za nyengo kuti):
   a. Windy (mphepo ya mkuntho):____
   b. Rainy (mvula):____

c. Hot (kutentha):____

d. Cold (kuzizila):____

e. Drought (Chilala):____

8. How do local people predict whether the following season will have rainfall in plenty or in deficit?
   Kodi mumadziwa bwanji kuti chaka cha mawa mvula igwa yambiri kapena yochepa?
   ____
   ____

9. Are the local people able to predict floods?
   Mumatha kulosela kuti kukhala madzi osefukila?
   If yes, how?____
   Mumadziwa bwanji?
   ____

10. Are there local ways of influencing the onset of rains? If yes, explain
    Pali njira zina zomwe mupanga/kugwiritsa ntchito poyitana kapena kumanga mvula? Ngati zilipo fotokozani?
    ____
    ____
    ____

11. In your view, do you think the climate pattern has changed over the past years?
    Mukuona ngati nyengo zasintha ndi m’mene zinalili kale?
    ____
    ____

12. If yes, what changes have taken place? Tick all that apply
    (Ndichiyani chimene chasintha?)

Less rainfall	:	____________
Erratic rainfall	:	____________
Frequent droughts	:	____________
Too much rainfall	:	____________
Frequent floods	:	____________
Delayed onset of rains	:	____________

13. If yes, what do you think has caused the change?
    Ngati mwaona kusintha, chadzetsa kusintha kwa nyengo kumeneku ndi chani?

____
____

14. How do people cope in times of food shortages? - Tick all that apply
    (Kodi anthu amapeza bwanji chakudya nthawi ya njala?)
    Help from relatives around (achibale konkuno) : ____________
    Help from relatives working elsewhere (achibale akutauni) : ____________

Help from the Government (aboma) : ___________
Help from NGOs (Mabungwe) : ___________
Piece work (Ganyu) : ___________

15. Are there any traditional foods that are resistant to droughts that could be used in times of food shortages? List them. (Kodi pali mbewu/zomela za makolo zimene mumadya nthawi ya njala? Ndizomela ngati ziti?
____

16. What are their main sources of drinking water? (Madzi okumwa mumatunga kuti?)
____

17. How do you ensure drinking water is safe? (Mumasamala bwanji kuti madzi akhale aukhondo nthawi zonse?)
____

18. Have you ever taken, or do you regularly take, any action out of concern for climate change? (Kodi mumatenganawo mbali ku nkhani ya kusintha kwa nyengo?) (probe each member)

____

PART 3: INDIGENOUS KNOWLEDGE RELATED TO DISEASES

19. What diseases do you expect in the following seasons:
ndimatenda anji mumakumana nawo munyengo izi;

a) rainy season dzinja)____
b) dry season (chilimwe)____
c) cold season (chisanu)____

20. Do you think there are some diseases which have come/increased/decreased because of changes in weather pattern?
Alipo matenda amene mukuona ngati adza chifukwa cha kusintha kwa nyengo?
____
____

21. Can you describe your overall harvest over the past years?
Mungafotokoze kuti zokolola zanu zakhala zikuyenda bwanji (probe; kutsika, kukwera kapena chimodzimodzi)
____
____

22. Do you think climate change has played a major role in the process? If yes please explain?
Ngati pali kusintha kwa nyengo, mukuona ngati kwatengapo mbali yanji?
____
____
____

23. How do you diagnose the following diseases or conditions:
Kodi mumadziwa bwanji kuti matendawa ndi;

Disease/ condition	Vernacular name for the disease	Causes (zoyambitsa matenda)	Diagnosis (mumadziwa bwanji/ zizindikilo)
Malaria	(malungo)		
Cholera	Kolera		
Dysentery	(kamwadzi)		
Malnutrition	(kuperewera kwa zakudya mthupi)		

24. Are there preventive and curative prescriptions for the above conditions/ diseases? If yes, explain.
Pali njira zopewera kapena zochizira matendawa. Ngati zilipo, fotokozani?

Disease/ condition	Preventive prescription (njira zopewera)	Curative prescription (njira zochizira)
Malaria		
Cholera		
Dysentery		
Malnutrition		

PART 4: INDIGENOUS KNOWLEDGE MANAGEMENT

25. Who is the custodian of traditional/ indigenous knowledge on climate change?
Kodi ndi ndani amene amaonetsetsa kuti njira zimene makolo amapanga/kugwiritsa polosela nyengo kapena, kupewa/kuchiza matenda kuti zisungidwe (m'badwa wamtsogolo kuti udzaziwe)?

____

26. How is this knowledge shared?
Kodi nzeru za makolo mumazigawa bwanji ndi m'badwa watsopano?

____

27. How do you ensure that this knowledge is preserved for posterity?

Kodi mumaonetsetsa bwanji kuti nzeru zamakolozi zisungidwa bwino komanso kutetezedwa kuti m'badwa wa wamtsogolo uzapindule nawo.

---

28. Do you belong to any group or association that ensures conformance to standards (such as disaster management committee, agroforestry committee)?
    If yes, name the association or grouping.
    Kodi muli mu gulu kapena bungwe lina lililonse lomwe limaonetsetsa zakusintha kwa nyengo?
    29. Do you think climate change is something that is affecting or is going to affect you, personally?
        Kodi kusintha kwa nyengo kwakukhuzani bwanji pa inu nokha?
        Kodi mukuona kuti kusintha kwa nyengo kuzakukhuzani bwanji kutsogoloku pa inu nokha?

    ____

PART 5: CONCLUSION

30. Do you have any questions or comments which you would like to ask or share with the interviewing team?
    Muli ndi mafunso kapena ndemanga yina yiliyonse pa zomwe takambiranazi?

    ____
    ____
    ____

Thank you very much.