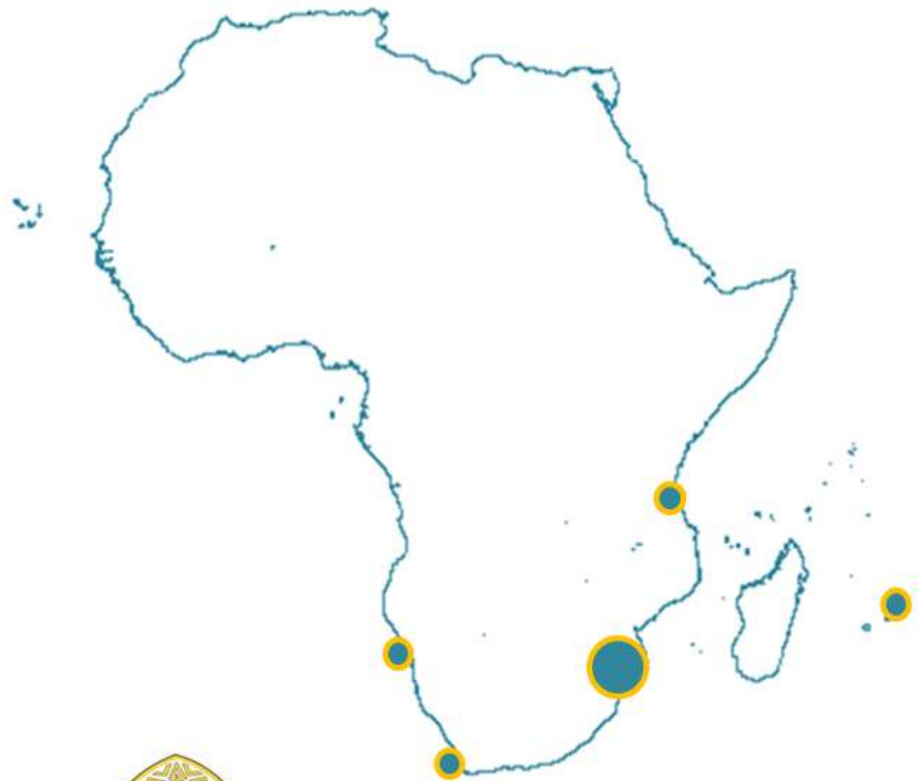


Sub-Saharan African Cities:

A Five-City Network to Pioneer Climate Adaptation through Participatory Research and Local Action



Baseline Study



Maputo





**Sub-Saharan African Cities: A five-City Network to
Pioneer Climate Adaptation through Participatory
Research & Local Action**

Maputo Baseline Study

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List of Acronyms

CCAA	Climate Change Adaptation in Africa
CCCI	Cities and Climate Change Initiative
CIF	Climate Investment Fund
DFID	Department for International Development
EDM	<i>Electricidade de Mocambique</i>
FIPAG	<i>Fundo de Investimento e Património de Água's</i>
GEF	Global Environment Facility
ICLEI	International Council for Local Environmental Initiative
IDRC	International Development Research Council
INGC	<i>Instituto Nacional de Gestão de Calamidades</i> – National Institute for Disaster Management
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
MICOA	<i>Ministério para a Coordenação da Acção Ambiental</i> – Ministry for the Coordination of Environmental Affairs
NAPA	National Adaptation Plan of Action
PARPA	<i>Plano de acção para a redução da pobreza absoluta</i> - Absolute Poverty Reduction Action Plan
PEUMM	<i>Plano de Estrutura Urbana do Município de Maputo</i> – Urban Master Plan of Maputo Municipality
PPCR	Pilot Programme for Climate Resilience
ProMaputo	<i>Programa de Desenvolvimento Municipal de Maputo</i> - Maputo Municipal Development Programme
RUA	Rapid Urban Air Quality Assessment
TPM	<i>Transportes Públicos de Maputo</i>
UNFCCC	United Nations Framework Convention on Climate Change



Preface

The global climate is controlled by complex interactions between marine and terrestrial systems. These interactions generate a variety of climatic variables across different regions and exert significant controls on day-to-day developments at the global, regional and local levels. Climate change is defined by the International Panel for Climate Change (IPCC) as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (IPCC 2007). Climate change may be a result of natural internal processes, external forcing or from anthropogenic changes such as increased carbon dioxide (CO₂) emissions. However the United Nations Framework Convention on Climate Change (UNFCCC) makes a clear division between anthropogenic causes that alter the composition of the atmosphere and the natural causes attributing to climate variability. Climate change, as defined by the UNFCCC, is any ‘change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and is in addition to natural climate variability over comparable time periods’ (IPCC 2001) and the IPCC (2007c) concur that anthropogenic forcing is a major driver.

Climate change is expected to have severe physical, social, environmental and economic impacts on cities worldwide, both directly and indirectly. These are anticipated to be felt with greater intensity in the developing world, particularly Africa. Although there are some uncertainties surrounding the understanding of earth’s complex systems, there is strong evidence in current literature and climatic measurements to demonstrate that, as a result of increasing greenhouse gas emissions, atmospheric and sea surface temperatures (SSTs) are rising.

Some of the changes likely to manifest from the projections are:

- changes in rainfall and precipitation patterns (flooding and drought),
- increases in temperature,
- increasing frequency and intensity of storm surges or extreme events,
- increasing average global sea levels due to melting glaciers and thermal expansion (permanent and non-permanent inundation) and,
- changes in wind speed.

This baseline study aims to identify and discuss the relevant literature pertaining to climate change in Africa with reference to past and projected climatic variability and how this is likely to impact upon local governments as service providers.

Local governments, as the sphere of government closest to their constituents, are required to make decisions and set directions for promoting social, cultural, environmental and economic well-being. Extreme climatic events and variability impact upon local governments and the day-to-day activities and services they provide to the communities that fall within their jurisdiction. These impacts raise challenges and come with risks and vulnerabilities that need to be strategically managed to ensure resilience. The risks associated with climate change pose a serious threat to local governments’

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ability as service providers to meet their own mandates. These threats may not necessarily arise as a direct result of climate change but rather indirectly as a result of a chain or cascade of events.

A changing climate will affect people's access to, and the quality of, basic goods and services such as water, shelter and food as well as other key priorities for human wellbeing such as education, employment and health. Current literature indicates that although, during extreme climatic events, the entire local human population is impacted upon, it is those who are impoverished who find it harder to recover from climate change related impacts as they have limited access and choices with regard to natural, social political, human, physical and financial capital that forms part of the holistic livelihood assets (IPCC 2007c). Deprivation of these assets increases vulnerability to climate change, and climate change in return increases deprivation. Understanding the basis of livelihood assets determines the ability of people to cope with climate-induced vulnerabilities. The key goal is to reduce the vulnerability to changes and to sustain and enhance livelihoods of people, with particular attention to the poor through adaptation and coping mechanisms.

Adapting to climate change is a necessary active initiative to reduce the vulnerability of the natural and human systems. Adaptation is becoming increasingly vital as climatic changes currently experienced are reportedly increasing in magnitude and frequency. Therefore the magnitude and frequency make the reduction of vulnerability an increasingly difficult task to achieve, particularly for developing nations who, comparatively to developed nations, have limited capacity and resources to implement coping mechanisms.



1. The project in context

The official mandate of ICLEI¹ – **Local Government for Sustainability - Africa** – is to work with Sub-Saharan African countries towards sustainable development and this project works towards that. The project is entitled *Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through Participatory Research and Local Action*. ICLEI-Africa falls under the auspices of the Climate Change Adaptation Africa (CCAA) programme funded by International Development Research Council (IDRC) and Department for International Development (DFID). The “Five City Network” project aims to address the knowledge, resource, capacity and networking gaps by strengthening the ability to plan for, and adapt to, impacts associated with climate change.

Increased adaptive capacity at the local government level, by building understanding and awareness of projected threats, would enable future planning and decision-making abilities to encompass climate change. This would reduce the vulnerability of the communities, services and infrastructure that fall within their jurisdiction. The first step is to identify the impacts and risks associated with climate change variability and subsequently make informed decisions. This leads toward the identification of mechanisms that increase adaptive capacity and climate preparedness thus enabling local governments to cope with such impacts. The first phase of the project is to identify the risks and impacts at a local level, looking at various local government sectors. The Risk Assessment comprises of a number of stages namely:

- An overview of the risks and impacts associated with climate change that have already been documented (a baseline literature review – referring to this report).
- A southern African climatic variable overview of the past, present and projected changes for: sea level, temperature, wind speeds, rainfall and precipitation patterns.
- A cost-benefit analysis of present and projected risks at the local level.

Five urban centres were chosen for this project; **Cape Town** in South Africa, **Dar es Salaam** in Tanzania, **Maputo** in Mozambique, **Walvis Bay** in Namibia and **Port Louis** in Mauritius.

These cities were chosen as they are large, home to a large number of people, are rapidly developing and are coastal economic hubs with harbours that contribute to their national GDP. Adaptation needs to be initiated quickly so that each city can contribute to the understanding of climate change, its vulnerabilities and adaptation strategies. Each city is represented in an individual case report. Port cities form a nexus between growing population and trade, and thus an excellent focus for investigating impacts and adaptation needs under changing climate.

¹ ICLEI – Local Governments for Sustainability is an international association of local governments and national and regional local government organizations that have made a commitment to sustainable development. ICLEI was founded in 1990 as the International Council for Local Environmental Initiatives. The organization is now officially called 'ICLEI - Local Governments for Sustainability', encompassing a broader mandate to address sustainability issues. ICLEI – Local Governments for Sustainability – Africa (ICLEI Africa) is the regional secretariat based in Cape Town, South Africa.

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This report focuses on **Maputo, Mozambique** (Figure 1) and the impacts of flooding that can be expected with a changing climate.

The first section of this report provides an overview of the climatic changes in Africa with regard to various climatic changes, moving towards a more detailed review at a regional level (Mozambique) and then specifically at a local level for Maputo; the infrastructure and services that fall under the municipality’s jurisdiction, and the impacts and risks for these sectors relating to flooding and climate change. The Chamanculo community will be used as a focal point.

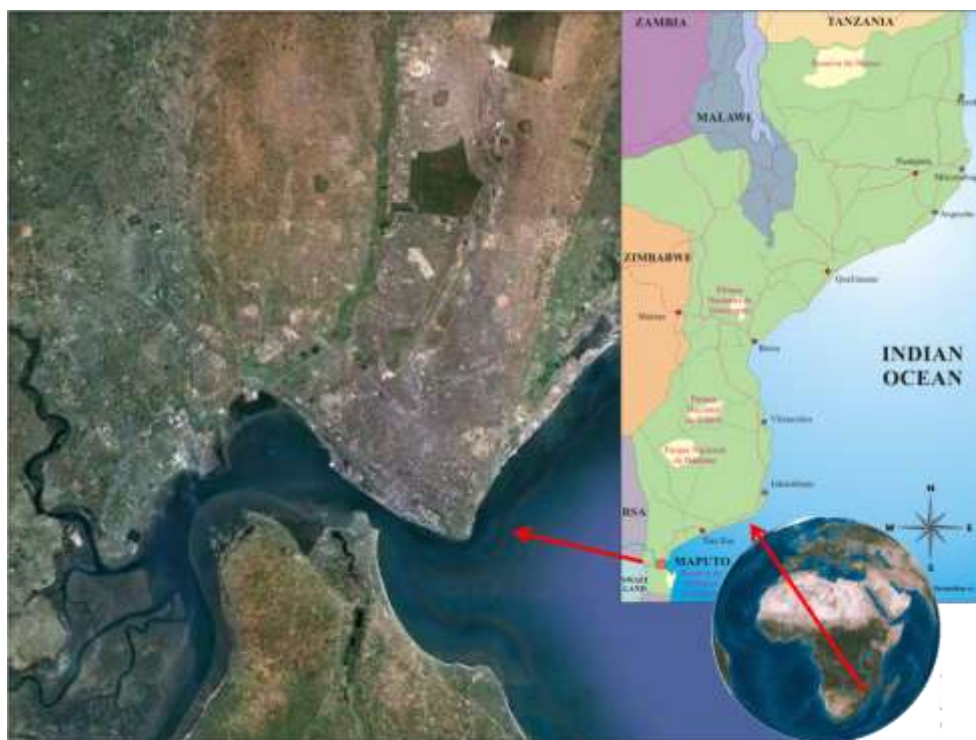


Figure 1. Study focus area - Maputo, Mozambique².

² Oxford Cartographers © & Google Earth.



2. Africa - climate change and flooding

Africa, covering more than one fifth of the total land area of earth, is the second largest continent and host to one billion people (United Nations 2010). It is a continent with abundant natural resources but remains the most underdeveloped continent globally. Extreme poverty, poor access to water, sanitation and health services and malnutrition from inadequate food supplies slows her progress (Sandbrook 1985). This means that the average sub-Saharan African will bear a three-fold population-based risk of suffering adverse effects of climate change when compared to a global total (Byass 2009), a heavy burden to bear for the population group that has contributed least to the forcing of climatic change (IPCC 2007c). The Stern Report (2006) concludes for Africa: ‘The poorest will be hit earliest and most severely. In many developing countries, even small amounts of warming will lead to declines in agricultural production because crops are already close to critical temperature thresholds. The human consequences will be most serious and widespread in sub-Saharan Africa, where millions more will die from malnutrition, diarrhoea, malaria and dengue fever, unless effective control measures are in place’ (Stern 2006).

Projections

TEMPERATURE: Africa is experiencing the physical effects of climate change and variability as experienced worldwide. Consensus in the scientific community’s predictions gives us a warming of approximately 0.7°C, more so in the southern regions rather than in the central regions (IPCC 2007). Between 1961 and 2000 an increase in warm spells over southern and western parts of Africa was observed, with a decrease in the number of extremely cold days (New *et al.* 2006). According to the IPCC (2001), mean surface temperatures are projected to increase between 1.5°C and 6°C by 2100; this warming trend is anticipated to give rise to changes in precipitation that will be accompanied by sea-level rises and increased frequency of extreme events in Africa, such as sea storm surges, floods, gale force winds and cyclones (Desanker 2009).

RAINFALL: Projections give a 10-20% decrease in rainfall by 2070 and a fall in river-water levels of as much as 50% by 2030, in various parts of Africa (UNECA 2010). Projections indicate that 230 million Africans will face water scarcity by 2025 as a result of decreasing water resources and as a result increasing constraints on water resources, especially in hotter climates. Much water infrastructure will require upgrading to maintain adequate supplies for meeting current needs and the increased demands of the future. This will need harmony among the wide diversity of water users ranging from agricultural production to fishing, navigation, industrial production and domestic consumption to ecosystem sustainability (UNECA 2010).

FREQUENCY & INTENSITY: The intensity of severe weather is expected to be greater over the next 50 years on the African continent. The IPCC (2007a) states it is likely that “future tropical cyclones will become more intense, with larger peak wind speeds and more heavy precipitation associated with ongoing sea surface temperature increases”. The scientific, peer reviewed studies used to inform the assessment, as well as studies that have since been published, indicate that climate



change will affect the intensity, frequency and paths of strong storm and wave events. They also indicate a global trend towards increased intensity of cyclones over the past few decades – most notably in the North Atlantic and Indian oceans (IPCC 2007b).

Vulnerabilities

Africa is particularly vulnerable to climate change and associated climate variability as the situation is aggravated by the interactions of ‘multiple stresses’. These ‘multiple stresses’ include: i) endemic poverty, complex governance and institutional dimensions; ii) limited access to capital, including markets, infrastructure and technology; iii) ecosystem degradation; and iv) complex disasters and conflicts. These in turn have contributed to Africa’s weak adaptive capacity, leaving the continent vulnerable to deal with impending changes (IPCC 2007c).

Food security in many parts of Africa is likely to be severely compromised. Agricultural production, including access to food, in many African countries is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly in marginal semi-arid and arid areas, are expected to decrease. This would further affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020 (IPCC 2007c), and crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected (Venton 2007).

Climate change will aggravate water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress. Climate change and variability are likely to impose additional pressures on water availability, water accessibility and water demand in Africa. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. About 20% of Africa’s population (about 200 million people) currently experience high water stress. The population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively (IPCC 2007).

Changes in a variety of ecosystems are already being detected, particularly in southern African ecosystems, at a faster rate than anticipated. Climate change impacts on Africa’s ecosystems include according to one study, between 25 and 40% of mammal species in national parks in sub-Saharan Africa becoming endangered. Local food supplies are projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, and also likely to be exacerbated by continued overfishing (IPCC 2007c).

Human health, already compromised, will be further negatively impacted by climate change and climate variability. It is likely that climate change will alter the ecology of some disease vectors in Africa, and consequently the spatial and temporal transmission of such diseases. Most assessments of health have concentrated on malaria but the need exists to examine the vulnerabilities and



impacts of future climate change on other infectious diseases such as dengue fever, meningitis and cholera, among others.

Climate change is a real challenge when dealing with natural disasters. Climate is often thought of as only the long-term averages of weather elements. However impacts on a local scale are likely to depend more upon changes in the frequency of extreme events than on changes in the average conditions. The increased frequency and/or severity of extreme events will increase human vulnerability to natural disasters such as droughts, floods, mean sea-level rise and storm surges and cyclones. Semi-arid areas and coastal and deltaic regions are particularly vulnerable. Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5-10% of GDP (IPCC 2007).

Flooding facing Mozambique & Maputo

It is projected that the number of people globally at risk from coastal flooding will increase from 1 million in 1990 to 70 million in 2080 (ActionAid 2006). Flooding tends to have immediate direct impacts on the poor especially amongst developing countries of the south. In following with the global trend, rapid urbanization has also led to large numbers of people, especially the poor, settling and living in fragile areas such as floodplains in and around urban areas (Douglas *et al.* 2008) in the country. This pattern of settlement – that has resulted in the emergence and concentration of slum communities – has led to much higher vulnerability to flooding in port cities and towns such as Beira, Quelimane and Maputo. Many rural people migrate to towns and cities, adding large new populations to existing slums and these migrants, in turn, add to the urban activities that increase the flow of rainwater to rivers and thereby the intensity of urban flooding (ActionAid 2006).

In 2000, heavy rains and cyclones in the country resulted in the ‘worst flooding in 50 years and brought widespread devastation to Maputo, as well as Matola. Upwards of one million people were directly affected in Maputo and Matola. The floods disrupted the country’s water and sanitation services and this resulted in outbreaks of dysentery and cholera’.

Seasonal flooding can be an important ecosystem function of refurbishing nutrients in the soil. The nutrients and organic material deposited enrich the soil, increasing its fertility and agricultural productivity (Bridge 2002), increasing agricultural productivity. However, extreme flooding events can also disrupt activities such as agriculture, livestock fisheries and transportation. Flooding is also compounded by ‘vulnerability factors’ such as lack of investment in smallholder agriculture, maize distribution gaps, weak social networks and the numerous direct and indirect effects of HIV/AIDS (Archer *et al.* 2007).

3. Legislation and international obligations

International Obligations

Mozambique acknowledges that, although it is responsible for little of the global emissions contributing to climate change, it can still play an important role in both mitigating and adapting to



climate change and thus adheres to international climate change efforts to ensure environmental sustainability.

1995 - The **United Nations Framework Convention on Climate Change** (UNFCCC) was ratified by Mozambique.

2003 - **Initial National Communication** was submitted, and was prepared within the UNFCCC secretariat guidelines. Mozambique is working on its Second National Communication that will assess climate vulnerability and adaptation options for those sectors not included in the first National Communication such as health, education and fisheries.

2005 - The **Kyoto Protocol** was ratified (as a non-Annex I Party) and the National Plan for Capacity Building in the context of the Clean Development Mechanism under the Kyoto Protocol was developed as a result.

Mozambique is also a signatory to various treaties and protocols aimed at safeguarding the environment in general, whether specifically aimed at ecosystem health or the reduction of poverty via the maintenance of sustainable ecosystems. These include:

- The African Convention on the Conservation of Nature and Natural Resources,
- The UN Framework Convention on Climate Change,
- The UN Convention for the Combat of Desertification,
- The Convention on International Trade in Endangered Species of Wild Flora and Fauna,
- The Convention on Biological Diversity,
- The UN Declaration on Human Settlements,
- The Millennium Declaration,
- The Action Plan for Sustainable Development,
- The Treaty of Cross-border Conservation Areas,
- Vienna Convention on the protection of the ozone layer,
- Montreal Protocol on substances that destroy the ozone layer and the respective London and Copenhagen amendments,
- Nairobi Convention for East African marine and coastal areas,
- Basel Convention on the control of trans-border movements of dangerous residuals, and
- The Bamako Convention on dangerous waste.

National context: Mozambique's sustainability strategies

The existing general environmental legislation is adequate for mainstreaming climate adaptation (Ribeiro & Chaúque 2010) and Mozambique has several key policies that specifically address climate change. Much of the other legislation aims at both sustainable development and environmental sustainability, which will enhance Mozambique's resilienc to climate change. Given the scarce resources available to implement all these strategies, plans and policies, enhancing synergies between activities would increase the effectiveness of existing resources for climate adaptation. The

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Ministry for the Coordination of Environmental Affairs (MICOA) has already undertaken valuable efforts to coordinate the work of the various Rio Conventions (MICOA 2005) and strategies to create synergies among the other conventions are being developed.

1995 - The **National Environment Policy** (1995) – this constitutes the main instruments by which the government of Mozambique gives clear recognition to the interdependency between the environment and development.

1996 - The **National Environment Management Programme**. Developed by Mozambicans for their country, this document gives an overview plan for the environment in Mozambique. It also contains the National Environmental Policy, Environmental Legislation and enabling strategies

1997 - **Environment Frame Law** aims to systematically integrate environmental aspects into development.

1995 - The **Energy Policy** aims to increase capacity and access to low cost supply of energy; in addition, to develop conservation technologies and environmentally beneficial uses of energy. The policy emphasises the need to reduce the consumption of wood and charcoal fuels.

1996 - The **National Land Policy**

1997 - The **Land Law** ensures that the population have access to their land resources and participate in the management of such resources, sustainably and with socially equitable use.

1997 - The **National Policy on Forest and Wildlife** aims to manage forest and wildlife resources sustainably.

1999 - The **Policy on Disaster Management** aims for the elimination of poverty and the establishment of a contingency plan in view of the recurring incidence of calamities (often climatic) that affect the country's social and economic development.

2000 - The **National Energy Strategy** aims at increasing the number of users with access to energy sources, especially by promoting efficient use and environmental protection. It does not take into account any climate change implications or any mitigation measures.

2002 - 2004 - **Assessment of the Economic Impact of Climate Change** focused on the effect of economic liberalisation on local coping strategies and adaptive capacity in the face of drought and floods (O'Brien and Vogel 2003, Eriksen *et al.* 2009).

2003 - **Agenda 2025** aims to improve the socio-economic situation of Mozambique by 2025, and although climate change is not specifically addressed it does present human settlements and sustainable urban development as a priority.



- 2003 - The **Law on Disaster Management** primarily provides an instrument for the management of emergencies rather than preventative or longer term measures to address social causes of vulnerability.
- 2004 - The **National Strategic Long-term Plan** of the National Institute of Disaster Management (INGC) also primarily provides an instrument for the management of emergencies.
- 2004 - The **Constitution of Mozambique** commits the government to ensuring sustainable development by adopting policies and promoting initiatives that guarantee the ecological balance, conservation and preservation of the environment, aimed at improving the quality of life of its citizens.
- 2006 - 2009 **Absolute Poverty Reduction Action Plan (PARPA II)**. This plan was to reduce the incidence of poverty from 54% in 2003 to 45% in 2009. This plan influenced all donor support to Mozambique for four years and natural disasters were addressed but not in terms of urban development.
- 2006 - **Master Plan for Prevention and Mitigation of Natural Disasters** was designed to complement PARPA II and to fill in strategic gaps in the different governmental sectors related to risk management, vulnerability reduction, prevention and mitigation of natural disasters. This recognises that effective disaster management is a key component of poverty reduction and sustainable development. To this end disaster risk mapping for planning and monitoring purposes was undertaken. It does, however, only address issues at a national level, and does not give special attention to urban areas.
- 2007 - **National Adaptation Plan of Action to Climate Change (NAPA)**. The NAPA was developed in response to serious floods, when a need for disaster preparation and management, and greater environmental management became apparent. NAPA identifies urgent needs with regard to climate change through a participative assessment process. This includes: i) strengthening the warning system for natural disaster prevention; ii) capacity-building and awareness-raising for farmers to deal with the effects of climate change; iii) reducing effects in coastal areas; and iv) improving water resource management. The NAPA, however, only plans for a national-scale not a city scale i.e. Maputo.
- 2007 - The **Environmental Strategy for Sustainable Development of Mozambique**. This provides: i) guidelines for stakeholders involved in development programmes and includes capacity-building for implementation, and setting national and local objectives for integrated management and preservation of natural resources and ecosystems; ii) setting up institutions with the technical capacities required for urban planning, development of infrastructure, waste management, and water and sanitation services; iii) providing the technical and financial support required to strengthen the country's capacity to measure, curb and evaluate environmental pollution (including any impacts on health and climate change issues); and iv) keeping demographic growth within the limits of socio-economic and



sustainable development objectives. It also addresses climate change issues focussing on mitigation of greenhouse gasses but has little reference to climate change adaptation.

2007 - The **National Water Policy** aims to guarantee sufficient and sustainable water resources in both quantity and quality. It focuses on poverty reduction, and ways to minimise the negative impacts of floods and drought, such as improving drainage systems in urban areas. It facilitates investment in the promotion of access to drinking water. It has seen success in city centres but not yet in peri-urban slum areas where such measures would dramatically reduce the inhabitants' vulnerability to natural disasters.

2007 - The **National Water Resources Management Strategy** aims to develop effective and integrated management of water resources as a means of contributing to sustainable socio-economic development. It focuses on floods but not on greater climate change impacts.

2008 - The **UN Joint Programme for Disaster Risk Reduction and Emergency Preparedness** aims at: i) mainstreaming disaster risk and vulnerability reduction in national development plans and programmes, including development of policy and norms; ii) strengthening government and civil society capacities for disaster risk reduction at central, provincial and local levels; and iii) setting up a National Information System including early warning, and cross-sector information sharing and knowledge management for disaster risk reduction.

2008 - The **UN Joint Programme for Environmental Mainstreaming and Adaptation to Climate Change** supports the governments' efforts towards sustainable development through mainstreaming of environment and specifically climate change policies, and adaptation of human activities to climate change.

2008 - The UN Africa Adaptation Programme has a more strategic focus aimed at creating the environment in which more informed and appropriate adaptation decisions and practices can be undertaken to reduce and eventually eradicate poverty within the context of sustainable development.

2010 - Phase 1 of the **Pilot Programme for Climate Resilience (PPCR)** was accepted and will be funded by the World Bank. A preliminary step in this Pilot Programme – an in-depth assessment on the potential climate change impacts in Mozambique for the next 50 years – is currently under preparation. This is part of the Climate Investment Fund (CIF).

In addition MICOA has put the following in place:

- Implementation of strategy and action plan for biodiversity conservation in Mozambique under the Convention on Biodiversity;
- Strategy and action plan for preventing and combating the uncontrolled bush fires;
- Strategy and action plan for preventing and combating soil erosion;
- Implementation of National Training Plan for Implementation of the Clean Development Mechanism under the Kyoto Protocol;

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- Implementation of the project evaluating the need for national capacity self-assessment of overall management of the environment;
- Action plan to combat drought and desertification under the Convention of Nations on combating drought and desertification; and
- Establishment of youth organizations aimed at environmental conservation in Mozambique (MICOA 2005).

Local Context: Maputo's environmental sustainability strategies

Many of the national policies, strategies and plans have included strategic recommendations and proposed actions that should contribute to the formulation and deployment of climate change adaptation and mitigation measures. What is needed now is for these to be integrated in a systematic way into municipal agendas.

Maputo Municipality has made some progress and has developed the following tools for sustainable development, particularly in the light of climate change:

- 2006 - **Solid Waste Management Strategic Plan of Maputo City** aims to implement and improve solid waste collection and related economic aspects, including adopting the 'polluter pays' principle. Establishing a more efficient solid waste management system will surely help to mitigate some of the negative effects related to climate change such as collecting waste to avoid the obstruction of drainage channels.
- 2007 - **Sustainable Consumption and Production (SCP)** for Maputo and Matola Cities. This SCP initiative is a follow up of the 10 Year Framework Programme on Sustainable Consumption and Production in Africa, which identifies key priorities concerning energy, water, urban development, and industrial development. It does not specifically address potential climate change impacts in urban areas.
- 2007 - **ProMaputo: the Maputo Municipal Development Programme** is a 10-year development plan that is divided into two stages (2007-2009 and 2010-2016). The first stage will strengthen the city's institutions and finances so that it can undertake more ambitious programmes. Climate change is not specifically addressed by the first part of the programme. The second stage focuses on improving the city's infrastructure (drainage systems, roads, and coastal protection) to better handle climate-driven events (Kass 2010). Although the programme does not specifically address issues related to climate change, its urban planning and proposed physical interventions should have strong mitigation effects.
- 2007 - **Rapid Urban Air Quality Assessment (RUA)** project was launched by the Maputo Municipality to tackle air pollution through collaboration with local educational and research institutions. It aims to evaluating emission levels within the municipality and surrounding areas to facilitate rapid decision making.



2008 - **Urban Master Plan of Maputo Municipality (PEUMM)** was prepared within the scope of the Maputo Municipal Development Programme (MMDP) and is the main urban planning instrument of Maputo City, which defines the spatial vision and strategic planning priorities of the city. It aims to identify priority areas for public investment, establishes municipal principles for addressing issues related to urban planning and provide clear guidelines for private investments and/or initiatives and to establish a data collection system that can be permanently updated. It identifies areas of Maputo city that are vulnerable to extreme events related with climate change and provides guidelines for future urban development interventions also related with climate change impacts. The strategic projects include, among others: slum upgrading; land requalification for development of social/public services and infrastructures; land provision for urban expansion; promotion of urban diversification of activities and functions, in a bid to prevent peri-urban slums and spatial segregation of poor communities; and reduce social segmentation through provision of infrastructure, services and amenities in slum areas. There is concern that a lack of financial resources is slowing progress within this programme and the new Early Warning System/Warning of Tropical Cyclones developed the National Disaster Management Institute and the National Meteorology Institute (Kass 2010).

International support for implementing adaptation measures remains important. One way to advance implementation of adaptation would be to include the integration of climate risk policy across all climate-sensitive sectors such as agriculture, water and sanitation, health and infrastructure. In addition, a clear aid policy statement from the Government of Mozambique, indicating preferences for receiving aid in form of programmatic, project and technical assistance would help to set priorities, particularly with regard to the mainstreaming of gender into climate-informed development (Ribeiro and Chaúque 2010).

4. Mozambique and its vulnerabilities

Mozambique is located in south-eastern Africa, south of the equator, with its entire eastern border lying on the Indian Ocean. It borders the Republic of Tanzania to the north, Malawi, Zambia, Zimbabwe, South Africa and Swaziland to the west, and South Africa to the south (Figure 2). This long, thin country covers an area of around 785,000 km² with a 2,515 km long coastline. There are many islands along the coast including: the Quirimbas archipelago in the Cabo Delgado province; the Mozambique Island and the Islands of Goa and Sena in the Nampula province; the archipelago of Bazaruto in the Inhambane province; and the Islands of Inhaca, the Elephants and Xefina in the Maputo province.

The country is divided into 11 provinces and 128 districts, administrative posts and localities. In total 33 municipalities comprise the major urban centres; including 10 provincial capitals and the country's capital, Maputo (NAPA 2007).

The terrain is mostly coastal lowland (the average elevation is only 370 ms above sea level) with a vast network of trans-boundary Rivers and tributaries emptying into the Indian Ocean (NAPA 2007, UNHABTAT 2009).

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Figure 2. The topography of Mozambique: showing low topography at the coast (darkest green), higher interior and northern regions, and neighbouring countries.

Mozambique’s agro-climate is clearly delineated into three zones:

- a) The northern zone of the Zambezi River has a distinct rainy season and is where there is sufficient water available for crops for a full growing season, with drought conditions occurring only twice every ten years.
- b) The central zone, between the south of the Zambezi River and the north of the Save River, experiences drought conditions approximately four years in every ten.
- c) The southern zone has a high risk of drought conditions, with drought conditions seven out of every ten years (NAPA 2007).

There are 20.4 million people living in Mozambique (National Census 2007) with more women (52.8%) than men and the population is growing at 3.6% a year. The population density in the northern region is highest (~23 people/km²) and lowest in the south (~14 people/km²). The majority of the inhabitants (73%) live in rural areas though this is changing as more people migrate to cities in search of work when climatic conditions make farming tough (NAPA 2007).

Even with one of the world’s highest economic growth rates, it is still one of the poorest countries in the world (Bambaige 2007). A 16-year civil war destabilised the country but since the peace agreement was signed in 1992, Mozambique has worked hard to rebuild by implementing a number of market-based policies combined with donor assistance. All these factors have led to an increase in the country GDP yearly growth rate, which has now stabilised at 6.3% (CIA 2011) and a reduction in the inflation rate (Bambaige 2007). Mozambique depends strongly on foreign aid which accounts for about half of its annual budget and according to the 2004 UNDP statistical reports, the majority of the population (70%) still live below the poverty line of USD 2.00 per day (Bambaige 2007).



The economy of Mozambique is primarily based on agriculture, livestock and fisheries. More than 80% of the population are engaged, either formally or at a subsistence level, in agriculture. The climatic conditions in the country's central and northern regions are good for farming and accessible surface water provides ample opportunities for irrigation. These conditions are favourable for cash crops such as cashew nuts, sugar-cane, cotton, tea, beans and tropical fruits (NAPA 2007, Ribeiro and Chaúque 2010). The industry sector contributes 26% to the GDP, followed by services (45%) and agriculture (29%) (CIA 2011).

Mozambique has a tropical to sub-tropical climate that is moderated by the influence of the mountainous topography in the north-west of the country. Seasonal variations in temperature are around 5°C between the coolest months (June to August) and the warmest months (December to February). Temperatures are warmer near to the coast, and in the southern lowland regions (25-27°C in summer and 20-25°C in winter) compared with the inland regions of higher elevation (20-25°C in summer and 15-20°C in winter) (Sweeney *et al.* 2008).

The wet season lasts from November to April during the warmer months of the year. The north receives 150-300 mm of rainfall per month whilst the south receives less (50-150 mm of rainfall per month). The topography causes local variations to this north-south rainfall gradient with the highest altitude regions receiving the highest rainfalls. As a result of Mozambique's long coastline the whole length of the country lies in the path of highly destructive tropical storms and cyclones that occur during the wet season. The heavy rainfall associated with these events contributes a significant proportion of wet season rainfall over a period of a few days (Sweeney *et al.* 2008). Since 1970 Mozambique has been hit by 34 major cyclones and four major flood events (2000, 2001, 2007 and 2008) (UN HABITAT 2009).

Inter-annual variability in rainfall in Mozambique is also strongly influenced by Indian Ocean Sea Surface Temperatures, which can vary from one year to another. The most well documented cause of this variability is the El Niño Southern Oscillation (ENSO) that causes warmer and drier than average conditions in the wet season of eastern southern Africa in its warm phase (El Niño) and relatively cold and wet conditions in its cold phase (La Niña) (Sweeney *et al.* 2008).

Observed Climate Trends

Temperature: Mean annual temperature has increased by 0.6°C since 1960, an average increase of 0.13°C per decade (Sweeney *et al.* 2008, IPCC 2007). In particular, an increase in temperature has been observed for December and August. Daily temperatures have shown a significant increase in the frequency of 'hot'³ days and nights in all seasons. The average number of 'hot' days per year in Mozambique has increased by 25 (6.8% of days) between 1960 and 2003. The rate of increase is observed most strongly in winter (March to May) as the average number of hot days has increased by 3.2 days per month (an additional 10.2%) over this period. The average number of 'hot' nights per year increased by 31 (an additional 8.4% of nights) between 1960 and 2003. The rate of increase is

³ 'Hot' day or 'hot' night is defined by the temperature exceeded on 10% of days or nights in the current climate of that region and season.



observed most strongly in December to February as the average number of hot nights has increased by 3.6 days per month (an additional 11.6%)(Sweeney *et al.* 2008).

The warming tendency has not been uniform across the country. Between 1960 and 2005, winter temperature increased by up to 1.6°C over the centre of the country, but only approximately 1.1°C in the north. The mean annual maximum temperature in the north before 1990 were often below 30°C but after 1990 has been consistently above 30°C. The central regions recorded mean maximum temperatures around 31°C before 1990, and significant increases thereafter (Queface and Tadross 2009).

In addition, there was an increase of 9 days in the duration of the longest heat waves during September-November and reduction of cold nights and cold days over the same period, whereas the number of hot nights and hot days has increased over the whole of the country. This is most notable in the north where the number of hot nights has increased by 25% during the December-February season and 17% during the September-November season. Droughts are therefore increasingly marked by higher mean maximum temperatures, which in turn augment evaporation (Tadross 2009).

The frequency of ‘cold’⁴ days and nights has decreased significantly since 1960 in all seasons except September-November. The average number of ‘cold’ days per year has decreased by 14 (3.9% of days) between 1960 and 2003. This rate of decrease is most rapid in March-May as the average number of cold days has decreased by 2.1 days per month. The average number of ‘cold’ nights per year has decreased by 27 (7.4% of days). This rate of decrease is most rapid in March-May as the average number of cold nights has decreased by 2.9 nights per month (9.5%) over this period (Sweeney *et al.* 2008).

Precipitation: Mean annual rainfall over Mozambique has decreased at an average rate of 2.5 mm per month (3.1%) per decade between 1960 and 2006. This annual decrease is largely as a result of decreases in December-February rainfall, which has decreased by 6.3 mm per month (3.4%) per decade. However, when observing daily precipitation (over a 43 year period) it is noted that despite the observed decreases in total rainfall, the proportion of rainfall falling during ‘heavy’ events has increased at an average rate of 2.6% and 5-day annual rainfall maxima have increased by 8.4 mm per decade, with largest increases in the wet season December-February (Sweeney *et al.* 2008).

Tadross, however, reports that significant past trends in rainfall are not readily apparent, largely due to the high inter-annual variability of rains over different seasons compared to the period of record. There are, however, indications of a later start to the rainfall season, and longer, more frequent dry spells in the north-east of the country during March-May and September-November. In 2005 the start of the rainfall season was delayed by up to 45 days at specific locations (Tadross 2009).

⁴ ‘Cold’ days or ‘cold’ nights are defined as the temperature below which 10% of days or nights are recorded in current climate of that region or season.

Extremes: Mozambique has experienced a succession of droughts and floods (Figure 3), which has had damaging consequences for social and economic development. The most severe drought periods were recorded in 1981-1984, 1991-1992 and 1994-1995; while floods were observed in 1977-1978, 1985, 1988, 1999-2000, 2001 and more recently in 2007-2008 (UN HABITAT 2009).

Floods are often exacerbated by cyclones. Since 1970, Mozambique has been hit by 34 significant cyclones or tropical depressions and four major flood events (2000, 2001, 2007 and 2008). In particular, the number of recorded cyclones during the 1999-2000 wet seasons was extraordinarily high and flooding had terrible consequences. In early 2000, a combination of torrential rains and tropical cyclones caused the most devastating floods in the history of Mozambique, killing 700 and causing US\$ 600 million in damage (UN HABITAT 2009).

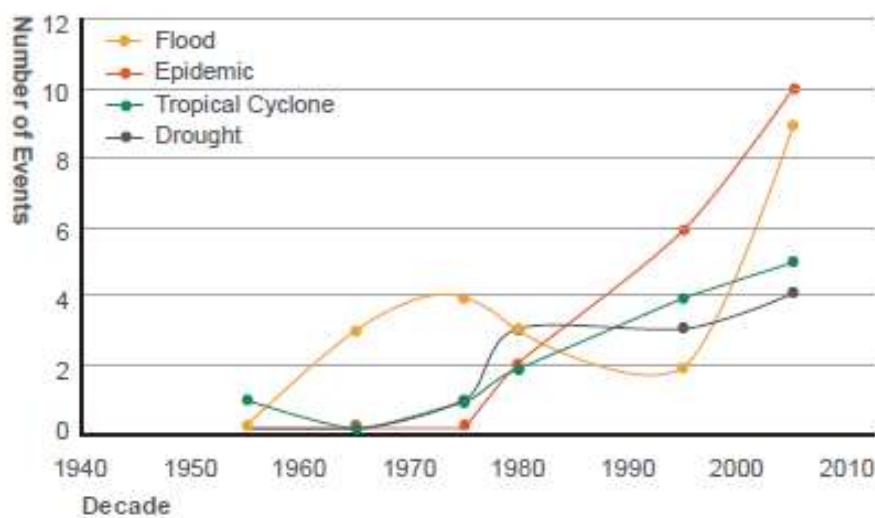


Figure 3. Number of natural disasters in Mozambique (period 1956 – 2008). Source Queface, 2009⁵.

The central region is more prone to floods, tropical cyclones and epidemics, followed by the south, which with its tropical dry savanna climate is more prone to droughts than the centre. The northern region is dominated by a tropical rainy climate and a moderately humid climate modified by altitude, respectively (INGC 2009).

Projections

Temperature: The mean annual temperature is projected to increase by 1.0 to 2.8°C by the 2060s, and 1.4 to 4.6°C by the 2090s. Warming is projected to be more rapid in the interior regions of Mozambique than those areas closer to the coast. All projections indicate substantial increases in the frequency of days and nights that are considered ‘hot’ in current climate (annually ‘hot’ days will occur on 17-35% of days by the 2060s, and 20-53% of days by the 2090s). Days considered ‘hot’ by

⁵ Sources used for Figure 3 include INGC, FEWSNET, British Association for Immediate Care (BASICS) www.basedn.freeseerve.co.uk/; UNDP/CRED (2006) Munich Reinsurance Company www.mmathan.munichre.com.



current seasonal standards are projected to occur on 26-76% of days by the 2090s. Nights that are considered 'hot' for the annual climate of 1970-99 are projected to increase more quickly than hot days, occurring on 25-45% of nights by the 2060s and 29-69% of nights by the 2090s. Nights that are considered hot for each season by 1970-99 standards are projected to increase most rapidly in December-February, occurring on 47-97% of nights in every season by the 2090's. All projections indicate decreases in the frequency of days and nights that are considered 'cold' in current climate. These events are expected to become exceedingly rare, and do not occur at all under the highest emissions scenario by the 2090's (Sweeney *et al.* 2008).

The highest increases in temperature are projected for the inland regions and during September-November months. Maximum temperatures increase between 2.5°C and 3°C and similar increases in minimum temperature are projected over the Limpopo and Zambezi valleys during the September-November months. Seasonal variability in maximum temperature decreases in the North during the September-November months, but increases over most of the country during March-August. By 2080-2100 increases in temperature are projected to increase by as much as 5-6°C over the Centre during September-November and increases in the likelihood of extreme maximum daily temperatures above 35°C are simulated for all regions, increasing by 25-33% by 2080-2100 (Tadross 2009).

Precipitation: Projections of mean rainfall do not indicate substantial changes in annual rainfall. The range of projections from different models is large and show both negative and positive changes (-15% to +34%). Seasonally, however, the projections tend towards decreases in dry season rainfall, and increases in wet season (December to February) rainfall. The increases in wet season rainfall are largest in the north of Mozambique. Overall, models consistently project increases in the proportion of rainfall that falls in heavy events, of up to 15% by the 2090's. The proportion of total rainfall that falls in heavy events is consistently projected to increase in December to January by up to 18%. Models are also broadly consistent in indicating increases in March to April but decreases for the rest of the year. Rainfall, by the 2090's is projected to increase by up to 20 mm in 1-day events and 34mm in 5-day events. Mozambique's climate is strongly influenced by ENSO but there is no consistency in the projections of the amplitude of future El Niño events so this contributes to uncertainty in the projections. Mozambique's coastal lowlands may be vulnerable to sea-level rise. Sea-level in this region is projected by various climate models to rise by a minimum of 0.13-0.18mm to a maximum of 0.43-0.56 mm by the 2090s, relative to 1980-1999 sea-level (Sweeney *et al.* 2008).

An increase in rainfall over most of Mozambique is projected for December to May, however, increases in evapo-transpiration will exceed that of rainfall during June to November. Higher increases in rainfall are suggested towards the coast and greater seasonal variability during all seasons across the coastal zones of the South. Over the entire country most stations also suggest an increase in variability during June-August. The annual average over the entire country indicates a slight increase in rainfall (10-25%) compared to the average annual rainfall during the 1960-2000 period. The spread between models is large, however, indicating that the changes in rainfall are not as consistently simulated as are changes in temperature (INGC 2009).



Across all zones, increases in evaporation will likely be greater than increases in rainfall during the dry season, suggesting that the dry season will become drier everywhere by around 2055 and even more so by 2090, especially for central regions. In the interior the increasing temperatures will lead to increased evaporation, greater than that of the coastal region. This will be greatest during September-November, particularly over the Limpopo and Zambezi river valleys. This is just before the onset of the rains, which depending on changes in rainfall, could result in decreases in soil moisture before the main cropping season starts. It is likely there could be a delay in the start of the rains over some areas as a result of a combination of: i) stronger subtropical anticyclones delaying the southward migration of the ITCZ; ii) potentially a southward shift of mid-latitude cyclones; and iii) a reduction in moisture availability during winter.

Generally, the climate may be more extreme, with hotter drought occurrences and more extreme floods, particularly in the southern parts. The central region, particularly those regions at lower altitude, is likely to be the most severely impacted by climate change (INGC 2009).

For more details on projected climate change in this region see the ICLEI Tadross and Johnston (2011) report: *Projected climate change over southern Africa; Mauritius, Mozambique, Namibia, South Africa and Tanzania*.

Mozambique's vulnerability

The climatic effects on human activities and natural resources can be described by two factors: sensitivity and vulnerability. Sensitivity is the degree to which the system responds to changes in the climatic conditions and, vulnerability indicates the degree to which the system can cope with its impact, since vulnerability does not only depend on what the system is exposed to but also on its capacity to adapt to climate change. The NAPA report (2007) highlights the following overarching areas of vulnerability in Mozambique to climate change:

Geographic: Mozambique's long coastline (~2,700 km) makes it highly susceptible to sea-level rise and flooding (Figure 4., Kass 2010). As the country is in the trajectory for some of the tropical cyclones and depressions that are formed in the Indian Ocean, the coastal zone is often negatively affected. Projections indicate a likely increase in temperatures that will lead to increases in the frequency and severity of droughts in the interior and floods in coastal regions.

This report is focussed specifically on the flooding risks associated with climate change. Floods in Mozambique are caused not only by rainfall but also by the water discharge from dams in neighbouring countries situated upstream. As a result of the number of river basins located in the country, including nine river basins from international rivers, Mozambique is already vulnerable to floods regardless of whether flooding intensity increases or not. In addition flooding is difficult to regulate since it depends on these cross-border river systems. As a result, the lowlands are facing flooding risks that are further accelerated by climate change impacts.

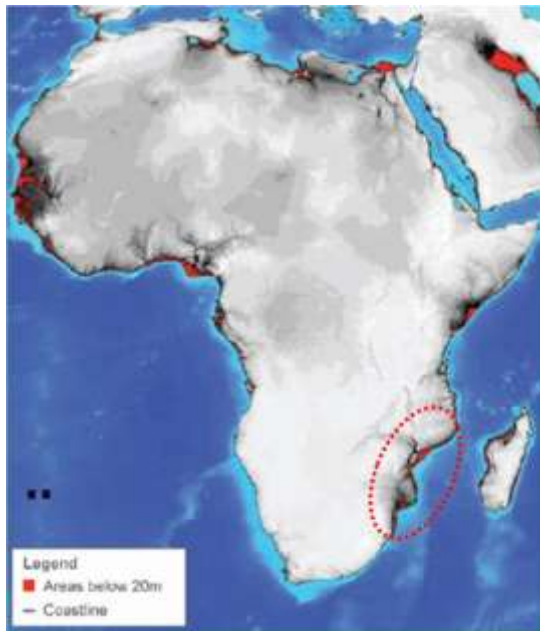


Figure 4. Mozambique is especially vulnerable to flooding from sea-level rise as much of its area is low-lying coastal plains and is traversed by 39 rivers that contribute riverine flooding.⁶

In the years 2000 and 2001, the country was affected by serious floods as a result of torrential rains in neighbouring countries that led to flooding in many river basins within Mozambique. The damage from the 2000-2001 floods are estimated at 800 human deaths and over US\$ 750 million in property damage. The negative effects of floods are widely known worldwide and in Mozambique, and result in *inter alia*: i) inundations; ii) loss of lives and

property; iii) loss of crops; iv) outbreak of diseases; v) displacement of people; vi) loss of biodiversity; and vii) disruption of normal economic activities.

Social: Many Mozambicans live in conditions of absolute poverty, as well as food and nutritional insecurity with severe consequences to human health. Nutritional deficiencies are exacerbating the effects of HIV/AIDS. In addition, outbreaks of epidemics such as cholera, malaria and dysentery, have compounded people’s already precarious living conditions. The long civil war in the country resulted in increased migration of the population to urban areas, with adverse impacts on the environment. Poor infrastructure combined with lack of access to basic services such as water and sanitation has led to a number of health problems in cities including malaria, diarrhoeal diseases and cholera. HIV/AIDS is also one of the major threats to the country’s economy with 12.2% of the adult population aged from 15-49 years old infected (Bambaige 2007).

Food security: Most Mozambicans rely on rain-fed agriculture for food and food production needs to increase to meet the increasing demand caused by rapid population growth. However, climate predictions indicate less rain which will impact negatively on food security. In addition, crop epidemics often occur during and after an extreme event, reducing agricultural production and worsening the emergency situation of agricultural families. Food and nutritional insecurity, as well as the above mentioned epidemics can exacerbate the effects of HIV/AIDS and other diseases, increasing people’s vulnerability to climate change.

In a MICOA survey of government officials, NGO staff and community leaders and members’ perceptions (621 people in total) of severity of natural disasters were ranked. This resulted in the following ranking: drought was rated the extreme event that affects the country most (45.2%), followed by floods (34.5%) and tropical cyclones (20.3%). Other environmental problems that affect

⁶ From INGC 2009.

the country include: i) cascade effects of drought, floods and cyclone; ii) epidemics and plagues; iii) slash-and burn practices; iv) industrial accidents; and v) erosion (NAPA 2007).

4. 1. Maputo and its vulnerabilities

Maputo is the capital city of Mozambique and is located in the south of the country on the coastal plain that forms the northern and southern shores of the Bay of Maputo (Figure 5). It lies at the confluence of three rivers: Maputo, Umbeluzi and Incomati; whilst the Infulene River skirts the city, adjacent to an agricultural area that supplies products to Maputo. To the north lies the district of Marracuene and to the west the city of Matola. A metropolitan system called Greater Maputo links Maputo, Matola and Marracuene and has a fluctuating population of 2.0 to 2.5 million. There are no formal spatial, urbanisation and land use plans in Greater Maputo, yet many of the sectors such as transport, waste management, produce markets, housing and labour markets of Maputo and Matola are clearly interconnected (Dray and Nhancale 2010).



Figure 5. A map of the city of Maputo within a larger geographical perspective⁷.

Maputo City has a jurisdiction of 347 km² and is home to over a million inhabitants (National Census 2007) who live at a density of ~3,200 people/km². Unlike many African cities, Maputo's population growth is slowing down (only 1.2% a year) to just half the national average population growth rate of 2.4% a year. This relatively slow growth is due to emigration from the city to neighboring areas in Maputo province, such as the city of Matola, and Boane and Marracuene districts. As a result, Maputo province showed a population growth rate of 4% - much higher than the national average (National Census 2007). The city holds 45% of the total Mozambican urban population and

⁷ GoogleEarth.

according to the 2004 UNDP report, more than half (54%) are considered to live below the poverty line of USD 2.00 per day (Nhaca and Vieira 2010, Dray and Nhancale 2010). In Maputo, recent data indicate an increasing rural-urban migration contributing to higher poverty and vulnerability levels (UN HABITAT 2009). Approximately 75% of Maputo City's residents live in informal settlements.



Figure 6. The 'cement city' or centre of Maputo City⁸.

Maputo is an important port for mineral exports from South Africa. The industrial sector is growing and the most significant industry is the Mozal aluminium smelter, which since 2002 has more than doubled Mozambique's GDP. In 2011, Mozambique's GDP was estimated at a figure around US\$ 23.87 billion (CIA 2012). Maputo is also a hub for tourists, investors, migrants from rural areas and economic migrants from surrounding countries. It contributes over 30% to the national GDP and has an estimated GDP per capita over three times that of the national average (MMPII). In a provincial context the per capita GDP for Maputo city is five times that of Niassa, Cabo Delgado, Zambézia and Manica provinces combined, four times that of Nampula, Tete and Inhambane provinces, and twice that of Sofala province (Dray and Nhancale 2010).

The city of Maputo is located in a tropical rainy area. There are two seasons: the warm and humid season and the fresh and dry season. An annual rainfall of 860 mm falls predominantly in the warm season, between December and March, with rain expected on 93 days of the year. Mean annual temperatures range from 18.6°C to 27.4°C (Dray and Nhancale 2010).

The Maputo area comprises the coastal plain (with its small coastal dunes and river sediment deposit) and higher consolidated dune areas. Both are soft, low-density substrata and thus are highly conducive to erosion. As the human population has burgeoned in the last 20 years, development and the need for land have been extensive. As a consequence there are few natural

⁸ <http://www.ganeandmarshall.com/destination/Mozambique/Maputo.html>



habitats left; just a little natural vegetation on the coastal zone to the north of the municipality on the Inkomati coastal plain; dune vegetation, wetlands and estuaries, and relatively well-conserved mangroves areas in some areas. Most of the trees in and around Maputo are ones that provide food and resources ; cash-crop bearing trees such as cashew, coconut, and mango, and wood-providing trees such as casuarinas and jacarandas (Dray and Nhancale 2010). Maputo Bay does boast some rare corals at Inhaca Island that are protected by the oldest Marine Protected Area in East Africa (Perry 2003).

Maputo is structured into seven municipal districts divided into 64 discrete neighbourhoods. The city centre or ‘cement city’ lies in the lowest parts of the city (Figure 6). This is the only really urbanized part of the city and is home to only ~10% of the population. This is the commercial core where most administrative buildings and services are found. From here there is a radial expansion along the main avenues. These areas beyond the cement city are considered as semi-urbanized and non-urbanized (Dray and Nhancale 2010). Initially these areas were considered peri-urban, with low-densities of people living in rural lives. As the city grew these areas became inundated with migrants and ‘reed’ neighbourhoods⁹ without any infrastructure being developed. After independence in 1975, the civil war began and refugees fled to the city. Again the city expanded with no planning and no infrastructure (Dray and Nhancale 2010), people were simply building houses where they could find space. As a result there is now development in areas that would be considered inappropriate or even a health hazard. The extremely high densities of people living with no infrastructure also present a reduced quality of life. Although some people returned to the rural areas after the peace agreement, the city continues to attract economic migrants partly as a result of its strategic location close to South Africa which places pressure on a city already suffering a deficit in infrastructure and services Maputo Municipal Development Programme II (MMDP II).

Observed climatic trends

As described in Section 4, Mozambique has seen an uninterrupted sequence of drought and floods, with the floods often exacerbated by torrential rains associated with cyclones. Cylone Demoina in 1984 resulted in extensive and considerable damage in Maputo. The Umbeluzi's catchment was subjected to intense rainfall as the cyclone moved over that part of the country. Large tracts of flood plain along the Lower Umbeluzi were flooded, leaving a number of people dead. The capital city's main water treatment plant was severely affected and as a result, the city remained without water for a few days. Similarly, electricity supply to the city and surrounding areas was also halted for a few days. The only road that connected Maputo with Swaziland and South Africa was flooded - and destroyed completely in some places - and a railway bridge near Boane received some structural damage. Important agricultural areas around the Lower Incomati were destroyed and the water supply to the town of Moamba was disrupted temporarily. In terms of transport infrastructure, parts of the EN1 road (from Moamba) were damaged, but most importantly, the Moamba bridge was

⁹ Reed neighbourhoods are the informal settlements that develop in the peri - urban areas. Often, these structures have reed walls and zinc roofing material

completely destroyed, leaving the town without direct access to or contact with the neighbouring districts.

The amount of rain recorded during the 1999-2000 wet seasons was extraordinarily high (CCCI 2009), particularly during the months of February to March 2000. This caused the most devastating floods in the history of Mozambique killing 700 people and producing damage of US\$ 600 million (McBean and Henstra, 2003; Kundzewicz et al, 2001).

Mean sea-level has risen (Figure 7) around Maputo from 1960-2002 (INGC 2009) with associated erosion and salt water inundation.

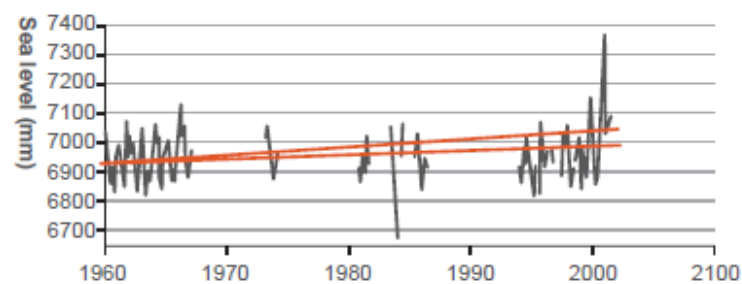


Figure 7. Mean sea-level records from 1960 to 2002 for Maputo¹⁰.

Projected climatic trends

The main climate-related hazards with destructive consequences projected for Maputo are a rise in mean sea-level and an increasing intensity of floods, droughts and cyclones.

The projected **sea-level rise** would result in flooding of the lowest areas of Maputo (Figure 8). This is the most densely populated area and where slum dwellers are concentrated, the area that was affected during the 2000-2001 floods (NAPA 2007, INGC 2009, Kass 2010). It was projected that in the next 20-30 years most of the coastal area of Maputo, including its harbour and other important infrastructures, will be negatively affected by sea-level rise if no adaptation measures are adopted (INGC 2009). Sea-level rise is already creating significant problems for the city, including salination of its fresh-water supply (Kass 2010). It is suggested that, without new coastal defence, a sea-level rise of 5m by 2100 would flood the entire area of the Avenida da Marginal and the port and its rail links would need to be relocated. A new coastline dominated by steep cliffs would develop (INGC 2009).

¹⁰ From IGNC 2009.

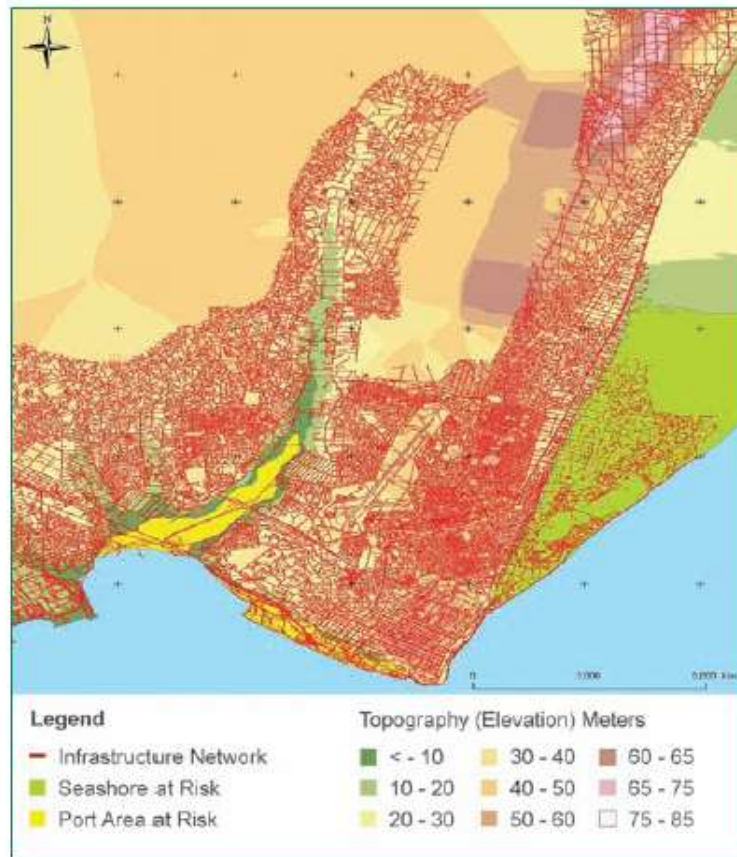


Figure 8. Maputo risk assessment for 2030 in the face of rising sea-levels¹¹.

Tropical **cyclones** are a major threat to the coastline of Mozambique, with currently about one cyclone a year makes landfall. Strong cyclones, even those that do not make landfall, generate large waves that could potentially impact the local coastline. Climate change projections indicate that cyclones may become more intense. A Third World country such as Mozambique can certainly not afford traditional engineering solutions to wide-scale cyclone or coastal climate change impacts (Rossouw and Theron 2009).

This report will focus most on the impacts that the projected **flooding** are likely to have on Maputo as these are the single biggest threat to development. The floods in 2000 should be seen as an indication for what is likely to come in the future. The torrential rains led to the worst flooding in 50 years and it directly affected 2 million people and forced 650,000 to leave their homes, it cost US\$ 600 million and reduced economic growth from a target of 10% to below 4% (Holmberg 2007).

Maputo Vulnerabilities to Flooding

The IPCC defines ‘vulnerability’ as “the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. In this respect

¹¹ From INGC 2009.



vulnerability is seen as the function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity” (IPCC, 2001).

Urban development in the coastal zone brings multiple risks. It exposes people to seaward hazards such as storms, flooding and cyclones, and it can damage sensitive ecosystems including mangrove forests that protect the coastline and provide numerous other co-benefits, which in Maputo are already threatened by a growing population (IIED 2007). Vulnerability on coastal zones is a worldwide problem as 10% of the world population live in coastal areas that lie within just 10 m above sea-level. Nearly two-thirds of urban settlements with more than five million residents are at least partially in the 0-10 m zone; and 21% of the urban populations of least developed nations are in the zone, compared to only 11% in developed countries. Maputo is no exception and is extremely vulnerable (UN HABITAT 2010) as it is prone to both flooding and droughts (Kass 2009), and lies in the cyclone path (INGC 2009). A preliminary assessment of climate change impacts in the urban areas of Maputo (INGC 2009) identified the following vulnerable areas:

- Coastal zones and their associated ecosystems,
- Human settlements and infrastructure,
- Health, food security and waste management (see Section 5),
- Transportation system (see Section 5),
- Wetlands and urban agriculture.

Its coastal location means that Maputo’s **freshwater** sources are subject to saltwater intrusion from rising sea level (Kass 2010). Already salty intrusions have caused damage to agriculture (INGC 2009).

The Maputo and Beira **harbours** are crucial to Mozambique’s economy but analyses of available seawater levels at both Maputo and Beira show that current annual maximum recorded seawater levels reach above the crest of many protective seawalls and revetments. In addition, many of these ageing structures are in a state of poor repair (Rossouw and Theron 2009).

The upper layer of the soil in most of the municipality is made of fine low-density sands that erode easily by wind but particularly by water. The **erosion** ravines, particularly those in steep ravines with light vegetation cover, such as between Av. Patrice Lumumba and Av. 25 de Setembro, on the slopes of the Maxaquene embankments are deepening. In the Bay of Maputo, coastal erosion occurs mainly along the beach and Avenida da Marginal between Mira Mar and Costa do Sol. Construction during the 1950s over the dune line along the Marginal road altered the coastal dynamics and eliminated the natural feeding source of sands for these beaches. The destruction of the mangrove forests also contributes greatly to the increased risk of erosion (Dray and Nhancale 2010). Although Avenida da Marginal has been recently rehabilitated, adequate protection barriers have yet to be built, thus it is still vulnerable to erosion (UN HABITAT 2009).

The city’s three **islands** are vulnerable too as they already exhibit clear evidence of climate change effects. For example, water quality in wells is degrading contributing to a scarcity of potable water. Desertification due to drought is exposing sand dunes and with worsening wind erosion, is causing a



loss of coastline as at Portuguese Island and is reducing the amount of arable land available for domestic agriculture (UN HABITAT 2009).

Any further sea-level rise would flood the lowest-lying areas (that are the most populated), with serious consequences for the **urban poor** whose capacity to adapt to climate change is limited, as they are unable to improve their dwellings or move to safer areas (CCCI 2009). This, in combination with cyclonic torrential rains makes flooding the biggest risk to Maputo.

Nhaca and Vieira (2010) report that 75% of Maputo inhabitants live in informal settlements with slum characteristics such as: i) dense unregulated growth; ii) lack of common infrastructure services (such as water and electricity); iii) homes made of precarious materials; and iv) are often built on unsuitable land (risk of flooding and erosion). As settlements expanded in Maputo, it was into low-lying and marshy areas with a high flood risk (Spaliviero 2006). In the Luis Cabral slum neighbourhood residents argue that flooding has worsened since 1980, pointing out that the 2000 floods completely destroyed the area. A single one-day rain event can cause floods that persist for three days. If the rains last longer than three days, the water depth rises to a metre and takes a month to subside (ActionAid 2006).

A study (Bunce 2010) showed that communities in Mozambique rated climate variability and/or change as a stressor and threat to their livelihoods. The threat to their livelihoods increased by 'double exposure' to other stressors such as: i) price hikes in fuel and food; ii) disease; and iii) poor health (especially HIV/AIDS). In addition communities are becoming more vulnerable with time. It seems likely that as coastal regions in Africa continue to attract migrants, and as land and marine ecosystem services are degraded, then the risks to urban and rural livelihoods from climate change will be further amplified. Consequently, the risk of adverse impacts for the urban poor will increase, especially considering their incapacity to improve their dwellings or move to safer areas (UN HABITAT 2009).

What is Maputo doing?

Kass (2010) provides an excellent synopsis of how advanced Maputo is in terms of adaptation strategies to tackle impacts such as flooding. The NAPA sets the stage at a national level but there is no specific Maputo plan as yet. There are, however, provisions in the national plan on how to start addressing the climate change adaptation at the city scale. The municipality has identified areas where the city is vulnerable to floods (from heavy rains, cyclones, and sea-level rise) but has yet to formulate adaptation strategies.

In response to the 2000 floods, and in anticipation of further sea-level rise due to climate change, the Mozambique government began relocating people from high-risk low-lying areas that were settled before they could be declared inappropriate. The NAPA plan for building new villages that can withstand flooding is that villagers move to new settlements but still retain ownership of their original land and continue to farm it. However, many of these relocation efforts have proven unsuccessful because of a lack of jobs in the vicinity, so that relocated residents often return to their former homes in flood-prone neighbourhoods. Until the government is able to ensure that people



can live successfully in their new homes, any relocation attempts may well be ineffective (Kass 2010).

The report “Learning to Live with the Floods” (MICOA 2004) provides details on how to make floods less deadly, for example by: including an early warning system, rezoning slums, improving sanitation, improving construction in areas prone to floods, and reducing deforestation (Asante *et al.* 2007, Kass 2010).

4.2. Chamanculo ‘C’ Community

ICLEI will be focusing on the Chamanculo “C” community as it is a particularly vulnerable community in Maputo (Figure 9) and already suffers from negative climate change impacts. Chamanculo means ‘huge bath’ and refers to the fact that this low-income district experiences severe flooding on a regular basis. There are 26,000 residents in Maputo’s low-income Chamanculo C district, which is one of four districts in the Chamanculo township. This amounts to around 5,000 households distributed in 40 blocks (CA 2010). There was a great influx of internally displaced people in the *bairro* or suburb during the civil war when rural people began seeking refuge in protected urban areas. Many of the displaced people have since returned to their home villages following the end of the war, but those who remain still face a lack of access to reasonable social services. They are vulnerable to various forms of human discrimination, violence, and abuse, and they live under very poor living conditions (LWF 2010).

There is much development assistance planned for Chamanculo. The Cities Alliance Project work will be carried out by the Maputo city council with technical assistance from the Italian development cooperation office. The Cities Alliance Project will support the undertaking of preparatory activities concerned with the project known as “*Support for the Upgrading of the Chamanculo C Neighbourhood in accordance with the Global Strategy for Urbanising and Reordering Informal Settlements in the Maputo Municipality*”. It is expected that this and future investments would bring about a series of positive environmental impacts as a result of better ordering of land use and occupation while improving dwelling conditions, upgrading public sanitation and security, eliminating disease-carrying insects, and minimising the factors related to unhealthy conditions and social vulnerability (CA 2010).

Another project ‘Chamanculo Human Rights and the Health of Women Project’ aims to contribute to the improvement of the social and economic conditions of people of Chamanculo, through promotion of human rights and the empowerment of women. This population is characterized by domestic violence and other related injustices, which disproportionately affect women (LWF 2010).

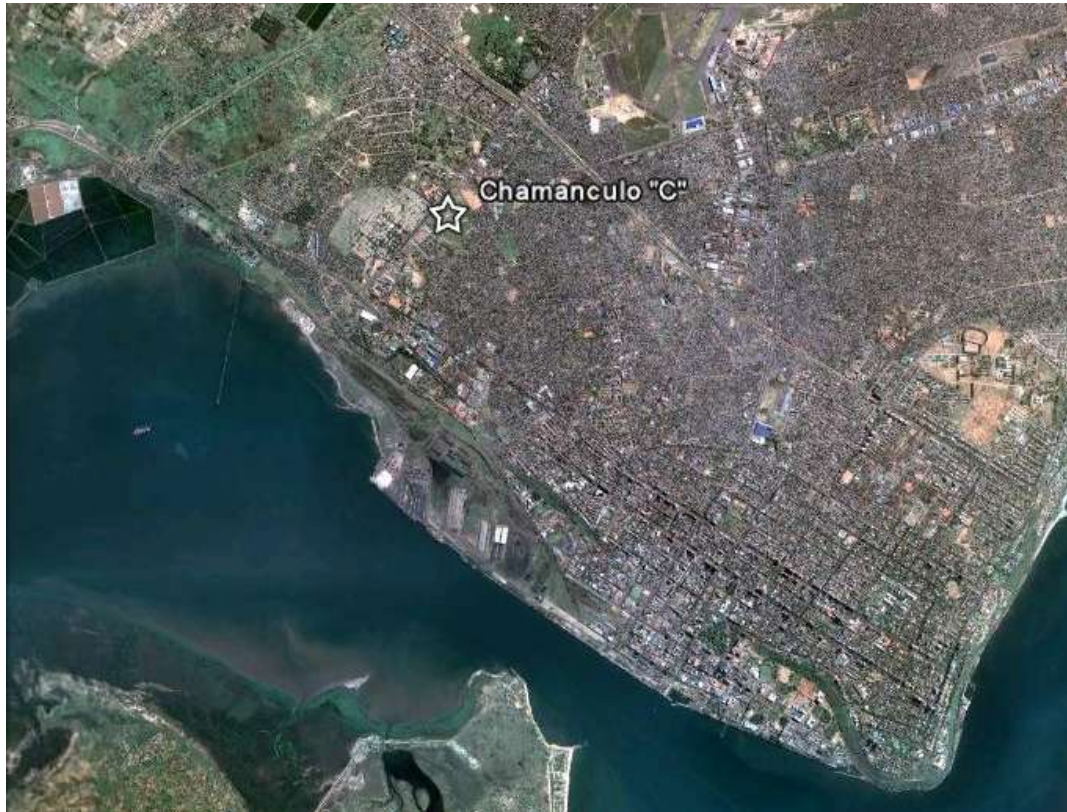


Figure 9. Location of Chamanculo 'C' within Maputo¹².

5. Sectoral risks and impacts: flooding in Maputo

A recent assessment on threats and climate change in Maputo indicated the following vulnerabilities for the city (UN Habitat 2010):

- Increased number of extreme weather events;
- Increased average sea-level rise;
- Coastal erosion;
- Contaminated and decreased water resources;
- Loss of biodiversity, ecosystems, natural and marine resources;
- Damage to residential, key industrial and municipal infrastructure;
- Change in local temperature and precipitation; and
- Increased health problems due to heat stress.

The risks and impacts upon sectors such as water and sanitation, energy, transport and health ultimately and inherently affect livelihoods. Thus risks and impacts associated with flooding (both storm-driven intermittent and permanent inundation) will also embody the impacts upon livelihoods. Although Maputo will be subject to the impacts of droughts, extreme temperature,

¹² www.earth.google.com



cyclonic events and sea-level rise this report will focus specifically on the effects of flooding. For more information on other impacts please refer to the rest of **ICLEI country reports** within this suite: specifically Mauritius (cyclones), Namibia (sea-level rise), Tanzania (drought) and South Africa (extreme temperatures).

5.1. Livelihoods

The term ‘livelihoods’ is defined as the way and the means of ‘making a living’ (Chambers and Conway 1992; Bernstein 1992; Carney 1998; Ellis 1998; Batterbury 2001; Francis 2000; and Radoki 2002); the capabilities, activities and assets (both material and social resources) required for a means of living (Carney, 1998) and ‘refers to people and their dependence upon their surrounding resources for their well-being, such as water, shelter, land, agriculture, livestock, knowledge, money, social relationships and so on’ (Chambers and Conway, 1992). These resources, either natural or derived from natural, however, cannot be disconnected from the issues and problems of access and changing of structural systems such as political, economical, socio-cultural and especially environmental circumstances. This study investigates the likely impacts and risks upon services and the cascade of risks and impacts that may lead to livelihood alteration or deprivation.

Changes in the environment and environmental degradation associated with climate change are likely to impact on the resources that people depend on for their livelihoods and thus their survival. Urban dwellers rely more on service providers (for water and sanitation, energy and a means of transport to and from work places and markets) more than directly from the natural environment. Peri-urban and rural communities also rely on some of these basic services in addition to natural resources such as grazing for livestock and soil and water for crop production. Many communities have to cope with risks and uncertainties but those living closer to the land are most affected by erratic rain, diminishing resources, grazing pressure, spreading of diseases, increase in food prices and inflation. If climate variability and extreme events occur more frequently and more intensely, these impacts are likely to disrupt day-to-day business activities and delivery of basic services, impacting people’s ways of living and their ability to maintain a sustainable livelihood. These impacts and risks are likely to influence management and use of resources and the choices that people make.

The basic services provided by local governments are vulnerable to changes in climate. For the purpose of this study, the general vulnerabilities associated with sea-level rise and sea storm surges upon the local government services are discussed with the aid of international cases. The four sectors are:

- Water and sanitation;
- Transport;
- Health;
- Energy.



5.2. Water and Sanitation

Background

Water is critical for sustained livelihoods: a lack of access to adequate water supply (both in quality and quantity) for domestic uses can be a major cause of declining nutritional health and disease and morbidity. Domestic water is often a production input and is essential for direct household consumption and/or income generation. The amount of time used to collect water, and to deal with related health hazards, can be immense, especially for women and girls, and has been well documented (Ludi 2009).

Only 55% of Maputo's houses have piped water, with only 16% having indoor piped water (National Census 2007). The rest of the population use wells. The supply of water to the Maputo Municipality is run by predominantly Mozambican-owned *Fundo de Investimento e Património de Água's* (FIPAG) supply system and through private, generally informal systems.

The FIPAG water supply is primarily obtained from the Umbeluzi River and stored in the Pequenos Libombos reservoir. The supply from the dam is unsustainable. In wet years Pequenos Libombos might supply ample water, however, supply is greatly reduced during a two- or three-year drought series (Wils *et al.* 2001). There is a rising demand in household water from: population growth, more people connected to pipes, and consumption increases for those who are connected to pipes. Industrial demands are increasing and the highest demand is for agricultural irrigation. In an analysis (Wils *et al.* 2001) it was found the only really effective policy for reducing pressure on the Pequenos Libombos reservoir is to combine water rationing for irrigation when there is a shortage with income compensation for the farmers and an aggressive subsidy to convert farmers to more efficient irrigation methods. It is a common challenge in most developing countries that the majority of water use is for irrigation. Agriculture provides essential food and income and irrigation water is much cheaper to provide than household water because it is generally untreated (Wils *et al.* 2001). FIPAG has made significant investments to improve the service provision, including a second water treatment works on the Umbeluzi River that should double the capacity that FIPAG can supply to Maputo (WASH 2010).

In addition to the Umbeluzi River the city relies on an **aquifer** system where water is brought up from a depth of approximately 50 m. These aquifers have been largely exploited by both public services and private operators. The private operators act mainly in the peri-urban areas, obtaining water from boreholes and wells, and the quality of the water is not always assured. Steps are being taken to regulate the quality of these private suppliers and also to open boreholes for water supply to communities and schools.

In Maputo, in general, the quality of the water is being affected by indiscriminate use of land and by the operation of inadequate or degraded urban infrastructures. The rivers, particularly the Infulene, are contaminated by the discharge of residual domestic and industrial waters and agricultural pesticides (Dray and Nhancale 2010).



Sanitation and Drainage

There are three sanitation systems: i) the sewerage network, which is limited to the Cement City and parts of Bairro do Jardim; ii) septic tanks, used in both urbanized and semi-urbanized areas; and iii) latrines (open or improved), used in the informal settlements and peri-urban areas. The sewerage network drains to the sewage treatment plant, which then discharges into the Infulene River. This plant was designed for 90,000 users. High levels of faecal coliforms are present near the storm water drainage discharge points in Maputo Bay. Contamination of shallow aquifers (between 15 and 30 meters) by inadequate sanitation systems is severe throughout the municipal area, causing the spread of disease (Dray and Nhancale 2010).

The rainwater drainage system covers only 30% of the total area of the city. Most of the network was built in 1940 and is presently saturated and obsolete. The remaining 70% of the municipality have no formal drainage systems, with the exception of a few cases where specific measures were taken to resolve critical problems, such as in the 25 de Junho, Benfica, Polana Caniço, Urbanização, Mafalala and Jardim neighbourhoods (Dray and Nhancale 2010).

Impacts and Vulnerabilities

Floods are already affecting the water supply structure in Maputo and this is likely to continue at an exacerbated rate as climate change impacts increase. The greatest risk is that flooding will reduce the municipality's ability to provide good quality drinking water – it has been shown that at cholera outbreak sites water quality had decreased (Zandamela 2007). Flooding may damage the pipe network that brings water to residents reducing the amount of water to communities that may force them to consume untreated water or to buy expensive treated water. As over half of Maputo lives below the official poverty line of US\$ 2 day this is an expense that many cannot afford. Although flooding would recharge underground aquifers, many shallow aquifers would then be liable for contamination for sanitation pits flooded by the water table or overflowing latrines. This would increase the likelihood of diseases spreading through high-density urban areas. Furthermore, if latrines are overflowing people will resort to open squatting that will again increase health risks. Lack of access to clean water may lead to conflict and violence (refer to Mozambique Case Study in section 5.4 below).

Saltwater intrusions from the rising sea-level will reduce the amount of fresh underground water suitable for drinking or irrigation. Salt poisoning of soils that have had salty water irrigation would lead to reduced agricultural productivity and thus livelihoods. In addition more land further inland would have to be converted to agricultural land reducing the amount of already threatened natural environment remaining around the city. Areas that are flood prone become increasingly degraded desperate and are the refuge for the extreme poor that cannot afford to live anywhere else.

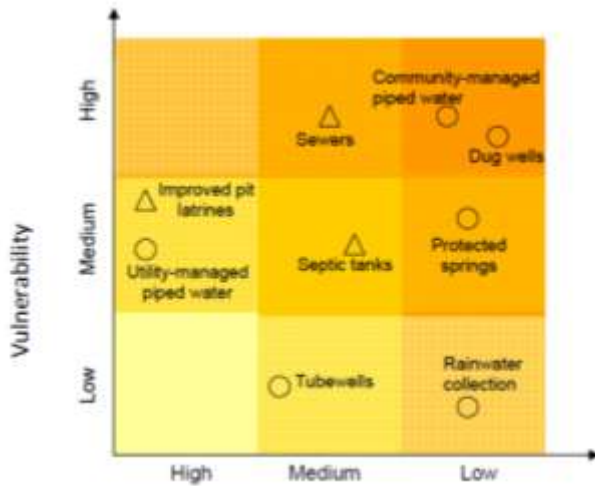


Figure 10. Resilience of water technology under an increased rainfall scenario¹³.

Figure 1- indicates that it is evident that the peri-urban communities within Maputo with dug wells and community-managed piped water are the most vulnerable and have the least adaptability and thus need national and municipal scale interventions (WASH 2010).

Table 1 illustrates a few of the impacts associated with floods on water and sanitation services and facilities, which encompasses impacts upon livelihoods. These identified effects are not exhaustive, nor are they confined to Maputo, Mozambique.

Table 1. Water and Sanitation sector: Impacts and vulnerabilities associated with flooding.

Impacts upon Water and Sanitation	Impact on livelihoods
<p>Water Supply</p> <ul style="list-style-type: none"> • Risk of aquifer over-exploitation. • Risk of erosion around the wells caused by water flowage. • Increased risk of developing disease-transmitting vectors (mosquitoes) in the puddles created around the springs/ wells. • Risk of developing diseases related to water as a result of poor maintenance of wells and the surrounding area. • Salt water intrusion into freshwater systems in coastal zones is anticipated to increase. • Flooding causing strong water flows in aquifers thus increasing capacity for water. • Decreased availability in freshwater for domestic and industrial use. • Sedimentation of aquifers. • Sea water intrusion into underground aquifers. • Reducing quality of water in aquifers. • Salt water intrusions into fresh water. • Poor and limited water supply to residents. • Changing flood plains and greater damage to properties and infrastructure. <p>Sanitation</p> <ul style="list-style-type: none"> • Contamination of water supply sources due to latrines overflow. • Increased risk of increase in vectors that transmit diseases (mosquitoes, flies, small rodents). • Lack of maintenance and unhygienic conditions can lead people to avoid the use of latrines. 	<ul style="list-style-type: none"> • Increased pressure and stress on fresh water supply • Impacted water sanitation in the poorer, vulnerable areas • Cascade effect on health as a result of increased likelihood of contamination of fresh water sources • Poor water access and poor water quality • Any business that uses water will suffer reduced productivity, leading to reduced income, employment decreases

¹³ From WASH 2010.

- Changes in land use (i.e., potential flood areas could begin to be targeted for residential occupation).
- Solid waste disposal in drainage channels, causing blockage and water contamination.
- Indiscriminate waste water discharge in the channel, causing water contamination.
- Increased public health risk due to the use of discharged water for human consumption by the surrounding population.
- Increased risk of developing disease-transmitting vectors (mosquitoes) along the ditches.
- Increased flooding and erosion in the channel discharge areas, affecting nearby land use, structures and facilities.
- Water pollution downstream, bringing impacts on public health and potential impacts on ecologically sensitive areas (e.g. mangroves, wetlands).
- Sewerage water seeping into fresh water supply if flooding becomes more prevalent as storm water drainage is lacking.

Case studies

Port Harcourt city, **Nigeria**, is like Maputo, now more than ever before experiencing unpredictable high intensity rainfalls. These factors result in mass flooding of neighbourhoods. In these areas, one recurring problem is the overflow and clogging of latrines, as well as the erosion of pit and septic tank structures. The major problems arising from these are surface water contamination and loss of accessibility to the latrine during flood. Often, the most affected are the urban poor who live in densely populated neighbourhoods where households share on-site latrines located outside their living rooms. For women in such areas this is an issue, as loss of access also translates to loss of privacy for defecation. The result is that most residents are now compelled to “wrap and throw” their excreta into runoffs. This further worsens the health risks and undermines local gains in sanitation coverage (Rural Africa Water Development Project 2010). In Port Harcourt the solution has been to install raised pit latrines (Figure 11).

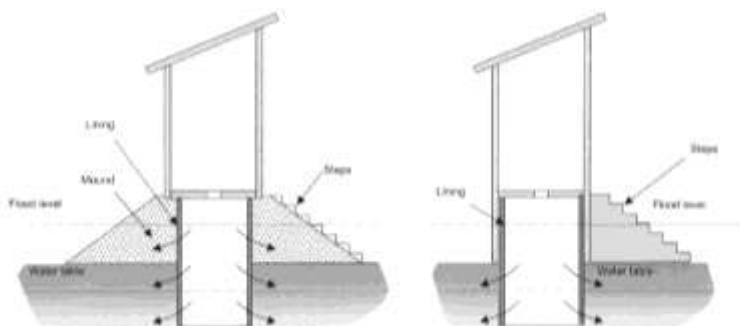


Figure 11. Raised Pit Latrines such as those used in Port Harcourt¹⁴.

¹⁴ <http://www.lboro.ac.uk/well/resources/fact-sheets/fact-sheets-htm/lcsahgt.htm>



5.3. Transport

Background

Maputo has little to offer in the way of accessibility and mobility, as most of the population live far from their places of work, and there is insufficient and precarious means of transport. According to the Urban Development Plan for Maputo (PEUMM) document released in 2008, there are also problems with traffic circulation, parking and regional connections.

The municipality has 35 km of paved roads and 64 km of non-paved roads. Over the last years the municipality has made a great effort to rehabilitate and maintain the road network, with funds made available through the MMDP.

Access to and circulation in the city has decreased as a result of the increase in the population and in the number of vehicles, and given the deficiencies in traffic management, lack of parking areas, in addition to the lack of structured alternative routes. This results in impacts on the quality of the urban environment (namely the quality of the air and noise) and increases the risk of road accidents.

The city has public transport provided by *Transportes Públicos de Maputo* (TPM) and by private operators through the local minibus taxis or *chapas*. Many of the *chapas* operate under irregular conditions, contributing to the disorganization of traffic and a higher number of road accidents. However, they play an important role in social terms, since they are able to reach areas that, due to the poor condition of the roads, the TPM are unable to service. The government is investing in increasing the public transport fleet and putting in place stricter regulation of the *chapas* (Dray and Nhancale 2010).

Impacts and Vulnerabilities

Floods damaged roads that are already of a poor quality slow progress of construction of new roads and maintenance of ailing road and bridge infrastructure. In particular, where the city's drainage network channels flood water, there is a heightened risk of erosion of infrastructure. There is little in the way of alternative routes so these routes during flood events carry increased traffic moving people and goods around the city. There are also emergency vehicles using these congested roads during flood events and the increased traffic load increases the risks of accidents involving both vehicles and pedestrians (Dray and Nhancale 2010).

In addition to reconstruction and maintenance costs, flooding also has indirect costs such as disrupted market access when the roads are not passable. Flooding limits the movement of food supplies to and from markets and causes price increases and this becomes more pertinent when the demand in flooding periods increases due to loss of crops and livestock. For example, the 2000 flood caused a 70% price increase for maize, a staple food (INGC 2009). During the 2000 flood the affected areas experienced other food price increases of up to 70% for two to three months, there after prices decreased to normal levels (INGC 2009) with consequences for consumption expenditures.



Most people living in Maputo are not be able to respond economically to the higher costs of consumption and therefore they would have to adjust to lower consumption levels; a reduction in livelihoods.

Potential **adaptation** measures against flooding include *inter alia*: i) construction of roads with drainage systems; ii) increased road levels; iii) alternative routes; iv) stronger foundation and bridges; v) softening of the broader landscape through planting of vegetation to absorb flood waters; vi) restoration and maintenance of wetlands to absorb flood impact; vii) Communication, Education and Public Awareness. A pilot project was undertaken with a 20 km road in Limpopo used as a baseline case. The project assumes design profiles to include future higher traffic levels and greater resistance to flood damages based on historical flooding trends, and it is expected that this construction will reduce losses from flooding by 50%. In addition the baseline assumes flood loss exposure to be reduced by 50%. This reduction is due to an integrated minor drainage systems adjusted to accommodate a 1-in-20 year flood and profiles for major structures, e.g. bridges, to accommodate a 1-in-40 years flood.

Such construction may be expensive but the magnitude of the costs can be understood based on a study from Micronesia that calculated the construction costs of a road with and without climate change adaptation options integrated. The upfront costs of the road increase if climate change adaptation is considered but will be offset by lower maintenance costs and the net costs consequently will be lower after 15 years. Over 50 years total construction, maintenance and repair costs of the road without climate change adaptation measures showed to be 56.5% above the costs for a road with adaptation measures included. In addition to the net cost savings of a road project with adaptation, the improved road will also facilitate easier access for emergency and relief in flooding periods and will reduce periods with inadequate market access. Furthermore more rapid emergency response will potentially decrease the number of incidences of disease. The 2000 flood showed that where roads were more rapidly reconstructed, the areas stabilised and returned to normal conditions faster compared to areas that were isolated for longer periods.

The highways of Maputo could potentially be less vulnerable to climate change if adaptation measures, in terms of drainage systems, stronger foundations and bridges and alternative routes, were taken into consideration. Based on experiences from previous flooding events in 2002 in Mozambique and internationally available data on adaptation measures, it is likely that with adaptation there could be significant benefits associated with more climate safe road design (Halsnæs and Trærup 2009).

Table 2. Flooding impacts on transport infrastructure in Maputo.

Type	Impacts upon Transport	Impact on livelihoods
Road	<ul style="list-style-type: none"> • Blockage of roads causing delays. • Flooding causes diversions, often onto roads not capable of carrying the higher loads. • Traffic congestions and accidents. • Inundation of roads by water or sand, causing structural damage. • Erosion of bridges, pavements and roads adjacent to the coast needing rebuilding and fortressing against future events. 	<ul style="list-style-type: none"> • Limits access routes for both emergency personnel during an event and normal business movements during and after • Delays to the work place and markets, with consequences of raised prices in the event of constant demand • Work hours lost reducing productivity and income • Risk to public safety
Rail	<ul style="list-style-type: none"> • Erosion of railway infrastructure. • Inundation of railways by water. • Reduced use of rail to transport goods to Ressano Garcia. 	<ul style="list-style-type: none"> • Causes delays and cancellations of trains • Unable to reach destination • Work hours lost – reducing income
Air	<ul style="list-style-type: none"> • Reduction in business transacted through Maputo if goods and capacity lose this vital link to local and global economies. 	<ul style="list-style-type: none"> • Reduces accessibility to airports • Delay in exports/imports
Port	<ul style="list-style-type: none"> • Erosion to coastal infrastructure and equipment. • Damage to boats at sea if storms are more intense than expected. • Closure of the harbour during storm events. • Erosion to harbour wall. • Damage to boats anchored at port, both private yachts and commercial vessels. • Any proposed extensions to the port should carefully consider vulnerabilities to climate change impacts. 	<ul style="list-style-type: none"> • Days at sea lost • Work hours lost – reducing income • Delay in exports/imports

Case studies

In Rockhampton, **Australia**, all transport infrastructures were submerged in the January 2011 floods (Figure 12). This amounted to at least AUS\$ 1.5 billion but final figures have not been released as damage is still be tallied in the aftermath. Very few stretches of road were left untouched by weakened surfaces, potholes, verges, road base wash away or more serious structural damage. Some of the worst effected roads include the major highways.



Figure 12. A flooded runway in Rockhampton, Australia leaves boats as the only viable transport until the flood water subsides. ¹⁵

5.4. Health

Background

The public health system in the city of Maputo is considered reasonable, when compared to other municipal sectors such as transport. The Municipality has five hospitals, 15 health centres (public and private), nine health posts (public and private) and 20 private clinics and doctors' rooms. However, the distribution of the health facilities is not sufficient to meet the needs of over one million inhabitants. In addition some highly populated areas have few or no formal health facilities (Dray and Nhancale 2010).

The mortality rate in the city is fairly high and is attributed to problems linked to sanitation, poor quality of water and poor nutrition, the main causes of disease among the population, and to the deficient operation of the health posts.

Impacts and Vulnerabilities

The biggest health risk that floods bring to Maputo is cholera. It is a disease that is associated with both floods and droughts, both of which are projected to increase with climate change. Increased temperatures increases the levels of cholera bacteria in tropical seas and lakes, while changes in rainfall affect the transmission potential and the presence of vector- and water-borne pathogens.

¹⁵ <http://www.brisbanetimes.com.au/photogallery/environment/weather/flood-disaster-surges-on>



Maputo needs to also plan for increases in other vector-borne diseases considered sensitive to climate change such as malaria, leishmaniasis, chagas disease, lyme disease, African trypanosomiasis, and onchocerciasis. Increased food insecurity from flooded agricultural lands will lead to under-nourishment, particularly for children. Lack of water is associated with poor sanitary conditions, which affects child mortality as well as school attendance (particularly for girls) and maternal health. Heat stress and drought are likely to impact negatively on animal health, production of dairy products, meat and animal reproduction with consequences for food security, protein deficiency and malnutrition. Together these aspects of health vulnerability will negatively affect life expectancy and child mortality in Maputo unless adaptation measures are taken.

Table 3. Impacts of flooding on the health sector in Maputo.

Impacts upon Health	Impact on livelihoods
<ul style="list-style-type: none"> • Large waves, storms and flooding cause injury or death from drowning, electrocution, carbon monoxide poisoning and communicable diseases that often arise in the cleanup stage after such events when clean water and sanitation delivery is still adversely affected. • Increase in number of deaths from heat waves. • Increases in pressure on emergency services in extreme events, with service delivery backlogs in clinics and hospitals. • Chemical Hazards: contamination of flood water with oil, diesel, pesticides, fertilisers etc. • Spread of infectious diseases within communities as sanitation provision suffers and water contamination occurs: skin (cutaneous leishmaniasis) and respiratory diseases and diarrhoeal disease (cholera), of particular risk to the young and infirm. • Altered spatial distribution of some infectious disease vectors which may come into play as climate change is expected to have some mixed effects, such as a decrease or increase in the range and transmission potential of malaria in Africa (IPCC 2007). • Increases in frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change (IPCC 2007). • Increases in malnutrition and consequent disorders, with implications for child growth and development (IPCC 2007). • Harmful Algal Blooms (HAB) outbreaks may increase in number posing a threat to those who collect mussels and other seafood along the coast. These pose a threat to both human and marine life (Tibbets 2007). 	<ul style="list-style-type: none"> • Increased casualties • Hours of work lost • Medical bills to pay • Poor and limited water supply to residents • Dehydration • Loss of work by a primary income earner due to cholera or any other waterborne disease which will have serious ramifications for vulnerable families

Case studies

1. **Mozambique:** On 25 February 2007 two Red Cross volunteers who were part of a brigade publicising anti-cholera messages, which include putting chlorine in wells, were beaten to death, and accused of poisoning the wells with cholera. The mob also burned houses and destroyed bicycles and motorcycles, which are seen as only being owned by the wealthier population. Three people

were arrested but the crowd blocked the road to prevent them being taken out of the village. Then three days later, in Angoche district (just south of Mogincual) protestors attacked health workers accused of spreading cholera. They were already being protected by the police so the mob attacked the police with knives and spears, disembowelling and killing a police sergent and seriously injuring two other policemen. On the same day in Moma district (south of Angoche) a mob attacked a community leader accused of putting cholera in the wells; two policemen protecting him were hospitalised (Hanlon 2009).

5.5. Energy

Background

Mozambique is an energy-rich country. It has gas and coal reserves, hydropower potential in 39 rivers emptying into the Indian Ocean (including the Zambezi, the fifth largest river basin in the world) and a wealth of unexploited biomass, solar and wind resources (Hankins 2009).

State-run *Electricidade de Mocambique* (EDM) is responsible for the some of the generation, and most of the transmission and distribution of energy consumed in the country. EDM was created in 1977 as the state-owned national electricity utility. It became a public enterprise, expected to operate on commercial terms in 1995. Despite the 1997 Electricity Act paving the way for private sector involvement in generation, transmission and distribution, EDM remains a monopoly but is facing growth in demand for energy of about 8% per year (Manhice 2011). EDM power plants can provide 257 MW but currently only 140 MW is available (Figure 13). A large portion of generators in the regional capitals were not operational (2007) and so 97% of total electric energy was supplied by hydropower. EDM is, with Development Bank of Southern Africa, funding and rolling out connections in low income areas of Maputo. The programme expects to connect 12,000 households (at 200 W per household) (Hankins 2009).

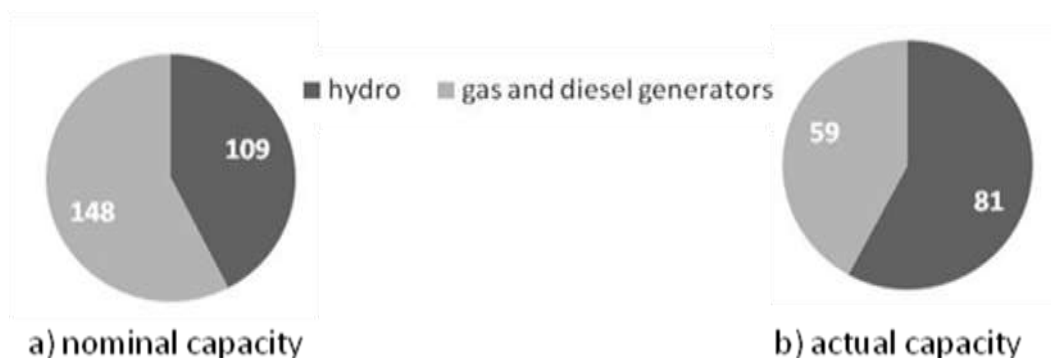


Figure 13. The nominal capacity (109 MW + 148 MW) vs. the actual capacity of electricity generated (81 MW + 59 MW)¹⁶.

¹⁶ Data from Hankins 2009.



Hidroelectrica de Cahora Bassa (HCB) runs the Cahora Bassa Hydroelectric power stations and associated transmission networks that convey power into the South African Power Pool (SAPP). Cahora Bassa Dam is the primary electricity source for the country, and a key source for Southern Africa. Cahora Bassa was built by a Portuguese, German, British and South African consortium between 1969 and 1974. In 2005, majority share ownership (85%) was transferred from the consortium owners to the Mozambican government. Cahora Bassa recently raised its power generation capacity by 240 MW to 1,920 MW and the US\$ 10.5 million upgrade of the dam was financed from the company's own balance sheet (Reuters 2010). Mozambique is in the difficult position of having to export electricity from Cahora Bassa via the South African Eskom transmission system, and re-import it for use in the south and Maputo. Because of this much energy is lost.

There is some resistance to the proposed Mphanda Nkuwa hydropower dam (ITC 2004, Hankins 2009) as the primary beneficiary of the power plant will be South Africa while Mozambique will remain with the lowest per capita use of electricity in the world (Hankins 2009), however, construction will begin in 2012.

MoTraCo is a joint venture company (the state power companies in Mozambique, South Africa and Swaziland) that conveys power from South Africa to the Maputo Mozal plant and to the EDM southern grid to stabilise Maputo's power supplies.

Theft of cables is rife and is setting expansion plans back as resources and time are spent on repairing stolen cables rather than expanding the network as needed. This costs both EDM and businesses that have to function without access to power (Nam 2008).

The average **charcoal** use of a typical Maputo family was found to be 70 kg per week (FAO 2000). Charcoal supply areas are becoming more distant from the consumption areas, for instance, charcoal is currently being brought to Maputo City from Chicualacuala and Massangena, which are located over 400 km away. There is also a growing trend of migration of producers from Maputo Province to Gaza Province because there is little left in Maputo. Additionally these producers have no culture of managing the forest resources that they use for charcoal production (GNP 2009). Assuming that 70% of Maputo's population of 1 million still depends on fuel wood and charcoal as domestic cooking fuels, and that wood fuel¹⁷ supply to Maputo has not increased since 1988, only 28% of the theoretical minimum energy requirements are currently covered. Supplies of wood fuels would thus have to increase almost four-fold to cover the minimum requirements (FAO 2000). In Maputo City about 25% of the population uses other sources to cook, which includes mainly liquefied petroleum gas (ProBEC 2009).

Solar energy usage is becoming more widespread. A solar panel factory (an Indian-Mozambican venture) in Maputo is set to begin production in the middle of 2011. A number of hospitals and health centres in Maputo and elsewhere in Mozambique already use solar panels, largely because

¹⁷ Wood fuel refers to both fuel wood and charcoal.



EDM cannot reach them and because the government for some time has been promoting solar power (Manhice 2011).

Impacts and Vulnerabilities

During floods failure of electricity is expected as power lines becomes submerged or pylon foundations are found in a wet, softened earth and subsequently collapse. Failure of transmission equipment leads to a decrease in demand due to interruption of production in flooded factories and a lack of electricity consumption in flooded houses (Williamson *et al.* 2009). Death from electrocution by submerged live wires is a threat. Mortality and morbidity as a consequence of power cuts at medical facilities can further increase the death toll after a flooding event. Damage to submerged sub-stations leads to a need for repairs and maintenance – this minimises the available budget for roll-out to communities that currently have no energy supply.

Table 4. Flooding impacts on the energy sector in Maputo.

Impacts upon Energy	Impact on Livelihoods
<ul style="list-style-type: none"> • Erosion of coastal power lines. • Flood inundation is likely to cause damage and losses to energy production facilities and infrastructure (power stations, high voltage lines etc) and reduce or negate their ability to meet energy needs. • Floods may cause an increased demand for energy as temperatures rise or fall and the need for climate control in homes and commercial space increases (Wilbanks <i>et al.</i> 2008). • Power outages as a result of floods destroying power lines (UNFCCC 2009). • Energy supply cut for pumping borehole water. • Loss of fresh produce from cold storage. • Decrease in economic growth. • Storage and landing facilities for import of fossil-fuel energies needs to be able to withstand increased storm frequency and potential inundation to prevent spillage which can cause loss of fuel and damage to an ecosystem that will already have a compromised resilience (Wilbanks <i>et al.</i> 2008). • Changing to alternative energy production mechanisms such as solar and wind must be undertaken with careful consideration for climate change. This is because cloud cover frequency may reduce the use of solar energy at the coast and changes to wind dynamics may also reduce wind farm energy outputs. Changes in sea currents in strength, direction and duration will need to be taken into consideration for wave-generated energy schemes (Perez 2009). 	<ul style="list-style-type: none"> • Limited fresh produce for consumption • Limited water supply for drinking, agriculture or industry

Case studies

1. During the 2008 floods in the **United Kingdom** 13 people died and 44,600 homes and 7,100 businesses were flooded, with the damage caused costing £ 3 billion. What has alarmed officials was the potential impact on the normal functioning of society - and the speed with which the summer of 2010's rainstorms led to flash flooding. A major power switching station at Walham, near Gloucester



was nearly flooded that would have affected provision of electricity to 500,000 homes and businesses in Gloucestershire and for relaying supplies to south Wales. Only with emergency assistance from the military was the floodwater kept inches away from overwhelming the plant (Shukman 2008).

Analysis of the Meteorological Office's rainfall series for 1914-2007 for the United Kingdom shows that in about 20% of years UK summer rainfall was greater than the median winter and autumn rainfalls. However, the UK summer rainfall for 2007 (357 mm) was the second highest on record, and only marginally less than in the wettest year - 1956 (358 mm) (Lane 2008).



6. Conclusion

The severe physical, social, environmental and economic impacts of climate change, both directly and indirectly, are anticipated to be felt with greater intensity in the cities of Africa. A changing climate will affect people's access to, and the quality of, basic goods and services such as water, shelter and food as well as other key priorities for human wellbeing such as education, employment and health. Africa is particularly vulnerable as the situation is aggravated by the interactions of 'multiple stresses'. These 'multiple stresses' include endemic poverty, complex governance and institutional dimensions; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These heavily reduce Africa's adaptive capacity (IPCC 2007).

Maputo is already experiencing floods that disrupt all sectors of local government and these impacts are already difficult to manage with cholera outbreaks and damage to infrastructure occurring with every flood. These flood events are likely to increase in frequency and intensity according to climate projections. The impacts of these floods (section 5 and Table 5 for a summary) are likely to result in a decrease in quality of life and ability to make a living for an average Maputo resident, if the city is unable to adequately meet its mandate of basic service provision. Already the city is shown to be unable to meet the needs of some sectors, particularly the burgeoning informal settlements and it means that these people will be most vulnerable to the changing climate.

It is important to make plans now to ensure as much resilience as possible to prevent major catastrophe and to allow local government sectors to continue to meet their mandate of basic service provision and thus allow the inhabitants of this port town to continue to make the best livelihoods they can, and to improve their opportunities. Besides mitigating and reducing emission and energy, adaptation is a vital component in order to prepare and increase resilience towards the risks and impacts. Maputo local authorities need to adapt and plan strategically to build resilience against climate change specifically to variability and extreme cases of temperature. There is a need for adaptation strategies and preparedness in protecting local communities and the environment on which they depend upon for their livelihoods and well-being.

In an IIED (Moser, C. and D. Satterthwaite, 2008) report it was highlighted that strengthening, protecting and adapting the assets and capabilities of individuals, households and communities is far more important in low- and middle-income countries than in high-income countries, because of the following:

- The limitations in urban governments' adaptive capacity, especially in providing needed protective infrastructure and services to low-income populations.
- The unwillingness of many city or municipal governments to work with low-income groups, especially those living in informal settlements, which usually include those most at risk from floods and storms.
- The key role of assets in helping households and communities to cope with disasters.



Adaptive capacity relates to the ability of households and community organizations to make demands on local governments and, wherever possible, to work in partnership with them (Moser and Satterthwaite 2008).

This report on Maputo focused specifically on impacts and vulnerabilities associated with flooding and is one of a suite of five reports; the others deal with sea-level rise (Walvis Bay), extreme heat (Cape Town), drought (Dar es Salaam) and tropical cyclones (Port Louis). These baseline studies and literature reviews will, when combined with the findings of the ICLEI Tadross and Johnston (2011) report: Projected climate change over southern Africa; Mauritius, Mozambique, Namibia, South Africa and Tanzania, GIS modelling and cost-benefit analysis, form the Risk Assessment. This will then form the basis from which the adaptation framework for the city will be developed. With this framework the city will be better able to plan for future development and be better prepared for any climate-related crises. This is best done through participatory action at the local level local government, researchers and communities and in this regard Maputo can lead the way for Mozambique.

Table 5. General Impacts of flooding associated with climate change upon municipal sectors.

<p>Water and sanitation</p>	<ul style="list-style-type: none"> • Damage to water supply infrastructure and properties. • Deposition of sand, mud and contaminants in urban freshwater supply and dams. • Increased wave action and flooding along the coast, causing: <ul style="list-style-type: none"> ○ Damage of storm water pipes; ○ Increase in storm water pollution. • Salt water intrusions into freshwater systems in coastal zones are anticipated to increase. • Decreased availability of freshwater for domestic and industrial use: <ul style="list-style-type: none"> ○ Increased pressure and stress on fresh water supply; ○ Water treatment capacity will need to increase; ○ Water sanitation in the poorer, vulnerable areas will be affected; ○ Knock-on-effect on health as a result of increased changes of contamination of freshwater sources.
<p>Transport</p>	<ul style="list-style-type: none"> • Destruction, damage and disturbance to harbours, jetties, boat ramps and other infrastructure such as roads, storm water outlets, electrical substations and distribution networks, main water pipes and beachfront promenades. • Floods are likely to cause diversion, delays and even suspension of transport services for the public, businesses and transfer of commodities. • Accidents, increase in time spent travelling, time waiting for floods to subside, risk to public safety.
<p>Health</p>	<ul style="list-style-type: none"> • Increased wind speeds will impact upon the health sector as a result of increased deaths from: <ul style="list-style-type: none"> ○ Drowning; ○ Electrocuting; ○ Carbon monoxide poisoning in the clean up stages after flood events; ○ Trees and other debris which are airborne due to wind. • Illnesses, such as infectious diseases (skin and respiratory diseases and stomach ailments), worsening of chronic illnesses, long-lasting psychological impacts, increased health threats through heat stress, headaches caused by high wind speeds and changes in air pressure. • Damage to clinics, hospitals and other infrastructure and services. • Increased pressure on emergency services. • Service delivery backlogs in clinics and hospitals. • Chemical Hazards: contamination of flood water with <i>inter alia</i> oil, diesel, pesticides, and fertilisers. • Increased drying effect. • Disruption of solid waste management. • Loss of hygiene and sanitation • increased pests and vectors breeding places.
<p>Energy</p>	<ul style="list-style-type: none"> • Damage and losses to energy production facilities and infrastructure (such as power stations and high voltage lines). • May cause an increased demand for energy for upgrades and adaptation: <ul style="list-style-type: none"> ○ Clean up operations; ○ Rebuilding of infrastructure and housing; ○ Erosion of coastal power lines.
<p>Livelihoods</p>	<ul style="list-style-type: none"> • Floods will threaten homes, infrastructure, transport, safety and basic services. • Floods will further exacerbate the anticipated sea-level rise and erosion impacts on informal settlements. • Reduction in clean water supply reduces availability for domestic and commercial consumption. • After sea storm surge events or heavy rainfall water may not be able to disperse and run-off and water may become stagnant leading to disease outbreaks. • Cyclones may also reduce natural resource capital on which the local inhabitants are heavily dependent.





7. Glossary

Anthropogenic changes: Human activities that change the environment.

Adaptation: In natural or human systems adaptation is a response to actual or expected stimuli, e.g., climate change or their effects, which moderates harm or exploits beneficial opportunities. In natural systems adaptation is reactive. In human systems adaptation can be both anticipatory and reactive and can be implemented by public, i.e., government bodies at all levels and private actors, i.e., individuals, households, communities, commercial companies and NGOs.

Adaptive capacity: It is the ability of people and systems to adjust to environmental change, e.g., by individual or collective coping strategies for the reduction and mitigation of risks or by changes in practices, processes or structures of systems. It is related to general levels of sustainable development such as political stability, material and economic well-being, and human, institutional and social capital.

El Niño-Southern Oscillation (ENSO): The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin wide warming of the tropical Pacific east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of two to about seven years, is collectively known as El Niño-Southern Oscillation, or ENSO. It is often measured by the surface pressure anomaly difference between Darwin and Tahiti and the sea surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global tele-connections. The cold phase of ENSO is called La Niña.

Resilience: Amount of change the exposed people, places and ecosystems can undergo without permanently changing states. That is, their ability to recover from the stress and to buffer themselves against and adapt to future stresses and perturbations.

Sensitivity: The degree to which people, places and ecosystems are affected by the stress, including their capacity to anticipate and cope with the stress. The effect may be direct or indirect.

Vulnerability: Vulnerability is the degree to which a system or unit (such as a human group or a place) is likely to experience harm due to exposure to risk, hazards, shocks or stresses. In relation to the concept of poverty, vulnerability is more dynamic since it captures the sense that people move in and out of poverty.



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