The main objective of this project is to develop an adaptation framework for managing the increased risk to African local government and their communities due to climate change impact. The ultimate beneficiaries of this project will be African local governments and their communities. The guiding and well-tested ICLEI principle of locally designed and owned projects for the global common good, specifically in a developing world context, will be applied throughout project design, inception and delivery.

Additionally, the research will test the theory that the most vulnerable living and working in different geographical, climatic and ecosystem zones will be impacted differently and as such, will require a different set of actions to be taken. Potential commonalities will be sought towards regional participatory learning and wider applicability. The five urban centres chosen for this study, based on selection criteria, include: Cape Town, South Africa; Dar es Salaam, Tanzania; Maputo, Mozambique; Windhoek, Namibia; and Port St. Louis, Mauritius.

Through a participatory process, this project will carry out a desk-top study, long-term, multi-discipline, multi-sectoral stakeholder platforms in five Southern African cities comprising of academics, communities and the local government in order to facilitate knowledge-sharing, promote proactive climate adaptation and resource opportunities available for African cities, develop five tailor-made Adaptation Frameworks and explore regional applicability. A network of stakeholders within each urban centre will be established, feeding into a larger regional network of local authorities and partners in Sub-Saharan Africa, and globally through existing ICLEI global (e.g. the ICLEI Cities for Climate Protection programme), ICLEI Africa and UCLG-A members and networks, ensuring global best practice, roll-out, and long-term sustainability.

Key words: Adaptation, Africa, Climate Change, Local Governments, Participatory Action Research, Policy.
Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through participatory Research and Local Action.
Sub-Saharan African Cities:
A Five-City Network to Pioneer Climate Adaptation through Participatory Research and Local Action

Baseline Study

Temeke Municipality

ICLEI – Local Governments for Sustainability

Adaptation
CITIES ADAPT
IDRC CRDI DFID
Sub-Saharan African Cities: A five-City Network to Pioneer Climate Adaptation through Participatory Research & Local Action

Temeke Municipality, Dar es Salaam Baseline Study

February 2011

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<th>Description</th>
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<tr>
<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<td>CCAA</td>
<td>Climate Change Adaptation in Africa</td>
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<td>DART</td>
<td>Dar es Salam Rapid Transit</td>
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<tr>
<td>DAWASA</td>
<td>Dar es Salaam Water and Sewage Authority</td>
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<td>DFID</td>
<td>Department for International Development</td>
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<td>ICLEI</td>
<td>International Council for Local Environmental Initiative</td>
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<td>IDRC</td>
<td>International Development Research Council</td>
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<td>ENSO</td>
<td>El Niño Southern Oscillation</td>
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<td>IIED</td>
<td>International Institute for Environment and Development</td>
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<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<td>IWRM</td>
<td>Integrated Water Resource Management</td>
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<td>MDGs</td>
<td>Millennium Development Goals</td>
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<td>NAP</td>
<td>National Action Plan to Combat Desertification</td>
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<td>NAPA</td>
<td>National Adaptation Programme of Action</td>
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<td>NBF</td>
<td>National Bio-safety Framework</td>
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<td>NBSAP</td>
<td>National Biodiversity Strategy and Action</td>
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<td>NEAP</td>
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<td>NFP</td>
<td>National Forestry Policy</td>
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<td>NSGRP</td>
<td>National Strategy for Growth and Reduction of Poverty</td>
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<td>ODA</td>
<td>Official Development Assistance</td>
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<td>SSTs</td>
<td>Sea Surface Temperatures</td>
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<td>SUDP</td>
<td>Strategic Urban Development Plan</td>
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<td>TANESCO</td>
<td>Tanzania Electric Supply Company</td>
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<td>UNCCD</td>
<td>United Nations Convention to Combat Desertification</td>
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<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<td>WHO</td>
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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 (2007a) 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’ 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 2007). 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.
The project in context

The official mandate of ICLEI – Local Government for Sustainability - Africa\(^1\) – 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 significant 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.

This report focuses on the coastal city of Dar es Salaam in the United Republic of Tanzania (Figure 1). It was chosen for the following reasons: i) it is the largest city in Tanzania; ii) it is the richest city (and thereby has the most to lose); and iii) owing to its port, it is an important hub of economic activity for the entire country. Within Dar es Salaam, there are three coastal municipalities namely: i) Ilala; ii)

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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.
Kinondoni; and iii) Temeke. Temeke Municipality was chosen as the focal point for this project as it has the largest coastal stretch. In addition, given the size of the entire metropolitan area, a finer-scale focus was required as a result of temporal and fiscal restraints of the project.

The report will provide an overview of the climatic changes in Africa with regard to various climatic variables, followed by more detailed review at a regional level (Tanzania) with specifics at a local level for Dar es Salaam. Lastly a review of the Temeke Municipality will be provided; which will entail a discussion of the infrastructure and services that fall under this municipality’s jurisdiction, and the impacts and risks relating to drought and climate change.

Figure 1. The geographical location of the city of Dar es Salaam, Tanzania and the the Temeke Municipality².

2. Africa: climate change and droughts

Africa, covering more than one fifth of the total land area of earth, is the second largest continent and host to a 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 city 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 climate change (IPCC 2007). 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


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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 same physical effects of climate change and variability as experienced worldwide. Consensus in the scientific community’s projections gives us a warming of approximately 0.7°C, more so in the southern regions than in the central regions (IPCC 2007a). 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 (2000), 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, which 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 of increasing constraints on water resources, especially in hotter climates. Much water infrastructure will require upgrading to maintain adequate supplies for meeting current needs and increased demands in the future. This will need harmony among the wide diversity of water usage for agricultural production, fishing, navigation, industrial production, domestic consumption, and ecosystem sustainability (UNECA 2010).

**FREQUENCY and INTENSITY:** Increasing frequency and intensity of severe weather is expected on the African continent to be greater over the next 50 years. The IPCC (2007a) states it is likely that “future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation associated with on-going 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 hurricanes over the past few decades – most notably in the North Atlantic and Indian oceans (IPCC 2007).

**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 most vulnerable to deal with impending changes (IPCC 2007).
Food security (including access to food) in many parts of Africa is likely to be severely compromised. Agricultural production, including access to food, in many African countries and regions 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 along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely 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 2007), and crop net revenues could fall by as much as 90% by 2100, with small-scale farmers being the most affected (Venton 2007).

![Figure 2. A dry dam in northern Tanzania due to the effects of drought (2010)](http://in2eastafrica.net/drought-spell-bad-for-economy-growth/)

Climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress (Figure 2). 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 (IPCC 2007). About 20% of Africa’s population (~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 will likely have a negative effect on tourism as, according to one study, between 25 and 40% of mammal species in national parks in sub-Saharan Africa will become endangered (IPCC 2007a). Local food supplies are projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued overfishing (IPCC 2007a).
Human health 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 of the local climate 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 in Africa could amount to at least 5-10% of GDP (IPCC 2007a).

**Droughts facing Tanzania and Dar es Salaam**

As a result of increased temperatures the ‘region will experience an increased number and duration of droughts, increased crop failures and have less fields and pastures due to water shortages’ (Palitza 2009, 1). It was reported that ‘in 2006, the production of maize, the main staple in the region, fell short by 2.18 million metric tons due to drought in Namibia, Mozambique, Swaziland, Zimbabwe and South Africa’ (Palitza 2009, 1). Researchers project that agricultural production will halve over the next 70 years, which will threaten the livelihoods of the farmers in this region where 70% of the population are small hold farmers (Palitza 2009). Climate change has a significant impact on vulnerable farmers as they invest tremendously on the production of crops for their well-being and ‘people will need to seek to work elsewhere because they cannot completely rely on agriculture anymore’ (Palitza 2009).

Although the IPCC has predicted increased rainfall in general for east Africa a new study (Williams and Funk 2011) suggests that the increased frequency of drought observed in eastern Africa over the last 20 years is likely to continue as long as global temperatures continue to rise. This poses increased risk to the estimated 17.5 million people in the Greater Horn of Africa who currently face potential food shortages. Increased warming of the Indian Ocean, which causes decreased rainfall in eastern Africa, is linked to climate change. As the globe has warmed over the last century, the Indian Ocean has warmed especially fast. The resulting warmer air and increased humidity over the Indian Ocean produce more frequent rainfall in the Indian Ocean region. The air then rises, loses its moisture during rainfall, and then flows westward and descends over Africa, causing drought conditions in Ethiopia and Kenya. In recent decades (1980-2009) there has been suppressed convection over tropical eastern Africa, decreasing precipitation during the ‘long-rains’ season of March-June. This trend toward drought contrasts with projections of increased rainfall in eastern Africa and more ‘El Niño-like’ conditions globally. Increased Indian Ocean SSTs appear likely to
continue to strongly modulate the Indian Ocean/West Pacific Warm Pool\(^4\) circulation, reducing precipitation in eastern Africa, regardless of whether the projected trend in ENSO is realized (Williams and Funk 2011).

3. Legislation and international obligations

National context – Tanzania’s environmental sustainability strategies

According to Andersson and Slungè (2005) Tanzania’s legal framework for environment, natural resources management and sustainability is well developed, and encompasses decentralised and local management of local resources. Since the impacts of climate change and variability cuts across all disciplines it is fitting to explore both water and environmental policies, especially for the study of Dar es Salaam (and the Temeke Municipality in particular) where the research is particularly focusing on drought episodes. The section below describes some of the pertinent policies relevant to this project.

1991 and ongoing - **National Reform Water Sector Policy**: Its goal is to ensure universal access to clean safe water supply within a distance of 400 m from households. The policy also considers water to be a basic need, and government’s role as that of a facilitator, co-ordinator, monitor and regulator for the provision of water and sanitation services to the public (Tanzania government gazette).

1994 - **National Environmental Action Plan (NEAP)** was the first step towards national plan with the objectives of reducing land degradation and deforestation, ensuring access to quality water, reduction of pollution, reduction of the loss of wildlife habitats and biodiversity and the reduction of the deterioration of marine and fresh water systems. The NEAP is to be implemented through the National Environment Policy (NEP).

1997 - **National Environment Policy (NEP)**: The NEP, initiated from NEAP, provides a framework for mainstreaming environmental considerations into the decision making process in Tanzania. This has an objective which states: ‘To ensure sustainability, security and equitable use of resources for meeting the basic need of the present and future generations without degrading the environment or risking health or safety.’ Though NEP does not pay explicit attention to climate change, the primary environmental issues brought forward include many of the concerns that would be addressed by no-regret\(^5\) climate change adaptation measures. In particular, the NEP highlights the importance of integrating environmental management in several sectoral programmes and policies.

1998 - **National Forestry Policy (NFP)**: This is a review of the 1953 version. It gives no direct reference to climate change despite the vulnerability of Tanzanian forests to changed climatic conditions. One of the main objectives of the NFP is to ensure ecosystem stability through conservation of forest biodiversity, water catchments, and soil fertility. The policy states that new

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\(^4\) Indian Ocean/West Pacific Warm Pool extends along the equator south of India into the central Pacific Ocean. These waters are warmer than any other open ocean on Earth, which drives heat and moisture circulations within the upper atmosphere and affects the synoptic climate of surrounding lands.

\(^5\) Policies, plans, or actions that would generate net social benefits whether or not climate change occurs.

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forest reserve for conservation will be established in areas of high biodiversity value and that biodiversity conservation and management will be included in the management plans for all protected forests.

2004 - **National Environmental Management Act No 20**: This addresses all environmental management issues of Tanzania (including legal and institutional framework) and governs related policies and frameworks. The right to a clean, safe and healthy environment and the duty to protect the environment are some of the principles enshrined within the Act (National Environment Management Council).

2005 - **National Strategy for Growth and Reduction of Poverty (NSGRP or MKUKUTA in Kiswahili)**: This is a National Framework that is based on goals of Vision 2025 and takes into consideration the targets for the Millennium Development Goals (MDGs) to reduce poverty, hunger, diseases, illiteracy, environmental degradation, and discrimination against women by 2015 (Thaxton 2007). The focus is outcome orientated and organized around: i) economic growth and reduction of income poverty; ii) improved quality of life and social well-being; and iii) good governance and accountability. With the National Environment Action Plan and the National Environmental Policy as guides it was decided the following be given priority: i) land degradation; ii) environmental pollution; iii) access to good quality water for the poor; and iv) loss of biodiversity, deterioration of aquatic ecosystems and clearance of forest and woodlands (Andersson and Slunge 2005). The link between health and the environment is addressed within the MKUKUTA framework through water and sanitation matters. Sustainable energy development is also briefly mentioned within the framework, although not really expanded upon. In recognition of the country’s proneness to prevalent floods and droughts, MKUKUTA supports improved opportunities for alternative and diversified incomes as coping mechanisms (Andersson and Slunge 2005).

2007 - **Tanzania National Adaptation Programme of Action (NAPA)**: This is linked with other national development policies, goals, objectives, plans, strategies and programmes. In addition, it supports/complements strategies and programmes of other multilateral environmental agreements that Tanzania is Party. These include: the United Nations Convention to Combat Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) among others. These have led to the development of the National Biodiversity Strategy and Action Plan (NBSAP), the National Action Programme (NAP), and the National Bio-safety Framework (NBF).

2009 - **The National Water Resource Management Act No 11**: This governs the country’s legal and institutional frameworks related to water and policy. The Act promotes the protection of water resources and outlines the actions to be followed during droughts and natural disasters, as well as provides details on water abstraction and use. The Act also enforces and promotes the existing National Water Policy (Tanzania government gazette).
Local context – Dar es Salaam’s environmental sustainability strategies

1993 - Sustainable Dar es Salaam Programme (SDP): This programme, completed in 1997, aimed to strengthen the municipality’s capacity to plan and manage the growth and development of the city in close dialogue with the urban farmers. Since completion of the first phase of the project, city networks have formed in both East and West Africa to share experiences and training opportunities, and urban agriculture has been recognized as a key part of a comprehensive solution to the problems of the runaway growth of cities in developing countries.

2004 - Strategic Urban Development Plan (SUDP): This provides the framework for city expansion and land use among other necessary inputs for urban productivity and poverty alleviation.

2009 - Nairobi Declaration: Mayors from 33 capital and major African cities, including Dar es Salaam, pledged to rapidly mobilise climate change adaptation and mitigation plans for their cities and to integrate these plans into city development strategies.

There was no available literature on environmental sustainability strategies for Temeke in particular.

4. Tanzania and its’ vulnerabilities

Tanzania is the largest country in East Africa (945,000 km²), comprised of both mainland (881,289 km²) Tanzania and the islands of Zanzibar, Mafia and Pemba (2,460 km²), 59,050 km² inland water bodies and 800 km of coastline. It shares borders with eight countries: Kenya and Uganda in the north; Rwanda, Burundi and Democratic Republic of Congo in the west; Zambia and Malawi in the south west; and Mozambique in the south. The northwest of the country encompasses around half of Lake Victoria, the second largest body of freshwater in the world, and the western and south-western borders abut the comparably massive Lake Tanganyika and Lake Nyasa. Tanzania also boasts the highest point in Africa, Mount Kilimanjaro, which is 5,950 m high, and the Serengeti, the site of one of the last major terrestrial mammalian migrations in the world and a prominent tourist destination.

Tanzania has a population of around 42 million people of which 26% (2010) live in the urban areas, the rest in rural areas (CIA World Factbook, 2011). Administratively, there are 20 regions and 113 districts through which climate change adaptation programmes can be implemented (Kahwa 2010).

Tanzania’s climate ranges from tropical to temperate, with altitudinal variation being responsible for the extremes. The average precipitation is 1,042 mm and temperatures range between 17-27°C. Although localized rainfall is complex, the country has two distinct regimes:

1) Bi-modal in northern Tanzania with long rains between March-May (called Masika) and short rains between October-December (called Vuli); and

2) A single rainfall season between November-April in the south of the country (NAPA 2007).
Observed climatic changes

According to meteorological data, monthly temperatures over the last thirty years are already showing an upward trend (NAPA 2007). Tanzania has experienced cyclic wet and dry spells (in terms of year classification based on rainfall amount) resulting in drought and flooding events. A decrease in surface water resources, drying up of wetlands and the lowering of the Lake Victoria water levels were some of the noted signs of drought events in the country leading to reduced crop production. A prolonged 6 year drought was experienced from 2000 in the country which resulted in low per capita income as a result of the effect on agriculture (Madaka 2007).

Rainfall data analysis from 1961 to 2007 within the Ruvu Catchment revealed a general decline in rainfall and is also observed in the catchment’s rivers’ flow (Figure 3, Kalugendo 2008). In another, precipitation analysis noted a slight yearly increase of 1.2 mm. The analysis further revealed cyclic fluctuations of drier and wetter periods since 1971 to 2005. These cyclic periods can be matched to flooding and drought periods experienced in the country (Mjemah et al. 2008).

![Figure 3](image)

Figure 3. A noted declining rainfall trend observed at Dar es Salaam International airport meteorological station, from 1954 to 1990.

Projections

The IPCC’s 4th assessment report (2007) projected the following for Tanzania:

**Snow Melt:** Kilimanjaro glaciers and snow cover are, if current climatological conditions persist, likely to disappear between 2015 and 2020 (for the first time in 11,000 years).

**Temperature:** All projections expect an average temperature rise of 2.2°C by 2100, with higher increases (2.6°C) in the months of June to August. Projections show that the mean daily temperature will rise by 3-5°C throughout the country and the mean annual temperature by 2-4°C (NAPA 2007).

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Sourced from Kalugendo (2008).

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Rainfall: Already the most recent and common rainfall trend in Tanzania is ‘a greater variability in cycles’ (NAPA 2007). There will also be an increase in rainfall in some parts while other parts will experience decreased rainfall. Projections further show that areas with the bimodal rainfall pattern will experience increased rainfall of 5-45% and those with unimodal rainfall pattern will experience decreased rainfall of 5-15% (NAPA 2007). This change in rainfall would make the central, western and southern part of the country unsustainable for agricultural production (OECD 2003). The International Institute for Environment and Development (IIED) study (2009) with macroeconomic modelling projected that wetter areas would be at risk of more frequent and severe rains, and that parts of the coastline faced flooding due to climate change. Variability of rainfall is predicted to increase as the result of increased frequency of El Niño events (IPCC 2001, 2007). Changes in the mean temperature and rainfall, and the increased variability of rainfall, are together likely to prolong the length of dry seasons annually and to increase the severity of periodic droughts. This will be pronounced in the interior part of the country which will be experiencing reduced rainfall. The coastal areas will be less exposed to droughts. However, in the coastal areas the increased mean rainfall, coupled with cyclical variation in it, is likely to result in more frequent and severe flooding. The predicted sea level rise of 0.1-0.9 m is likely to aggravate flooding in the coastal region (Paavalo 2008).

Vulnerabilities

Climate change has resulted in the migration of affected people from rural areas to urban centres such as Dar es Salaam, overwhelming the carrying capacity of the city’s infrastructure and services. In addition Tanzania faces the challenge of having to play host to refugees from war, poverty and ecological disasters in neighbouring countries. This exacerbates Tanzania’s vulnerability to a changing climate.

Rain-fed agriculture (including livestock farming) is the dominant sector of the Tanzanian economy, providing livelihoods, income and employment to over 80% of the population. It accounts for 56% of GDP and on average, 60% of export earnings, so this sector is crucial in terms of food production, employment generation, production of raw materials for industries and generation of foreign exchange. Continual underachievement of annual economic growth goals has been attributed to severe drought, leading to severe food shortages, food insecurity and hunger (NAPA 2007). It is projected that the effects of global warming could cut Tanzania’s GDP by 1% by 2030 but by as much as 68% by 2085; with the poor hit hardest (IIED 2009) and the effects of this cascading through all sectors. The urban poor would also suffer due to high food prices (IIED 2009).

Mixed farming has been identified as a strategy used to minimise crop failure especially during drought periods. This strategy is mainly relied upon by poor households for food security and as an income generating activity. Projected temperature and rainfall changes could decrease the average annual maize yield by 33%. Maize is a staple crop in Tanzania, grown by more than 80% of poor Tanzanians so this would have major implications for food security (NAPA 2007). However these projections may boost harvests of crops like barley, rice and wheat, but might hurt maize. Women would be the most negatively impacted, while impoverished smallholder farmers would be unable to capitalise on the benefits of rising food prices due to lack of funds for irrigation or other ways to boost production (IIED 2009). A change of staple crops to millet and cassava may be necessary in
the inner part of the country. There is also considerable uncertainty regarding the effects of climate change on the yields of most important cash crops such as coffee, cotton and tea (Paavalo 2008).

More than 70% of Tanzania’s rural populations are subsistence farmers relying entirely on rainfall. As a result of climate change effects (specifically drought) on water availability, there has been an increase in groundwater abstraction. The pressure on the ground water supply has in some instances led to saltwater intrusion from the river mouth and desiccated boreholes.

Communities living along the Ruvu River, in trying to cope with climate variability, have in fact exacerbated the water shortage problem. Farming along the river banks has resulted in reduced minimum flows of the river, further compounded by cultivation and mining activity in the greater catchment area. Here too, uncontrolled tree and bush felling have led to poor soil conditions (thus affecting crop yield), increased soil erosion and silting of the river (Kalugendo 2008).

Expected increased temperatures and changes in rainfall patterns will have strong impacts on wildlife in the country. Species migratory patterns will likely change, pests and diseases may increase, and competition for resources will become more prominent. Already, 14 species of dry country birds have responded to a drying climate and have expanded their range (NAPA 2007).

Along with warmer surface waters, deep water temperatures (which reflect long-term trends) of the large East African lakes (Victoria, Malawi) have warmed by 0.2-0.7°C since the early 1900s (IPCC 2007a). These deep tropical lakes are experiencing reduced algal abundance and decreases in productivity because the stronger stratification reduces upwelling of nutrient-rich deep water. Primary productivity in Lake Tanganyika may have decreased by up to 20% over the past 200 years, and for the East African Rift Valley lakes, recent decreases in fish abundance have been linked with climatic impacts on lake ecosystems (IPCC 2007a).

The 1997-1998 coral bleaching observed in the Indian Ocean was coupled to a strong El Niño Southern Oscillation (ENSO) and a clear indication of the potential impact of climate-change induced ocean warming on coral reefs. In the western Indian Ocean region, a 30% loss of corals reduced tourism in Mombasa and Zanzibar and resulted in financial losses of about US$ 12-18 million (IPCC 2007).

Mangroves and coral reefs, the main coastal ecosystems in Africa, will likely be affected by mean sea-level rise and increased frequency of storm surge events. Mangroves provide valuable nursery grounds for many fish species and many endangered species associated with these ecosystems, including manatees and marine turtles, could also be at risk, along with migratory birds (IPCC 2007).

Malaria, already responsible for most of Tanzanian deaths, is already being observed in places where its prevalence is traditionally very low as a direct result of change in temperature and rainfall regimes. The epidemic has been observed to extend to some parts of Tanga, Kilimanjaro and Arusha highlands where the disease was not previously prevalent. As more areas receive more rains, malaria could track greater areas across the country (NAPA 2007). Other epidemics (cholera, dysentery and other waterborne diseases) arise as a result of poor sanitation, inadequate sewage
systems and lack of clean drinking water and are often a compounding secondary effect of other disasters (Kahwa 2010).

As a result of running power cuts and blackouts, thermal-electric power sources are used in Tanzania. This results in an increase in environmental pollution (Kimbisa 2008). Frequent and prolonged droughts have resulted in temporary shut downs of major dams; the main source of power electricity in the country.

Tanzania is host to exceptionally varied ecosystems with a range of fauna, mammals and flora. As of 2005, 22% of Tanzania’s vascular plants were in the Kilimanjaro vicinity, and 140 mammalian species reside there along with 179 highland bird species and 88 species of reptiles. All of these species will likely be at risk due to the changing landscape and distribution patterns which have shifted due to weather patterns, decreased rainfall and population growth. With a shift to a generally drier climate, and a greater human impact, fire has and will continue to play a prominent role in promoting a yet drier overall environment. Over the last 100 years, Kilimanjaro has lost 300 km² of high altitude forest and the upper closed forest was lowered by 900m (Hemp 2006). Over the last 30 years, Kilimanjaro has lost 10% of its forest cover due to fire (OECD 2003). This loss of ‘cloud forests’ has resulted in 25% annual reductions of water sources derived from fog, affecting annual drinking water of 1 million people living in Kilimanjaro (IPCC 2007a).

The former mayor of Dar es Salaam City Council, Mayor Adam Kimbisa stated in a presentation given in 2008 that the roads and drainage systems in the city of Dar es Salaam were destroyed during the 2006 floods with a resultant lowering of the country’s GDP by 6% during that year as economic activity was curtailed. Again, it is the poor who are affected as informal settlements generally have inadequate or no drainage systems.

Over half of all disasters in Tanzania are attributed to drought, flooding and epidemics. Kahwa (2010) further comments that flood prone areas, such as along rivers, lake shores and the coast such as Dar es Salaam on the coast and Mwanza City on Lake Victoria already experience flooding in most parts of the city every rainy season. Their low-lying position is further exacerbated by infrastructural development such as urban-increased run-off and poor drainage. In response a national Disaster Management Policy was drafted but as yet no advanced disaster management technologies were adopted. Lack of access to early warning systems and weather forecast has been identified as exacerbating the situation especially in poor areas such as rural villages (Madaka 2007).

There are already signs of local-initiative coping mechanisms by those most vulnerable to climate variability events such as droughts; including water vending, brick making, trading of fire wood and charcoal, and providing non-motorised transportation such as bicycles.

The loss of human, natural, financial, social and physical capital, caused by the adverse impacts of climate change, especially severe droughts and floods, among many other disasters, are indeed of great concern to Tanzania. Poverty levels too have increased due to reduced water supply and crop yields (Kimbisa 2008). Most of the country is affected by drought, and drought analysis trends indicate that drought prone regions are hit once every two years (Kahwa 2010).
Climate change is thus strongly positioned to undermine hard-won national efforts to attain the Millennium Development Goals (MDG’s) and places poverty reduction efforts in jeopardy unless mitigation and adaptation plans are instigated (NAPA 2007). It is proposed that acting now will be cheaper than waiting for the future. Although Tanzanian Official Development Assistance (ODA) funding is expected to increase as extreme events become more frequent these increases in foreign assistance will not be enough to keep Tanzania on track with its Millennium Development Goals (Venton, 2007). As 2030 is the deadline for meaningful adaptation it is essential that adaptation is a central part of Tanzania’s Vision 2025 development plan (IIED 2009).

4.1. Dar es Salaam and its vulnerabilities

The City of Dar es Salaam is the largest city in Tanzania and hosts a major port located along the Indian Ocean coast (Figure 3). Though Dar es Salaam lost its official status as capital city to Dodoma in 1974, it remains the centre of the permanent central government bureaucracy and continues to serve as the capital for the surrounding Dar es Salaam Region. The Temeke District is administratively divided into 3 divisions and 24 wards.

The topography of the area ranges from low-lying coastal plains around the city centre (20 m) to the Pugu and Kisarawe hills (260 m) in the south west (Kasonta and Kasonta 1999). The Dar es Salaam Region covers an area of 1,800 km$^2$, and is divided into 3 municipal councils: i) Temeke; ii) Kinondoni; and iii) Ilala (Fig. 1). Temeke is the largest municipal district, and Ilala the smallest. About 1,393 km$^2$ of the city is land mass, and the rest is made up of 8 offshore islands (DCC 2004).

According to Kalugendo (2008) the population of Dar es Salaam is projected to be 6 million by 2020. It is the fastest growing city in the world with a population doubling time ~16 years (Davis 2010). This will raise the water demand to 970,000 m$^3$/day. This is a disturbing prospect for a city already under pressure and unable to meet its water demands. In addition the vast majority of the city’s inhabitants – seven out of ten – live in unplanned settlements that cause major challenges to urban infrastructure. In an effort to improve their situation, urban poor use any available space to grow food. In backyards and vacant lots people grow crops and raise livestock to feed their families.

Dar es Salaam experiences an equatorial type of climate, characterized by hot and humid days throughout the year but peaking from October to March (up to 35°C). During the cool months of May to August, temperatures average at 25°C (DCC 2004).

Dar es Salaam is characterized by two main rainfall seasons; October to December, and March to May (DCC 2004). The city receives rainfall of between 1000 and 1400 mm a year, mainly during the March to May season (Kasonta and Kasonta, 1999). There is a differentiation in mean annual rainfall between the low-lying coastal plains (800mm to 1200 mm) and the mountainous regions (up to 1500 mm) (Kalugendo 2008). In addition, Dar es Salaam’s climate is also characterized by monsoon winds; north-westerly winds between November and March, and south-westerly between April and October. These winds have an effect on air and water temperature, winds and rainfall (Mahongo 2006).
Current climate variability in Dar es Salaam has resulted in a decrease in rainfall, thus threatening recharge to the Ruvu River Catchment and thus the water supply to the City. With a decrease in river flow, aquifer recharge is also affected. Evident too: siltation of water courses from soil erosion, heavy irrigation from rivers contributing to reduced minimum flow rates, and modification of natural soil cover condition (resulting from bush fires, uncontrolled tree felling and urbanisation) (Kalugendo, 2008).

The bedrock of the Dar es Salaam region is dominated by sandstones and limestone (dominating the coastal strip) and the area is characterised by a series of lineaments and faults (Kasonta and Kasonta, 1999), essential for groundwater recharge. There are sand and gravel aquifers and weathered limestone aquifers (up to a depth of 40 m along the coast). Since Dar es Salaam is located along the coast, the coastal aquifers are susceptible to salt water intrusion. Currently the city pumps more than 100 litres per minute, tapping more than 50% of the boreholes (Kasonta and Kasonta, 1999).

Human activity and land use practices upstream and alongside the Ruvu River impacts on the river’s water quantity and quality which leads to exploitation and water scarcity. Wide spread and heavy reliance on groundwater could lead to sea water intrusion, thus altering and reducing the quality of groundwater (Kalugendo 2008). The groundwater is also at a risk of pollution from on-site sanitation facilities, used by more than 80% of the dwellers (DCC 2004).

5. Sectoral assessments

5.1. Livelihoods

The term ‘livelihoods’ is defined as the way and the means of ‘making a living’ (Chambers and Conway, 1992; Bernstein et al. 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) than directly from the natural environment. Peri-urban and rural communities 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.

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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.

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The risks and impacts to basic services provided by local governments are vulnerable to changes in climate. For the purpose of this study, the general vulnerabilities associated with drought upon the local government services are discussed with the aid of case studies.

Further exploration of the term *livelihoods* delves into social indicators such as population growth and density, life span, poverty and source of income. These factors are explored below for the greater city of Dar es Salaam and then narrowed down to Temeke Municipality.

Dar es Salaam is considered to be one of the fastest growing cities in Sub Saharan Africa, with an overall population growth rate of 4.3% per year (in 2004). The city’s GDP has been growing steadily (observed during the period 1992 to 2002); the 2002 statistics indicated a 16% contribution to the national GDP. In 2002 the City was reported to have an unemployment rate of 46.5%, and of those employed, 95% was in the informal sector (DCC 2004), and the remainder in government and public cooperation (formal sector). Despite several interventions put in place, poverty still remains high in the city (DCC 2004).

The cost of living in Dar es Salaam was recorded to be high from the 2002 Household survey. The survey indicated that 7.5% of the population lacked food security, and 17.6% were unable to have basic needs met. Major economic activities contributing to the 2002 GDP included; internal trade (16.6%), manufacturing, tourism, urban agriculture, transport and communications, forestry and fishing (29% in 1997), mining and quarry, construction, utility services, finance and insurance, and public administration and education (DCC 2004).

The annual likelihood of a poor household having to deal with a household "crisis" in Dar es Salaam is already very high. In a survey it was found that two thirds of all of households were hit by a major expense involving a medical bill, festival, or ceremonial commitment. In one third of all the households either the main breadwinner lost his job, abandoned his family or died. Ten to 20 % of households were evicted from their home within a year, and 40 to 50% missed days of work in the last month due to injury or illness (IFPRI 2003). So residents are already vulnerable. Climate change will only exacerbate this situation.

Temeke, although the largest municipality in Dar es Salaam, had the second highest population of 948,498 inhabitants (projected for 2007). The population growth rate for Temeke was 4.6% (higher than Dar es Salaam as a whole - DCC 2004). Very importantly the majority of industrial establishments in the city are located in Temeke. The municipality also contributes to the most land (33,000 hectares) used for cash and food crops (DCC 2004).
The risks and impacts on basic services provided by local governments, and hence inhabitants livelihoods, are vulnerable to changes in climate. This study looks into the general vulnerabilities associated with drought upon local government rendered services, and related international case studies for comparison purposes. The four sectors of interest to be discussed further are:

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

5.2. Water and Sanitation

Background
Water and sanitation, is a key sector and service provided by local government, and is likely to be affected by climate change, particularly as a result of drought. As a result water use efficiency, water rights and emergency preparedness are questioned. Water utilities become vulnerable to water shortages, and technical maintenance of the system is imperative in order to respond to the effects of drought. Increased demands are imposed on surface water resources, resulting in competition for individual and residential supplies, agriculture, fisheries and industry (The Water Tap 2001).

Dar es Salaam currently gets its water supply from the major Ruvu River, which originates from the Ulugulu Mountains lying to the north-west, flowing towards the Indian Ocean in the east. River recharge is mostly dependant on rainfall falling on its catchment area and springs located in the Uluguru Mountains. The river is not regulated nor is the system managed adequately. Consequently, it remains vulnerable to adverse impact from draughts and occasional floods.

The water demand for Dar es Salaam service area in 2008 was estimated to be around 410,000 m$^3$/day while the actual water supply is about 126,900 m$^3$/day from surface sources and 50,000 m$^3$/day from groundwater. Water from the Ruvu River is collected and stored in storage tanks to then be distributed through a pipeline grid (DCC 2004).

The groundwater quality is currently generally good and within acceptable drinking standards, however, a few boreholes have high salinity and conductivity exceeding 2000 µS/cm. It is projected that the population of Dar es Salaam City will be about 6 million in the year 2020, raising the water demand to about 970,000 m$^3$/day (Kalugendo 2008). Since, along with rainfall, the Ruvu River and its tributaries feed the groundwater system, any adverse effects to the river has a negative impact on the quality and availability of the groundwater (Kasonta and Kasonta 2008). Borehole water accounts for 20% of domestic and industrial processing supplies. However, this borehole water is vulnerable to pollution from on-site sanitation systems used by 80% of the population in the City (DCC 2004).

In 2004, there were water shortages in terms of service delivery to the people of Dar es Salaam. Kinondoni Municipality was only serving 60% of its population, Temeke Municipality 68%, and Ilala Municipality only 52%. The rest of the unserved demands were the responsibility of Dar es Salaam Water and Sewage Authority (DAWASA), to be serviced mainly from deep and shallow boreholes.
These boreholes are owned publicly or privately (Figure 4) and contribute 5% to the City’s water supply. Access to clean and safe water for rural and peri-urban dwellers is catered for through DAWASA’s shallow and deep boreholes. The purchase of drill rigs by the 3 municipalities of the Dar es Salaam region allowed for 25 boreholes to be drilled in Kinondoni, 137 boreholes in Temeke and 162 boreholes in Ilala (DCC 2004). In addition, there are shallow hand-dug boreholes (less than 10 m in depth), which are typical of the coastal sedimentary aquifers.

Sanitation provision in Dar es Salaam is deficient: most people do not have access to a hygienic toilet; large amounts of faecal waste are discharged to the environment without adequate treatment; and this is likely to have major impacts on infectious disease transmission and hence quality of life of the immediate community and those downstream (Hutton et al. 2007). High population density and growth rate (both internal and from migrations) has had a negative impact on Dar es Salaam’s solid waste system (removal and disposal) (Figure 5). The City of Dar es Salaam has, however, embarked on a number of activities that have improved on waste disposal and removal (DCC 2004).

Government inclusion of community involvement in the implementation of Integrated Water Resource Management (IWRM) plans was not previously a priority, however, this is changing. Changes within the structural plans are encouraging communities to become more actively involved in projects dealing with conservation of water resources, ecosystems, efficient and effective water use, law enforcement and implementation of water rights (Kalugendo 2008).

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7 image ©J. Davila, UCL (www.agwa.no)
Impacts and Vulnerabilities

In a recent study (Napacho and Manyele 2010) it was found that many residents of Temeke drink water of dubious quality from several of the shallow and deep wells maintained by local resident water officials. Also, during the rainy and dry season, potable water scarcity becomes a major issue leaving many residents to seek other alternative drinking water resources. During these times of adversity many residents succumb to various diseases such as malaria, gastroenteritis, and cholera.

It was found, when comparing water sources, most of the chemical parameters were above the permissible levels i.e. highly polluted. However the municipal tap water was of the highest quality and shallow wells had higher nitrate content than deep wells. It was recommended that Temeke should improve sewerage systems in the area, prohibit release of chemical wastes from industrial activities, provide the community with deep wells, and educate the community to abandon use of shallow wells as a source of drinking water.

About 68% of Temeke Municipality’s population is serviced with clean and safe water. The rest of the un-served, mainly from rural and peri-urban areas, are provided for by the Municipal Council through several means such as the construction of water schemes and coordination of the operation and maintenance of not-yet-handed-over water projects. During drought periods, when water demand is high, the municipality’s capacity to provide water to the people is compromised and insufficient (DCC 2004).

In the past (the drought of 1996/7) residents of Dar es Salaam supplemented their surface water supply with groundwater. This led to an increase in borehole (well) drilling that was promoted by a seemingly widespread recommendation to conjunctively use groundwater with surface water. Groundwater was accessible and affordable to all city residents (Kalugendo 2008). Kimbisa (2008) states that as a result of reduced water supply (a direct drought-induced effect) rationing of water for household and industrial use was imposed. He further states that shallow and deep borehole drilling programmes and projects increased as a response to drought. If unregulated, all this drilling could increase salt water inundation into available fresh water courses and destabilize the ground surface. According to Mjemah et al., 2008, during the period 1971-2006 there was a decrease in

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Figure 5. Solid waste affects surface and groundwater quality at Msasani beach in Dar es Salaam

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8 sourced from (www.findtarget.com)

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annual groundwater recharge to the Dar es Salaam aquifers, a slight increase in total annual precipitation and an increase in mean monthly temperature maximums (Kalugendo, 2008). Over pumping of the Gerezani Creek in the 1990s led to increased salinity which has since led to boreholes being abandoned (Kasonta Kasonta, 2008).

On a national level, drought will affect the flow of water through the country’s hydropower facilities, which would lead to a reduction in energy production, affecting all facets of life in the city.

Table 1 illustrates a few of the impacts of drought on water and sanitation services and facilities, which encompasses impacts upon livelihoods. These identified effects are not exhaustive, nor are they confined to Tanzania and Dar es Salaam.

**Table 1.** Impacts of drought on water and sanitation services and facilities.

<table>
<thead>
<tr>
<th>Impacts on Water and Sanitation</th>
<th>Impact on livelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Decreased water supply and availability.</td>
<td>● Increased casualties from dehydration</td>
</tr>
<tr>
<td>● Reduced quality due to siltation and stagnant water.</td>
<td>● Increased geographical dispersal of water borne diseases</td>
</tr>
<tr>
<td>● Increased demand on water resources for human consumption.</td>
<td>● Decreased availability of fresh water supply (drinking water and for cooking purposes)</td>
</tr>
<tr>
<td>● Increased demand on water recourses for agricultural irrigation.</td>
<td>● High livestock mortality rates</td>
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<tr>
<td>● Increased demand on water resources for livestock watering.</td>
<td>● Decreased water supply causing dehydration</td>
</tr>
<tr>
<td>● Increased temperatures cause increased surface water evaporation and evapotranspiration.</td>
<td>● Decreased water supply reduces sanitation and hygiene</td>
</tr>
<tr>
<td>● Damage to fish habitat, loss from fishery production.</td>
<td>● Decreased food production (food shortages)</td>
</tr>
<tr>
<td>● Loss of navigability of rivers and canals.</td>
<td>● Loss of human life from food shortages, heat, suicides, violence</td>
</tr>
<tr>
<td>● Increased costs for Water companies on new or additional water supplies.</td>
<td>● Increase poverty rates</td>
</tr>
<tr>
<td>● Availability of water to fight wildfires is reduced.</td>
<td>● Water user conflicts</td>
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<tr>
<td>● Rusting of water pipes.</td>
<td>● Low water supplies and water pressure make fire fighting more difficult</td>
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<tr>
<td>● Reduced water supply for sewerage systems.</td>
<td>● Fewer recreational activities</td>
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<tr>
<td>● Reduced water for flushing of toilets.</td>
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<tr>
<td>● Reduced water for residential purposes and hygiene.</td>
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</tr>
<tr>
<td>● Higher costs, levels of competition and potential conflict for water resources between users including industrial facilities, power generators (for cooling and hydropower), public water suppliers and the agricultural community.</td>
<td></td>
</tr>
</tbody>
</table>
Case studies
1. In the Mediterranean, the role of water users and beneficiaries in planning and water management is not being adequately considered. However, individual water users are responsible for the extensive arbitrary exploitation of water resources and for groundwater over extraction. The most important effects of those practices are manifested in the:

- Drop in groundwater levels (which indicate a decrease in the volume of water stored), in several parts of the country. This decrease has continued over the years, up to the point that several springs and wells have dried up, and several aquifers have been pumped to exhaustion. This is the case in the Damascus, Kalamoun, and North Aleppo, Hama Kneitra, Rikkah and Hasakeh areas.

- Deterioration of water quality and increased salinity, experienced in the Eastern Damascus Valley and Beida to the west of Palmyra, Damsarkho, Hamidieh, Akkar valley at the Syrian coast and other areas.

5.3. Transport

Background
The effect of climate change, and in particular drought, on a country’s transport system are not always direct, however, droughts can cause cascade effects such as loss of navigability of water courses therefore reducing availability of food imports (often food aid in times of severe drought). In addition drought-related non-production leads to reduced produce volumes thus less need for transportation; thus impacting those livelihoods depending on the transport industry.

The availability and access to transport infrastructure influences access to markets and thus vulnerability to food and fuel shortages. Tanzania’s transport networks are sparse even by African standards. Dar es Salaam hosts the country’s main harbour run by the Tanzanian ports Authority which is the end/start point of the road and rail network. Only a fraction of roads are passable in all seasons and only about 1% of the total road network is paved. There are two rail systems in the country. Both the Tanzania-Zambia Railway Authority (TAZARA) and the Tanzania Railway Corporation operate from Dar es Salaam but there is less than 4 km of railroad for 1000 km². Transport infrastructure is currently already a bottleneck to development despite efforts to fund improvement. The promotion of markets requires both infrastructure investments in communications and transport networks and institutional reforms. The strengthening of markets can reduce vulnerability in several ways. Access to markets mitigates local shortages and limits the ability of local monopolies to misuse their power. It also extends the opportunities to engage in income-generating activities and to specialise so as to increase productivity (Paavola 2008).

According to Kanyama et al. (2004) the government of Tanzania has a poverty reduction programme that addresses sustainable public transportation. Tanzania’s National Transport Policy endeavours to achieve improved capacity and quality of urban transport network, having a sustainable and environmental friendly transport system and an enhanced mobility and affordable transport system (DCC 2004) but this must be resilient in the face of increased frequency of climatic extremes.
In Dar es Salaam the rapid growth of population and the size of the city are directly linked with a rapid increase in vehicles. Dar es Salaam city hosts over half of the total vehicles found in Tanzania. There is a mismatch between the traffic density growth rate and the road network development. Although some efforts had been made to increase the capacity of Dar es Salaam roads since the mid 1990’s, the existing road network is still inadequate to meet requirements of the fast growing vehicle population. Minibus taxis dominate the motorised public transport system and as Dar-es-Salaam continues to grow spatially and in terms of population, the demand for public transport increases, which in turn creates the need for increased numbers and operations of minibuses. Accordingly, these buses exacerbate long queues, congestion and increased rate of accidents in Dar-es-Salaam (Kanyama et al. 2004).

A project to try and alleviate the chronic congestion faced by commuters is the Dar es Salaam Rapid Transit (DART) project which is expected to start operating in 2012. The system will use guided buses (Bus Rapid Transit) on segregated bus lanes, and minibus taxis will no longer be allowed to operate on the routes, but will operate as feeder services to the DART arterial routes (TA 2011).

**Impacts and Vulnerabilities**

The rapid expansion of the city has led to a poor and unsafe transport system. Direct effects of drought on roads may include subsidence of land from evaporation after heavy rainfall events; this leads to potholes which increases the need for road maintenance. In times of drought it may be critical to move food aid and water to vulnerable communities within the city and good road access will be vital for this. Some effects of drought on the transport service systems are not direct but inferred. An influx of environmental refugees (people no longer able to sustain livelihoods due to climatic and environmental changes) and political refugees from unstable neighbouring countries will further test the transport system in Dar es Salaam and its main employment and production zone, Temeke municipality.

The climate projections for Dar es Salaam include flooding of coastal areas and so flooding also needs to be briefly addressed and built into adaptation frameworks. Besides destroying crops and pastures, floods in January 2010 have also washed away sections of roads, bridges and the central railway linking Dar es Salaam port to the Lake Tanganyika port of Kigoma that serves neighbouring Burundi, DR Congo and Zambia (Pana 2010).

Table 2 illustrates likely impacts of a drier, hotter climate on transport and the cascading effects on livelihoods.
Table 2. The impact of drought and coastal flooding on the transport sector.

<table>
<thead>
<tr>
<th>Impacts upon Transport</th>
<th>Impact on livelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Water transport routes may become less navigable.</td>
<td>- Inability to travel to work and market places and seek health assistance</td>
</tr>
<tr>
<td>- Increased importation of water and food (higher costs).</td>
<td>- Increased food and fuel prices</td>
</tr>
<tr>
<td>- Erosion and deposit of sand make roads impassable.</td>
<td></td>
</tr>
<tr>
<td>- Disruption of ground and marine transportation systems as a result of severe weather (e.g., strong winds unbalancing freight trucks, sea storms disrupting shipping, and local drought affecting the navigability of inland waterways).</td>
<td></td>
</tr>
<tr>
<td>- Inundation of transport routes, transport infrastructure and distribution facilities and flood damage caused by rising sea levels.</td>
<td></td>
</tr>
<tr>
<td>- Flooding from increasingly intense downpours will increase the risk of disruptions and delays in air, rail, and road transportation, and damage from</td>
<td></td>
</tr>
<tr>
<td>- mudslides in some areas.</td>
<td></td>
</tr>
<tr>
<td>- Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and permanent flooding of airports, roads, rail lines, and tunnels.</td>
<td></td>
</tr>
<tr>
<td>- The increase in extreme heat will limit some transportation operations and cause pavement and track damage.</td>
<td></td>
</tr>
<tr>
<td>- Increased intensity of strong winds would lead to more evacuations, infrastructure damage and failure, and transportation interruptions.</td>
<td></td>
</tr>
</tbody>
</table>

Case studies
1. The economic impacts of flood and drought in Kenya from 1997-2000 showed that the transport sector was the hardest hit costing US$ 777 million, and accounted for 89% of the total cost of damage during the floods (Connor et al. 2009).

2. Hurricane Katrina, U.S.A., caused an estimated US$ 134 billion in damage and seriously disrupted transportation systems. Highway and railroad bridges were heavily damaged or destroyed, necessitating rerouting of traffic and placing increased strain on other routes, particularly other rail lines. Replacement of major infrastructure took from months to years. Barge shipping was halted, as was grain export out of the Port of New Orleans, the nation’s largest site of grain exports. The extensive oil and gas pipeline network was shut down by the loss of electrical power, producing shortages of natural gas and petroleum products. Total recovery costs for the roads, bridges, and utilities as well as debris removal have been estimated at US$ 15 billion to US$ 18 billion.
5.4. Health

Background
Warming is predicted to increase the incidence of insect-borne diseases such as malaria, schistosomiasis and trypanosomiasis in Tanzania. The increased frequency of droughts and flooding is in turn likely to increase the frequency and magnitude of epidemics of water-borne diseases such as typhoid and cholera, as well as to influence the incidence of mosquito-borne diseases. There are also intimate connections between nutritional status and health. In general, malnutrition and food shortages will increase morbidity and mortality related to infectious diseases. Finally, warming will aggravate the impacts of air pollution on respiratory illnesses which already kill as many Africans as malaria and more than diarrhoeal diseases (Paavalo 2008, IPCC 2007).

The health system in Tanzania is governed by the National Health Policy of 2007. As a result of this policy the Primary Health Sector Development Programme 2007-2017 was implemented. The policy and health programme is incorporated into the National Strategy for Growth and Reduction of Poverty (NSGRP or MKUKUTA; see section 3) (Kiria 2009). The principle of the NSGRP (encompassing those of the national health policy and primary health sector development programme) is carried out at the municipal level. Only 40% of the health sector budget is managed directly at district level and is never enough to provide for equitable and quality health care (Kiria 2009)(Figure 6). However, the Municipality provides health care that is preventive, promotive, rehabilitative, and curative. Temeke has four hospitals (two public and 2 private owned), four health centres (1 public, 3 privately owned) and 101 dispensaries (26 public, 75 private owned). In addition, in Temeke there are 24 pharmacies and 350 part II drug shops. Generally, the population of Temeke can access health services within an average of 5 kilometres from their homes (CCHP 2008).

According to the Tanzania Demographic and Health Survey (2005), while there is some improvement in some of the health indicators, there is deterioration in others.

Improvements: total fertility rate is up from 5.6 children per woman in 1999 to 5.7; under-five mortality has improved from 146.6/1,000 live births in 1999 to 112/1,000; 94% of mothers received antenatal care from a trained service provider for their most recent birth.

Deterioration: maternal mortality is up from 529/100,000 live births in 1996 to 578 in 2004; only 46% of mothers had the delivery of their latest child attended by a health professional.
Impacts and Vulnerabilities

Temeke falls below the country averages for under-five mortality rate which is 154/1,000 (42 more deaths/1,000) and is about on par for Maternal Mortality Rate at 524/100,000 live births. The top five causes of outpatient morbidity, in order, are malaria, acute respiratory infections, diarrhoea diseases, intestinal worms, and pneumonia. The top five causes of deaths in under-five children in Temeke Municipal Council are severe malaria, pneumonia, anaemia and diarrhoeal diseases. The top five major causes of deaths among adults are malaria, clinical AIDS, pneumonia, tuberculosis, and anaemia (Kiria 2009). This increases vulnerability to climate change impacts such as drought and these communities must be considered at high risk.

From 1921, forecasts of malaria epidemics have been based on the established relationship between rainfall and malaria mortality, creating probably the first malaria early warning system. Usually malarial epidemics are linked to excessive rainfall. However, in some regions, malaria epidemics are linked to below-average rainfall and this is a risk for Tanzania. Malaria is already highly prevalent; the spread of the vector borne disease to new parts of Tanzania will stretch health care abilities.

With the prevalence of diarrhoea diseases within the municipality the ongoing delivery of reliable, safe drinking water is vital to public health. This is already exacerbated during drought periods when water restrictions are imposed and water availability is a concern. Drought leads to a loss of food security and with less nutrition, maintaining a healthy immune system will become difficult, stressing health facilities.

As people rely on fewer and fewer water supplies, should one become contaminated it will affect a greater number of people. In addition, less water available to each household in times of drought means priorities for water will be for consumption rather than hygiene. Concurrently, as hygiene deteriorates the risk of disease increases.

Table 3 outlines likely consequences of a hotter, drier Dar es Salaam and what that is likely to mean for the Temeke Municipality’s ability to continue to provide adequate health care.

Table 3. Drought effects on health care services.

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9 © http://www.untanzania.org/newsdetail.asp?newsid=62
Sub-Saharan African Cities: A Five-City Network to Pioneer Climate Adaptation through participatory Research and Local Action.
Case studies
1. In Venezuela and Colombia, malaria cases increase by more than one third following dry conditions associated with El Niño.

2. In Sri Lanka, in pre-DDT times, the risk of malaria increased three-fold following the failure of the monsoon which was also associated with El Niño (WHO factsheet 192).

5.5. Energy
Background
In Dar es Salaam most households use charcoal as their main source of fuel for cooking, making Tanzania’s commercial and industrial hub the leading consumer (69%) of the product in the country. This is threatening the sustainability of Tanzania’s forests, with important repercussions for both mitigating future climate changes but also immediate impacts on local biodiversity that drives their natural resource base. In fact approximately 90% of the total energy use in Tanzania is based on wood fuel (UNHABITAT 2009). Coupled with drought, not only will the Dar es Salaam population have no fuel but harvesting of the wood is unlikely to be sustainable enough to allow for post-drought recovery which will have long-term impacts on the availability of the fuel source. This will put more pressure on the municipal supply of energy.

In 2007, only 11.1% of the population was connected to the national grid, up from 9.3% in 2006. The provision of electricity is concentrated to larger cities and urban areas, whereas the rural areas have very low access to electricity, about 2% (SIDA 2010). The organisation responsible for electricity...
generation, transmission and distribution in Tanzania is the Tanzania Electric Supply Company (TANESCO). The parastatal is responsible for 98% of the country’s electricity supply. The country’s power generation system encompasses the use of hydro, thermal and gas power of which hydropower contributes the most (71%) to Tanzania’s electrical power generation (NAPA 2007).

The country faces a major challenge of providing 90% of the remaining population access to electricity. This requires huge investments, hence the need for both international and local investors to participate in expanding the country’s power sector. As the country is becoming more and more focused on providing electrical power, the need for new capacity is increasing rapidly (NAPA 2007).

Kerosene is the second major energy source for cooking after charcoal, though its consumption is now decreasing due to rising prices. The third is fuel wood which is mostly used by rural inhabitants, local beer brewers and military camps. There is also cooking gas which is supposed to be cheap but it’s also increasingly becoming expensive. Also there is diesel used for cooking and to light oil-lamps, especially in areas where paraffin and other sources of energy is scarce (NAPA 2007).

**Impacts and Vulnerabilities**

Lack of precipitation will cause problems with the hydropower production, which in turn will affect electricity rates, energy revenue, and the ability to purchase alternate sources of energy. Prolonged dry seasons reduce hydropower dams’ capability to generate sufficient electricity. During drought periods there is an increase in sedimentation of dams which could also cause damage to hydropower generation equipment (Dodman 2008). During 2006/2007 Tanzania experienced power blackouts due to low water levels and the inability to produce hydropower at normal capacity as a result of the drought. These power cuts in return created cascade affects on consumers reliant upon electricity for day to day activities. There is an increased demand for alternate power resources such as charcoal especially during the blackouts as it is cheaper (Sangi 2010).

The impacts of no power or limited or inconsistent power will affect all sectors, reducing commercial potential and affecting every resident of Dar es Salaam at the household level. The municipality will have to have alternative measures in place and adaptation strategies that will allow for continued livelihoods to allow the city to meet its development goals.

Table 4 identifies likely impacts on the energy distribution within a city to its inhabitants as a result of mean sea level rise and sea storm surges.

**Table 4. Impacts of drought on the energy sector.**

<table>
<thead>
<tr>
<th>Impacts upon Energy</th>
<th>Impact on livelihoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited water reduces hydropower supply.</td>
<td>Increased costs resulting from higher energy demand, particularly increased peak demand in the summer for cooling</td>
</tr>
<tr>
<td>Increased demand for electricity during prolonged droughts and high temperatures as cooling demands for domestic and commercial use rises.</td>
<td></td>
</tr>
<tr>
<td>Increased episodes of power outages (black outs).</td>
<td>Spoilage of food</td>
</tr>
<tr>
<td>Hydroelectric power companies will need to look into other fuel sources or alternative renewable technologies.</td>
<td>Increased costs associated with</td>
</tr>
</tbody>
</table>
Case studies

1. The man-made Lake Kariba, bordering Zimbabwe and Zambia, has provided hydropower to these countries for many decades since 1959 (Figure 7). However during drought periods, such as during the 1980’s and early 1990’s, water levels declined below the level necessary to supply the country’s hydropower needs. The towns and cities of Zimbabwe experienced frequent power cuts as a result and had to resort to other means of energy such as importing from neighbouring countries or an increased reliance on firewood. There are flood risks too: with the construction of Kariba and the disruption in the rhythm of the river, the people had to adapt to the new situation. One of the adaptations was the movement of human settlement closer to the river, since the dam removed most of the peak floods. In so doing, these people exposed themselves to risk of flooding in years when the dam managers needed to release water from the dam, such as high rainfall seasons. This was the case in February 2000, when, following a season of unusually high rainfall, Kariba Dam filled faster than expected and there was need to open the floodgates. In excess of 12,000 people were displaced in south-eastern Zambia by the floods that were caused by this release. Riverine fields were flooded and homes destroyed, and cases of drowning were reported; and all this devastation because the flow-pattern of the river has been changed by the dam (WCD 2000).

Figure 7. Lake Kariba at full capacity in between dry spells 10.
6. Conclusions

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).

Tanzania is no exception and Dar es Salaam, the most populous city in the country will be heavily affected by the increasing drought conditions throughout the country and coastal flooding. Temeke Municipality in particular and greater Dar es Salaam in general, is vulnerable at all municipal sector levels. Already many are suffering health stresses, which will be further exacerbated by climate change. Transport and energy networks will be placed under even more strain by increased demands as more ‘economic’ migrants seek work in the city. Dar es Salaam and Temeke, will struggle to meet development goals designed to improve the livelihoods of their residents. The need for clean water and good sanitation is a common thread that affects all sectors and needs to be resilient to an increasingly changing and variable 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. In Dar es Salaam (and Temeke in particular) 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 report (Moser, C. and D. Satterthwaite, 2008) 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 for Temeke and Dar es Salaam focused specifically on impacts and vulnerabilities associated with drought and is one of a suite of five reports. The other reports deal with extreme temperature (Cape Town), cyclonic winds and torrential rains (Port Louis), flooding (Maputo) and rising sea-levels (Walvis Bay). These baseline studies and literature reviews will, when combined with the findings of the ICLEI Tadross and Johnston (2011) report: Project 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 able to plan in a better way for future development and be prepared for any climate-related crises. This is best done through participatory action at the local level via local government, researchers and communities and in this regard Dar es Salaam can lead the way for Tanzania.
7. Glossary

**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:** 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.

**Anthropogenic changes:** Human activities that change the environment.

**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. 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.

**Subsistence:** The action or fact of maintaining or supporting oneself at a minimum level.

**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.
8. References


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