Climate change health, agriculture and disasters analysis in Mozambique:

CDKN Project Reference TAAF-0029b

Kulima Integrated Development Solutions, CSIR and University Eduardo Mondlane

List of Acronyms

ACCRA	African Climate Change Resilience Network
ADPP	*Ajuda de Desenvolvimento de Povo para o Povo* (Development Aid from People to People)
AR4	Assessment Report 4
ARA	Regional Water Administration (Mozambique)
BES	*Boletins Epidemiológicos Semanais* (Bulletin for Epidemiological Survey)
BE-PS	*Boletins Epidemiológicos Postos Sentinela* (Bulletin for Epidemiological Survey in Sentinel Post)
CB-DOTS	Community-based directly observed therapy for short course
CBO	Community-based Organisation
CDKN	Climate & Development Knowledge Network
CENOE	National Operative Centre of Emergency (Mozambique)
CERUM	Centres of Multiple Use
CGCMs	Coupled General Circulation Models
CHASS	Clinical HIV and Aids Strengthening System
CLACC	Capacity Strengthening in the Least Developed Countries for Adaptation to Climate Change
CSAG	Climate Systems Analysis Group
CSIR	Council for Scientific and Industrial Research (South Africa)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSOs	Civil Society Organisations
CTV	*Centro Terra Viva*
CVM	Mozambican Red Cross
DNA	National Directorate of Water (Mozambique)
DfID	Department for International Development (United Kingdom)
DoE	Department of Epidemiology of MISAU
EADS	Environmental Strategy for Sustainable Development
EIA	Environmental Impact Assessment
ENAMMC	*Estratégia Nacional de Adaptação e Mitigação das Mudanças Climáticas* (National Climate Change Strategy)
ENARC	*Estratégia Nacional para a Redução do Risco de Desastres e de Adaptação às Mudanças Climáticas* (National Strategy for Disaster Risk Reduction and Climate Change Adaptation)
ENSO	El Nino Southern Oscillation
ESAN	*Estrategia de Segurança Alimentar e Nutricional* (Food Security and Nutrition Strategy)
EWS	Early Warning System
FEWSNET	Famine Early Warning Systems Network
FHI360	Family Health International
GIS	Geographical Information System
HIA	Health Impact Assessment
HIS	Health Information System
ICT	Information and Communications Technology
IIAM	*Instituto de Investigação Agrária de Moçambique* (Agricultural Research Inistitute)
INAM	*Instituto Nacional de Meteorologia* (National Meteorology Institute)
INE	*Instituto Nacionel de Estatistica* (National Statistics Institute)
INGC	*Instituto Nacional de Gestão das Calamidades* (National Disaster Management Institute)
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature

LDC	Least Developed Countries
MCT	Ministry of Science and Technology (Mozambique)
MDG	Millennium Development Goals
MICOA	Ministry for the Coordination of Environmental Action (Mozambique)
MICS	Multiple Indicators for Cluster Survey
MINAG	Ministry of Agriculture
MoPH	Ministry of Public Works and Housing (Mozambique)
MISAU	*Ministerio da Saude* (Ministry of Health)
MPD	Ministry of Planning and Development (Mozambique)
NAPA	National Adaptation Programme of Action
NED	*Núcleo de Estatísticas Distritais* (Center for District Statistics)
NEPAD	New Partnership for Africa's Development
NGOs	Non-Governmental Organisations
NIH	National Institute for Health (Mozambique)
PARPA	*Plano de Acção para a Redução da Pobreza Absoluta* (Poverty Reduction Strategy)
PESS	*Plano Estratégico do Sector Saúde* (Health Sector Strategy)
NIMR	National Institute for Medical Research (Tanzania)
PIDOM	Housing internal pulverization for Malaria Control
PNCM	*Programa nacional de controlo da malaria* (National Programme for Malaria Control)
PPCR	Pilot Program for Climate Resilience
REDD	Reducing Emissions from Deforestation and Forest Degradation
RVE	*Responsável provincial pela vigilância epidemiológica* (Provincial Surveillance System Officer)
SADC	Southern African Development Community
SAN	Food and Nutritional Security
SETSAN	Technical Secretariat for Food and Nutritional Security (Mozambique)
SRES	Special Report on Emissions Scenarios
TB	Tuberculosis
TCE	Total Control Epidemics
UNDP	United Nations Development Programme
UEM	*Universidade Eduardo Mondlane*
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United nations Childrens Fund
VAC	Vulnerability Assessment Committee
WFP	World Food Programme
WHO	World Health Organisation
WP	Work Package for CDKN Mozambique project
WWF	World Wide Fund for Nature

Table of Contents

1. Introduction

Due to both extreme events of climate (droughts, cyclones, and floods) and food insecurity, diarrheal diseases, and vector-borne diseases are very common in Mozambique. For example, between 1980 and 2008, there occurred 103,347 deaths attributed to droughts, floods and storms, and epidemics (Van Hasselt and Chapman, 2010). In combination with exposure to climate factors, poverty, inadequate housing and limited access to prevention measures are drivers of vulnerability which also contribute to the high prevalence of these diseases (MISAU, 2012a).

The Intergovernmental Panel on Climate Change (IPCC) concluded with high confidence that human health could be further negatively impacted by climate change and climate variability, making special mention of malaria in southern Africa (Boko et al, 2007). The area of malaria endemism is likely to expand as a consequence of the predicted increase in temperature. During the wet season, a combination of high temperature and humidity will facilitate the multiplication and spread of mosquito species, including the female of *Anopheles funestus* and *gambiae*, which spread malaria. Furthermore, the predicted reduction in rainfall will result in low crop yields, leading to limited access to food of adequate quantity, quality and diversity.

Future changes will be manifest not only through incremental changes in temperature and rainfall, but also in the extreme events to which Mozambique is exposed, namely floods and cyclones. The IPCC has concluded that extreme events may increase in magnitude (IPCC, 2012). More frequent floods and cyclones also result in crop losses, particularly along the main river basins and coastal areas, respectively. The consequence is malnutrition and heightened vulnerability of people to other diseases.

Water-borne diseases such as cholera and dysentery will also likely be affected by climate change. Low rainfall will also result in limited availability of water, including for basic personal hygiene. As a consequence there will be an increase in cholera and diarrhea outbreaks even during periods of drought. On the other hand, the predicted floods during the wet season will also increase the frequency of cholera cases due to contamination of drinking water and deterioration of sanitary facilities (Watkiss and Hunt, *no date*).

Kulima Integrated Development Solutions, in conjunction with the Council for Scientific and Industrial Research (CSIR) in South Africa and Universidade Eduardo Mondlane, in Mozambique, undertook a project on climate change health, agriculture and disasters analysis in Mozambique funded by CDKN at the request of the government of Mozambique. The project was divided into three work packages and a report for each of these work packages was submitted. The current final report represents a synthesis of the previously submitted work package reports and largely follows the same structure as these.

Work Package 1 was made up of four deliverables:

1.1 Stakeholder map (government and non-government in Mozambique)
1.2 Analysis of existing relevant projects and availability of relevant data
1.3 Evidence for good practice on climate change and health in other countries
1.4 Establishment and initial meeting of a multi-stakeholder steering committee

Section two of this report introduces the background and rationale for the project. Section three provides a stakeholder map of current government and non-government initiatives in Mozambique that are of relevance to this project. Section four elaborates on the stakeholder map by illustrating relevant projects that have been undertaken by stakeholders, whilst paying particular attention to the availability of relevant data for use in work packages two and three. Section five provides an overview of good practice on climate change and health in other countries, interrogating good practice and lessons that are applicable to the Mozambican context. Section six reports on the establishment and initial meeting of a multi-stakeholder steering committee, comprising representatives of the Mozambican government, who oversaw this project.

Given the likely implications of climate change and disasters for health, Work Package 2 had two main objectives: to analyze the spatial distribution of the prevalence of major health conditions and diseases across the country, and to conduct two high resolution case studies of the interaction between climate change and health in Mozambique, particularly in Macossa and Machaze (in Manica province) and in Memba and Nampula City (in Nampula province).

The specific four deliverables for Work Package 2 were:

2.1 Analysis of spatial prevalence of major health conditions;
2.2 Downscaled climate projections;
2.3 Analysis of risks of future climate change to human health through expert judgment;
2.4 High resolution case studies of health impacts from climate change in Machaze and Macossa districts of Manica province and Memba and Nampula City of Nampula province.

Section seven of the current report provides the methodology adopted for Work Package 2. Section eight reviews the existing sources of information on health conditions prevalent in Mozambique, and in particular focuses on their theoretical linkages to climate parameters. Section nine highlights downscaled climate projections for Mozambique and identifies insights from the expert judgment workshop on priority future risks. Section ten presents the high resolution case studies of health impacts from climate change in the two districts each in Manica and Nampula provinces.

The final section of work - Work Package 3 - had three main objectives:

- To review good practices from other countries in developing policy responses to improve human health under climate change
- To assess entry points and opportunities for the inclusion of climate change and health considerations in major Mozambican development plans, strategies and policies, based on screening of Agenda 2025, the Poverty Reduction Strategy 2010-14 (*Plano de Acção para a Redução da Pobreza Absoluta*, PARPA), the Environmental Strategy for Sustainable Development (EADS) the Health Sector Strategy (*Moçambique Plano Estratégico do Sector Saúde* (PESS) 2007-2012), the recently-released National Climate Change Strategy (*Estratégia Nacional de Adaptação e Mitigação das Mudanças Climáticas*, ENAMMC 2013-2025) and the National Policy on Disaster Management (and proposed National Strategy on Disaster Risk Reduction and Climate Change Adaptation).
- To provide recommendations, building on the outputs of WP1, 2 and 3, on ways forward for Mozambique.

In order to fulfil the above objectives, section eleven provides a review of good practices from other countries in developing policy responses to improve human health under climate change. Section twelve takes each of the key development plans, policies and strategies in turn, screening them for climate change and health impacts, and assessing entry points and opportunities to address these risks. Section thirteen details recommendations and next steps for Mozambique.

2. Background and Rationale

Mozambique's geographical location in southeastern Africa, in the Intertropical Convergence Zone, means that it is exposed to a number of climate hazards – including droughts, floods and cyclones, as well as incremental climate change. Temperature increases of up to $3^{O}C$ are projected, as is an increase in average rainfall, although water availability is likely to decrease due to higher evapotranspiration (INGC, 2009). Droughts currently occur every 3 to 4 years, and the country has areas that are classified as semi-arid and arid where rain—even when above average—is inadequate, resulting in critical water shortage and limited agriculture productivity.
Currently 60% of the population is coastal, and sea level is projected to rise by between 30 and 500cm by 2100, depending on the scenario and model used. Although the high level of uncertainty means tropical cyclones are difficult to project into the future, the trends over the past 30 years show that cyclones have expanded their geographical range southwards. Additionally they have become more intense and, partly as a result of increasing exposure of coastal populations, have had increasingly adverse impacts in terms of deaths and damage to infrastructure (INGC, 2009). The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation confirms that increasing intensity and wind speeds of tropical cyclones is likely to continue (IPCC, 2011). As well as in relation to cyclones, Mozambique experiences regular flooding as a result of being the most downstream country in a number of major river basins, including the Limpopo and Zambezi.

Climate change adds an additional stress to the development context in Mozambique, and threatens to undermine achievements made to date. The country is classified as Least Developed (LDC), and although its human development index has been improving in real terms, it is still ranked 184^{th} worldwide on the scale of development (UNDP, 2011). Major health issues in the country include malnutrition, HIV and TB, and water- and vector-borne diseases (e.g. cholera and malaria). Addressing these are the three Millennium Development Goals; number 1 – eradicate extreme poverty and hunger; number 5 – improve maternal health; and number 6 – combat HIV/AIDS, malaria and other diseases. A 2010 review of progress towards these goals shows that the chances of meeting the various sub-indicators at the moment is only "potential", with the exception of halting the growth in malaria by 2016, which is "probable" (Republic of Mozambique, 2010). Climate change threatens actual and potential progress in all of these. Similarly, processes of development, which often mean urbanisation and moving towards cities at the coasts, can increase the exposure to climate hazards. Climate change is also associated with the deterioration of human health because it increases the incidence of malaria, cholera and other diseases related to the prevailing environmental conditions.

Improving the health status in Mozambique and addressing climate change are both enshrined in a number of overarching government development strategies, including the Poverty Reduction

Strategy III, 2010-2014 (*Plano de Acção para a Redução da Pobreza Absoluta*, PARPA) and the Agenda 20/25 (which in turn filters into Strategic District Development Plans). As with many climate change-related issues, direct responsibility for climate change and health rests with several line ministries. The Ministry for the Coordination of Environmental Affairs (MICOA) is the Designated Lead Authority on climate change under the United Nations Framework Convention on Climate Change (UNFCCC), and has responsibility for in-country coordination. The National Disaster Management Institute (INGC) takes the lead on disaster preparedness and response, working through its provincial delegations and in close cooperation with the National Operations Centre (CENOE). Its work is informed by the National Disaster Management Strategy. The Ministry of Health (MISAU) takes the lead on health issues. Its work is governed by the Health Strategy (*Moçambique Plano Estratégico do Sector Saúde* (PESS) 2007-2012). The Food Security Technical Secretariat (SETSAN) works to achieve the Second Food and Nutritional Strategy (*Estrategia de Segurança Alimentar e Nutricional*, ESAN II).

However, all are currently impeded in their ability to address climate change and health issues by the lack of an evidence base to inform policy and practice.

The health impacts of climate change in Mozambique have been understudied to date. The National Communication to the UNFCCC and the National Adaptation Programme of Action recognise that climate change will bring about health impacts, but do not elaborate on the nature and distribution of these impacts. Similarly, INGC published a report in 2009 investigating the effects of climate change on disaster risk in the country, highlighting growing risk, but not elaborating on the specific risks throughout the country. At the same time, there is an increasing call for health policy to be informed by research findings (Whitworth, 2006). As a result, the aim of this project is to "Develop a preliminary, Mozambique context specific assessment (based on case studies) which researches, derives and recommends the basis for determining climate change responses that will build resilience to climate change in a way that will be likely to result in outcomes that will improve human health under the projected climate changes, including reductions in disaster impacts on human health".

3. Stakeholder Map

Mozambique has a wide variety of government and non-government actors working in the field of climate change. This section lists these stakeholders, including their contact details and projects/programmes with which they are concerned. Further information on these projects is found in section four.

Institution or Organization	Areas of interest in climate events				Address, Telephone, website, officers (name and e-mail)
	Political dimensions (or institutional commitment)	**Agriculture dimensions**	**Public health dimensions**	**Disasters Management (preparedness and response)**	
MICOA Ministry for the Coordination Of Environmental Affairs	(a) Coordination of environmental affairs (b) Development of several policies and strategies: (1) Environmental legislation, (2) National Action Plan (NAPA) for climate change		Joining steering committee for SANA outcomes (action plan) of Libreville Declaration	Act as guardian of protection and prevention of environment and environmental resources; Joining technical teams (CVM, INGC, MISAU) in disasters management and health issues in refugees camps.	Av. Kassuende 167, Maputo, +258 21 49 2403. www.convambientais.gov.mz or www.legisambiente.gov.mz Officer: Eduardo Baixo ebaixo@hotmail.com
MTC/INAM Ministry of Transportation and Communications National Meteorological Institute	(1) Coordination of meteorological issues; (2) Capacity building in meteorological issues	(a) Exploring climatology and agro meteorology issues; (b) Research on climate change impact on agriculture: (1) Rainfall as ENSO phenomena, (2) Organization of Crop Calendar based on patterns of probability of occurrences of dry and wet spells and growing degree-days		i) Forecasting, monitoring and evaluation climatic issues; ii) Alert and early warning system; Research on CC: (1) The role of INAM in drought/desertification mitigation, (2) Satellite imagery in drought mapping and monitoring, (3) comparison between natural water resources and poverty in Mozambique	Av. Mukumbura 164, Maputo, +258 21 49 11 50 www.inam.gov.mz or http://www.meteo.inam.gov.mz Dr Atanasio Manhique, Deputy Director atanasio_m@inam.gov.mz

MINEC/INGC Ministry of Foreign Affairs and Cooperation National Institute for Disaster Management	State parastatal with responsibility for disaster management			Disaster management and coordination of prevention, rescue victims of disasters and rehabilitation of affected infrastructures	Rua Resistência XX, Maputo Director - João Ribeiro +258 823222400 ingc@ingc.gov.mz
MISAU/DSA Ministry of Health Department of Environmental Health	Development of strategies addressing prevention of water/food borne diseases, sanitation and air/soil pollutants		Surveillance of environment determinants of public health; Provision of preventative and promotional health services Monitoring and evaluation	Joining technical teams (CVM, INGC, other stakeholders) in disasters management and health issues in refugees camps.	Av. Eduardo Mondlane 1008, Maputo, +258 21 312172. www.misau.gov.mz Ana Paula Cardoso
MISAU National Institute of Health			Epidemiological and public health research		Av. Eduardo Mondlane 1008, Maputo veronicacasno@yahoo.com.br +258 825 172 907
MINAG Ministry of Agriculture	Line ministry with primary responsibility for agricultural production	Leads policies on agricultural production		Works in conjunction with SETSAN to monitor food security and risk mitigation of disasters	Praça Heróis, Maputo, +258 21 460011. www.minag.gov.mz Praça Heróis +258 21 460011.
MPD Ministry of Planning and Development	Line ministry responsible for national planning. Lead ministry for World Bank Pilot Program for Climate Resilience				Av. Ahmed S Touré 21 +258 82 3026673 www.mpd.gov.mz Xavier Chavana, PPCR Focal Point xchavana@gmail.com
MINAG/SETSAN Ministry of Agriculture Secretariat for Food Security	Research in food security	Collaboration with other stakeholders in the coordination of safety net Food and Nutrition			

MCT Ministry of Science and Technology	Line ministry for science and technology that coordinates research activities				Av. Patrice Lumumba www.mct.gov.mz +258 213 52800 Sergio.pereira@mct.gov.mz +258 824 953 620
UEM University Eduardo Mondlane	State university			Academic research in climate change issues, particularly centred around the physics department	Av. Praça 25 de Junho, Maputo, Tel 21 427851 www.saber.ac.mz or www.uem.mz Dr Antonio Queface, antonio.queface@gmail.com Prof Boaventura Cuamba Boaventura.cuamba@uem.mz Dr Alberto Mavume a.mavume@gmail.com
UDM Mozambique Technical University	Private university			Member university of the PeriPeri U pan-African network of universities on disaster risk reduction; runs short courses in disaster risk reduction	Rui Maia Brito Av. Albert Luthuli 418 +258 823055178 www.udm.ac.mz
Higher Institute for Science and Technology ISCTEM	Private university		Specializing in health studies		Av. Zedequias Manganhela 322 +258 823094130 isctem@isctem.com www.isctem.com
WB The World Bank				Development of climate change strategies and business plans in support of national initiatives to advance the sustainable development agenda. An important dimension of this effort is the development of a corporate Strategic Framework for Climate Change and Development (SFCCD)	Av. Kenneth Kaunda 1224, Maputo Maputo www.worldbank.org/mozambique Tel: 21 482334; Cell: 82 320 1640 Mr. Rafael Saúte: rsaute@worldbank.org

UNDP United Nations for Development Programme	UNDP performs a capacity building program which aims are: • Preparation of a National Disaster Management and the establishment of a network of support through NGOs, public institutions and local government in order to encourage and support community initiatives and local disaster reduction; • Establishment of a fund to support local and community initiatives to reduce disaster; • Production of information about geographic areas and population at risk of disasters; Also runs the Mozambique component of the JICA-funded Africa Adaptation Programme				Av. Zimbabwe , Maputo +258 21 481464 www.undp.org.mz Officer: Eunice Mucache Clara Landeiro, Technical advisor adaptation clara.landeiro@undp.org

UNEP United Nations for Environment Programme	With both financial and technical support, UNEP and UNDP assist government decision-makers and a wide range of other stakeholders to manage the environment in a way that improves livelihoods and leads to sustainable growth.				www.unep.org or www.unpei.org/mozambique Ms Anna Kontorov, Climate Change Adaptation Officer anna.kontorov@unep.org
UN-HABITAT				Researching disaster risk reduction in the cities of Maputo and Beira, and facilitating the production of a regional disaster risk reduction "DIMSUR" centre to promote cross-country learning	Pasquale Capizzi, pasquale.capizzi@unhabitat.org
UNICEF United Nations Children's Fund	UNICEF has collaborated with the government in reducing the vulnerability of women & children to natural disasters and strengthening mechanisms for preparation, protection and response to emergencies and natural disasters across the country through initiatives to protect these against the immediate effects of these especially in the area of water, sanitation and hygiene promotion and				Av. Zimbabwe 1440, Maputo, Tel. 21 48 1100 www.unicef.org

	prevention of diarrheal diseases.				
WFP World Food Programme				The World Food Program in Mozambique, is involved in the management of disasters through emergency action and development, using the help food. The activities carried out by this UN agency has the main aim to reduce the vulnerability of individuals and communities suffering from food insecurity.	Av. Zimbabwe 1302, Maputo +258 21 482200 www.wfp.org/countries/mozambique
GTZ Deutsche Gesellschaft für Technische Zusammenarbeit	The GTZ has concentrated its activities on strengthening the capacities of local community-based organizations in disaster risk management through use of traditional mechanisms adopted by communities such as the use traditional boats for search and rescue operations and simulation activities flood.	Introduction of new seeds and farming techniques, as well as the promotion of use of local seed in order to reduce vulnerability;		Provision of basic kits to local communities, with instruments of early warning to improve the response and rescue systems; Promotion of workshops and training for local activists to prevent disaster preparedness and response; Promotion of workshops with local authorities on risk management; Promoting the use of community radio stations to broadcast bulletins and meteorological warning	Avenida F.O. Magumbwe 976, Maputo. Tel.: +258-21-491245, Fax: +258-21-492323. GTZ-Mozambique@mz.gtz.de, www.gtz.de
Fewsnet (MIND) Famine Early Warning System Network (Mozambique Integrated Information for Decision-making)	Strengthen national early warning systems; Improve access to and use of integrated information on early warning and reduction disaster risk; Fill gaps in available	Support for the Early Warning Department (MINAG), improving systems for monitoring and disseminating information on the agricultural season;		Promote the implementation of a new early warning system; Working with ARA-SUL to ensure that the modeling efforts full and new monitoring equipment are translated into early warning systems to local level; Realization of profiles on livelihoods in areas at risk of	Mozambique Country Office Tel: +258 21 461872 Fax: +258 21 460588 Email: Mozambique@fews.net or http://www.lifelineenergy.org/project_mb_disaster.html

	information about extreme events and vulnerability; research on community risk assessment	Collaboration with SETSAN in the coordination of safety net Food and nutrition		disasters; and production of national maps on extreme events;	Director Olanda Bata, obata@fews.net, Deputy Director Antonio Mavie, amavie@fews.net
MSF-Belgium Medicins sans frontieres				Join other stakeholders (MISAU, INGC, UNICEF, WFP) in relief missions to populations in distress and victims of natural disasters	Av. Agostinho Neto 1040, Maputo, +258 21 307946. www.msf.org
CARE INTERNATIONAL	Implementation of capacity building programme for community based organization in early warning issues				Av. Mártires da Machava 596, Maputo +258 21 492064 www.care.org Mr Ataide Sacramento, Adaptation Learning Program Advocacy Officer asacramento@care.org.mz
CVM Mozambique Red Cross				Assistance to vulnerable groups (food, water and healthcare) in collaboration with government departments and other stakeholders	Av. Agostinho Neto 284, Maputo +258 21 497724 www.redcross.org.mz
Livaningo	Mozambican CSO that focuses on environmental education			History of advocating for DRR education, particularly among children in urban areas	António Reina Reina@virconn.com +258 82 300 0450
ABODES	CSO specializing in organic agriculture	Agricultural research and implementation			Lina da Silva linaevaristo@gmail.com +258 82 306 1920
Centro Terra Viva	CSO specializing in natural resources management				www.ctv.org.mz Director General Alda Salomão aldasalomao@ctv.org.mz +258 82 305 1660/ 21 416 131
Save the Children	Provide community awareness training as well as preparedness training for			Response to climate events (food, temporary classroom)	Rua Tsamba 398, Maputo Tel. +258 21 493140 www.savethechildren.org

	government institutions, local NGOs and community leaders.				Mr Melq Gomes, Africa Climate Change Resilience Alliance coordinator mgomes@savechildren.org
World Vision Mozambique World Vision Mozambique	Participates in the climate change working group			Join government institutions and other NGOs in disaster management	Av. Agostinho Neto 620, Maputo. Claudio Eugenio Jamal, DRR Coordinator Claudio_eugenio@wvi.org

4. Existing Projects in Mozambique

A wide range of initiatives relating to climate change, health, agriculture and disasters are also underway in Mozambique, spearheaded by the stakeholders outlined in section three. These include research projects, advocacy and implementation of activities to reduce vulnerability, and an increasing array of initiatives related to the developing policy framework to address climate change in Mozambique.

Of particular relevance is the current flurry of activities to prepare a national strategy for climate change in the country. Currently, as the Designated National Authority for the UNFCCC, MICOA is best placed to spearhead this process. This has been reinforced by the World Bank, who is supporting development of the strategy through the Pilot Program for Climate Resilience. However, substantial discussions have taken place within the country (Archer van Garderen, 2012). One reason for this is that INGC has the mandate to deal with disaster risk reduction, and has made significant progress in this regard. Over the last four years two phases of research have been led by INGC, assessing the potential impacts of climate change on disaster risk (INGC, 2009).

As with section three, this section is differentiated, as far as possible, by the nature of the projects. It starts with projects and initiatives managed by government ministries and parastatals, then moves to academia, before turning to multi-lateral and bi-lateral donors, and then NGOs and CSOs. The section concludes with initiatives that are run by organisations based outside of Mozambique. Wherever possible information is given on the title, scope and duration of projects and initiatives.

4.1 Ministries and parastatals

Ministry for the Coordination of Environmental Affairs (MICOA)

The main responsibility of MICOA is to coordinate the implementation of the Environmental Strategy for Sustainable Development. This mandate includes the coordination and harmonization of plans and programs of all stakeholders in the development of the country, ensure the integration of the environmental, social and economic variables in the process of planning the development of the country. MICOA is responsible for the development of appropriate policies and laws that will ensure the sustainability of resource use and for promoting public environmental awareness and culture in Mozambique. Directly related to climate change, MICOA coordinates the preparation of national communications to the UNFCCC, a process that involves different sectors including agriculture and food security, health, disaster management, etc. Currently MICOA is preparing the National Strategy for Climate Change and the National REDD strategy. MICOA also implements some projects on the ground, such as:

- "*Coping with drought and climate change*", in collaboration with UNDP, Funded by UNDP, project area: Guijá district/Gaza province, project duration: 2007-2011
- "*Integrating vulnerability & adaptation to climate change into sustainable development, policy, planning & implementation in East & Southern Africa*". Implemented by: ACTS, MICOA/UNEP. Funded by: UNEP (GEF), GTZ. Project area: nationwide. Duration: 2008-2011.
- CC-DARE *(Climate Change and Development – Adapting by Reducing Vulnerability).* This project is being implemented in collaboration with INAM, UEM, CDS-ZC and the Municipality of Xai-Xai.

Ministry of Planning and Development (MPD)
This ministry is responsible for monitoring the implementation of PARPA and the Five Year Government Plan. Accordingly, this institution guides other institutions in the preparation of annual social and economic plans for funding through the State Budget. MPD encourages the inclusion of climate change adaptation in the social and economic plans of all sector of the society to ensure that the development process is not hampered by climate change.

Ministry of Science and Technology (MCT)
This ministry is responsible for coordinating research and drafting research policies and priorities. There is a proposal of creating of a climate change research center with the role of coordinating climate change research across the country.

National Directorate of Water (DNA) – Ministry of Public Works and Housing (MOPH)
DNA is responsible for water supply, sanitation and management of river basins. This institution is a key stakeholder in disaster management, through the Regional Water Administrations (ARA). The ARA provides early warning about floods in major river basins.

Technical Secretariat for Food and Nutritional Security (SETSAN)
In 1998 the Cabinet approved the Food and Nutritional Security Strategy (ESAN), then created SETSAN to coordinate the implementation of this strategy. The mandate of SETSAN is to coordinate the formulation and implementation of food and nutritional security policies and programmes by all stakeholders, including the Government, NGOs and CSOs. SETSAN operates under MINAG. SETSAN promotes food and nutritional security, acting as a facilitator through initiatives towards improving the availability and quality of information on vulnerability and food and nutritional insecurity, with the ultimate goal of supporting informed decision-making towards the reduction of poverty and food insecurity in the country. SETSAN is member of the early warning system, where it responds for food security.

Ministry of Agriculture (MINAG)
MINAG plays an active role in the implementation of actions towards reducing the vulnerability of rural communities to climate change through the improvement of production systems, crop diversification and improvement of the diet of people living in areas vulnerable to drought. Key institutions within MINAG include the National Directorate of Agrarian Services, the National Directorate of Agrarian Extension and the Mozambique Institute of Agrarian Research.

The National Directorate of Agricultural Services is responsible for the following activities: crop production, early warning systems in close collaboration with INAM and INGC, seed production, and coordination of food security, irrigation, plant breeding and genetic improvement. The responsibility of the National Directorate of Agrarian Extension is to transfer technologies, disseminate innovative initiatives and knowledge with the objective of increasing the productivity and yields in the agricultural sector. The IIAM is responsible for conducting research in different matters related to crop and livestock production, including plant breeding and genetic improvement to increase resistance to drought or diseases. Hence, IIAM plays an important role in reducing the vulnerability of rural people relying on rain-fed agriculture for subsistence.

Ministry of Health (MISAU)

This ministry is part of the national early warning systems, where it is responsible for providing information of the occurrence of diseases linked to climate and coordination of response actions. It also houses the National Institute for Health – its main research and surveillance arm.

National Institute for Disaster Management (INGC)

This public institution under the Ministry of State Administration has the mandate of coordinating disaster preparedness and response, including the implementation of the guidelines of the policy on disaster management in Mozambique towards reducing the vulnerability of people, socio-economic activities and infrastructure. INGC is strongly involved in early warning systems and in evacuating people in the event of emergency situations through the National Operative Centre of Emergency (CENOE) to ensure that the impact of climate related hazards cause the minimum impact on human lives and socio economic development. INGC supports the development of arid and semi-arid areas through the Centres of Multiple Use (CERUM), which among other activities disseminate technologies to improve crop yields and help local communities to identify non-agricultural sources of livelihood to reduce the vulnerability of people to drought. INGC implements several projects, including:

- *"Study on the impact of climate change on disaster in Mozambique, INGC Project phase I*". Implemented by INGC, funded by Danida/GTZ/UNDP. Project area: nationwide. Duration: 2008-2009 (INGC,2009).
- "*Responding to climate change in Mozambique, INGC Project - Phase II*". Implemented by INGC. Funded by Danida/UNDP/Norway). Project area: nationwide. Duration: 2010-2011 (projects completed and nearing publication).

National Institute of Meteorology (INAM)

INAM is a key stakeholder in disaster management due to its contribution in generating data and knowledge on climate and climate variability. It is a key member of the early warning systems, responsible for providing weather forecasts, which are a key element for the assessment of risk of climate-related disasters. The key roles of this institute are as follows: (i) to plan and ensure the functioning of meteorological stations and weather forecast centres and (ii) to record, analyze, archive and publish results of meteorological observations for use by other institutions in adaptation to climate change. Currently alert are produced for strong winds either associated with cyclones or other systems, extreme rainfall (above 25mm, 50mm or greater in a 24 hour period) and heat waves (although this is still at a preliminary stage). These warnings and alerts are sent to media and INGC. When alerts refer to a specific geographic location, even at local scale, INGC cascades the information through their system of provincial delegations to the concerned districts. INGC is also responsible for coordinating appropriate responses.

4.2 Academia

The **Eduardo Mondlane University** (UEM) is the main academic institution involved in climate change and disasters, human health and impacts of climate change on food security, including the identification of drought resistant crop varieties to reduce the vulnerability of rural communities to climate change. Relevant departments include the department of physics (Faculty of Sciences), Faculty of Agronomy and Forestry Engineering, Faculty of Medicine and department of geography.

UEM is also involved in training a new pool of researchers in these fields. However, ISCTEM and UCM also conduct research and training on human health, while UDM is involved in disaster related research.

4.3 Multi-lateral and bi-lateral donors

World Food Program (WFP)
The World Food Program is involved in disaster management through emergency action and development, using food aid. The aim of this UN agency is to reduce the vulnerability of individuals and communities suffering from food insecurity.

United Nations Children's Fund (UNICEF)
UNICEF has collaborated with the government in reducing the vulnerability of women and children to natural disasters and strengthening mechanisms for preparedness, protection and response to emergencies and natural disasters, especially in the area of water, sanitation and hygiene promotion and prevention of diarrheal diseases. In the event of disaster, UNICEF is involved in emergency activities in helping the affected population to restore access to health care, temporary housing, educational activities and adequate sanitation.

United Nations Development Program (UNDP)
UNDP provides technical assistance to the government in strengthening the coordination capacity of INGC, participates in the strengthening of policies for water management and environment and in mainstreaming climate change in sectoral plans and strategies. In recent years UNDP implements several projects in the country, including:

- UNDP and UNEP have run a number of recent projects relating to climate change and disaster risk reduction (including the first phase of the EU/DIPECHO Disaster Risk Reduction in Southeastern Africa and the Southwestern Indian Ocean "Waters Winds Fires"); and the multi-million dollar JICA-funded Africa Adaptation Programme has also worked in Mozambique.

Pilot Program for Climate Resilience (World Bank)
This global initiative, funded by the Strategic Climate Fund from the Climate Investment Funds, has been taking place in Mozambique since 2011, and prioritises a number of sectors with relevance to this project, namely water, sanitation and flood protection. PPCR is currently working in conjunction with MICOA to develop Mozambique's Climate Change Strategy, which will be ready in October 2012.

Famine Early Warning Systems Network (FEWS NET)
FEWSNET is part of USAID. The main objectives of FEWSNET in Mozambique are:

- to strengthen national early warning systems;
- to improve access to and use of integrated information on early warning and disaster risk reduction;
- to fill gaps in the availability of information on extreme events and vulnerability;
- to provide USAID-Mozambique information on disaster analysis and management, emergencies and strategic planning

4.4 Non-Governmental Organisations and Civil Society Organisations

Mozambique Red Cross (CVM)

CVM is involved in disaster prevention and response. It provides assistance to vulnerable groups in collaboration with Government institutions such as MINAG, MISAU and INGC. CVM promotes access to water, food and health care to people affected by disasters. CVM also has a disaster preparation program, which focuses on empowering people in skills to reduce the negative effects of disasters on their sources of livelihood.

Abiodes – *Associação para desenvolvimento sustentável*

Abiodes is a CSO created in 1998. Abiodes gained strength as the national coordinator for the preparation of the participation of CSOs in the World Summit on Sustainable Development in 2002. Abiodes has defined three main programmes, which are a) agriculture and food security, b) environment and biodiversity and c) lobby and advocacy for a sustainable development. Abiodes has also carried out a project to monitor the urban water and sanitation services in Maputo.

CARE Mozambique

CARE Mozambique is an international NGO. The organisation focuses geographically on Inhambane and Nampula provinces. CARE Mozambique works in four areas namely, a) agriculture and natural resources, b) HIV/AIDS and health, c) water and sanitation and d) emergencies. With regard to agriculture and food security, CARE Mozambique collaborates with IIAM on research on drought resistant crop varieties.

International Union for Conservation of Nature (IUCN)

IUCN Mozambique is an international environment organization. The main focus is on the conservation of nature and natural resources. Recently implemented projects include:

- Livelihoods and landscape strategy (regional scope Uganda, Mozambique, Tanzania) implemented with Dutch funding from DGIS in cooperation with DNTF, UEM and district administration in Derre,
- Climate change and development – Recognising the role of forest and water resources in climate change adaptation with funding from Finnida (Regional scope Uganda, Mozambique, Tanzania);
- Joint UN programme on Environment and Adaptation to Climate Change in cooperation with WFP, UN-Habitat, GAO, INGC, MICOA, DNA and Chicuacuala district.

World Wide Fund for Nature (WWF)

WWF Mozambique's main areas of expertise are protected area management, CBNRM, coast and marine biodiversity and conservation, forests, threatened species, environment education and wetlands. The organisation is specialised in a broad range of environment and climate change areas.

Livaningo

Livaningo is an association with activities concentrated in Maputo and Matola cities. Its expertise area is the urban environment particularly concerning pollution and toxic waste. Livaningo is very active in raising awareness about climate change issues.

Centro Terra Viva (CTV)

CTV was created in 2002 primarily as a centre for investigation and advocacy. The mission of the organisation is to improve the technical and scientific foundation upon which environment policies and legislation is based and to strengthen the participation of the civil society through informed contributions to environment management. Its main objective is to monitor the implementation of policies and laws. The key focus areas are land and forests. CTV is member of the national technical group on developing a REDD strategy and the Forum on community management of natural resources.

Africa Climate Change Resilience Alliance (ACCRA)/Save the Children

ACCRA is a DFID- and CDKN-funded, NGO Consortium-led initiative working in Mozambique, Ethiopia and Uganda (led by Save the Children in Mozambique). ACCRA aims to increase governments' and development actors' use of evidence in designing and implementing both humanitarian and development interventions that increase poor and vulnerable communities' adaptive capacity. During its first phase (2009-11) it developed a Local Adaptive Capacity Framework and used this to structure research. In its second phase, currently underway, ACCRA will be focusing on capacity building and advocacy, enabling governments, development partners and ACCRA members to use community-level findings for policy and practice.

4.5 Organisations based outside Mozambique

The SADC Climate Risk Capacity Building project

This USAID-funded project, implemented by CSIR, Kulima Integrated Development Solutions and the Climate Systems Analysis Group (CSAG) at the University of Cape Town, aims to equip decision-makers with up-to-date information on the impact and risk of climate change and variability. A handbook has been produced, containing novel high-resolution climate projections for the SADC region (obtained by both statistical and dynamical downscaling), together with information on vulnerability, impacts and adaptation (Davis, 2011). Targeted training courses will be run in four countries, including Mozambique, before the end of 2012.

The Lower Olifants Community Health: Risks and Opportunities project

This project aims to learn how communities in the Lower Olifants catchment battle environmental pollution for a healthier tomorrow. Communities living near the Lower Olifants River in Mozambique and South Africa face environmental pollution risks and their health may be threatened. Sound evidence is needed to determine these health risks and identify coping strategies to best protect human health. This project began on the 1 June 2012 and aims to determine the extent to which water and air pollution may have an impact on the health of two communities in the Lower Olifants River Water Catchment Area, with the purpose of identifying potential human health risks and relevant coping strategies that will inform and guide locally-appropriate, sustainable solutions.

The Greater Limpopo Transfrontier Conservation Area Veterinary Subcommittee recently decided on the research and monitoring priorities for the region, and Massingir turned out to be the chosen research site on the Mozambique side, where various baseline health (zoonotic and water borne diseases), economic profiling, agricultural and cultural practice data are needed. The contact is Dr Danny Govender, a vet with SANParks Scientific Services.

4.6 Data availability

A key component of this project has been to assess the availability of existing relevant data for Mozambique, in order to avoid duplication and to make available information when assessing vulnerability in Moza,bique. This section outlines existing data sets that we have found.

4.6.1 Geographical data

Colleagues in the CSIR have GIS shapefiles for political boundaries (at various scales), water, roads, rail and population information.

The Multiple Indicators Cluster Survey 2008 also contains provincial level data concerning households, definition of household composition, women in reproductive age, birth history, and mothers or primary caretakers of children under the age of 5 (National Statistics Institute, 2009). During the anonymisation process several variables were removed from datasets, but we hope this will nonetheless be useful for the higher resolution studies.

The National Statistics Institute (*Instituto Nacional de Estatistica*, INE) also makes available some demographic data at district level on its website.

4.6.2 Health data

The National Institute for Health (NIH) is currently undertaking HIV surveillance in 36 national sites. NIH is also currently doing malaria mapping in Zambezia and has, in the past (2007-08) mapped oncocerciasis.

The Demographic Health Survey from 2009 is also likely to yield interesting data, and does include sites in Manica and Nampula provinces (INE, 2011). Data from 2003 is also available.

Greg Simpson did a questionnaire-based health survey in Massingir a few years ago. He never published the findings but does have the raw data which he may be willing to share if appropriately acknowledged (see also Simpson, 2007).

A number of papers have also been published on malaria research in Mozambique, suggesting that datasets are available. Abellana et al (2008) looked into the risk of malaria in Manhica district, Mozambique. They found that “the incidence of malaria in Manhica area presents a spatial pattern which is independent of the seasonal climatic conditions. The climate modifies the incidence of the malaria in the entire region but does not change the spatial pattern of the incidence of disease. Children under five years of age are at the highest risk of malaria infection.” One explanation of why some neighbourhoods were more at risk was that those that had the higher risk of malaria were located near the Incomati River. While this area is not the area of interest for our research, it does highlight the importance of land information in determining vulnerability to malaria.

Castillo-Riquelme et al (2008) studied the out-of-pocket expenditure of households when a member gets sick with malaria in Mozambique (though not our study sites) and South Africa. They found that 32 to 34% of households in Mozambique incurred what they called “catastrophic payments for malaria episodes” compared to 9 to 13% in South Africa. This shows it is important to understand how health might be impacted by climate change, because if malaria incidences increase, this indicates that there may be a large economic impact.

4.6.3 Climate data

INAM is the national meteorological and hydrological agency, and has primary responsibility for the generation of weather and climate information. As in many developing countries, the poor weather station network, which in turn suffered many years of neglect during the country's civil way, is a key determinant of the quality of weather and climate information, as these instrumental records are key inputs into models.

Recognition of the need to improve the network of weather stations is made in several key documents. Mozambique's National Adaptation Programme of Action (NAPA) – submitted to UNFCCC in July 2008, does list plans to upgrade their extreme weather early warning systems working with the Ministry of Agriculture and National Institute of Meteorology (MICOA, 2007). Similarly a World Bank report assessed the impact of the ICT poverty framework that was started in 2002 (World Bank, 2012). The case study areas are all cities, but they also assess INAM for their ICT-based capabilities for Early Warning Systems (EWS) and find,

"INAM gathers its input data (including rainfall, air temperature, air humidity, wind speed and direction, and air pressure) for predicting weather conditions from a network of its own stations and from external sources, which include both global centre and regional centers such as South Africa Weather Service. While INAM's own network includes both manned and automated weather stations, most of its automated stations were found to be not functioning or to be delivering insufficient levels of information. Two doppler radars were installed in the mid-2000s, but neither is fully operational. As a result, many important types of observation--such as upper air, marine, and lightning detection--are not effectively performed. In sum, the agency lacked any meaningful ICT-based EWS capability related to the prediction of floods and tropical cyclones and their impact."

Research generated during the first phase of INGC did produce downscaled climate projections which have subsequently been revised as part of the SADC Climate Risk and Vulnerability project (INGC, 2009; Davis, 2011). These projections will likely be accessible in GIS format if requested.

4.6.4 Agricultural data

SETSAN is the leader of the Mozambique Vulnerability Assessment Committee (VAC), a multi-stakeholder body that provides annual assessments on the projected state of food security during the coming rainy season. SETSAN has a national baseline study, including socio-demographic data, and also food security information on an annual basis, that we should be able to access through the relevant steering committee member.

5. Evidence for Good Practice on Climate Change and Health in Other Countries

Despite the major implications posed by climate change, public health has not yet identified its central role in the climate debate. Reasons for this situation include lack of understanding of the health effects of climate change and strong focus on existing health crisis. Consequently, very little empirically-based material is available. So, gaps of knowledge and awareness must be addressed, and various articles have called for this (St. Louis and Hess, 2008). This is in line with the rationale for our project.

The lack of data on climate change and health translates into minimal political commitments. Due to limited data availability and lack of guidance on assessment methods, few national communications to the UNFCCC address climate change-related health impacts in details. In Mozambique, for instance, despite the vulnerability of people to climate-related diseases, the first national communication (MICOA, 2003) did not include the vulnerability and adaptation assessment in the health sector. In the second national communication (MICOA, 2011), the sector was included, but due to lack of research data, vulnerability assessment was limited to describing the relationship between trends in the occurrence of malaria and cholera with trends in climate variables, mainly rainfall and temperature. Due to the lack of research and data in Mozambique, learning from the experiences in other tropical and developing countries would be a good step towards building internal research capacity to generate information that will inform decision-makers regarding the appropriate approach to cope with the impacts of climate change on human health.

The current section firstly gives a brief review of the nature of existing empirical evidence, then looks at good policies and practice in addressing climate and health risks, and then makes some suggestions for data needs and responses in Mozambique.

5.1 Empirical evidence

Some linkages between climate change and health have been made in the literature (Vincent and Cull, forthcoming). Weather patterns, and other aspects of climate, affect human health both directly and indirectly, via biological and ecological processes that influence the transmission of several infectious diseases (McMichael et al, 2003). One of the major health impacts of climate relates to the disease burden. The effects of climate on vector-borne malaria and water-borne cholera have been well-studied, given that they already pose existing risks in Africa (Boko et al, 2007). Fewer studies have looked at the links between other diseases, such as meningitis, Rift Valley fever, and Dengue fever, and climate-related variables (Jansen and Beebe, 2010; Anyamba et al, 2009; Cuevas et al, 2007). More indirect effects of climate on health relate to the transmission of HIV/AIDS, heat stress and respiratory illness, which are discussed here. Other indirect links of climate and health relate to cancer, mental health and stress-related disorders, zoonotic diseases and food-borne illness (Portier et al, 2010).

Identifying vulnerable regions and populations is essential to develop responses, focusing on regions of high endemicity of diseases that are sensitive to climate (for example, malaria) and areas at risk from several climate impacts relevant to health (for example, stress on food and water supplies due to droughts, risk of coastal flooding) (Patz and Kovats, 2002). Hotspots of both diseases and climate change will occur where human populations are already at risk from climate extremes (such as drought induced famine or flooding) and lack adequate health infrastructure. Millions of people in southern Africa suffer from food insecurity, mainly due to drought and lack of resources to import food and lack primary health services (Dube, 2003).

Decreased availability of water as a result of climate change could affect populations in the subtropics where water is already scarce. In most of Africa, diarrhea and diseases such as scabies, conjunctivitis and trachoma are associated with poor hygiene and result from a breakdown in

sanitation if water resources become depleted. However, excess of water, such as in the event of flooding also result in water-borne disease such as cholera caused by drinking contaminated water (Patz and Kovats, 2002). Post-flood infectious diseases have been observed in Mozambique (Kondo et al, 2002).

Vector-, water- and food-borne diseases and diseases associated with heat stress and water pollution are predicted to affect an increasing number of people in southern Africa (Dube, 2003) and worldwide (Ebi et al, 2006a; WHO 2011). Ebi et al (2006a) suggests that a starting point for the assessment of climate change impacts on health should be the evaluation of how populations currently cope with climate variability, particularly weather extremes such as floods, droughts, and heat events, to indicate where additional interventions are needed to improve the adaptive capacity and resilience to climate change. The assessments should not be restricted to the heath sector but be integrated across relevant sectors, especially water supply and sanitation, agriculture and food security, housing and disaster management because many of the possible measures for adapting to climate change lie primarily outside the direct control of the health sector. Accordingly, Ebi et al (2006a) and WHO (2011) suggest that inter-sectoral and cross-sectoral adaptation strategies are needed to reduce the potential health impacts of climate change.

As well as impacting human health directly, climate change also poses indirect threats through its effects on agriculture. Climate change impacts on agriculture include (i) increased droughts and floods are likely to increase production variability, (ii) considerable effect of microbes, pathogens and insects, (iii) increased sea and river water temperatures are likely to increase fish breeding, migration and harvest, (iv) increased water, shelter and energy requirement for livestock and (v) animal distress due to heat and its effect on reproduction (Aggarwal et al, 2009). All of these indirectly can affect human health, not least through influencing food security.

5.2 Good policies and practice

5.2.1 Heat-health plans

Southern Africa is projected to see large increases in temperature from climate change, which may lead to increases in health impacts from high temperatures and heat waves. A successful way that other countries have dealt with mitigating health impacts from heat and heat waves are through Heat-Health plans. These are generally collaborations between the Weather Service and Health Stakeholders. Unfortunately, these plans have all been developed for industrialized and temperate countries. There is some early work in Australia, which has a climate more similar to Mozambique. But the plans for temperate areas can still be a model that can be used to aid development of such plans in Mozambique. The interventions in these plans deal with known vulnerability factors of the communities (e.g., those who live alone, the elderly). The vulnerability factors for a population in Mozambique are not known, though it can be assumed that some may be similar (e.g., elderly, those who live in urban areas, those without access to electricity or cooling, those who are unable to cope or are isolated, those with pre-existing conditions). Some good examples of heat-health plans are;

Philadelphia – Kalkstein et al (1996) describes the development of the system. In this article, the decision trees for the hot-weather watch/ warning system is shown, as well as the interventions that are then used. These interventions are interesting as they show the range of activities that

Philadelphia does when a warning is implemented. These would not be the same interventions that a community in Mozambique may need; however, it is helpful to see what types of interventions other places use. Sheridan and Kalkstein (2004) is also a good general description of the method used in Philadelphia, and highlights where else this method is used (e.g., China, Italy and across the US). This also discusses the interventions planned. Ebi et al (2005) highlights the costs and benefits of the heat warning system in Philadelphia, and concludes that it has saved lives.

France – France developed a heat-health plan after the heat waves of 2003. Pascual et al (2006) does a good job in describing the rationale behind France's warning system, particularly how they had to weigh what meteorological factors are most related to health impacts with what meteorological factors can most easily and accurately be forecasted. This would be an important step that any weather service would need to take when developing a plan, and thus is a best practice example.

Australia – Victoria State's heat health plan underwent testing this past summer (December 2011-February 2012) (http://docs.health.vic.gov.au/docs/doc/Heat-health-alert-system-2011-12-information-and-guidance). It is not very developed as there are no specific interventions; however there are lists of who should be contacted with warnings. This could help for Mozambique to see what type of stakeholders might be notified. Dairy Australia does actually seem to have quite a lot of information on the impact of heat on cows, why it is important, what you can do, and alerts you can sign up for (http://www.coolcows.com.au/index.htm). This highlights that the need for heat-health warning systems is not just for people, but can also greatly impact agriculture (another best practice to keep in mind when developing such a plan).

This type of information is not really just applicable to heat-health plans, but rather highlights the connections that have to be made between really any climate variable of concern and health in order to develop actionable plans.

5.2.2 Climate change responses and policies

There are a number of policies, strategies, and platforms that exist to address health and climate change issues at the global and regional level. These include:

- the World Health Organization Statement on putting Health issues at the centre of climate agenda
- In 2010, at the Second Interministerial Conference on Health and Environment in Africa, African Ministers of Health adopted The Joint Statement on Climate Change and Health in Africa;
- In the 61st Session of WHO Regional Committee for Africa, SADC Ministers of Health adopted the framework for Public Health Adaptation to Climate Change;

Furthermore, in Mozambique, commitment to public health includes the Second National Communication to the UNFCCC (MICOA, 2011); the NAPA (2007), and the country's recognition of the Mozambique recognition on Libreville Declaration (MICOA and MISAU steering committee for health effects of climate events). Mozambique's Second National Communication does pay lipservice to the health sector as being affected by climate, but an in-depth discussion is impeded by the lack of empirical information (MICOA, 2011). With the National Climate Change Strategy currently under discussion, there is substantial policy space to remedy this situation as soon as

empirical data becomes available. Lessons can also be learned by approached adopted in other countries.

South Africa – South Africa has a National Climate Change Response Strategy (DEA, 2011). This white paper is broader than just health, though health is one of the key adaptation areas. The strategy highlights well how to discuss a government-wide strategy for mitigation and adaptation efforts in climate change. Perhaps of greater relevance is the Working Draft of a National Climate Change and Health Adaptation Plan for South Africa. This is a very high-level and general plan, however, it might be helpful to inform Mozambique on what is prioritized and types of plans the Department of Health in South Africa is thinking about to deal with climate change and health.

Kenya – Kenya is the only country in sub-Saharan country to be one of the seven WHO pilot countries in the Climate Change Adaptation to Protect Human Health project[1]. The focus of the Kenya project is on malaria prediction and prevention, specifically training and developing tools. The pilot project has four areas of adaptive capacity development:

1) Improved use of weather forecasting
2) Improved disease prediction capacity
3) Improved epidemic preparedness and disease detections
4) Improved outbreak response

This pilot project is currently underway, so end results are not known. However, it does highlight the similar steps that Mozambique would need to take to tackle its climate-sensitive health issues (e.g., four areas listed above could, in reality, be applied to any health issue).

Multiple countries - Capacity Strengthening in the Least Developed Countries for Adaptation to Climate Change (CLACC) – Climate Change and Health in Mozambique.
Report discusses general climate change and health issues for Mozambique. And then does a case study on flooding and health in Mozambique. They focus on the impacts of the 2000/2001 floods on malaria and cholera. Everything is at a provincial level, but could be good background information for our project.

The experience of Cuba also provides some lessons. In Cuba, climate change is predicted to determine the prevalence and distribution of diseases as such meningitis, acute respiratory infections, acute diarrheal diseases, dengue fever and bronchial asthma (Bultó et al, 2006).

Bultó et al (2006) concluded that primary health care is a key level for the implementation of preventive measures to reduce population vulnerability. However, in addition to improving primary health care programs, it is important to strengthen the linkage of the health sector with other sectors. In Cuba, there is a strong collaboration between disaster management institutions, Ministry of Health, Ministry of Science Technology and Environment that allows the use of climate forecasts to predict out-breaks of climate-sensitive diseases. Projections of disease outbreaks afford decision makers the opportunity to proactively initiate activities to reduce the impacts of out-breaks. In South Africa, temperature and rainfall forecasts have also been used to predict malaria incidents. This helps the planning of preventive measures such as the distribution of mosquito nets, repellents and pulverizations programs (Dube, 2003). In Mozambique these measures to mitigate malaria are implemented without a link with weather forecasts data. With malaria early warning systems the

[1] http://www.who.int/globalchange/projects/adaptation/en/index6.html

timing of when an epidemic will occur is known, which allows timely responses to prevent and contain malaria epidemics.

In Cuba the approach for strengthening the adaptive capacity of the health sector includes the following adaptation options and activities:

Adaptation option	Activities
Strengthen primary health care and public health system	Specific health promotion and preventive programs designed to reduce population vulnerability
	Educational programs of environmental risks, including climate variability and change and their effects on human health
Measures to improve health surveillance systems	Provide forecasts of the main climate-sensitive diseases to all levels of the national public health system
	Increase the number of early warning systems to predict epidemics
Immunization programs, particularly for high-risk groups	Maintain the current vaccination program and prioritize new programs
Improve sanitary conditions	Develop responses to increased sanitary demands in all fields (communal, drinking water, garbage, sewage, food and others) Maintain contingency plans
Educational programs on radio and TV and in news papers	Develop educational programs on the health risks associated with climate variability and change
Exchange information with international researchers working on climate change and health issues	Participate in international meetings and conferences
Publish forecasts of communicable diseases	

5.3 Data needs in Mozambique

As shown above, a large problem in climate change and health research in Africa is just the lack of reliable data, both on the current state of health (to track what is happening) and also on how climate variables impact health. The latter is important to not only predict what might happen, but also to set-up appropriate early warnings and interventions that will be applicable to communities and that will be effective. In order for Mozambique to reach their short term aim of “an enhanced understanding of the climate impacts on health” a real need is for data collection systems to be initialized, operationalised and used.

Thomson's article "Africa needs climate data to fight disease" (2011) describes well why climate and weather information is important for climate and health programs. An example is in Ethiopia about their new climate database, and that it is linked to the Roll Back Malaria Initiative. The *Instituto Nacional de Meteorologia* (INAM) is responsible for weather monitoring and forecasts. However, this information will not be useful without also health data and with understanding how climate variables impact health.

An example of the difficulties in linking health and climate variables is highlighted in some research about malaria and cholera in southern Africa. Malaria transmission is climate and weather sensitive and thus changes in climate will drive the distribution of the areas impacted by malaria (e.g. Ebi et al, 2005; Kleinschmidt et al, 2001; Jones et al, 2007; Boko et al, 2007). There are also many non-climatic drivers of malaria that have been found to strongly modify malaria transmission and the number of reported cases of malaria. For example, in a study in the KwaZulu-Natal province in South Africa, Craig et al (2004a, 2004b) found that the number of cases of malaria was more strongly related to the level of drug resistance (e.g. chloroquine) and HIV infection than climatic variables. In fact, the climate variables could not explain the number of cases, though they did appear to be significant drivers in the inter-annual variability of incidences.

In a study in Maputo province, Mozambique, Zacarias and Andersson (2011) found that malaria risk increases with maximum temperatures over 28 °C and relative humidity values. The authors did acknowledge, though, that the results suggest that non-climatic factors may also impact malaria transmission.

In a study in Lusaka, Zambia, Sasaki et al (2009) studied the impact of precipitation and drainage networks in the city on cholera outbreaks and found that they were strongly associated with the amount of precipitation. In addition, this association was impacted by the coverage of drainage networks, and areas with less coverage were associated with higher incidences of cholera (Sasaki et al, 2009). These studies highlight the importance of modifying factors (e.g. physical and health infrastructure, health status, poverty) on the health outcomes of the area. Thus, research, policies and programmes aimed at understanding and mitigating health impacts from climate change, must take into consideration these cross-sectoral modifying factors.

Chilundo et al (2004) found that the collection, quality and availability of malaria data to managers were not of high quality, and they suggested a national database for malaria. Gimbel et al (2011) looked at primary care health data (not malaria) in the Sofala Province, and found that their data were of quality. Questions remain as to whether this standard of monitoring is present across all provinces.

6. Establishment of a Multi-Stakeholder Steering Committee

A key component of our approach to this assignment, particularly given the aim to undertake research to inform policy, is to be participatory. A request was made of CDKN by the government of Mozambique to undertake this research, recognising a gap in empirical data around the links between climate change, health, agriculture and disasters. In order to ensure that the government feels continuing ownership of the process, and to improve the effectiveness of results dissemination

into government departments, a multi-stakeholder steering committee has been established. This steering committee will be kept informed as the project unfolds.

The steering committee was initially established by CDKN's preferred service provider in Mozambique, OneWorld Sustainable Investments, and comprised the institutions that requested this project, namely:

- INGC (National Disaster Management Institute)
- MISAU (Ministry of Health) (chair)
- MICOA (Ministry for Coordination of Environmental Affairs)
- SETSAN (Technical Secretariat for Food Security)

Bilateral meetings were held with each of the steering committee members from 10th to the 14th June (Figueiredo Araujo from INGC, Julaya Abdulla Mussa from MISAU, Eduardo Baixo from MICOA, and Francisca Cabral from SETSAN). All steering committee members affirmed their support for the project, and assistance with availability of data, as required.

7. Methodology

The methodology employed to meet the objectives of the project, and specifically for Work Package 2 of the project, combined reviews and analysis of existing information, and primary qualitative research.

7.1 Disease prevalence and linkages to climate parameters

Section eight focuses on the key diseases that are closely related to climate parameters and known to be public health concerns in Mozambique – namely malaria, cholera and dysentery. For each disease, a literature review assesses the theoretical linkages between the disease and climate parameters, and then also assesses links with contributing non-climate factors. An outline of the baseline of current situation of each disease in Mozambique is then provided, based on existing surveillance and past epidemiological records, compiled by the Ministry of Health. Whilst not as directly related to climate factors as the three diseases, an overview of malnutrition is also provided. Malnutrition is important both as an outcome of climate-related hazards (e.g. precipitated by crop failure following drought), and also as a factor that contributes to people's vulnerability to contracting malaria, cholera and dysentery (and other diseases).

7.1.1 Sources of health information in Mozambique

In Mozambique, the main source of public health conditions is the Health Information System (HIS). HIS is fueled by the Department of Epidemiology (DoE) Surveillance System. The district is the starting point (peripheral level) of collecting health data from several health facilities through the Centre for District Statistics (*Núcleo de Estatísticas Distritais* – NED) to be sent to the provincial level (intermediate level). At this level, the provincial surveillance system officer (*Responsável provincial pela vigilância epidemiológica* – RVE) is responsible for sending data to the Ministry of Health (MISAU - central level). The DoE is responsible for analyzing data and delivering information to provincial and district level (feedback information) or to decision-makers and other stakeholders.

There are two main health collecting data mechanisms: weekly and monthly collecting of data. There are standardized information forms for both mechanisms: for weekly collecting data mechanism there are bulletins called BES (*Boletins Epidemiológicos Semanais*) and for monthly collecting data mechanism the bulletins are called BE-PS (*Boletins Epidemiológicos Postos Sentinela*). Obviously, the central level expects to receive annually 52 BES and 12 BE-PS bulletins from each province. However, this referring system faces challenges resulting in health information gaps (see Table 1 for 2010). The referring system is based on telecommunications network (faxes and telephone mobile connections). There are some failures in sending data due to inadequate equipment. For example, faxes not working.

Table 1: Health information sources in Mozambique in 2010 (*Source: Balanço do Plano Económico e Social de 2010 da Direcção de Planificação e Cooperação, 2011*)

Province	**BES expected (N)**	**BES received n(%)**	**BE-PS expected (N)**	**BE-PS received n**
Niassa	52	30 (57.7)	12	10
Cabo Delgado	52	13 (25.0)	12	11
Nampula	52	35 (67.3)	12	7
Zambézia	52	29 (55.8)	12	10
Tete	52	39 (75.0)	12	7
Manica	52	17 (32.7)	12	2
Sofala	52	45 (86.5)	12	11
Inhambane	52	37 (71.2)	12	12
Gaza	52	41 (78.8)	12	8
Maputo province	52	45 (86.5)	12	-
Maputo city	52	39 (75.0)	12	10
Total	572	370 (64.7)	132	90

7.2 Downscaled climate projections

Novel high-resolution downscaled climate projections were recently generated for the southern African region (Tadross et al, 2011) and are presented here. These climate projections were made from a six member ensemble. Each member is a downscaled global projection of future climate change to a higher resolution (about 60 to 80 km in the horizontal) over the African continent for the period 1961-2100. The global projections have been obtained from six coupled global climate models (CGCMs) that contributed to Assessment Report 4 (AR4) of the Intergovernmental Panel on Climate Change (IPCC). They represent the A2 SRES (Special Report on Emission Scenarios) emission scenario, which assumes business as usual.

The six CGCMs are as follows:

- CSIRO Mk3.5: Version 3.5 of the Coupled Global Climate Model (CGCM) by the Commonwealth Scientific and Industrial Research Organisation in Australia (CSIRO)
- UKHADcm3: The third version of the United Kingdom's Met Office Hadley Centre Coupled Ocean-Atmosphere Global Climate Model.
- GFDLcm2.0 and GFDLcm2.1: Versions 2.0 and 2.1 of the Coupled Global Climate Model of the Geophysical Fluid Dynamics Laboratory (GFDL) of the National Oceanic and Atmospheric Administration in USA.
- ECHAM5: The fifth generation climate model developed by the Max Planck Institute in Germany.

- MIROmr: The MIROC3.2-medres Model for Interdisciplinary Research on Climate 3.2, medium resolution version, of the Japanese Agency for Marine-Earth Science and Technology.

All downscalings of the global projections were performed using the conformal-cubic atmospheric model (CCAM) of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and were generated by the CSIR. The downscaling was used to achieve higher spatial resolution of the projections over Mozambique. The time period 1961-1990 was selected as a present day reference climate, and projections shown are for 2046-2065.

The qualitative approach adopted by this project was to use expert judgment to assess the likely implications of these projected changes in temperature, rainfall and relative humidity on disease prevalence. The possible impacts on human health from malaria, cholera and dysentery under these projections were discussed at an expert workshop convened in Maputo in September 2012. Current diseases prevalence and future projected temperatures and rainfall in Mozambique were presented to experts from MISAU, Food Security and Nutrition Technical Secretariat (SETSAN), National Disaster Management Institute (INGC) and World Bank (see appendix A for the meeting agenda, and appendix B for the list of participants). Themes of discussion arising from this workshop were, in turn, used to inform the investigation for the high level case studies. Health impacts themselves were not modelled, and as such, the impacts of climate change on health are not quantified here. Rather, the impacts that these general trends in climate may have on health are discussed; though it is acknowledged that projecting specific impacts would take a lot more information and the use of a health model.

7.3 An expert meeting in Maputo

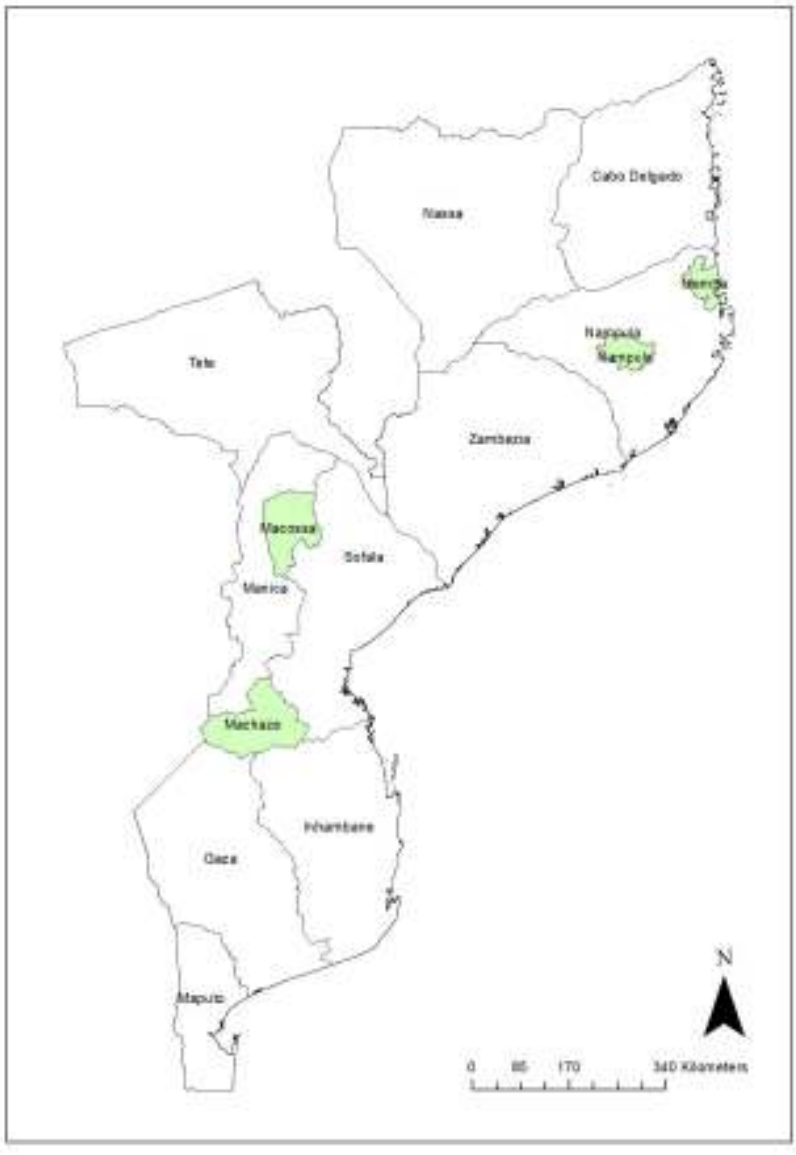
Instead of innovative health modeling, an expert meeting was held in Maputo in September 2012 (see appendices A, B, and C for the agenda, list of participants, and meeting minutes). The meeting was attended by members of the project team together with other professionals, both within the Mozambican government and outside, who are concerned with climate change, disasters and/or health issues in the country. The purpose of this meeting was to present current epidemiological data and the downscaled climate projections, and get their inputs into how such projected changes in climate might alter disease prevalence. Discussions at this meeting were also used to inform the priorities for exploration in the high level case studies.

7.4 High level case studies of health impacts from climate in Manica and Nampula provinces

To describe the magnitude of the health climate change problems, high resolution case studies were conducted in Manica province (Machaze and Macossa districts) and Nampula province (Memba district and Nampula City)(see map 1 below). These sites were selected by the project steering committee prior to the start of the project due to the perceived vulnerability of local people to the impacts of climate change on human health, associated with extremely wet periods (for example, during tropical cyclones in Memba) and more intense and frequent droughts in Manica, and because all four districts have been neglected by other studies and health improvement interventions. Fieldwork consisted of interviewing a total of six local key informants from the public health sector, responsible for collecting/reporting systems and from community-based public health practitioners

dealing with health conditions sensitive to climate events (being two at Nampula city, one in Memba, one in Macossa, and two in Machaze). Appendix D outlines the interview schedule which guided discussions, and Appendix E provides a transcript of each interview. Fieldwork comprised face-to-face interviews and analyzing local collecting/reporting sources. In Machaze district interviews were conducted via cellphone due to the absence of the interviewees during the period of fieldwork.

As a complementary approach, and taking into account the difficulty of projecting the extreme climate events, we analyzed the co-occurrence of weather events (particularly floods, cyclones) and the main health threats at that site or their impacts on health or the health sector network. Both approaches enabled us to develop a conceptual framework of interaction of the climate change events with health status and the health sector.



Map 1: Location of districts of Machaze, Macossa, Memba and Nampula City in Mozambique

8. Prevalence of Major Health Conditions in Mozambique and their Linkages to Climate Parameters

This section takes the priority diseases in turn, examining how climate factors affect their prevalence and providing a current baseline situation in Mozambique.

8.1 Malaria

Mozambique has both epidemic and endemic malaria incidences, and is one of the top ten countries in the world most impacted by malaria (INGC, 2009). The parasite, *Plasmodium falciparum,* is the most common and is responsible for more than 90% of the infections recorded. Infections by *Plasmodium malariae* and *Plasmodium ovale* represent only 9% and 1% of malaria cases, respectively (MISAU, 2012b). Currently malaria accounts for 44,000 to 67,000 deaths annually in all age groups in Mozambique (INGC, 2009). It is not yet well understood if climate change will work with or against malaria control efforts.

8.1.1 Impacts of climate factors on malaria

The impact that climate factors can have on malaria are multi-faceted and non-linear. Temperature and rainfall are the most studied climate factors in relation to malaria, though there are still large debates on the impact of these on malaria. Relative humidity is also considered to be an important factor, however very little is known about the impact. In general, there are optimal ranges of climate conditions where malaria risks are highest. These conditions must occur together, however there is debate on what these ranges are; this debate is driven in part by the multi-faceted and non-linear impact that climate has on malaria. In addition, it is driven by the fact that non-climatic effects have been seen, in many cases, to be more important drivers of malaria risk than climate factors. It has also been found that small changes in temperature are magnified to much larger changes in malaria transmission; thus small differences in projections of temperatures may have large effects on the projections of malaria. In order to fully characterize the impact of climatic variables on malaria, multiple factors with high spatial and temporal resolution need to be considered (Parham and Michael, 2010). The below discussion will highlight the general impacts of climate on malaria.

Temperature is a climate factor that has a large impact on malaria. Throughout the lifecycle of the parasite and mosquito, temperature can impact its growth and survival. For example, parasite development ceases at 16^{o}C and transmission of malaria below 18^{o}C is not likely because mosquitoes generally will not survive through the whole transmission cycle. And at extremely high temperature (~40-42 ^{o}C), thermal death of mosquitoes occurs and there is no transmission (Craig et al, 1999). Thus, there are optimal temperature ranges when malaria transmission peaks. However, these ranges and thresholds are still under debate and should be used cautiously. This is in part due to the fact that temperature is not the only climate factor that impacts malaria.

When average yearly temperatures are below 15^{o}C, it has been reported that there will be no transmission of malaria, at 18^{o}C there will only be epidemics in warmer years, and average yearly temperatures of 22^{o}C are needed for stable transmission (Craig et al, 1999). However, these thresholds were set using yearly averages of temperature. It is also important to consider temporally resolved temperatures and the diurnal temperature fluctuations (e.g., range in

temperature during each day) to understand the risk of malaria. The former is important as optimal temperatures for malaria transmission are not enough, the other climate factors (e.g., rainfall) must also occur. Changes in temperature during the day have been shown to impact the risk of malaria transmission. If the fluctuations of temperature throughout the day are considered, then it has been found that at colder daily average temperatures (i.e., <20^{o}C) the risk of malaria transmission is increased from what is generally thought. This is because the mosquito and parasite are exposed to warmer temperatures for at least part of the day. The opposite was found with warmer daily average temperatures, where large fluctuations in the temperature during the day decreased the risk of malaria from what is generally thought (Paaijmans et al, 2009). Malaria risk is very sensitive to temperature, with small changes being magnified to lead to much larger health risk impacts (Pascual et al, 2006; Patz and Olson, 2006).

The necessary temperatures and other climate variables must coincide for malaria transmission. The relationship between rainfall and malaria is not linear. Sometimes too much rain will lead to fewer than expected malaria cases (for many different reasons including destroying breeding sites) while small amounts of rain after a drought may lead to more malaria than expected where water pools and creates breeding sites (Thomson et al, 2005). If areas have permanent water bodies (e.g., lakes or rivers) then malaria transmission is still possible, even with low rainfall. In a study in Zimbabwe, the number of reported malaria cases was driven by intense rainfalls (Hoshen and Morse, 2004). Many models assume that the minimum level of rainfall needed for seasonal malaria transmission is a monthly rainfall of 80 mm for at least four consecutive months (Van Lieshout et al, 2004; Craig et al, 1999; Ebi et al, 2005). It is neccessary, however, that adequate rainfall and temperatures both occur. A global analysis that used climate projections from present to 2100 indicated a decrease in the exposure of malaria in Mozambique driven by the projected decreases in rainfall (Tanser et al, 2003). Currently there is little understanding of the impact of relative humidity on malaria transmission. A study in Maputo Province did find that that malaria risk was associated with maximum monthly temperatures of 28-35^{o}C and relative humidity values of 54.5-83% (Zacarias and Andersson, 2011).

In general, many studies have found that most of the projected future spread of malaria will be on the edges of the current areas with malaria, for example where it is currently too cold for transmission (Paaijmans et al, 2009; Pascual et al, 2006; Ebi et al, 2005; Hoshen and Morse, 2004; Van Lieshout et al, 2004; Zhou et al, 2004; Tanser et al, 2003).

8.1.2 Impact of non-climatic factors on malaria

Malaria is strongly impacted by non-climatic factors (Béguin et al, 2011; Zacarias and Andersson, 2011; Gething et al, 2010; Abellana et al, 2008; Thomson et al, 2005; Craig et al, 2004a; 2004b). In fact, during the last century, global temperatures have increased, yet the global range and intensity of malaria transmission have decreased (Gething et al, 2010). In addition, it has been estimated that the projected future impacts on malaria are around two orders of magnitude smaller than the impacts possible from appropriate and effective malaria control measures (Gething et al, 2010). A study in Manhiça found that the spatial pattern of malaria incidence is independent of seasonal climatic conditions, though the climate is associated with the incidence of malaria in the whole region (Abellana et al, 2008). In a study in South Africa it was found that the number of cases of malaria was more strongly related to the level of drug resistance (e.g. chloroquine) and HIV infection, than climatic variables. In fact, the climate variables could not explain the number of

cases, though they did appear to be significant drivers in the inter-annual variability of incidences (Craig et al, 2004a; 2004b). Land use change, thereby impacting microclimatic conditions and creating or destroying breeding habits, are also very important factors that impact malaria risk (Pascual et al, 2006; Patz and Olsen, 2006). Thus, to properly characterize the impact of climate change on malaria into the future, not only are spatially and temporally resolved climate projections needed, but so are projections of non-climatic factors, such as land use, socio-economic, demographic and vulnerability information.

8.1.3 Malaria prevalence in Mozambique

Mozambique is among the ten countries most affected by malaria in the world. Malaria is the main cause of death in Mozambique, although diseases such as HIV/AIDS are gradually increasing their relative contribution. The number of people of different ages dying from malaria is estimated to be between 44,000 and 67,000 per year. About 682,000 pregnant women and 2.8 million children under the age of 5 years are under malaria risk in the country (INGC, 2009). Malaria is endemic in Mozambique, affecting more than 90% of the total surface area (Figure 1). Arid areas and mountainous areas are generally less affected by malaria, because limited humidity (dryness) and low temperature prevailing in these areas prevent the rapid multiplication of mosquitoes, respectively. With the predicted increase in temperature and flooding events, malaria-causing mosquitoes will occur in areas currently not affected (INGC, 2009). Apart from climatic conditions, poverty, inadequate housing and limited access to prevention measures, contribute to the high prevalence of the disease (MISAU, 2012a).

Malaria is the main cause of medical consultations and admissions in hospitals (45% of total admissions and 56% of paediatric admissions). According to the report on Millennium Development Goals (Republic of Mozambique, 2010), malaria is the main cause of death of children under the age of five (42.3%), followed by AIDS (13.4%), pneumonia (6.4%) and diarrheas (5.9%). Therefore, it represents a high cost for the National Health Services. The number of malaria cases reaches the pick during the wet season, from December to April. Malaria has social and economic impact because infected people will not work or go to school, thereby increasing food insecurity and poverty levels.

The rate of prevalence in children less than five years old varies between 35% and 60% and more than 80% of these children suffer from anaemia, one of the main complications of malaria. During pregnancy malaria is also a big risk factor. It is one of the main causes of premature births and/or low weight at birth, about 35% of the pregnant women carry the parasite and more than 60% suffer from associated anaemia. Though there is a decreasing tendency, the mortality rate associated with malaria is still very high.

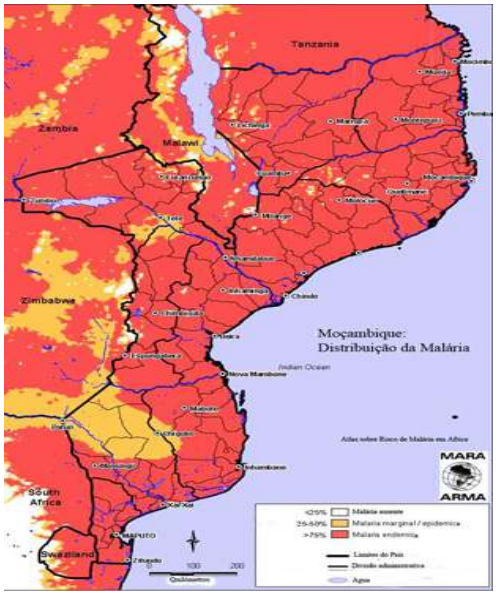
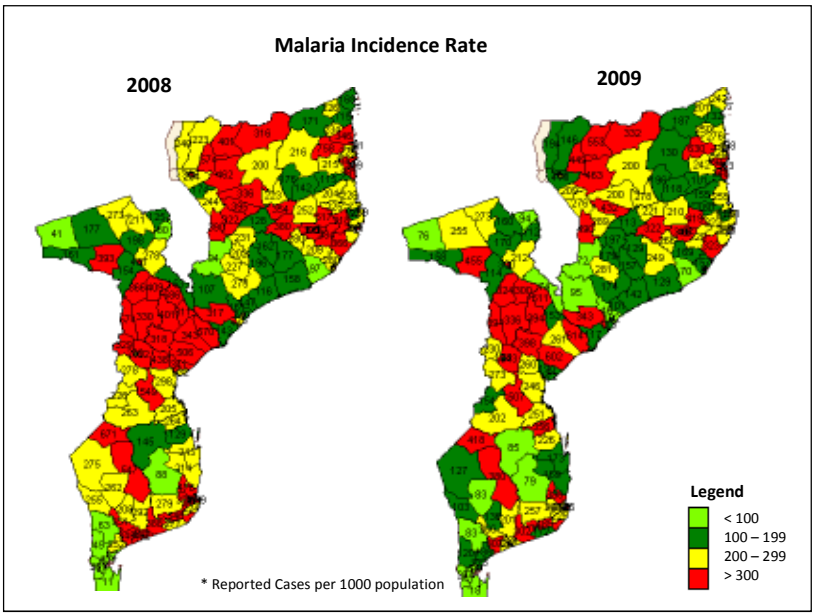


Figure 1: Distribution of malaria in Mozambique (2005) (*Source: www.mara.org.za*)

The main malaria vectors in Mozambique are *Anopheles funestus* and *gâmbiae*. *Plasmodium falciparum* is the most frequent, being responsible for more than 90% of the infections recorded, whereas infections by *Plasmodium malariae* e *Plasmodium ovale* represent only 9% and 1% of malaria cases, respectively (MISAU, 2012a).

There was a considerable decline in the incidence of malaria from 2008 to 2010 (Figure 2) and in mortality rate (Figure 3), mainly as a result of the implementation of the malaria control program (MISAU, 2012a).



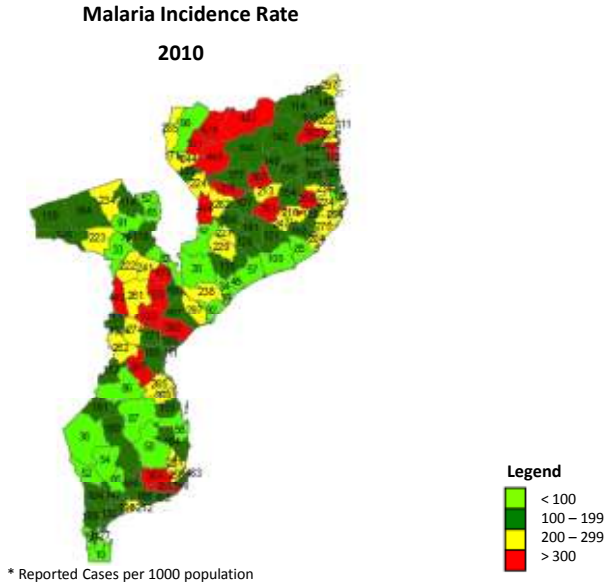
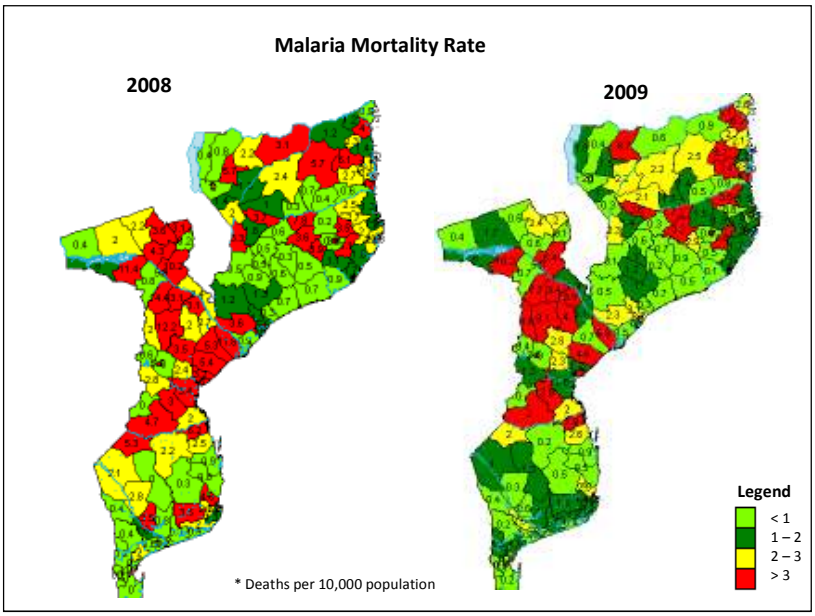


Figure 2: Incidence of malaria in Mozambique, 2008, 2009, 2010. (*Source: Relatório de Revisão do Programa da Malária, 2010.*)



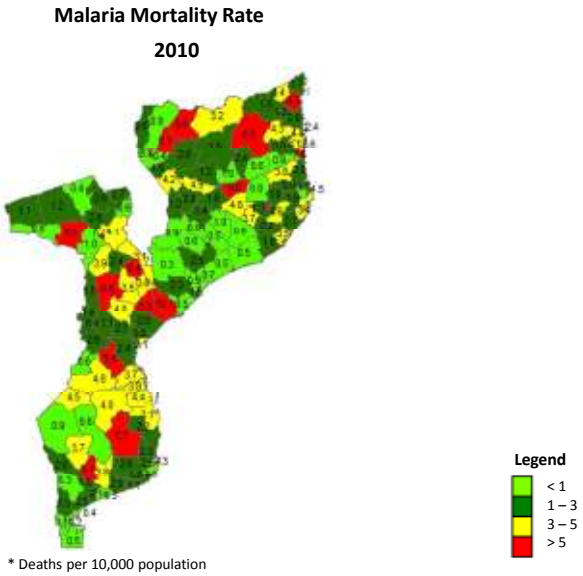


Figure 3. Malaria mortality rate per 10000 inhabitants, 2008, 2009 and 2010. (*Source: Relatório de Revisão do Programa da Malária, 2010.*)

Children under the age of five and pregnant women are the most vulnerable factions of the population. Nampula and Zambézia are the provinces with the highest prevalence of malaria in children (60.4% and 50.3%, respectively), whereas Maputo city and province are the least affected, with less than 10% prevalence (Figure 4). The prevalence of the parasite among pregnant women is around 16%.

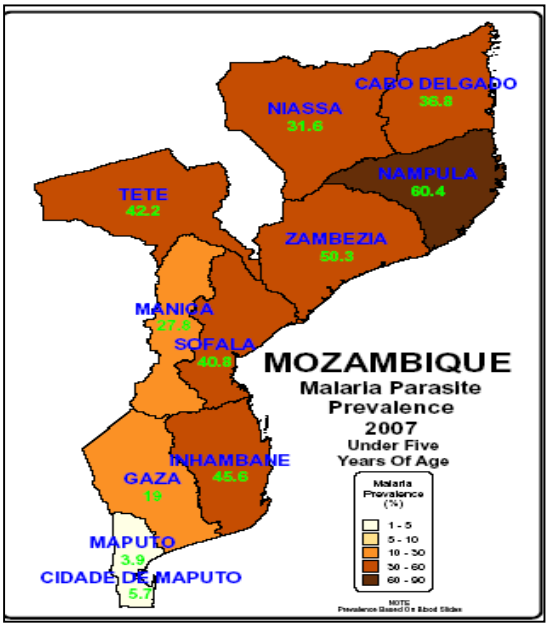


Figure 4: Prevalence of malaria parasites on children under the age of 5 years in Mozambique (*Source: Relatório de Revisão do Programa da Malária, 2010*.)

Malaria records in children under the age of 5 years showed a decline from 134 cases per 10000 children in 2003 to 80 in 2009 (Republic of Mozambique, 2010). The percentage of pregnant women that received mosquito nets during pre-natal consultations increased sharply between 2009 and 2011, from 76.6% to 92%. During the last 5 years there has been a general decline in malaria cases, from about 6.5 million cases in 2007 to about 3.2 million cases in 2011 (MISAU, 2012b). In Nampula, the number of cases declined from about 950,000 in 2009 to 800,000 in 2010, whereas in Zambezia the number of cases declined from about 580,000 in 2009 to 400,000 in 2010. These are the most populated provinces.

Child and mother health is a key priority of the Government of Mozambique, as outlined in the 5-year Government Plan (PQG 2010 – 2014). Considering the high child and mother morbidity and mortality caused by malaria, in line with the MDG 6 - Combat HIV/AIDS, malaria and other diseases, whose goal is to halt, by 2016, and begun to reverse the incidence of malaria and other major diseases; MDG 5 – improve maternal health and MDG 4 - reduce child mortality; a National Program for Malaria Control is being implemented in the country, with the following objectives:

- To increase the coverage of domiciliary spraying to 90% and improve the management of insecticides
- To increase to 90% the coverage of treated mosquito nets distributed to pregnant women
- To improve diagnostic and treatment capacity at all levels, from central to local

The use of mosquito nets is among the most effective methods to prevent malaria. The percentage of under-fives sleeping the previous night under a mosquito net increased from 10% in 2003 to 42% in 2008, with a higher increase in the rural areas (Republic of Mozambique, 2010).

8.2 Cholera

Cholera is an acute intestinal disease caused by the bacterium *Vibrio cholerae* after ingestion of contaminated water or food. There are two types of *Vibrio cholerae* namely; O1 and O139 (Colwell, 1996). Cholera symptoms usually appear suddenly and a person infected with cholera will experience the following symptoms: diarrhoea, falling blood pressure, cramps in the legs and low body temperature. Other symptoms include vomiting, struggling to pass urine, dehydration and fainting or collapsing (Sack et al, 2004).

8.2.1 Risk factors for cholera

The most cited risk factors of cholera are closely related to poor environmental conditions and lack of basic infrastructure. In this respect, human migration, high population density, poor access to safe water and lack of proper sanitation contribute to the spread of cholera (Constantin de Magny et al, 2012; Fernandez et al, 2012; 2009; Ali et al, 2002).

There are several other environmental risk factors described related to the origin of cholera prevalence, such as sea surface temperature, air temperature, plankton production and rainfall (Constantin de Magny et al, 2012; Fernandez et al, 2012; 2009; Ali et al, 2002).

8.2.2 Impact of climate factors on cholera

Climate change influences the epidemiology of cholera, as it is a water-borne disease. The changes of various bio-physicochemical parameters of water, for example temperature, salinity, pH, and abundance of phytoplankton, have an impact on distribution and survival of *Vibrio cholerae* (Mendelsohn et al, 2008; Patz and Kovats, 2002). In addition, El Niño events are also a strong determinant of interannual climate variability in many countries and they result in changes in land and sea surface warming and precipitation patterns (WHO, 1999). In Dhaka (Bangladesh), between 1980 and 1998, cholera incidences were associated with El Niño events (Pascual et al, 2000). Furthermore, this event was confined to the coastal regions, where it triggered spring epidemics of the disease (Pascual et al, 2000). A similar event occurred in Peru which resulted in the reappearance of cholera (Rodo et al, 2002).

The role of climate in the transmission of cholera has been investigated (focusing on temperature and rainfall) in recent years due to the growing concern about the effects of climate change on infectious disease dynamics (Patz and Kovats, 2002). Various studies have linked rainfall and temperature with cholera outbreaks (Constantin de Magny et al, 2012; Pezeshki et al, 2012; Emch et al, 2010; Saski et al, 2009; Fernandez et al, 2008; Mendelsohn et al, 2008; Constantin de Magny et al, 2007; Lama et al, 2004; Pascual et al, 2002; Patz, 2002; Bouma and Pascual, 2001; Kustner and du Plessis, 1991). In general, higher temperature and rainfall (with events such as floods) or low precipitation (with events such as droughts) increases the risk of cholera (Constantin de Magny et al, 2012; WHO, 1998; Kustner and du Plessis, 1991). For example, a study that was done in South Africa (Kwa Zulu Natal) found a strong association between cholera incidences with precipitation and sea surface temperature. However, non-climatic factors such as chlorophyll-a and sea surface height, showed a moderately strong and weak association, respectively (Mendelsohn et al, 2008).

Furthermore, other studies found that floods/extreme events of precipitation have a strong positive correlation with cholera outbreaks (Constantin de Magny et al, 2012; AICC, 2006; WHO, 1998; Kustner and du Plessis, 1991). The results of a study in Senegal showed that floods in eleven regions

exacerbated a cholera epidemic (Constantin de Magny et al, 2012). Kustner and du Plessis (1991) also found that most patients who were affected by cholera in their study in South Africa were from the rural areas with an annual rainfall in excess of 600mm.

In addition, two studies in Zambia demonstrated a positive correlation between cholera incidences with higher precipitation and rainfall (Fernandez et al, 2009; Saski et al, 2009). The first study indicated that an increase in temperature 6 weeks before the rainy season and an increase in rainfall 3 weeks later resulted in the high number of cholera cases (Fernandez et al, 2009). The second study discovered that an increase in precipitation correlated positively with the occurrence of cholera outbreaks, while the non-climatic factors such as insufficient drainage networks were also associated with cholera incidences (Saski et al, 2009).

Non-climatic factors such as economic status and geographical location (e.g. rural areas) also play a major role in cholera distribution. In Bangladesh, Emch et al (2010) found that not only rainfall influenced cholera incidences, but also economic status because poorer people have less access to clean water and proper sanitation. Furthermore, it was also discovered that low precipitation (e.g., drought) also plays a role in cholera outbreaks (Pezeshki et al, 2012). These findings were confirmed in a study conducted in Iran, which showed that apart from higher temperature, humidity and low precipitation also plays a role in the incidences of cholera (Pezeshki et al, 2012). High incidence of cholera was also observed when a very severe and prolonged drought occurred in Sarawak (Benjamin et al, 2005).

8.2.4 Projections of cholera and interventions

Currently there are models under development that can be used to project the number of cholera cases on short time scales and can perform well (Rinaldo et al, 2012). These models take climate and non-climate factors into account.

Pascual et al (2000) pointed out that climate factors are not enough to understand the size and timing of cholera outbreaks. To improve our insight into cholera prevalence it is very important to take into account the immunity levels of the population of the region (Pascual et al, 2000). A study that was conducted in Zimbabwe highlighted the importance of considering topographical elevation as a geographical and environmental risk factor in order to plan cholera preventive activities linked with water and sanitation in endemic areas (Fernandez et al, 2012). Furthermore, elevation information, among other risk factors could help to spatially orientate cholera control (Fernandez et al, 2012).

Other researchers pointed out the following as preparedness methods: development of early warning systems, outbreak prediction and monitoring of environmental temperature (Fernandez et al, 2009; Mendelsohn et al, 2008; Lama et al, 2004).

8.2.5 The cholera situation in Mozambique

Cholera was recorded for the first time in Mozambique in 1973 in the Sofala province, then again in 1978. The disease was initially restricted to the cities of Maputo, Beira, Nampula and Quelimane. However, during the last two decades the disease expanded its distribution, affecting all the provinces of the country, including rural areas (Figure 5). In areas affected by floods, the mechanism of infection is through drinking of contaminated water (Patz and Kovats, 2002), whereas in areas affected by drought, the diseases occur due to lack of water for basic hygiene and lack of safe

drinking water. Drier areas of the country such as most of Gaza, Inhambane and Tete provinces are less affected by the disease than wetter provinces such as Zambezia. Densely populated areas, such as the cities, are the most frequently affected areas, mainly due to poor sanitation. Southern Mozambique is less affected by cholera than the central and northern regions. Zambezia is the most affected province, with cholera cases being recorded every year (MISAU, 2009). This province has the lowest rate of consumption of safe drinking water of the country (24%), while Maputo City has the highest rate of consumption of safe drinking water (94.3%). The national coverage of safe drinking water supply increased from 37.3% in 1997 to 56.0% in 2009 (Republic of Mozambique 2010). This trend in the supply of drinking water might in part explain the decline in the number of cholera cases from about 45000 in 1999 to about 15000 in 2008 (MISAU, 2009). Cholera cases reach a peak during the late wet season months, from January to March, which is the period of floods and cyclones.

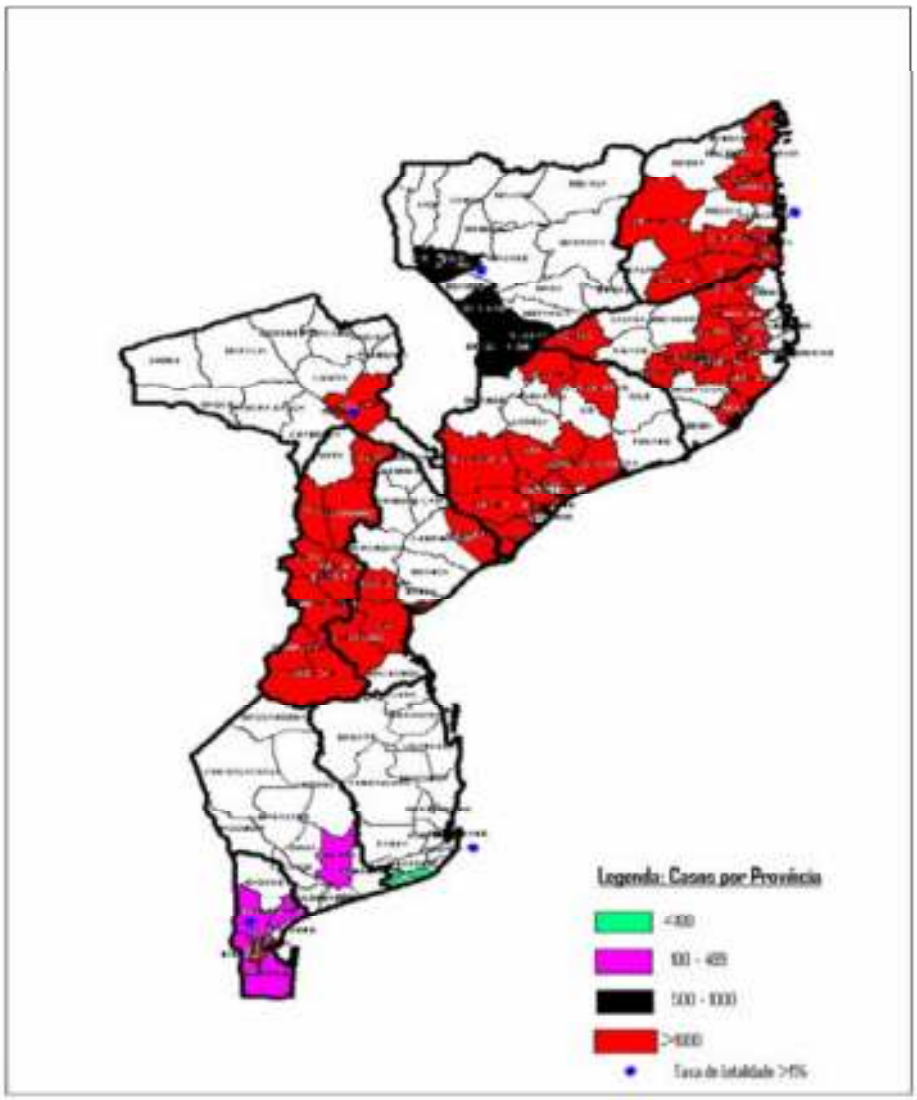


Figure 5: Distribution of cholera cases in Mozambique in 2009 (*Source: MISAU/Departamento de Epidemiologia*)

8.3 Dysentery

Dysentery is an infection of the intestines that causes diarrhoea (i.e. the passing of three or more watery stools a day) containing blood or mucus. Other symptoms of dysentery include stomach cramps, fever, nausea and vomiting. These symptoms may last for 4-7 days and are self-limiting. There are two main types of dysentery: (1) dysentery caused by shigella bacteria (bacillary dysentery or shigellosis) and (2) dysentery caused by an amoeba (a single-celled parasite) called *Entamoeba histolytica* (amoebic dysentery or amoebiasis) found mainly in tropical areas.

8.3.1 Risk factors for dysentery

Poor hygiene and eating contaminated food are risk factors for both types of dysentery. Shigellosis has been associated with outbreaks of disease related to use of contaminated swimming facilities such as artificial ponds and other small water bodies with limited water movement and without disinfection. Contamination of natural water bodies and water ways usually occurs through accidental faecal releases.

Additional factors that have an important influence on shigellosis transmission include poverty levels/socio-economic status, population density, personal hygiene, food preparation methods, toilet type and water sources (Zhang et al, 2009; Kelly-Hope et al, 2008; Chompook et al, 2006).

8.3.2 Impact of climate factors on dysentery

Climate factors influence the spread of dysentery by playing an important role in the transmission process, as well as influencing spatial and seasonal distributions, and inter-annual variability and long-term trends (Kelly-Hope et al, 2008). Specific climatological factors influencing bacillary dysentery include temperature, precipitation, evaporation and relative humidity. A positive correlation between these factors and bacillary dysentery (monthly incidence) was found in northeast China (Huang et al, 2008). A negative correlation was found between bacillary dysentery and air pressure. Using ridge regression and hierarchical cluster analysis, it was found for the period 1987-1996 relative humidity, temperature and air pressure affected transmission of bacillary dysentery (Huang et al, 2008).

Results of two other studies (Liao et al, 2009; Jia et al, 2007) corroborate results mentioned above where it was found that higher incidence of bacillary dysentery was caused by higher air temperature and higher relative humidity. A third study noted that relative humidity, minimum temperature and air pressure one month prior were statistically influential factors for dysentery incidence in North-Eastern China (Guan et al, 2008) Thus it would appear that the incidence of dysentery may be forecasted using projected temperature, relative humidity and rainfall data, and possibly air pressure one month prior.

Such a forecasting exercise was carried out for Jinan, Northern China. Maximum temperature, minimum temperature, rainfall, and air pressure (all one-month lag) and relative humidity (no lag) were significantly correlated with the incidence of dysentery in Jinan (Zhang et al, 2008). After controlling for seasonality, lag time and long-term trends, a model suggested that a 1°C increase in maximum temperature may relate to more than 10% increase (95% confidence interval 10.19-12.69%) in the cases of bacillary dysentery in Jinan. The thresholds for the effects of maximum and

minimum temperature were 17 °C and 8 °C, respectively, in the northern parts of the city (Zhang et al, 2007a).

Some research has considered the relationship between El Niño Southern Oscillation (ENSO) and bacillary dysentery in China. Results showed that the monthly Southern Oscillation Index (SOI), a broad index of ENSO, may be a useful early warning indicator of potential dysentery risk in China (Zhang et al, 2007b).

8.3.4 Dysentery interventions

Interventions to reduce risk of transmitting shigellosis include promotion of breastfeeding, improved water supply and sanitation (especially latrines and garbage disposal) and housefly control (Chompook et al, 2006).

8.3.5 Climate events and linkages with dysentery outbreaks

In Mozambique, the incidence of dysentery is likely to change and expand in range, frequency and severity. An outbreak associated with heavy rains/ floods was experienced in 2000. In February 2000, heavy rains were experienced over southern Mozambique and the Limpopo River broke its banks north of Maputo, contaminating the water supply and causing dysentery among the local communities (World Bank, 2010).

In a Vietnamese study, climate (specifically rainfall, temperature and humidity) played a role in defining high- and low-disease periods, but it did not seem to be an important factor influencing disease outbreaks (Kelly-Hope et al, 2008). Therefore, the relationship between dysentery outbreaks and climate appears to be complicated.

8.4 Other diseases

Although malaria, cholera and dysentery are arguably the most critical diseases that are linked to climate parameters, there are also some other climate-sensitive health conditions. These include lymphatic filariasis, onchocerciasis, schistosomiasis, trypanosomiasis and the plague. Currently these diseases are not considered important for public health, and thus little emphasis is placed on their incidence in the surveillance systems. The project steering committee did, however, specifically mention their interest in the plague in the terms of reference for this project. Neither national level MISAU nor the health directors in the case study districts mentioned the plague as a public health issue during fieldwork. At central level, the most recent available data cites two provinces reporting cases of the plague: Zambezia (with 77 cases) and Tete (with 23 casts) – both 10 years ago. Similarly the last reported case of trypanosomiasis was in 1988.

8.5 Malnutrition

Food security is an important element to ensure good nutritional status and is defined as physical and economic access to sufficient food in terms of quality and quantity, and which are socially and culturally acceptable (SETSAN, 2008). Frequent droughts, floods and cyclones that with increasing in frequency and severity affect the country and result in food insecurity and malnutrition. In Mozambique, the nutritional status is commonly analyzed among children under age of five years. Three types of malnutrition are highlighted by (i) low weight at birth, (ii) chronic malnutrition and

(iii) acute malnutrition. Provinces with food insecurity, food hunger and malnutrition reflect poverty levels. On the other hand, people with poor housing (84%), inadequate water sources (54%) and inadequate sanitation (14%) were drastically affected by acute malnutrition (SETSAN, 2008). Using food insecurity as "proxy indicator" for malnutrition, SETSAN (2008) concluded that Sofala (33%), Tete (17%) and Nampula (15%) are the provinces most affected by malnutrition (figure 6).

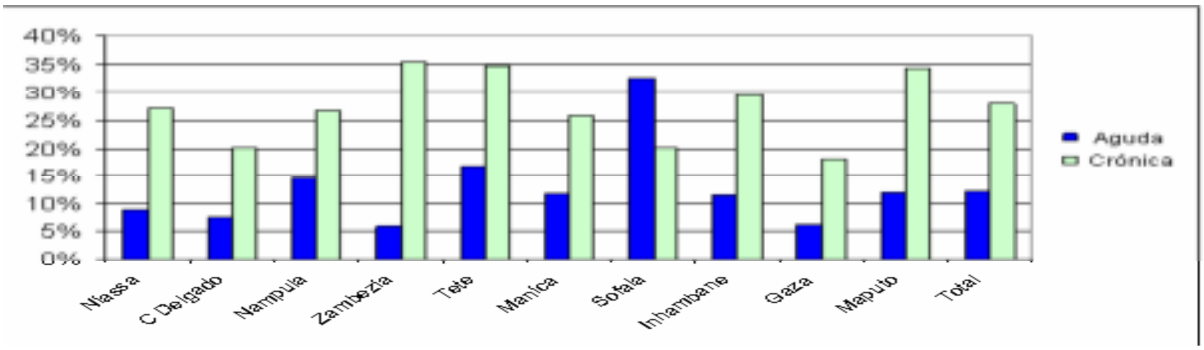


Figure 6: Acute and chronic malnutrition prevalence in Mozambique in 2008 (*Source: SETSAN 2008*)

8.5.1 Acute Malnutrition

Acute malnutrition, or low weight-for-height, indicates a deficit of muscle mass in relation to the expected amount in a child with the same height. This situation is caused, among other factors, by a low level of food consumption (SETSAN, 2008). The levels of acute malnutrition in under-fives decreased from 7.9% in 1997 to 5% in 2003 and 4% in 2008 (MICS, 2008), a percentage that lies within the limits considered normal by WHO. Nampula province (the most densely populated of the country) has the highest rate of prevalence of acute malnutrition in under-fives, namely 8.9%. Niassa, Nampula, and Zambézia provinces have higher percentages of chronic malnutrition in under-fives than the national average of 4% (Republica de Moçambique, 2010).

Acute malnutrition is caused by inadequate intake of nutrients. Although the consumption of food quantity, or calorie intake, seems satisfactory, diet quality is a serious problem, mainly due to lack of diet diversification and low intake of micronutrients. Anaemia is a widespread nutritional deficiency in Mozambique, it is a condition partially caused by iron deficiency, but many times associated with parasite infections that cause blood loss.

The quality of diet in Mozambique, in terms of nutrients and diversity of food, has improved over recent years. Food Security and Nutrition (SAN) situation generally deteriorates in response to prolonged droughts, floods or cyclones that result in poor crop yields or due to increases in food prices. According to MISAU (2012c), the average percentage of people dying in hospitals from severe malnutrition during the last 5 years (2007-2011) is around 11%, slightly higher than the recommended <10% by World Health Organisation (WHO).

8.5.2 Chronic Malnutrition

Chronic malnutrition or low height-for-age is a situation of persistent deprivation of food and is caused by chronic or repeated infections or by inadequate nutritional consumption (SETSAN, 2008). Gastrointestinal parasites also contribute to chronic malnutrition. It results from untreated acute malnutrition. It is estimated that 44% of children in Mozambique suffer from chronic malnutrition

(MICS, 2008), which is a serious public health problem according to the classification of the WHO (República de Moçambique 2010). Despite the satisfactory economic growth experienced by the country during the last decade, progress towards reducing chronic malnutrition has been slow. The distribution of under-fives suffering from chronic malnutrition follows a north-south geographical tendency. The southern provinces of the country tend to have a lower percentage of under-fives with chronic malnutrition than those of the centre, and the central provinces tend to have a lower percentage of under-fives with chronic malnutrition than the northern provinces of the country (with the exception of Niassa). The provinces with the highest percentages of under-fives suffering from chronic malnutrition are Cabo Delgado, with 56%, followed by Nampula province, with 51%. Zambezia, Niassa, Tete and Manica have intermediate rates, around 45%. The provinces with the lowest rates (<40%) are Inhambane, Gaza, Maputo province and Maputo City. Chronic malnutrition contributes to child mortality, undermining efforts to achieve of MDG 4 - reduce child mortality (República de Moçambique 2010).

8.5.3 Low weight for age

The percentage of low weight for age, one of the indicators of nutrition surveillance, reflects the level of nutritional health in under-fives. From 1997 to 2008 the rate of prevalence of low weight in under-fives has gradually decreased in the country. While the rate of prevalence of low weight in under-fives was 26.1% in 1997, it decreased to 23.7 % in 2003. With these levels of decrease the country has accelerated the rate of reduction of the prevalence of low weight in under-fives and is on the road to meeting the target of the millennium goal (17%) before 2015 (Republic of Mozambique, 2010).

8.5.4 Underweight births

The rate of underweight births remained high in 2010, with an average across all provinces of the country around 10.5% (MISAU, 2012c), a decline from 11.3% recorded in 2008. This is an indication of malnutrition among pregnant women, and consequently poor health condition. Nampula is the province with the highest percentage of underweight births, with an average of 13.5% between 2008 and 2010, followed by Sofala, Cabo Delgado and Zambezia. Maputo province, Gaza, Inhambane and Manica are the provinces with consistently lower percentage of underweight births (around 7-8%) (MISAU, 2011).

In line with MDG 4 – reduce child mortality, the Government of Mozambique developed the multisectoral action plan for the reduction of chronic malnutrition in Mozambique**,** with the main objective of reducing chronic malnutrition in children under the age of 5 to 30% in 2015 and to 20% in 2020. Other objectives include:

- To reduce underweight births from 15% in 2008 to 10% in 2015 and 5% in 2020
- To reduce anaemia in women of reproductive age from 50% in 2010 to 30% in 2015 and 15% in 2020
- To increase the coverage of vitamin A supplementation to pregnant women from 60% in 2010 to 70% in 2015 and 90% in 2020
- To reduce the anaemia of pregnant women from 53% in 2002 to 30% in 2015 and 15% in 2020

9. Downscaled Climate Projections for Mozambique

9.1 Temperature

Monthly average and monthly maximum temperatures were modelled for both time periods studied. The averages of these monthly values were calculated for 1961-1990 and 2046-2065 and are labelled "T_ave" for average monthly temperature and "T_max" for average monthly maximum temperature in the following figures.

The average temperatures for the two time periods studied are shown in Figure 7.

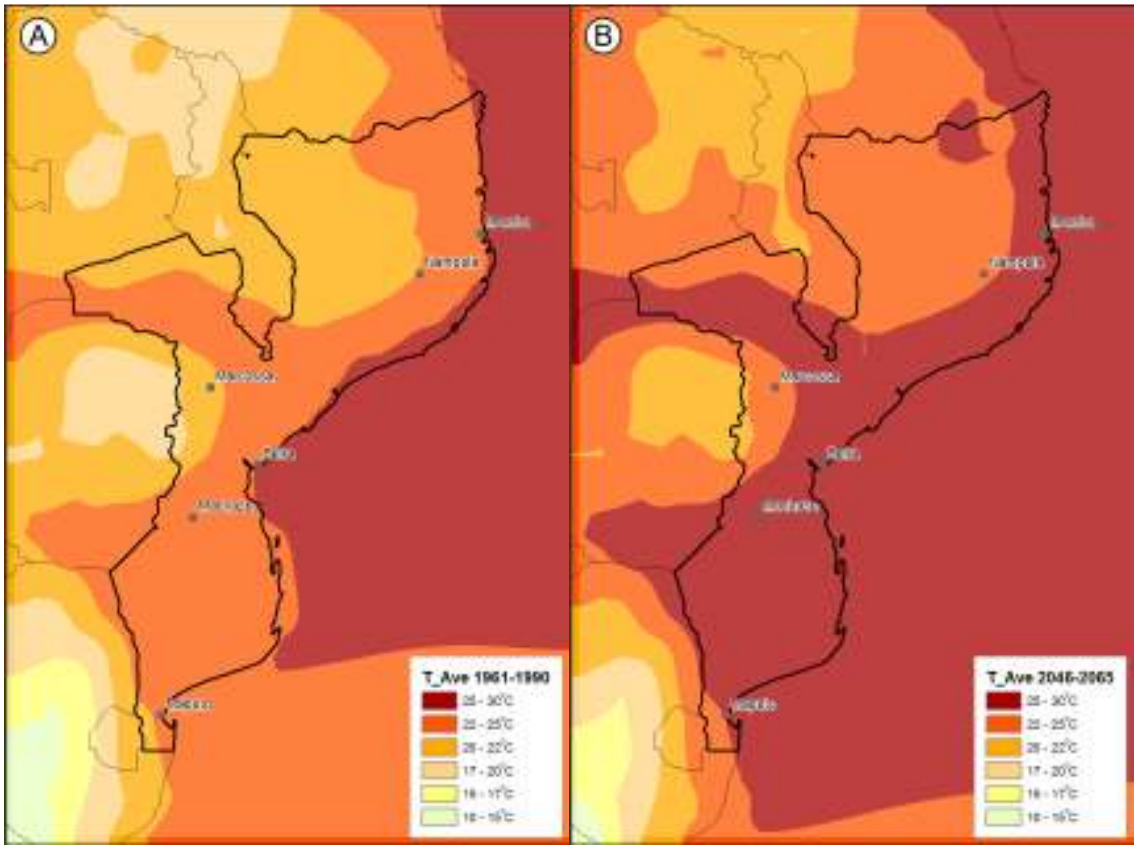


Figure 7: Modelled average monthly temperature (T_ave) for A) 1961-1990 and B) 2046-2065

In the reference time period of 1961-1990, only a small part of the northern coast is shown to experience average monthly temperatures of 25-30^{o}C. However, it is projected that in 2046-2065 that the entire coast and much of the interior will experience such high temperatures. It is projected that in 2046-2065, all except the very western part of the country will experience average monthly temperature above 22^{o}C. This is the temperature at which it has been suggested, and is used in many models, that is necessary for stable malaria transmission (Craig et al, 1999).

Figure 8 below highlights the average monthly temperature anomaly. An anomaly is the change between the two projections. In this case, a positive anomaly indicates a projected increase in the average temperature in 2046-2065 from 1961-1990.

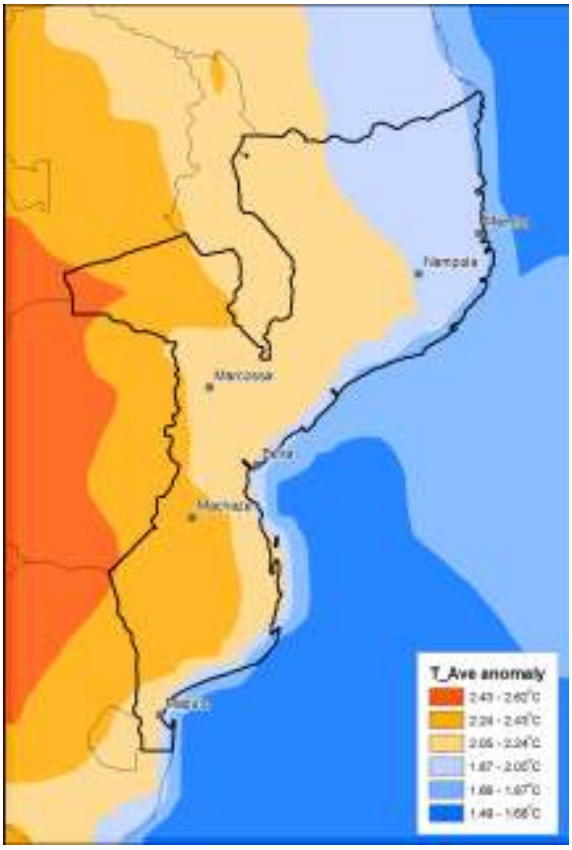


Figure 8: Average monthly temperature (T_ave) anomaly modelled for 2046-2065 using 1961-1990 as a reference period

As can be seen in Figure 8, all of Mozambique is projected to experience increases in temperature. The coastal regions are projected to experience the smallest increase in average monthly temperature, with the western parts of Mozambique projected to have the largest increases in average monthly temperature.

Figure 9 below displays the modelled average monthly maximum temperature (T_max) for the two time periods. Figure 9 highlights that it is projected that not only average monthly temperature will increase, but maximum temperatures are projected to do so as well. In 1961-1990, very high average monthly maximum temperatures of 29-34^{o}C were mostly experience in the southern and central interior of Mozambique. However, in 2046-2065 it is projected that almost the entire country will experience average monthly maximum temperatures of 29-34^{o}C.

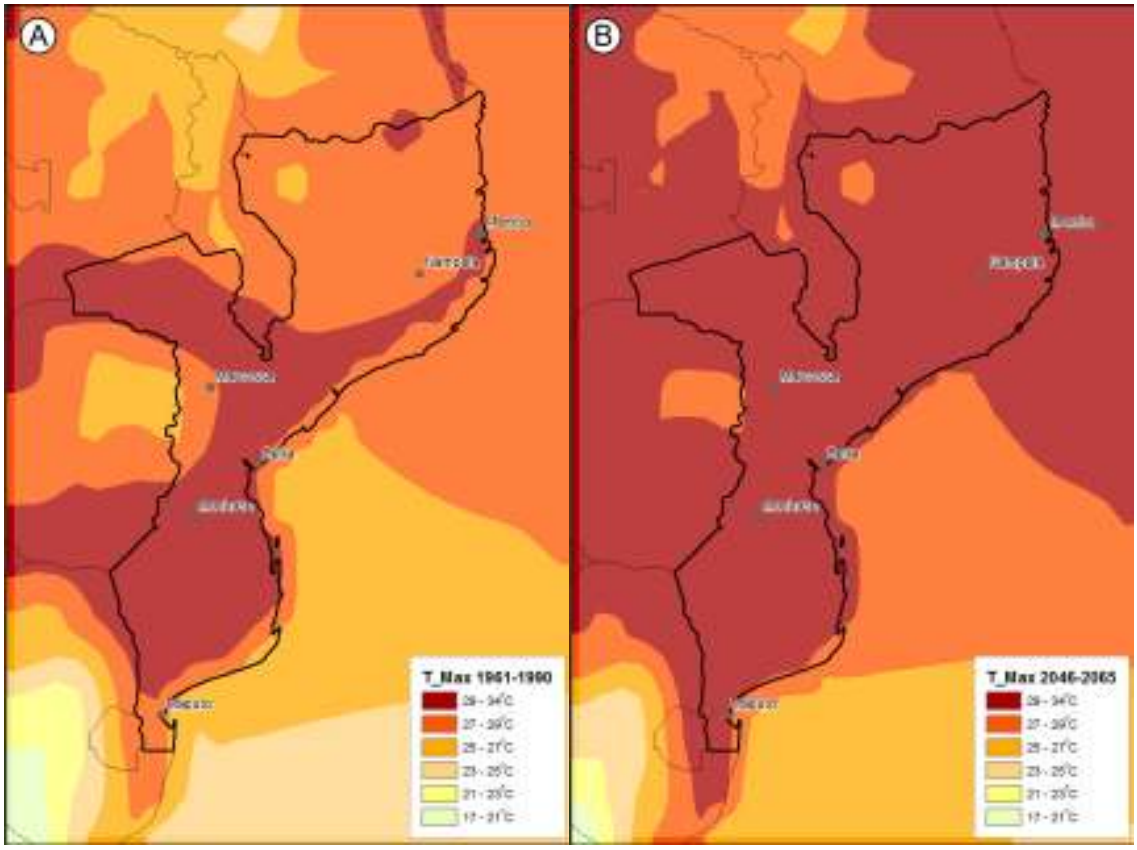


Figure 9: Modelled average maximum temperature (T_max) for a) 1961-1990 and b) 2046-2065

Figure 10 highlights the anomaly for the average monthly maximum temperature. As in the average monthly temperature anomaly, all of Mozambique is projected to experience an increase in average monthly maximum temperature. It is projected that the northern and coastal regions will experience the smallest increase in temperature, while the interior and western part of Mozambique is projected to experience the largest increase in average monthly maximum temperature.

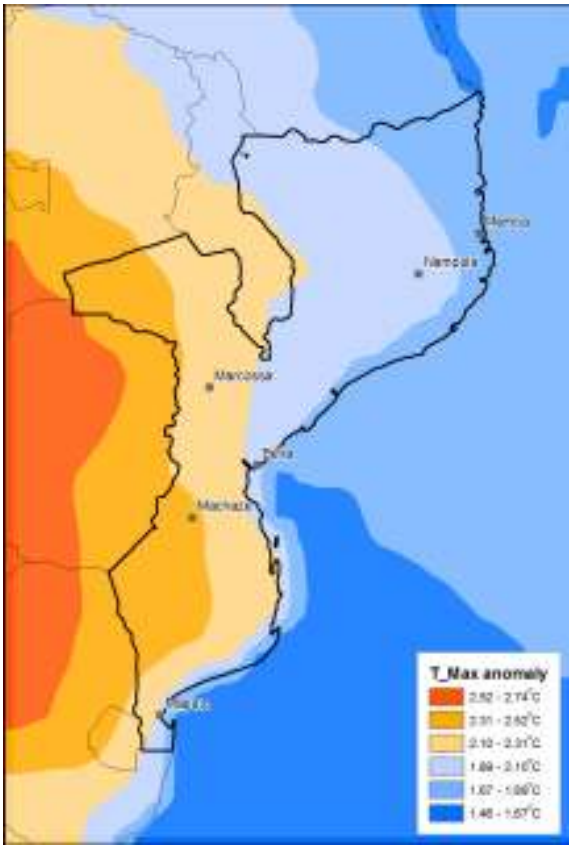


Figure 10: Average monthly maximum temperature anomaly for 2046-2065 as compared to a reference period of 1961-1990

These increases in average and maximum temperature may impact public health directly through increased negative health conditions related to heat. In addition, as described above, malaria, cholera and dysentery are all impacted by temperature.

In general, warmer temperatures will provide conditions more suitable for malaria transmission, though too high temperatures have been shown to decrease malaria transmission. Additionally, warm temperatures alone are not enough for malaria transmission, rainfall (or some source of water) is also needed. Warmer temperatures may provide favourable conditions for increase in cholera transmission; however, climatic factors such as higher rainfall (e.g. floods) and higher relative humidity are also important. For bacillary dysentery, warmer temperatures may be more conducive for increased transmission; however, increased rainfall and also higher relative humidity may be necessary climatic factors.

9.2 Rainfall

The monthly rainfall throughout the time periods studied were modelled, and then averaged for the two time periods (i.e., 1961-1990 and 2046-2065) to produce the average monthly rainfalls for those periods. The percentage change in these average rainfalls were calculated and shown in Figure 11 to highlight the areas that are projected to see large changes in rainfall. In Figure 11, all areas in blue are projected to experience a decrease in rainfall.

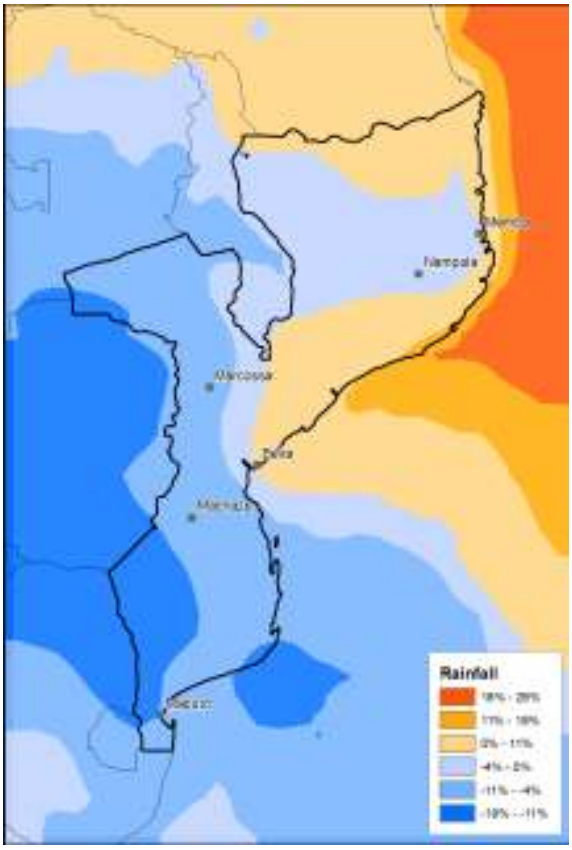


Figure 11: Percentage change in average monthly rainfall for 2046-2065 compared to 1961-1990

It is projected that only the northern coast of Mozambique would experience an increase in rainfall in 2046-2065. A global analysis of malaria and climate also found a decrease in rainfall in Mozambique in climate projections, and this decrease drove a projected decrease in the exposure of malaria in Mozambique (Tanser et al, 2003). Similarly, for dysentery, decreased rainfall may reduce exposure to and transmission of bacillary dysentery, despite increased temperatures. However, a decrease in rainfall (e.g. droughts) could increase cholera exposure and transmission.

9.3 Relative humidity

The average monthly relative humidity (RH) was modelled for all years of the time periods studied; these were then averaged to calculate the average RH (RH_Ave) for the periods of 1961-1990 and 2046-2065. Figure 6 displays the average RH anomaly. All the areas of the map in blue are areas where it is projected that there will be a decrease in average RH in 2046-2065.

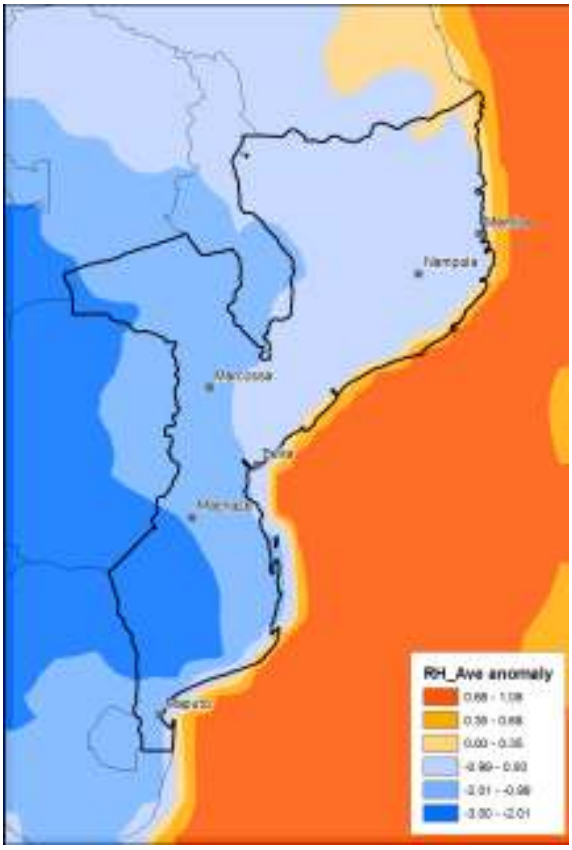


Figure 12: Average RH (RH_Ave) anomaly for 2046-2065 compared to 1961-1990 as a reference

All areas except for small parts of northern Mozambique are projected to experience decreases in RH. This may lead to a reduced transmission risk of bacillary dysentery, since evidence suggests that increased temperature, rainfall and relative humidity combined play important roles. Also, a decrease in relative humidity may reduce exposure to and transmission of cholera.

9.4 Potential climate impacts on health

Since, as stated above, the methodology employed in this report is largely qualitative, with no novel health modelling, in this section we summarise the linkages between various diseases and climate (and some non-climate parameters), in order to illuminate how the future disease burden and epidemiology may unfold in Mozambique.

Malaria, cholera and dysentery may be impacted by climate factors, though the impacts are not straight-forward. The above climate projections give an indication of how the general climatology of Mozambique is projected to change into the future under a "business as usual" scenario of climate change. These are helpful in describing, in general, the possible trends, but are not detailed enough to fully describe the potential health impacts. In addition, non-climate factors are also key factors for determining the impact of these diseases.

For example, for non-climate factors for bacillary dysentery such as personal hygiene and hand-washing with clean water play a critical role in reducing the inter-personal transmission of the bacteria. Use of toilets versus pit latrines has also shown to influence the incidence of bacillary

dysentery. Poor containment of sewerage and sewerage spills into water used for drinking and recreational purposes increases the risk of the spread and transmission of the bacteria. While climate projections suggest a warmer, drier climate for many parts of Mozambique, reduced relative humidity as predicted, together with improvements in socio-economic status and personal hygiene will all influence the incidence of bacillary dysentery in the future.

Non-climatic factors such as low socio-economic status, high population density, poor access to safe water, decrease in hygiene and lack of proper sanitation contribute to the risk and transmission of cholera. The projected warm and dry climate suggests that climate change may increase the spread of cholera in Mozambique; however a more detailed analysis is needed.

The transmission of malaria is highest under optimal climate ranges that must occur together. Many studies have found that the areas for concern for the increased spread of malaria due to a changing climate are those areas on the edge of current malaria transmission areas where the climate factors are not favourable now (i.e., temperatures too cold), but may change into the future. However, as it is the combination of climate factors that impact malaria transmission, the potential increase in malaria risk from projected increased temperatures in Mozambique may be offset by the projected decreases in rainfall. In fact, an earlier global study found a decrease in malaria exposure in the future driven by this decrease in rainfall (Tanser et al, 2003). As in cholera and dysentery, non-climatic factors can have very large impacts on malaria risk and transmission, and must be considered when planning malaria control efforts.

9.4.1 Emerging themes from the expert meeting

The experts at the expert meeting endorsed the importance of malaria and cholera as the main climate-related diseases in Mozambique. Another highlighted disease was onchocerciasis which, like malaria, is carried by mosquitoes that breed in stagnant water. To date, all public health programmes addressing onchocerciasis have taken place in the northern region of the country. Experts also noted that incidences of measles tends to increase in times of flood, and that overall, there has been an exponential growth in the number of measles case each year.

The expert meeting also discussed the issues of indirect health impacts of climate change. The general feeling was the climate change will exacerbate existing challenges in Mozambique. Caution was expressed regarding the linkages between food production (itself directly related to climate parameters) and food security, which is now accepted to involve questions of access as well as availability. Typically the northern region of Mozambique produces the most food yet still has the highest levels of malnutrition. Malnutrition is an existing issue of concern in Mozambique, since pregnant women who are malnourished will give birth to malnourished babies, in turn raising the probability of life-long health problems. A disease known locally as konzo has been observed in Mozambique, and is caused through the eating of bitter cassava that has not been processed correctly. People eat this unprocessed bitter cassava in times hunger when there are no other alternatives (typically in cases of drought when other crops have perished). Whilst changing climate conditions may exacerbate the conditions that give rise to this disease, experts were quick to point out that improving access to foods (including when their own crops have failed), and improved education on growing a variety of crops and preparing the food to preserve nutritional content is essential – and is taking place in the country regardless of climate change.

10. High Resolution Case Studies in Manica and Nampula Provinces

As explained above, Manica and Nampula provinces were selected for analysis by the project steering committee based on their perceived risk of climate impacts on health in conjunction with the fact that they have been relatively understudied. This section mirrors the structure of the report as a whole, giving an overview of the prevalence of key climate-related diseases and then presenting some analysis of the climate exposure of each district. Results from qualitative research with health professionals in each district are then presented, focusing on their perceptions of vulnerability of public health status to climate change.

10.1 Disease prevalence

Table 2 outlines the number of cases of the various diseases in Manica and Nampula provinces, compared to the country as a whole.

Table 2: Public health conditions sensitive to climate change observed during 2009-2011 in both selected sites (*Source: compiled from Ministry of Health (2011) and Department of Epidemiology weekly bulletins*).

Diseases	Manica (nr of cases '000)			Nampula (nr of cases '000)			National (nr of cases '000)		
	2009	2010	2011	2009	2010	2011[2]	2009	2010	2011
Malaria	3,8	3,0	2,7	9,5	8,0	8,3	40	34,5	33,4
Cholera	0,2	0	0,4	0,37	0,008	0,8	0,2	0,5	2,13
Dysentery	0,13	0,15		0,34	0,26		1,7	1,8	1,7
Malnutrition	48.3%		41.9%	51.0%		55.3%	43.7%		42.6%
L. Filariasis	These are considered neglected diseases currently. However, there are efforts to put them at top of the agenda and the forthcoming MISAU climate change programme probably will play huge role particularly through surveillance system and research.								
Onchocerciasis									
Schistosomiasis									
Trypanosomiasis									
Plague	There are no cases notified since 2004								

10.1.1 Malaria

Although the malaria mortality rate in both provinces shows a decreasing trend, a relatively larger proportion of national cases come from Nampula province (830,000 in 2011) than Manica (270,000 in 2011), out of a national incidence of 3,340,000 million cases. During the first half of 2012 (January – June), more than 400,000 cases were observed in Nampula city, the double of what was observed in both visited districts of Manica, according to reporting bulletins received from the local health sector.

10.1.2 Cholera and dysentery

As shown in Table 2, the number of cholera cases in Manica and Nampula, as across the country as a whole, have fluctuated over the past 3 years. Cases of dysentery have similarly fluctuated. During the first half of 2012, diarrheal diseases were common in Nampula (80,000 cases) and Manica

[2] Note that Nampula province failed to send in data for the first six months of 2011. As a result, the data in this column is inaccurate and, since the national system is based on the submission of provincial data, it also is not a true representation. See also section 5.1.4.

(40,000 cases). On average, Nampula City has diagnosed 10-15 cases of cholera per day, whereas Manica were less than 5-10 cases. However, dysentery caused by Shigella dysenteriae (13,000 cases in Nampula and 7,000 in Manica) was an important diarrheal disease.

10.1.3 Meningitis and measles

Although there is little theoretical evidence to link meningitis and measles to climate parameters, these diseases are monitoring and reported through the health bulletins. We include them here as a measure of comparison – to identify whether the malaria and cholera/ dysentery trends observed over the past few years are mirrored by other diseases. Meningitis is most common in Nampula (more than 330 cases, lethality rate 21% annually) but most serious in Manica (41 cases with 32% of lethality rate). However, meningitis cases in Manica (Machaze) are increasing. In contrast, Manica has high burden of measles (18.6%) when compared to Nampula (0.1%). Between January and June 2012, Nampula notified 43 new cases of measles and Manica 11 cases (Source: reporting bulletins from local health sector). As these figures show, relatively speaking both meningitis and measles are small public health issues relative to malaria and cholera/dysentery.

10.1.4 A note of caution on data availability

Epidemiological data is managed at national level within MISAU, but dependent on the effective collection of data at local level, and effective communication of that data from district level to provincial level and then to national level. Recording and reporting systems are not in place for some diseases, including onchocerciasis, schistosomiasis and trypanosomiasis and even for some diseases that are on the list of compulsory notified diseases. During the first semester of 2011, Nampula province failed to transmit bulletins to national level. Reasons for failure of the intended reporting systems can relate to various factors, including a delay in data analysis at the collection site due to high workloads for staff/absent staff; failure of the telecommunications network (internet, telephone, fax) at any point within the chain; and delays in road transportation as a back-up mechanism to transport data to central level.

10.2 Climate risks

10.2.1 Manica

Both Machaze and Macossa districts in Manica province frequently experience severe droughts. During 2012 the tropical cyclone Funso was the most important climate event that affected rainfall patterns in Manica province (including the city of Chimoio), and occurred in January. During January and thereafter, Funso was linked to the shortage of rain, with the seasonal totals lower than normal (see Figure 13, which compares Chimoio with other major Mozambican cities), compounding similar lower-than-normal totals in 2011. Lack of tap water is a chronic problem, with about 95% of people collecting water from boreholes, rivers and lakes. Sanitation is poor, including open sea defecation. Houses are mostly traditional, built using local building materials (MAE, 2005). This socio-economic setting reveals high level of poverty, which contributes to social vulnerability to climate change and variability.

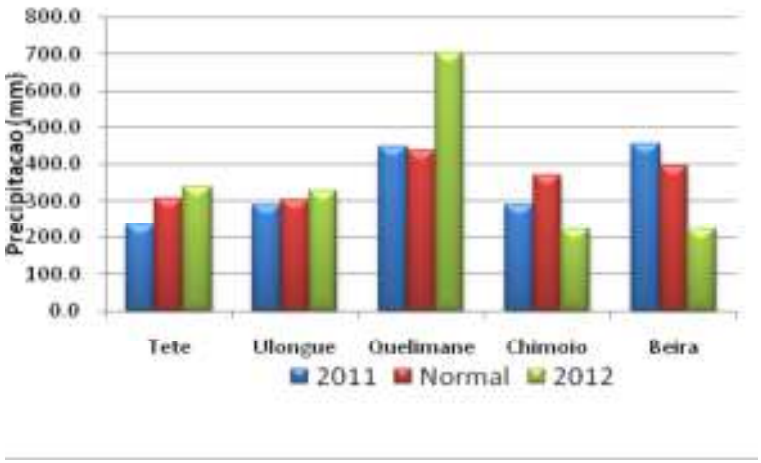


Figure 13: Cumulative rain amount in Central Zone of Mozambique during 1st half of 2012 (INAM, 2012)

10.2.2 Nampula

Whilst the inland province of Manica is relatively dry, Nampula province, in the northern region of the country, tends to experience floods. During 2012 rainfall was between normal and above normal in weather stations except for Pemba, Mueda and Montepuez (see Figure 14). In Nampula rainfall recorded during the reporting January and February 2012 exceeded the normal pattern. Being coastal, Memba district is frequently exposed to tropical cyclones. Similar to Machaze and Macossa, in Memba lack of tap water affects about 95% of the population, who are thus forced to use untreated water collected from rivers and lakes, increasing risk of water-borne diseases. Sanitation is poor, including open sea defecation. Houses are mostly traditional, built using local building materials (MAE, 2005). As with Manica, this socio-economic situation contributes to social vulnerability to climate change.

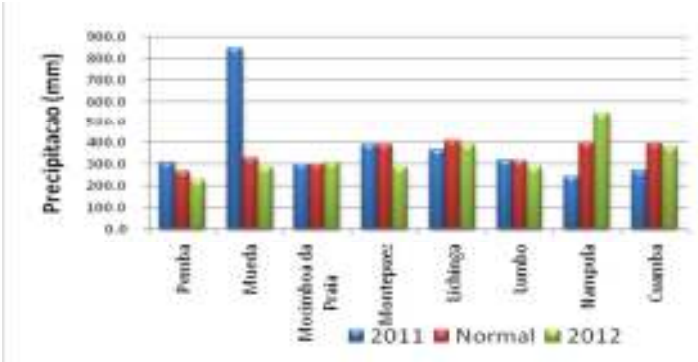


Figure 14: Rainfall totals in northern zone of Mozambique during the first semester of 2012 (INAM, 2012)

10.3 Perceptions of health professionals on the climate risks to public health

As outlined in the methodology, district level health professionals were interviewed to determine their perceptions of the climate risks to public health in their area of work. Initially, health

professionals were selected by the project team based on their own knowledge of the public health sector in Mozambique, with subsequent interviewees determined by snowball sampling. To be eligible for inclusion, each health professional had to meet several criteria; namely they had to be connected with the public health sector through working for a public health programme that deals with conditions sensitive to climate parameters; and they needed to have been in their current post for at least one year. It was also important that at least some professionals were working outside of MISAU. The reason for this is that generally such people have insights from direct community-based experience, and thus compliment the official views and epidemiological data available through the MISAU reporting hierarchy. One logistical constraint was their availability during the time of fieldwork: two interviews were ultimately conducted telephonically as opposed to in person. Table 3 summarises the characteristics of the respondents. Appendix D outlines the interview schedule and Appendix E provides the transcripts of each interview.

Table 3: Characteristics of public health interview respondents

Type	Manica	Nampula
Government	None	-Data collection officer for epidemiological surveillance (NED) in Memba
Non-government	-CHASS officer for malaria and tuberculosis (responsible for rapid malaria diagnosis) -2 from ADPP total control epidemics (TCE) (responsible for prevention of malaria through interior home pulverization (PIDOM) with insecticides and distribution of insecticide-treated bed nets for the most vulnerable population groups such as pregnant women and children under five years.	-FHI360 officer for malaria and tuberculosis -Kulima officer for community volunteerism for malaria, tuberculosis and women's health programme

Undertaking a content analysis of the interviews, we identified four dimensions of the climate risks to public health:

(i) The most prevalent public health conditions,
(ii) Risk factors for reported public health conditions
(iii) Self-perceived climate change effects on health and vulnerabilities to climate change
(iv) Actions required to deal with climate change.

10.3.1 The most prevalent public health conditions

Interview data from the local level confirms the picture painted by the provincial and national level statistics: malaria, cholera, dysentery and malnutrition are the most common health problems in both provinces – with HIV/AIDS and tuberculosis also mentioned. Despite meningitis not being common, it is a serious health problem in both provinces due to its lethality – ranging from 21% in Nampula to 32% in Manica.

10.3.2 Risk factors for reported public health conditions

There is a set of social and economic factors influencing the prevalence of those health problems. In rural areas, the women health seeking behavior is dependent on the husband or mother-in-law consent to pursue health care. Many women face challenges in accessing health care due to their gender. In addition, weather events are seen as barrier to health care access due to its impact on health network. Moreover, the health network is not covering all people. Most of people living in rural areas need to walk long distances to reach the nearest health facility. Finally, vertically-based health programmes and lack of health- relevant information can act to impede effective allocation of health care at the local level.

10.3.3 Climate change effects on health and vulnerabilities

Memba and Nampula city are impacted by floods and cyclones. Both events are related to cholera outbreaks and increasing malaria cases. Inadequate sanitation in conjunction with sky-open defecation exacerbate cholera occurrence. On the other hand, Macossa and Machaze are impacted by droughts, fueling cholera, dysentery and other diarrheal diseases by inadequate water supply. Most of people live in flood-prone and cyclone-prone areas in Nampula province. Floods and cyclone have impacts on public health and the health network. In addition, rural communities are not prepared to deal with natural events and their populations are dispersed, particularly people living in areas geographically inaccessible. The combined effect is difficulty in emergency response and rescue.

10.3.4 Actions required to deal with climate change

Based on recognition of the links between climate change and health, all respondents recognized the need for a health and climate programme to deal with climate change in Mozambique. Such a programme should include a national agenda for research on climate events with impacts on health. It should also address the need for institutional development and capacity building to address climate change issues in the health sector. In addition, there is a need for a contingency plan to deal with effects of rapid-onset natural hazards, such as floods and cyclones. Moreover, in order to ensure any national-level initiatives are effective at local level, community involvement and community funding are essential components to the community preparedness in dealing with climate change.

10.4 Initial recommendations arising from the fieldwork

The national level experts and health professionals in the four districts do make the link between various climate conditions and adverse impacts on public health, but further modeling is required to assess the exact nature of these links. The process of research undertaken here highlighted some existing challenges within the current system of collecting and storing data related to disease prevalence. Having a functional surveillance system is a critical prerequisite to investigating accurate linkages between disease outbreaks and climate parameters. Effective surveillance will then generate the evidence required to design effective awareness-raising and training programmes which cover appropriate responses to these increased risks. Such evidence can be used, in turn to inform the implementation of a credible health information system. That health information system should embody an effective communication channel to transmit early warning of potential risks to health professionals, and also to inform communities about risks and preventive measures.

11. Review of Good Practice in Policy Responses to Improve Human Health under Climate Change

A brief literature review highlighted several principles of good practice for policy responses to improve human health under climate change. According to Ebi et al (2006a) to strengthen adaptation to climate change in the health sector, key steps need to be taken, including:

(i) the description of the associations between disease outcomes and climate variability and change;

(ii) the identification and description of the current strategies, policies, and measures designed to reduce the burden of climate-sensitive health determinants and outcomes; and

(iii) the identification of additional adaptation policies and measures that could be undertaken over the short term to increase the capacity of individuals, communities, and countries to effectively cope with the weather or climate exposure of concern.

Public health adaptation knowledge gaps are widespread in a variety of contexts, and include:

- resolution of climate modelling to local scales;
- research on climate change science and health impacts locally;
- surveillance of environmental exposure and health impacts;
- guidance on mainstreaming climate change adaptation;
- tools to build awareness at community and institutional level, convey messages effectively and stress urgency to act; public health adaptation best practices and lessons learned; and
- policies to ensure sustained funding of climate change research, adaptation programmes and plans (Paterson et al, 2012).

Work Package 2 went some way towards addressing these knowledge gaps, by providing downscaled climate data for Mozambique and providing a qualitative assessment of the risks of climate for major diseases (i.e.. malaria, cholera and dysentery). This section aims to learn from other countries in terms of identifying appropriate adaptation practices.

In small island countries and least developed coastal countries that are vulnerable to tropical cyclones, floods and droughts, Ebi et al (2006b) documented the following ongoing interventions to reduce the impacts of climate change on the health sector:

(i) development of early warning systems to enhance opportunities for disease control, although many small island countries still need to build the capacity to develop integrated climate and health early warning systems;

(ii) implementation of effective health education programmes;

(iii) undertaking of research to improve the understanding of the interaction between climate and health;

(iv) implementation of environmental education plans;

(v) improvement of health care infrastructure;

(vi) development of disaster preparedness plans;

(vii) vector monitoring and control;

(viii) improvement of water supply systems and waste management;

(ix) improvement of monitoring and surveillance systems; and
(x) strengthening of vaccination programmes.

Ebi et al (2006b) recommended the following additional interventions to improve the capacity of the health sector to anticipate and prepare for climate variability and change:

- Research to improve the understanding of the interaction between climate and health; to map the spatial prevalence of climate-sensitive diseases and the distribution of vector species, and to improve the understanding of the social, cultural and economic factors that determine the vulnerability of people to climate sensitive diseases
- Improve the collection and analysis of health, meteorological, environmental and socio-economic data at local (district), provincial and national scale; identify gaps in the existing data and develop strategies to fill the existing gaps in data
- Improve health surveillance systems to allow the assessment of the impact of climate change and variability on human health. Establish better data management systems, including data analysis and data sharing among institutions
- Develop institutional arrangements for knowledge sharing at national and regional level, promote multidisciplinary working groups to study the impacts of climate change and vulnerability on human health, develop effective mechanisms of information sharing, improve understanding of climate and health interaction through workshops
- Advocacy and community awareness of the impacts of climate change and variability on human health
- Mainstream climate change into health policy, strategies and action plans

This section looks first at the extent to which climate change is considered in health policies, and then second at the extent to which health is considered in climate change policies.

11.1 Climate change in health policies

Consistent with the emphasis of this project – on cholera, malaria and dysentery as the major health implications of climate change in Mozambique - this section focuses on health policies from around the world and examples of how they address climate risks (focusing on the three diseases) and adaptation in order to make recommendations for Mozambique.

Table 4 summarises the mention of health and climate change adaptation in supranational territories (the European Commission for Europe), countries (Zambia, Scotland, USA, Australia, Uzbekistan, Tanzania, South Africa) and a transboundary river basin (Lake Victoria basin). Mention of health and climate change adaptations for the countries (and supranational territory and transboundary river basin) differs in degree.

Common themes mirror those outlined above, and are for improved surveillance and monitoring (endemic and epidemic diseases), planning appropriate adaptation strategies (which often includes early warning systems), and raising education (of both clinicians and the general public) regarding the possibility of emerging diseases and infections (Samet, 2009). The extent to which adaptation strategies are elucidated also varies widely: Australia and Uzbekistan highlight the need for vulnerability assessments; the USA and Europe suggest sound principles; whereas Zambia, South

Africa, the Lake Victoria basin variously specify particular context-specific adaptation strategies. By definition, national level strategies have such wide targets that it is often difficult to be comprehensive in detailing the nature of adaptation.

Table 4. Mention of health and climate change adaptations in a variety of contexts

Region/Country	**Type / Reference**	**Mention of health (extract) and adaptations**
Zambia	Report - George Kasali (2008)	"Zambia can begin to reverse the deteriorating health trends in the population by implementing climate-informed policy interventions. This implies that investments are required to start the process of mainstreaming climate risk reduction and adaptation into plans and programmes of the health sector." When climatic and/or other hazards cause outbreaks of diseases, the response strategies recommended for use by households include the following: • Going to the medical clinic • Seeking traditional healers for herbal medicine • Using medicinal plants to treat diseases • Boiling water or treating it with chlorine • Buying and using mosquito nets and repellents • Burying ditches to eliminate stagnant water and prevent waterborne diseases • Getting support from NGOs and the government These strategies are not always effective. The ultimate aim should be to help build sustainable livelihoods to better cope with threats and reduce vulnerability to health impacts from climate change.
USA	US EPA (online)	Specific health adaptation approaches include: Monitoring emerging health risks Planning urban adaptation strategies, such as planting trees to minimize heat build-up in cities and manage storm water, or promoting the use of cool roofs to reduce energy needs and improve air quality Preparing emergency response plans, which include providing cooling centres for extreme heat events Improving public communication during specific health risks such as extreme heat events or poor air quality days
Europe	European Commission Green Paper of 29 June 2007 on adapting to climate change in Europe - options for EU action [COM(2007) 354]	"The Green Paper cites in particular drought, floods, reduced access to safe drinking water, loss of biodiversity, degradation of ecosystems, a higher risk of famine, population displacements owing to a rise in sea level in the deltas, as well as the health impact of more frequent extreme weather events and illnesses dependent on climatic conditions." Recommendations include: "Everyone, from ordinary citizens to decision makers, both in the private and public sectors, can play a role in adaptation measures. Action should be taken at the most appropriate level and be complementary, especially

		between public authorities. For example, at national level special attention could be paid to improving disaster and crisis management - in particular risk prevention (by mapping vulnerable areas) and swift response in the event of a disaster - and to developing adaptation strategies. At regional level, spatial planning is important for adapting to climate change, while at local level efforts should focus on practical land use and land management techniques and on raising awareness. “
Australia	Government Position Paper on Adapting to climate change and Climate Change Adaptation Programme	Three core areas to support: Supporting research Grant programmes for local councils and professionals Major national vulnerable assessments
Uzbekistan	UNDP (2012)	Knowledge - Health care system personnel are not fully aware of the relationship between climate change and variability and health impacts. There has been no specific training of the personnel in regard to adaptation to climate change and mitigating its negative health impacts. Capacity - The level of knowledge and skills to prevent diseases connected with climatic factors are also limited among the general population. Monitoring and surveillance - The climate and health monitoring and surveillance systems are not conducted at the right geographical and temporal scale that would allow observations of trends and make advance forecasts to direct interventions against climate sensitive diseases. Research - No mechanisms currently exist to give early warning to the health system and undertake preventive measures. No research is currently conducted to observe the trends and the health system does not have clearly developed indicators that would give a chance to react. Thus no early warning system has been developed.”
Tanzania	LTS Africa (2010)	Gender empowerment and not only gender inclusion is recommended Address the implementation gap between policy and action A national or regional research, oversight and advocacy facility with the mandate to promote the responsible interpretation and use of climate science and change scenarios
Lake Victoria	Wandiga (2006)	Malaria: Among the adaptations to highland malaria has been the use of traditional curative measures (using local herbs as insect repellents or anti-malarials). It appears that this is a crucial adaptation strategy in Muleba, Kericho and Kabale, particularly given the high poverty levels in the area. Surveys carried out by the

		National Institute for Medical Research (NIMR) in Tanzania noted that traditional healers have knowledge and skills useful for malaria disease management (diagnosis, treatment, and prevention). Further, NIMR laboratory analyses of traditional herbs established their efficacy and safety. Toxicity varied from low to very high (Mwisongo and Borg, 2002). Cholera: The role of the local administration is increasingly narrowing down to creating awareness about the disease. The NGOs on the other hand assist the communities in operationalizing the advice received by providing material support Watershed protection policies and effective early warning systems assist with adapting to increased cholera outbreaks too. Also improved flood forecasting, better early warning systems, improved communications and support for strategies which mitigate risk.
South Africa	National Climate Change Response Plan	Health is one of the key adaptation areas in the Response Plan. Planned priorities are listed and include the following: • Managing ambient air quality, which is ongoing • Ensure food security and sound nutritional policies • Develop and roll-out public awareness campaigns on the health risks of high temperatures • Design and implement heat-health plans (examples of the success of these are in the WP1 report) • Develop a health data-capturing system that records data • Improve the bio-safety of the current malaria control strategy. The current strategy includes the use of DDT, however, this may have long-term effects on human and ecosystem health • Strengthen the awareness programme on malaria and cholera outbreaks

11.1.1 Lessons learned from Zambia and the Lake Victoria basin

Given their geographical proximity to Mozambique and similarities of climate change risks for health, particular policy recommendations from the Zambia and Lake Victoria basin reports are laid out here.

For Zambia, Kasali (2008) highlights that the main risks for the country are the burden of communicable climate-sensitive diseases. Recommendations are thus that:

- "The adverse impacts of climate variability/change on human health in Zambia are real and consequently there is need for the Ministry of Health to urgently integrate climate risk management and adaptation measures into the national health strategic plan.
- The National Malaria Control Centre should start working with the Meteorological Department and other stakeholders to develop an early warning system for malaria in Zambia.

- The supply and delivery of medical drugs by the Ministry of Health to health facilities should be synchronised with the seasonal fluctuations of diseases. This will eliminate stock-outs of drugs during peak transmission periods when they are critically needed.
- The climate-informed interventions should not focus on malaria only but must also include other climate-sensitive diseases that are exerting a significant death toll on the Zambian population.
- The Ministry of Health, local governments, NGOs and other stakeholders must urgently embark on vigorous information and education campaigns on the utility of insecticide treated nets for malaria prevention. This should occur in riverine communities where these subsidised nets are being wrongly diverted for catching fish.
- Zambia requires a multi-disciplinary capacity for research on the effects of climate change on human health. The Ministry of Health can incorporate this capacity-building component into its current Integrated Disease Surveillance and Response programme.
- Local governments must promote the climate-proofing of sanitation facilities in their communities, especially in urban areas.
- The government, cooperating partners, NGOs and other stakeholders must take a multi-pronged approach to improving rural health by implementing community-based activities aimed at improving incomes, water supply/sanitation, and food security simultaneously.
- The Ministry of Tourism, Environment and Natural Resources must work closely with the Disaster Management and Mitigation Unit to ensure that Zambia mainstreams adaptation to climate change/variability into its national development planning. This will certainly speed up the pace for meeting the MDG targets.
- The government must explore the integration of traditional medicine into current official health care delivery systems in Zambia.
- Funding of climate change activities in Zambia should not be a prerogative of external development partners only but must be supported with allocations from the national budget.
- Government, NGOs and the mass media must work together to inform the general public on issues of climate change adaptation. Additionally, the Ministry of Education should incorporate climate change issues into educational curricula at primary, secondary, and tertiary levels."

For Lake Victoria, Wandiga (2006) states that "Future adaptation programmes should take into account the diversity of factors that influence a society's capacity to cope with the changes. Such programmes should take into consideration the demographic trends and socio-economic factors, since these have an effect on land use, which may in turn accelerate or compound the effect of climate change. Trends in demographic, socio-economic development would definitely have a dampening effect on the potential consequences of climate change. HIV/AIDS, malaria, diarrheal diseases, respiratory diseases and others play an important role in the people's health, productivity and responsiveness to external threats. The programmes dealing with these diseases must therefore be factored into the analysis of the future effects of climate change on the vulnerable system."

11.2 Health in climate change policies

Whilst incorporating consideration of climate change into health policies is one way to address the issue, the other is to include recognition of health in climate change policies. According to their website, the World Health Organization actively engages with countries to promote effective climate

and health policies which promote health protection (http://www.who.int/globalchange/health_policy/en/). Nevertheless, very few countries have specific climate change acts and policies and even less mention health in those policies. For example, Scotland has a Climate Change Act but health is not mentioned.

Several countries, states and provinces have climate change mitigation strategies that focus on curbing greenhouse gas emissions. Some countries have climate change adaptation strategies, in which health is sometimes mentioned depending on the predominant diseases (for example, if vector borne diseases are of concern) faced by that country (an example is Belgium, National Climate Commission, 2010). Four example plans were found that were climate and health adaptation plans: South Africa, Michigan (USA), Cook County (Chicago) and Western Australia.

South Africa's National Climate Change and Health Adaptation Plan, issued by the Department of Health (2013) outlines the broad approach of the health sector in South Africa to tackle the challenge of adaptation to climate change, in the light of the unique challenges prevailing in the country. The aim of the South African Climate Change and Health Adaptation Plan is to provide a broad framework for health sector action toward adaptation to climate change following extensive stakeholder engagement. The plan gives a broad programme of activities to be undertaken or spearheaded by the South African health sector, gives specific examples and indicates potential partners, schedules and budget implications.

The Michigan Climate and Health Adaptation Plan (Cameron et al, 2011) focuses on a set of collective core beliefs and identifies three goals stemming from these beliefs, namely, recognising climate change as a public health issues; public health agencies will have the tools to respond to climate change within existing programmes; and attention should be given to vulnerable communities.

The Cook County (Chicago) Climate Change and Public Health Action Plan (Chicago PSR, N.D.) identifies five goals that may be helpful for Mozambique when preparing their Health Strategic Plan. They are:

Goal 1: To inform public health professionals, state agency personnel, policy-makers, healthcare providers, vulnerable populations and the general public on human health risks associated with climate change

Goal 2: To identify vulnerable populations who are especially at risk for negative health outcomes as a result of climate change

Goal 3: To move the focus from mitigation to adaptation and recommend potential adaptation strategies to address climate change effects on public health

Goal 4: To encourage planning and preparation for emergency response to protect the public's health against possible health outcomes resulting from climate change

Goal 5: To expand the scope of this plan to a state-wide preparedness plan in the future.
Their health priorities are air pollution and allergens, vector-borne diseases, waterborne diseases and water quality, food-borne illnesses and extreme heat and weather.

The Health Impacts of Climate Change: Adaptation Strategies for Western Australia report (Spickett et al, no date) provides background on likely health impacts of climate change in Western Australia and describes risk assessment and management steps as part of an adaptation process.

12. Screening of Key Mozambican Development Plans, Strategies and Policies

Improving the health status in Mozambique is enshrined in a number of overarching government development plans, strategies and policies. Here we screen Agenda 2025 (Comité de Conselheiros, 2003), the Poverty Reduction Strategy, 2010-2014 (*Plano de Acção para a Redução da Pobreza* - PARP) (Republica de Moçambique 2011), the Environmental Strategy for Sustainable Development – EADS) (Republica de Moçambique 2007), Health Strategy (Moçambique *Plano Estratégico do Sector Saúde* (PESS) 2007-2012), the recently-released National Climate Change Strategy (*Estratégia Nacional de Adaptação e Mitigação das Mudanças Climáticas*, ENAMMC 2013-2025), and the National Policy on Disaster Management (and proposed National Strategy on Disaster Risk Reduction and Climate Change Adaptation).

12.1 Agenda 2025

Agenda 2025 shows the roadmap for the development of the country. The overarching objective of Governance in Mozambique is the fight against poverty. A key component to reduce poverty is the development of human capital. Human health is a key component of the human and social capital because the component of health comprises the physical, psychological, spiritual and social well-being of the citizens and provides the necessary tools for each Mozambican to make use of his/her physical and mental productive capacity.

Most of the population lives in rural areas and in poor conditions in terms of food, housing, water supply and environment. Mozambique is extremely vulnerable to climate related disasters. Changes in the environment due to droughts, floods or cyclones, have serious consequences in the living quality of people. Agenda 2025 recognizes the worrying situation in the country concerning the vulnerability of people to endemic diseases with high mortality rates, such as malaria, malnutrition, cholera, diarrhoea and dysentery. These diseases are all sensitive to climate change and variability. Other diseases of concern include HIV/AIDS, acute respiratory diseases and tuberculosis. Agenda 2025 identifies the prevalence of endemic diseases; the vulnerability to natural disasters such as flooding, drought and cyclones; limited drinking water supply network; poor sanitation coverage; inadequate investment in health and education as the main threats to human capital, hence to efforts to fight poverty. However, it lacks a clear indication of the impacts of climate change on the development of the country, particularly on the development of human capital, establishing no relationship between diseases and climate change. This is probably because this document was prepared in 2003, when the Government of Mozambique was still in its very initial stage of taking into account environmental issues in the development agenda.

To overcome these weaknesses, Agenda 2025 proposes that by the year 2025 Mozambique is transformed into a country where people live in a healthy environment, with food security, sanitation and reliable supply of drinking water, adequate housing, access to education and work, and facilities for accessing healthcare and essential medicines.

Accordingly, the vision of the country is the expansion of the National Health Services to the whole territory with particular emphasis on preventive medicine, training of staff for the health units and provision of medicines. The fight against HIV/AIDS, malaria, tuberculosis, malnutrition, and mother and child protection are the priority actions to reduce the threats to the health sector. This would improve the living conditions of Mozambicans, but this requires the design and implementation of national policies that translate into a continuous improvement of basic living standards, which should comprise decent housing, diverse nourishment, drinking water, access to employment, practice of self-employment and access to basic information.
This suggests that evidences of linkages between climate change and health issues documented during WP1 and WP2 need to be communicated to decision makers of the health sector, which will inform policy reforms to accommodate the threat of climate change to the health sector. In particular, results of this project need to be taken into account in during the preparation of the Health Strategy (PESS) for the period 2013 – 2017.

12.2 Action Plan for the Reduction of Poverty (PARPA)

Vision 2025 is reflected in the Action Plan for the Reduction of Poverty (PARPA) (Republica de Moçambique 2011), which is a medium term (2011-2014) Government strategy that is the basis for the implementation of the 5 Year Government Plan (2010-2014), focusing on the objective of fighting poverty. In line with vision 2025, among key PARPAs strategic objectives is the development of human and social capital, to ensure the availability of a healthy and educated labour force to increase production and productivity in core areas of the economy. PARPA identifies HIV/AIDS, malaria, malnutrition and tuberculosis as factors affecting human and social development by reducing considerably the productivity of labour force, a part from causing mortality. These diseases increase the vulnerability of low income families to poverty. Therefore, attention to these diseases is a key component of efforts to achieve human and social development, which is a solid foundation of efforts to reduce poverty.

The government recognizes that climate change is a new development challenge that will hamper efforts to reduce poverty. Accordingly, it is a priority of the government to implement adaptation actions to climate change and reduce the vulnerability of people and economic sectors to climate disasters. Accordingly, to achieve human and social development, among other priority actions, of relevance to the CDKN project, PARPA calls for the need of:

(i) implementing activities of nutritional surveillance to reduce mortality caused by malnutrition in women and in children under the age of 5 years;
(ii) implementing the multi-sector plan for the reduction of chronic malnutrition;
(iii) promoting nutritional education in schools and communities;
(iv) designing and implementing a National Programme of Productive Social Action in response to chronic food insecurity and to the vulnerability to climate events and seasonal variability in agricultural production;

(v) improving the access to adequate drinking water and sanitation in rural and urban areas;
(vi) encouraging the transfer of populations living in areas under the risk of climate disasters to safer areas.

Government programmes have been selected for implementation at central and provincial level to achieve PARPAs objectives. Table 5 summarises those programmes that have relevance for climate change and health.

Table 5. PARPA's objectives and programmes relevant to climate change health, agriculture and disasters analysis in Mozambique

PARPA's objective	**Programme name**	**Programme objective**
Increase agricultural and fisheries production and productivity	Drought management	To reduce the vulnerability to hunger/famine caused by drought in areas that receive less than 500mm of rain per year or suffer from recurrent droughts
	Floods and Cyclone Management	To prevent the loss of human lives and the destruction of goods caused by natural disasters
	Agricultural production and productivity, food and nutritional security	To increase the production of food of adequate quantity, quality and diversity; and to strengthen the nutritional surveillance system
	Climate change	To promote environmental quality and mitigation, develop adaptation policies to climate change
Human and social development	Provision of adequate drinking water	To increase the coverage in the supply of adequate drinking water in rural and urban areas
	Sanitation	To increase the coverage of adequate sanitation in rural and urban areas
	Public health, with emphasis on the reduction of the impacts of endemic diseases and malnutrition	To reduce the impact of endemic diseases such as malaria, tuberculosis, HIV/AIDS and diarrhoea To contribute to the

		reduction of prevalence of chronic malnutrition

Although PARPA does not clearly emphasize the link between climate change and the prevalence of diseases, the implementation of these programmes will help reduce the impacts of climate change on the health sector. The main challenge is that existing promising policies, strategies, plans and programmes are not being fully implemented due to limited human and financial resources and equipment.

In addition to the need of efforts to reduce the prevalence of endemic diseases such as malaria, tuberculosis, diarrhoea, HIV/AIDS and to the reduction of chronic malnutrition, the five-year Government Plan also calls for the need of an increasing surveillance and fight against previously neglected diseases such as Lymphatic filariasis, onchocerciasis and intestinal parasites, which are also sensitive to climate change.

12.3 Environmental Strategy for Sustainable Development (EADS)

Through EADS (Republica de Moçambique, 2007), the government recognizes that some diseases with high morbidity and mortality such as malaria and cholera are caused by environmental problems. Accordingly, this strategy calls for the need of promoting local initiatives to build institutional capacity in assessing the link between the environment and health, and to apply the generated knowledge to prepare national policies aimed at reducing the threats of environmental problems to human health. Specifically, EADS calls for the need of implementing actions to control the environmental factors that contribute to malaria, cholera and other endemic diseases. However, EADS does not establish any direct link between climate change and disease burden.

12.4 Health sector strategy (PESS) 2007-2012

The health sector strategy (PESS) 2007-2012 was developed to be the main document congregating several health policies during the period 2007-2012. PESS 2007-2012 was part of the quinquennial programme of the Government of Mozambique and part of the Action Plan for Absolute Poverty Reduction (PARPA 2006-2009). PESS 2007-2012 was linked to the Africa Health Strategy 2007-2015 and to the New Partnership for Africa Development (NEPAD).

At the time of its development, deficient sanitation and water supply infrastructure had been linked to outbreaks of cholera, meningitis, dysentery and other environment-related diseases. At the same time, the national literacy rate was 47.8% (32.7% among women and 63.5% among men). The Demographic Health Survey (DHS) had demonstrated a strong association between residential setting (rural/urban), literacy rate among women and health-seeking behaviour. In light of this context, the vision of PESS 2007-2012 was to deliver high-quality and cost-effective health services to all Mozambicans. The mission was to promote well-being, especially among most vulnerable groups, through innovative interventions and to deliver sustainable health services to guarantee universal health access.

PESS 2007-2012 was focused on the following pillars:

i) Primary health care services
ii) Equity and social protection for vulnerable groups
iii) Universal access to health care and health services
iv) Promotion of evidence-based interventions
v) Community mobilization and community involvement
vi) Institutional development and capacity building
vii) Promotion of partnerships and local and international collaboration
viii) Promotion of healthy lifestyle and behaviours
ix) Advocacy

In terms of climate change, PESS 2007-2012 did not systematically incorporate this with regard to public health services. Given that preparation of the next PESS, 2013-2017, is shortly to take place, there is scope to incorporate climate change and health as an additional pillar.

The Ministry of Health (MISAU) has recognized that climate change is an important factor that will influence public health planning in the country. In 2012, the National Directorate of Public Health, with support from the World Bank, commissioned a report outlining key priorities for consideration in the next PESS (MISAU, 2012). Priorities identified were:

(i) **Human Resources for Health - trained and motivated to develop activities with a focus on climate change**

Many of the existing skills used in public health and healthcare are well established and applicable to dealing with the health effects of climate change, but new skills will also be needed. Skills used in certain types of disease surveillance are well established. Less well established are the skills and methods needed to integrate current and future surveillance activities and retrospective datasets with weather and climate information. Understanding of how to conceptualize and conduct epidemiological analysis using weather and climate as exposures is also preliminary. Methods and skill in combining spatial epidemiology with ecological approaches are also lacking. There is a strong need for the ability to translate vulnerability mapping and health impact assessments (HIAs) into behavioural changes and effective public health actions.

(ii) **Surveillance system focused on the interaction between climate change and health**

Given the degree of uncertainty associated with the unfolding of the consequences of climate change, it is imperative that public health monitoring and surveillance systems be reviewed and strengthened to increase their ability to detect health trends at an early stage. In addition, it would be ideal to encourage further integration of health monitoring with the existing climate early warning systems, so that potential triggers for public health conditions are identified. Every effort should also be made to integrate monitoring and surveillance systems across sectors, for example, health, environment, agriculture and human settlements. Mozambique must collaborate with international partners and relevant technical agencies with regard to the preparation of a framework for climate change and health monitoring and surveillance systems.

(iii) **Health Information System that incorporates registration of climate change**

The Ministry of Health must develop its role as an authoritative source of information on climate change and health, and assist decision-makers, health professionals, community stakeholders, academicians, and others who are working in this area. A national 'one stop shop' website where decision-makers and their advisors (including local government) can access information about climate, its health implications, and relevant coping or adaptation measures, may be of particular use.

(iv) **Health Research Agenda for public health issues related to climate change**

Research in Mozambique on the risks of climate change, and evaluation of efforts to adapt to climate change, is currently *ad hoc*, fragmented and limited in scope. It is essential that an integrated, cross-sectoral and long-term agenda of research be initiated to ensure that decisions and planning are evidence-based, and that adaptations implemented are the most cost-effective and cost–efficient. It is particularly important to investigate and document the differences in vulnerability within and between populations. The Ministry of Health must establish, in high risk areas, a series of model projects, in which a range of climate change adaptation actions might be implemented, with a particular focus on prevention and inter-sectoral action. We propose that a National Climate Change and Health Adaptation Steering Committee may play an important role in this regard.

(v) **Assessment of the groups most vulnerable to climate change**

In order to identify high risk locations and groups, it is important that a national vulnerability assessment be undertaken. Knowledge of such groups and locations will steer the adaptation plan toward those in greatest need, and will inform the strengthening of the health system and the management of risks. In this regard the assessment foreseen by the ENAMMC must integrate health sector specialists and stakeholders.

In addition, despite its demonstrated value, health impact assessment (HIA) procedures have not been widely adopted in Mozambique, and capacity in this regard is inadequate at all levels. HIA is often seen as a component of Environmental Impact Assessments (EIA). In respect of climate change and its consequences however, HIA has an independent and special role to play in avoiding further contributions to climate change (for example avoidable emissions), as well as the negative downstream health consequences. HIA processes may also be used to identify health co-benefit opportunities contained within the development policies and programmes of non-health sectors. For example, housing design and construction may hold opportunities to keep dwellings cooler in hotter parts of the country. It is of considerable importance that the health sector develops nodes of expertise in HIA, and works across sectors to ensure that the negative health consequences of major developments are averted, and that every opportunity possible is grasped to maximize the health benefits thereof.

(vi) **Integrated partnerships to deal with climate change and health**

The notion of inter-sectoral action was first mooted in the Alma Ata Declaration on Primary Health Care, has been a cornerstone of major public health milestones since, and was explored in greater depth at a World Health Organization Conference on Inter-sectoral Action for Health held in 1997. At that conference, inter-sectoral action for health was defined as *"a recognized relationship between*

part or parts of the health sector with part or parts of another sector which has been formed to take action on an issue to achieve health outcomes (or intermediate health outcomes) in a way that is more effective, efficient or sustainable than could be achieved by the health sector acting alone." The advent of climate change, and the need to adapt to it, has added urgency to efforts on inter-sectoral action, the importance of which has also been emphasized in the Luanda Statement. In line with the principle of ill health prevention, the health sector should build the capacities required to engage and negotiate across sectors in the interests of public health. For example, engaging with the Ministry of Transport and Communications in improving public transport system to reduce the number of vehicles on the roads may result in a reduction of smoke emissions. Also, liaising with INGC, as well as relevant provincial and local government authorities to ensure that housing that meets minimum health requirements may dramatically improve public health and reduce vulnerability to climate change.

(vii) **Communication and social mobilization on climate change and health**

Full public participation is essential for a successful climate change adaptation effort in Mozambique. The Ministry of Health must join the task forces' efforts to design and implement a long-term and comprehensive communications strategy to raise public awareness of climate change impacts and the advantages of early attention to adaptation. Such an education campaign should inform and encourage citizens to adopt actions and behaviours that minimize environmental damage and prepare individuals to cope with, for example, heat stress, and an increase in the frequency of disasters or service disruptions. Such campaigns may include encouragement of a culture of disaster preparedness and the measures to be taken on very hot days.

12.5 National Climate Change Strategy

Mozambique launched its National Climate Change Strategy (ENAMMC), covering the period 2013-2025 in November 2012 (MICOA, 2012). Recognising the risks that climate change poses to development targets in the country, the strategy outlines Mozambique's commitment to adaptation and mitigation, through low-carbon development and the green economy.

The specific objectives are, firstly, to make Mozambique resilient to the impacts of climate change, while minimizing climate risks to people and property, restoring and ensuring the rational use and protection of natural and built capital; secondly, to identify and implement opportunities for the reduction of greenhouse gas emissions that contribute to the sustainable use of natural resources and access to financial resources, technology affordable and reduce pollution and environmental degradation by promoting low-carbon development; and, thirdly, to create the institutional and human capacity, as well as exploring opportunities for access to technology and financial resource to implement the ENAMMC.

The Strategy sets a national priority to adaptation and mitigation of climate risk, while recognizing the need to seize the opportunities that the country has, subject to development actions, to reduce the impacts of climate change through a set of actions mitigation and low carbon development.

The strategic actions are thus grouped into the two main pillars (adaptation and mitigation) and cross-cutting issues listed below:

1. Adaptation and climate risk reduction

i. strengthening early warning systems
ii. preparing the response capacity to climate change
iii. increasing the capacity of water resources management
iv. increasing access and the ability to capture, storage, treatment and distribution of water
v. increasing the resilience of agriculture and livestock
vi. increasing the resilience of fishing
vii. ensuring adequate levels of food security and nutrition
viii. increasing adaptive capacity of vulnerable people
ix. reducing people's vulnerability to vectors of disease transmission associated with climate change
x. ensuring and protecting biodiversity
xi. developing mechanisms to promote tree planting and establishment of forests for local use
xii. developing mechanisms to build resilience of urban areas and other settlements
xiii. managing the development of tourist areas and coastal areas to reduce the impacts of climate change

2. Mitigation and low carbon development

i. improving access to renewable energy
ii. increasing energy efficiency
iii. ensuring compliance with the standards for regulated emissions from activities of the industry
iv. promoting low-carbon urbanization
v. control emissions from industrial processes including associated waste and wastewater
vi. developing low carbon agricultural practices
vii. reducing the rate of deforestation and wildfires
viii. planning and managing biodiversity and coastal ecosystems
ix. managing and recovering the waste

3. Cross-cutting issues

i. adjusting the existing legal framework in line with the ENAMMC
ii. adjust the existing institutional framework in line with the ENAMMC
iii. developing research on ENAMMC
iv. strengthening institutions that collect data for the greenhouse gas inventories and National Communications
v. developing and improving the level of knowledge and ability to act on climate change
vi. promoting the transfer and adoption of clean technologies

Health implications of climate change in Mozambique are explicitly recognised and addressed through the adaptation objective to “reduce people's vulnerability to vectors of disease transmission associated with climate change”. Reference to the potential adverse effects of climate change on well-being and food and nutrition security are also linked to health. Mechanisms proposed in the strategy to reduce this vulnerability include:

- strengthening capacity to prevent and control the spread of disease through proper vector mapping (distribution and spatial mobility)
- using and promoting clean technologies and creating spaces and areas for recreation and forest buffer zones in cities

- conducting a baseline study on the diseases that are favoured by climate change;
- establishing a system of surveillance and control measures on specific climate-related diseases

The strategy makes provision for each sectoral lead (MISAU in the case of health) to develop its own indicators for monitoring and evaluation of progress. The first action plan under the strategy, for the period 2013-2014, focuses on institutional reform and capacity building at all levels (in addition to community-level pilot projects).

12.6 National Policy on Disaster Management

Mozambique's National Policy on Disaster Management, defined in 1999, created a new legal framework for disaster management in the country, taking into account not only emergency response, but also pre-event preparedness (Republic of Mozambique, 1999). Principles embodied within the policy include community involvement, disaster risk reduction based on vulnerability assessment (of the most vulnerable people and places), free emergency assistance to the most vulnerable members of the population (including those in poor states of health and nutrition), and the setting up of an appropriate coordination structure (led by the National Disaster Management Institute, INGC, under guidance from the Coordinating Council for Disaster Management) and supporting civil society involvement. The general objectives of the policy are:

i. to avoid loss of human life and destruction of property by natural disasters or by man
ii. to incorporate disaster prevention into the overall national development process (through the PARP, as outlined in section 3.2)
iii. to promote domestic and external solidarity in the face of disasters
iv. to guarantee effective coordination and ensure participation in disaster management by the private and public sectors
v. to contribute to the conservation and preservation of the environment
vi. to promote regional or international coordination in disaster management, particularly in the case of disasters that originate in neighbouring countries

Implementation of the plan takes place through several sectoral plans of action. These plans are driven by the Technical Council for Disaster Management, comprising representatives of key line ministries. Of relevance to health are those within MISAU (pertaining to epidemic control measures and malnutrition surveillance) and the ministry of agriculture (on drought and famine monitoring).

At the time of finalising this report (April 2013), INGC had prepared a National Strategy on Disaster Risk Reduction and Climate Change Adaptation (ENARC) that was in the process of being formalised (Monteiro et al, 2012). The vision of the strategy is for Mozambique to become, in the next 25 years, 'a country with elevated alert levels and awareness of climate change by citizens and communities, whereby, as a result, the risk of exposure to vulnerability is minimized while the country as a whole benefits from the development opportunities offered by international solidarity around climate change.' The mission will be 'to prepare and capacitate people for action at larger scale.'

The key objectives of the strategy are to:

- Reduce by 15-20% the levels of vulnerability of those urban and rural communities most exposed to the risks and impacts of climate change (over a 20 year period);
- Be able to produce and disseminate quality knowledge of international standards on climate change and adaptation strategies for disaster risk reduction (over a 10 year period);
- Enable all communities in high disaster risk areas to respond with local means and resources to the challenges posed by climate change, in particular with actions of prevention, risk reduction and emergency response (within a 5 year period);
- Prepare the country to function in a coordinated and articulated manner at sectoral and territorial level on the transversal subject of climate change and disaster risk management (within a 5 year period);
- Prepare cities in the most at-risk areas for a new era, dominated by adaptation to climate change (within a 5 year period);
- Bring the private sector to contribute significantly to all national efforts of adaptation, including in the planning and implementation of investments; and
- Financing of adaptation and disaster risk reduction activities.

13. Recommendations

Based on the findings of Work Packages 1, 2 and 3 (and not repeating those recommended in MISAU's report on priorities), we make the following recommendations in order to effectively consider the risks of climate change on the health sector in Mozambique.

The policy framework in Mozambique exists to be receptive to climate change and health. The recently-released, cross-sectoral ENAMMC (and the proposed National Strategy on Disaster Risk Reduction and Climate Change Adaptation) complements MISAU's stated commitment to improve consideration of climate change issues in the 2013-2017 PESS.

13.1 Health climate change surveillance and early warning

As the fieldwork for Work Package 2 showed, despite Mozambique having designed a system of health surveillance and disease reporting, such a system is contingent upon all actors supplying the appropriate information, and some shortfalls have been noticed in the country. As shown above, effective and monitoring and health surveillance, the results of which are accessible to all relevant stakeholders, is also strongly recommended as a prerequisite for good practice in health and climate change policies in other countries.

In addition to improving the efficiency of the current health surveillance system, there is also a need to recognize the ways in which climate change impacts on health status and health strategy pose additional challenges. Based on a qualitative analysis, WP2 showed that the nature of climate change in Mozambique will have probable changes on epidemiologic patterns of existing diseases like malaria and diarrheal diseases (such as cholera and dysentery), as well as affecting malnutrition. In order to expand the surveillance system to include the capacity for early warning, there is a need

to link the health sector with climate monitoring organizations. Mainstreaming of health considerations into climate change monitoring in this way mirrors global calls for health and disaster risk reduction to be integrated with climate risk services under the Global Framework for Climate Services (Avellan et al, 2011). Establishing a system of surveillance and control measures on specific climate-related diseases has also been outlined as an objective in the ENAMMC (MICOA, 2012).

13.2 Research agenda on climate change and health issues

Improving the quality of the health climate change surveillance system will also generate much-needed data in order to be able to implement a research agenda on climate change and health issues. The ENAMMC highlights as a priority the need to conduct a baseline study on the diseases that may be affected by climate change (MICOA, 2012). The new 2013-2017 PESS should be able to accommodate this. In addition to modelling disease projections under climate change, more systematic analysis of vulnerability will be essential to inform priority areas for interventions.

13.3 National health climate change programme to link research to adaptation action

On the basis of a strengthened surveillance system and improved data availability to carry out the research needs identified above, Mozambique may wish to consider a national health climate change programme to focus on resilience and strengthening public health systems at all levels while paying particular attention to the most vulnerable groups. There needs to be a focus on how to better deal with short term climate variability, as well as planning for how to ensure that systems remain resilient and adaptable to changing risks in the longer term. Since climate change typically acts as a multiplier of existing health problems, or changes the location of existing health concerns and disease burdens, such a programme should also include education, awareness and outreach, for both clinicians and the general public, as identified as priorities in climate change and health policies in other countries. Examples of key elements to include prevention, early detection (linked to the surveillance and early warning systems) and encouragement of health-seeking behaviour in case of detection. In addition, a national health climate change programme could ascertain cost-effective and prompt ways of adding the climate dimension into existing national or community-based programmes and actions. For the longer term, cross-sectoral approaches that explicitly address adaptation priorities may be needed.

13.4 Partnership with other governmental departments and other stakeholders

Achieving any of the preceding recommendations is dependent on effective cooperation with other government departments and relevant stakeholders. The ENAMMC already makes explicit provision for this in terms of climate and health; and Mozambique's other overarching development plans and strategies also open up opportunities for this to become a reality. There is a need to build and strengthen both horizontal partnerships (among departments of the government at national level) and also vertical coordination (between national, regional and local levels).

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Appendix A: Programme for expert meeting

Programme of Workshop – Tuesday 11th September

Av. do Zimbabwe, Instituto de Formacao das TDM.

Time	Topic	Facilitator
08h30-09h00	Registration	Tracy Cull
09h00-09h30	Welcome and preliminary statements, including overview of the project	Joaquim Manhique
09h30-10h30	Presentation of climate projections and current health status	Katharine Vincent and Joaquim Manhique
10h30-11h00	Coffee break	All
11h00-12h30	Discussion on likely implications of climate change for spatial prevalence of health conditions, including freehand mapping and identification of mediating factors	Katharine Vincent and Joaquim Manhique
12h30-13h30	Lunchtime	All
13h30-15h00	Continued discussion and reaching concensus on future health risks of climate change	Katharine Vincent and Joaquim Manhique
15h00-15h30	Debriefing and closing remarks	Valério Macandza

Appendix B: Expert meeting list of participants

Nº	Name of participant	Provenience or Institution	Professional area of interest	Personal contacts (e-mail and telephone)
1	Joaquim Manhique	UEM/KULIMA	Public Health research	joaquim.s.i.manhique@gmail.com
2	Valério Macandza	UEM/KULIMA	Environment research	Vmacandza2001@yahoo.com
3	Katharine Vincent	KULIMA	Climate Change events research	Katharine@kulima.com
4	Tracy Cull	KULIMA	Climate Change events research	tracy@kulima.com
5	Ana Paula Cardoso	DNSP-MISAU	Public Health management	apaulacardoso@hotmail.com
6	Francisca Cabral	SETSAN	Climate Change impacts on food security analysis	fcabral@setsan.org.mz
7	Saul Walker	World Bank	Climate Change Specialist	swalker2@worldbank.org
8	Figueiredo Araújo	INGC	Climate Change disasters Manager	fig_araujo@yahoo.com.br
Apologies				
9	Abdul Mussá	DNSP-MISAU	Malaria Programme National Manager	ninomussa@gmail.com
10	Egídio Langa	DNSP-MISAU	Epidemiology of Infectious Diseases	Egidiolanga76@gmail.com
11	Eduardo Baixo	MICOA	Climate Change political commitment	ebaixo@hotmail.com
12	Olanda Bata	FEWs Net	Climate Change National Manager	OBata@fews.net

Appendix C: Expert meeting minutes

Minutes of the Experts Meeting,
11 September 2012
Av. do Zimbabwe, Instituto de Formacao das TDM.

Present:
Joaquim Manique (UEM); Valério Macandza (UEM); Katharine Vincent (Kulima), Tracy Cull (Kulima); Ana Paula Cardoso (DNSP-MISAU); Francisca Cabral (SETSAN); Saul Walker (World Bank); Figueiredo Araújo (INGC)

- all participants introduced themselves
- Joaquim Manhique gave an overview of the project as well as the aims of this experts meeting
- Katharine Vincent outlined the structure of the meeting: we have current health prevalence data as well as current and future climate data but the future impacts of climate on health are needed
    - So this is a qualitative methodology building on individuals' expertise.

- Two presentations were made:
    - Joaquim Manhique on the current health situation in Mozambique
    - Katharine Vincent on current and future climate in Mozambique
- Need to fill the "future disease prevalence under climate change" gap
- Outputs from this meeting will feed into the planned high resolution studies on the impact of climate change on health in 4 districts
    - This is the opportunity for experts to raise what they think is important to include in these studies

- **Konzo** - caused by the eating of bitter cassava that has not been processed correctly. People eat the toxic unprocessed bitter cassava because they have nothing else to eat – hence it is a drought coping mechanism that has adverse health and nutrition implications

- question asked re: what impacts on **malaria** – rainfall or temperature and the answer was both as warmer temperatures and increased moisture lead to more mosquitoes
- especially in the North, models show a correlation between the 2

- Mozambique contains many rivers that have their original in neighbouring countries – upstream countries are also expected to experience increased rainfall which will lead to flooding and possibly increased incidences of **cholera.**

- **Oncocerciasis** – carried by mosquitoes which breed in stagnant water (hence the prevalence of this disease is increased by flooding). Similarities in environmental links with malaria since both are vector-borne.

- The point was made that this disease is more prevalent in the North and although this was disputed (there have been some cases in the South), all programmes to combat the disease have taken place in the North.

- **Measles** – seems to increase in times of flood. The growth in the number of measles cases is exponential with more and more cases each year
- Data on the measles is available at district level
- (this can be assessed in the high resolution case studies)

- Concentrating on individual diseases is important but we also need to bear in mind **indirect impacts** of climate change on health.

- Correlation between health and food insecurity?
    - In the North – high levels of agriculture and most food produced and yet it also has the highest levels of malnutrition
        - Malnutrition is due to the lack of access to a diverse range of different foods/ important nutrients
        - Another important factor is the question of access – people do not have the financial means to buy food when their own crops fail.
        - People need to be educated to grow a greater variety of crops and on how to prepare food in order to preserve the nutrient content
        - Climate change (hotter and wetter) may make it possible to grow different crops which may improve the nutritional status of people but a cultural change is needed and this will take a long (generational) time
    - In the South – lower levels of production and yet there is much less malnutrition
- Malnutrition has long term impacts – pregnant women who are malnourished will give birth to malnourished babies and this can lead to life-long health problems

- In some districts in the south where crops have failed, communities have been allowed to diversify their livelihoods by chopping down trees (exceeding normal limits) and turning into charcoal to sell
    - In the long term this will cause more environmental problems and make people more vulnerable to flooding
- Point made that in this regard, mitigation strategies (clean energy) may therefore also be regarded as an adaptation strategy. Need convergence between mitigation and adaptation strategies
    - Is, however, a question of scale – in the long term and on a wider scale, a mitigation strategy such as clean energy is beneficial but in the short term and on a smaller scale (i.e. at the household level) it may be catastrophic as it removes a livelihood strategy (making and selling charcoal)

- Question raised about the impact of salinization and acidification on rivers and fisheries as fish are an important source of nutrition for many communities

- Limited data on river fisheries. Some data on coastal fisheries – impact of climate change is going to be largely negative

Ana Paulo Cardosa (MISAU)

- Climate change could worsen malnutrition
- Need to find ways to mitigate the impacts of climate change
- Difficult to find correlation between diseases and climate
- Need to forecast how people could be less vulnerable
- Have a multi-sectoral plan to combat malnutrition – there are many factors leading to malnutrition (not just culture. Also access; eating of toxic wild fruit in the case of no other options)

- Question asked of where you would use limited resources – to combat droughts in the South or the floods in the North
    - Both!

- Point made that there are few studies on Nampula
- We should target those areas that have not already been covered.

Figueiredo Araújo

- the Centre of Mozambique is most impacted by floods
- there are many issues connected to sanitation – many health problems could be lessened with proper sanitation
- after flooding, incidences of diarrhoea and malaria increases

- communities in the North and Centre already have poor public health facilities and services
- they are also the most vulnerable to climate change
- need "no regrets" solutions
    - better public health and nutrition <u>now</u> would also make people less vulnerable to future climate change

- Question: what other factors would make DRR responses easier / would aid DRR in the country?
    - Less poverty
    - Better roads
    - Improved internal human capacity

Exercise

Brainstorm what issues would improve health in Mozambique (no particular order and not necessarily under conditions of climate change):

- Improve sanitation
- Decrease levels of malnutrition
- Improve access to potable water
- Increased access to public health services
- Better education

- Financial resources (debate around this point. Financial resources on their own will not improve health but you need financial resources in order to do any of the other points)
- Improved Early Warning Systems and DRR
- Better environmental protection

Exercise
Look at each region in turn; identify the current health issues and then discuss how climate change will impact on these?

In the North of Mozambique:
Expected climate change: higher temperatures, more heat waves, higher rainfall but over a shorter season (NB! This is what the statistically downscaled models show)

- Malnutrition
    - Must remember that <u>one</u> of the reasons for malnutrition in the North is cultural and not only linked to environmental/ climate reasons – therefore climate change is not the only factor that needs to be taken into account when looking at the future of malnutrition
    - Climate change will be mixed – both positive (enable the introduction of new crops – add diversity to people's diets) as well as negative (e.g. shorter growing season)
- Malaria
    - Mosquito borne and mosquitoes prefer warmer and especially wetter weather
    - Would expect to see a greater force of infection in the North with spikes and troughs
    - Need more data on how heat waves and flooding will impact on mosquito's and therefore malaria
- Diarrhoeal diseases/ cholera
    - Prevalent especially in Nampula City/ flood prone areas
    - Water borne and related to poor sanitation – therefore highly impacted by floods
- Oncocerciasis
    - Also mosquito borne so climate change will impact on this disease in the same way that it impacts on malaria
- Measles
    - Cases of measles seem to be clustered especially on the border with Malawi but there is uncertainty over the reason for this
    - Flooding/ the destruction of roads may prevent the distribution of vaccines

In the Centre of Mozambique:
Expected climate change: warmer temperatures, drier in the west but wetter in the east. More intense cyclones according to IPCC SREX

- Malnutrition
    - More intense cyclones will destroy crops and lead to greater food insecurity in the Centre
    - Droughts in the west will impact negatively on crop production
    - Wetter conditions in the east may lead to greater opportunities for crop diversification.

- Malaria
    - Mosquito borne and mosquitos prefer warmer and especially wetter weather
    - Therefore may expect an increase in malaria cases in the east and a decrease in cases in the west
- Diarrhoeal diseases/ cholera
    - Expected increases in rainfall and cyclone intensity may lead to increased prevalence of diarrhoeal diseases/ cholera in the east, especially on the coast (not just because of flooding but more intense cyclones may destroy sanitation infrastructure)
    - Situation may be exacerbated by increased migration from drought stricken areas in the west.
- Oncocerciasis
    - Also mosquito borne so climate change will impact on this disease in the same way that it impacts on malaria
- Disaster-related immediate deaths and trauma
    - Expected increased extreme events in the east will lead to increased deaths and trauma
    - Also indirect impacts on health – damage to infrastructure, destruction of people's livelihoods (which could lead to migration; involvement in risky behaviour)

In the South of Mozambique:
Expected climate change: warmer and drier especially away from the coast. New cyclone activity. Potentially less rainfall and less rainfall in the traditional rainy summer season (according to statistical downscaling)

- Malaria
    - Mosquito borne and mosquitoes prefer warmer and especially wetter weather
    - Expected drier conditions in the South could see a lessening of malaria , especially in the inland areas
- Diarrhoeal diseases/ cholera
    - Cyclones may lead to possible future flooding which will impact negatively on sanitation which could result in outbreaks of diarrhoeal diseases/ cholera
    - Outbreaks of these diseases would be exacerbated by high populations (which could be made higher by an influx of migrants)
- Malnutrition
    - Increase in droughts could lead to decreased crop production
    - Less rainfall will also lead to a decline in the availability of potable water
    - Cyclones / flooding could limit people's physical access to markets. Destruction of people's livelihoods would also decrease their economic access to markets
- Disaster-related immediate deaths and trauma
    - Expected increased extreme events (cyclones and flooding) will lead to increased deaths and trauma
    - Also indirect impacts on health – damage to infrastructure, destruction of people's livelihoods (which could lead to migration; involvement in risky behaviour)

Appendix D: Interview guidelines

Questionnaire for field interviews in Nampula and Manica

Introduction to the CDKN project and purpose of the interview

1. Please tell me about your basic training and your experience as public health professional.

2. What is your role in this sector/organization?

3. What are the major public health problems that occur in this district?

4. In your opinion, what are the reasons for the occurrence of these problems here in this district?

5. What are the strategies or actions taken to deal with these problems?

6. In your opinion what is the interaction between climate events and the problems you mentioned?

7. What are the district vulnerabilities when facing the extreme events of the climate?

8. What can be done to deal with these vulnerabilities and/or climate events to minimize their effects?

9. Please give me three examples of actions or public health services to deal with climate events.

10. Do you have any questions for me or suggestions of other people to approach?

Thanks for your precious time!

Appendix E: Interview data

Interviewee 1 – NPO for TB and Malaria FHI360 district level project

Nampula, September 25, 2012

I am a Nurse 15 years ago! I worked as such in Majune district (Niassa province). I am here in Nampula City working to FHI360 programme officer for Malaria and Tuberculosis.

My principal role, as I said previously, is leading person for Malaria and TB at provincial level. I am responsible for supporting the government through community based volunteers to fight both diseases.

Obviously TB, malaria, HIV and diarrheal diseases such as cholera and dysentery are the most prevalent diseases in Nampula. The other most important public health problem is malnutrition.

The poverty and the development stage play huge role for existing health problems. Social factors like gender, particularly women, are preventing health care access. Additionally, malnutrition and natural disasters are co-events.

There are national programmes for the most serious health problems. For example, the PNCM (programa nacional de controlo da malaria) has strategies to fight malaria such as bed net distribution to the most vulnerable groups (pregnant women, children under age of 5), household pulverization with insecticides and community based communication and social mobilization.

It is true! Climate events particularly floods and cyclones are impacting on health. Both events are related to cholera outbreaks and increasing number of malaria. The sanitation is poor and its contribution to cholera incidence it is exacerbated by sky open defecation.

Most of the population lives in flooding prone and cyclones areas. This act a vulnerability factor resulting in human and infrastructure destroying.

I think the government may develop a contingency plan to deal with effects of natural disasters. Up to date, rescue actions are placed in moving late due to *ad hoc* funding approach.

I recognize that we have a limited knowledge about climate events. My opinion is this you academicians must develop research agenda in climate change issues in order to inform the society about climate events. The government must put in action capacity development among human resources to deal with climate events.

Many thanks.

Interviewee 2 – NPO for Malaria Kulima district level project

Nampula, September 25, 2012

I am a Mother and Child health Nurse since 12 years ago.

I am responsible of malaria programme in dealing with mobilization and training community volunteers to fight malaria.

Malaria is very important problem here. Other most important problems include malnutrition, diarrheal diseases and TB.

In Mozambique health care is provided by public health sector. However, the health network is not covering all population. The majority of Mozambican people have to walk long distances to reach the nearest health facility. The interventions are scarce and vertically based approach.

Community based volunteerism is one of our efforts to fight those problems. For example, for TB, malaria and malnutrition many community members are trained to be volunteer acting as links between community and health network. CB-DOTS, household pulverization, bed nets distribution, and iodated salt are the examples of action in place.

Cyclones and floods are impacting Nampula. After raining cholera and malaria rises.

As whole, the communities are not prepared to deal with natural events. People live in areas with limited access and therefore in case of flooding or cyclones occur many deaths.

Preparedness is needed! Funding mobilization is essential to deal with climate changes.

Capacity building, health climate programme are encouraged to be in place to deal with climate change.

Thank you so much.

Interviewee 3 – Health professional

Memba, September 26, 2012

Medical officer responsible for notifications of the most important diseases.

Health system information, recording and reporting particularly the DNO's (doenças de notificação obrigatória).

Without doubt malaria, TB, cholera, dysentery, measles and meningitis are the most notified diseases.

These diseases affect people in poverty conditions. I think poverty and lack of relevant information are acting as pitfalls in combating those diseases.

There are many national programmes designed to deal with these problems.

Here cyclones are the most important climate related events. Cyclones promote flooding destroying human lives and infrastructure. Both climate events also destroy crops exacerbating food insecurity, malnutrition and meningitis.

District level in not prepared to deal with these problems. Populations are dispersed into areas with limited access. Institutional preparedness is lacking.

It is urgent to put hands on action. . I think funding and capacity building are the most important steps to be taken to deal with climate events.

Operational research and surveillance are important in dealing with climate events.

Interviewee 4 – CHASS staff

Macossa, November 12, 2012

I am CHASS officer for malaria.

I am involved with the malaria programme at district level. I am acting as community involvement through volunteerism.

Malaria, measles, HIV, TB, malnutrition are the diseases concerning here.

Mis-information and poverty are preventing phenomena for the most important public health threats.

Many programmes are placed but as said there are barriers in dealing with these issues. However, some strategies are successfully put in action like household pulverization, bed net distribution and social mobilization.

Droughts are most prevalent. Charcoal production, hunting are common here.

People are dependent on natural resources. Hunting and deforestation are the most developed activities resulting in disequilibrium with its impact.

Re-allocating people to split them from conservation area (coutada 13).

Social mobilization, funding, information in best practices of land usage, research focused on climate events and social behaviors are fundamental.

Thanks.

Interviewees 5 and 6 – ADPP professionals

Machaze, November 13, 2012

These interviews were conducted telephonically.