

Cities and Climate Change

Urban vulnerability and resilience in southern Africa

SYNTHESIS REPORT

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The Regional Climate Change Programme Southern Africa (RCCP)

The RCCP aims to contribute to the achievement of southern Africa's climate change adaptation needs, socioeconomic development and poverty alleviation objectives, including the Millennium Development Goals.

By synthesising the relevant climate change science, developing strategic research and strengthening science-policy-governance-finance dialogue, the RCCP will build an evidence base for appropriate transboundary responses, strengthen the region's voice on international platforms and negotiations, and enhance its ability to equitably access the necessary finance for effective climate change adaptation.

The five-year Regional Climate Change Programme of work (2009–2014) with Southern African Development Community (SADC) partners on the impact of climate change, aims to increase regional participation in globally funded adaptation projects and improving resilience. The RCCP has four outputs, the first of which focuses on the scientific basis for understanding climate change impacts in southern Africa.



RECOMMENDED CITATION

Chapman, R.A. & Sasman, N. 2012. *Cities and climate change: urban vulnerability and resilience in southern Africa*. For the Regional Climate Change Programme for Southern Africa (RCCP), UK Department for International Development (DFID). Cape Town: OneWorld Sustainable Investments.

Acknowledgements

The following are acknowledged for their contributions:

The understanding gained on this research was assisted by the cooperation of Focus Groups in each of the urban centres of Beira, Dar es Salaam and Lusaka. Their assistance is gratefully acknowledged;

Pegasys Strategy and Development of Cape Town, South Africa, for their insights into the institutional arrangements in Lusaka;

Ms. Sue Taylor, Mr. Robin Richards and Ms. Patience Mutopo for their study on the nature of migration in southern Africa;

Dr Mark Napier of the Urban Land Markets Programme (Urban LandMark, South Africa) for his critical review of the original manuscript.

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Key messages

Urban populations in southern Africa have grown rapidly in the last 3 decades.

The populations in most urban centres have grown rapidly at about 3–6% per year for extended periods. The urbanisation was not driven by rapid economic growth but largely by an adaptation strategy adopted by the rural poor to escape struggling rural economies. Difficult environmental conditions, including loss of livelihoods during severe drought, contributed to the pressure for migration. City and town managers did not anticipate the influx of people and with few financial resources, people established in large peri-urban settlements. Of the major cities, Dar es Salaam is expected to continue growing spectacularly, with an increase in population of about 80% from 2010 to 2025. Kinshasa is likely to grow by 70% to 15 million people and become the second largest city on the continent.

Large proportions of inhabitants of these cities live in the informal settlements.

Few services have been provided in these informal settlements – water supply and sanitation, stormwater drainage, electricity, properly constructed roads and health facilities and crucially, lack of safe housing. Between 60–70% of people living in these areas are not employed in the formal sector. These people remain in poverty and are food insecure. They pay more for their water and for energy supplies. Services must be acquired privately, raising living costs and reducing opportunities for investment. Informal settlements are often located on land prone to hazards which is not marketable, but exposes them to the consequences of extreme weather. Pit latrines in these exposed areas may be flooded, contaminating water and spreading pathogens. Climate-related outbreaks of disease in urban areas are becoming more common, such as cholera, typically associated with extreme weather – with floods contaminating surface water and droughts causing competition for water from unprotected sources. Urbanisation has largely replaced one type of climate vulnerability experienced in rural areas with another.

Climate changes will result in higher temperatures and increasing incidence of extreme weather.

Higher temperatures are expected over the next 50 years, especially in the continental regions of 2–3°C and this will have an effect on water demand and quality. These same regions are already experiencing an increased intensity of daily rainfall, while the duration between rainfalls is increasing. This trend will continue for the foreseen future. Urban areas on the coastal areas of eastern southern Africa are exposed to a higher frequency of powerful storms.

The physical layout of cities plays an important role in creating efficiencies allowing effective management.

The geographical location, their geology and drainage systems all provide different challenges to inhabitants and municipal officials. Lusaka has a large water deficit and citizens pump water from the underlying dolomites. The poor sanitation and over-utilised pit latrines pollute the underlying aquifers. Low-lying towns such as Beira pose significant drainage problems. In Dar es Salaam inadequately maintained drains have become pathways for providing habitats for mosquito larvae and increasing opportunities for outbreaks of malaria and lymphatic filariasis.

International experience shows that urban centres should be zones of reduced vulnerability and sensitivity to extreme weather.

Physical infrastructure should be protective and emergency services able to respond more efficiently. Informal settlements on the periphery of southern African cities are often the focus of disaster management authorities and health authorities, indicating their vulnerability and sensitivity to severe weather. Most southern African urban centres however have a small tax base and disaster and other management plans therefore cannot be operationalised.

Improvement of basic services is the first priority of increasing climate resilience.

Economic growth in some southern African countries is creating investment opportunities for improvement of basic services. Urbanisation supported by appropriate services and well located land is an appropriate climate change adaptation strategy. In many urban centres, while local institutions are still required to carry out their service roles, the required capacity is lacking. Improvement of basic services that rely on preferred, cheaper options are often under-designed and under-specified for the intensity of use they experience. Thus improvements can become ineffective as a service option if the scale of investment is not large enough.

Opportunities exist to build institutional capacity to self-finance.

Building resilience is a long-term process. The ability to self-finance for predictable and continuous funding will allow sustainable and streamlined development. Donor funding is often project-based and variable, creating difficulties for maintaining revenue after donor sponsorship ends. Institutional capacity must also improve in order to, a) prevent unplanned settlements occurring through good urban planning and more rapid land release, b) increase the delivery of essential services and c) manage services sustainably so as to ensure continuity of supply. This requires strengthening of financial sustainability and human resources.

Continuous engagement by government and the private sector will yield results.

Proactive mechanisms to ensure the availability of well-located, secure land for new urban settlement is required to accommodate natural urban growth; and National Adaptation Plans of Action should be translated into locally-relevant plans and funded into reality. There are also opportunities for significant private sector input, such as large bulk water users assisting municipalities to increase their supplies of good quality water.

People living in unplanned and unserviced sites are exposed to a wide range of hazards. A fire in an informal settlement in Durban, South Africa.



1. Introduction

Urban centres in southern Africa (the 15 SADC countries in this case – Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, the Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe), are under pressure from many fronts, foremost of which is rapid population growth. The origin of this trend is in-migration (often from rural areas) and natural internal population growth (within the centres), bolstered by a high national fertility rate, particularly in the least developed countries (LDCs). The rural-urban migration is a transboundary demographic problem in southern Africa. People migrate from rural areas to urban areas in the same country, and then from country to country. There is a large regional transboundary movement of people. Although the maximum rates of arrivals of the 1980s and early 1990s has subsided somewhat, expansion of economic growth, supporting employment and the construction of infrastructure have not kept pace. Many migrants remain poor after settling into a new area (UN-Habitat, 2008).

Large populations inhabiting unplanned and unserved sites now exist on the peri-urban periphery of many towns and cities in southern Africa, in many cases located in unsafe areas and exposed to climate-induced hazards. Climate change and variability, which are experienced differently in each urban centre, bring primarily the challenging conditions of more frequent and intense extreme weather. The effects of these conditions have different impacts on livelihoods in the urban areas to those in rural areas – yet they hold out the promise of greater opportunities for risk mitigation by infrastructure development. The vulnerability of urban centres to these climate stressors depends on their level of exposure and the level of societal sensitivity or resilience.

1.1 Purpose of this report

This paper examines three case studies of urban centres which have been identified by the Regional Climate Change Programme (RCCP) (see Midgley and Davies, 2012) as being located in regional climate and development hotspots of vulnerability: they are: Beira (Mozambique); Lusaka (Zambia) and Dar es Salaam (Tanzania).

The objectives of the study were to examine in closer detail the climate-related vulnerabilities of each centre. The stresses experienced in each city are examined and general conclusions reached about the impacts of climate change in urban areas, as well as possible remedies. We acknowledge that the vulnerabilities of each of these urban centres to climate hazards are not necessarily replicated in all, or even most, other southern Africa urban centres. Our objective is, however, to draw some general lessons which could be widely applicable.

This report is one of a series of Knowledge for Adaptation titles published by the RCCP. This series is targeted primarily at SADC decision and policy makers and aims to support their leadership in securing government commitments in the climate change, health and development contexts, including influential institutions and other key stakeholders.

In the preparation of this document, Focus Groups were consulted in each of the urban centres mentioned above. They consisted of people from a mix of different institutional affiliations in each of the centres – a list of their affiliations is provided in an appendix. The groups' views on the vulnerability of each of their respective cities were used as a basis for constructing the arguments contained in the following discussion.

2. Drivers of expansion in urban populations

2.1 Global overview

In general, the more urbanised a nation is, the wealthier it tends to be (UN-Habitat, 2010). Cities usually represent the highest proportion of a nation's wealth. They create the conditions for wealth formation and provide economies of scale, and proximities of transactions make cities far more efficient than rural areas. For economic reasons then, transitions from low-income economies to middle-income economies are always accompanied by a rural-urban migration and a consequent rapid urban population growth.

Migration from the poorer rural areas takes place mostly for two major reasons:

- aspirational migration – migrants from small towns and villages search for better opportunities in bigger towns, are more literate and may be absorbed into better-paying jobs. They usually have improved levels of accommodation on arrival;
- distress migration – characterised by a lack of income opportunities in rural areas, by people often with poor skills who are mostly semi-literate and can only be absorbed into labour-intensive jobs and small businesses, if at all.

Environmental degradation is an additional push factor of migration and this has especially been experienced in the Horn of Africa where conditions were already marginal. This region is one example of how deterioration in environmental conditions results in conflict and migration. Future drivers of migration (including rural-urban migration, and migration to other countries) is likely to include the decline in agricultural production forced by rising temperatures and increased variability of rainfall. Projections of maize production in Africa indicate its sensitivity to temperature increases. As this is a staple crop, food insecurity is possible, prompting waves of migration by people in search of improved livelihoods. Most of these people are likely to move to urban areas.

2.2 Southern Africa as a subset of the global picture

During the 1960s to 1980s there was a substantial rural-urban migration in southern Africa. Demographic expansion in the urban and city areas was driven largely by this migration. The United Nations State of Cities Report (2010) notes that the population of African cities will triple over the next 40 years, and that urban living will be the dominant mode of livelihood, with 'megacities' and huge urban corridors that may accelerate economic growth.

Currently, natural population growth within the urban areas is becoming more of a driver of city size.

UN Habitat (2008) and Taylor *et al.* (2011) note that the bulk of movements tend to be circular and that many people maintain a rural identity. South Africa remains the most important objective of regional and international migrants and much of this occurs through a step-wise movement to intermediate urban centres before ending up in one of the major cities. Parnell and Walawege (2011) note that the natural population growth of cities might be a more important dynamic than regional and rural-urban migration. The authors also contend that the weak management of African cities means that environmental changes are likely to have significant consequences for cities.

Projections show that by about 2030, most of the population in the SADC states will be urban, given current rural-urban migration patterns and rates (UN-Habitat, 2008; Hughes *et al.*, 2010) (Figure 1). Dar es Salaam, Kinshasa and Luanda are three of the fastest growing cities in the southern African region (UN-Habitat, 2008). That report notes that in the 15 years from 2010 to 2025, Dar es Salaam is expected to have grown by 80%. Kinshasa is expected to have about 16.7 million inhabitants by 2025 and will be Africa's largest urban agglomeration (UN-Habitat, 2008). Dar es Salaam and Kinshasa are among the 10 fastest growing large cities in the world (UN-Habitat, 2008; 2010). Much of this urban growth in population has not been supported by equally rapid development of urban infrastructure, governance and economies (UN Habitat, 2008; 2010).

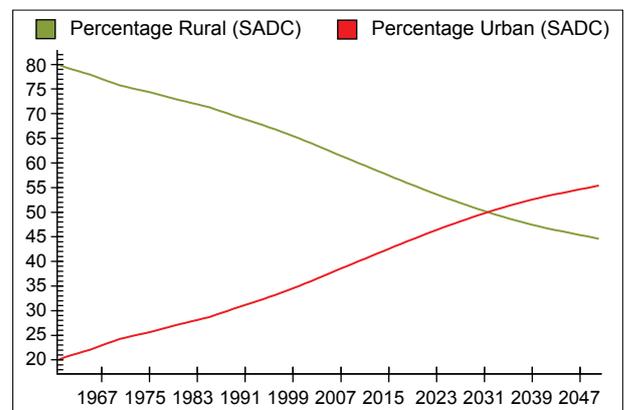


Figure 1: Southern Africa's percentage of urban population growth, compared to the rural component, projected to 2050

Source: Hughes *et al.*, 2010

Table 1: Urban conglomerates and growth rates in the SADC region up to 2050 (in thousands)

Country	Urban Agglomeration	2000	2005	2010	2015	2020	2025
DRC	Kananga	552	705	878	1 087	1 324	1 583
DRC	Kinshasa	5 611	7 106	8 754	10 668	12 788	15 041
DRC	Kisangani	535	664	812	1 002	1 221	1 461
DRC	Lubumbashi	995	1 252	1 543	1 899	2 304	2 744
DRC	Mbuji-Mayi	924	1 190	1 488	1 838	2 232	2 658
Madagascar	Antananarivo	1 361	1 590	1 879	2 235	2 658	3 148
Malawi	Blantyre-Limbe	538	667	856	1 103	1 407	1 766
Malawi	Lilongwe	493	662	865	1 115	1 422	1 784
Mozambique	Maputo	1 096	1 341	1 655	1 994	2 350	2 722
Mozambique	Matola	504	636	793	961	1 139	1 326
South Africa	Cape Town	2 715	3 091	3 405	3 579	3 701	3 824
South Africa	Durban	2 370	2 638	2 879	3 026	3 133	3 241
South Africa	Ekurhuleni (East) Rand)	2 326	2 824	3 202	3 380	3 497	3 614
South Africa	Johannesburg	2 732	3 263	3 670	3 867	3 996	4 127
South Africa	Port Elizabeth	958	1 002	1 068	1 126	1 173	1 222
South Africa	Pretoria	1 084	1 274	1 429	1 514	1 575	1 637
South Africa	Vereeniging	897	1 029	1 143	1 211	1 262	1 313
Zambia	Lusaka	1 073	1 265	1 451	1 666	1 941	2 267
Zimbabwe	Harare	1 379	1 513	1 632	1 856	2 170	2 467

Data Source: UNDP, 2009, from Taylor *et al.*, 2011

Peri-urban settlements in southern Africa are defined by their inadequate access to water, sanitation and other essential services (electricity supplies, surfaced roads, schooling, health and retail markets). The driving force for these settlements was the rural-urban migration push and the location of people onto privately-owned agricultural land (including rent seeking by the landowner) (Pegasys, 2011). The sizes of these poorly serviced peri-urban areas have expanded faster than the ability of the urban governments to supply those services.

As a general rule, people have settled in areas which are not valuable for other purposes (Pegasys, 2011). The nature of these criteria means that some aspect of the environment is compromised, which further adds to later vulnerability to climate change issues. Thus people settle in vulnerable areas: steep slopes or bottomlands which are vulnerable to flooding; near permanent water which could be stagnant (a source of disease or vectors of pathogens); or on very shallow soils where the installation of water supply and sewerage is not possible using municipal functions of limited resources. Settlements develop along the major access routes creating strip developments, increasing traffic congestion and erosion of the road infrastructure, and creating unsafe conditions for pedestrians (Pegasys, 2011). Waste services tend to be non-existent, so that surface waters are soon contaminated. In all peri-urban areas, adequate drainage is a problem. Shelters tend to be built by the inhabitants themselves, rather than professional builders, and of temporary materials which are more likely to collapse during extreme weather or when exposed to hazards such as flooding.

The UN has warned that the failure to correct the deficiencies in urban planning and service provision could

create an unstable future (Taylor *et al.*, 2011). The State of African Cities Report (UN-Habitat, 2008) suggests that unless cities and urban zones are better planned and serviced, urbanisation may be a source of conflict. Poor migrants and the current population compete over access to scarce resources. The UN-Habitat (2008) report does indicate that of all the regions in Africa, the population of southern Africa is growing the slowest in total numbers, although the rates are similar to that of North Africa and west and central Africa (UN-Habitat, 2008).

2.3 Why not one big city? The role of smaller urban centres

The World Disasters Report by the International Federation for Red Cross and Red Crescent Societies' (IFRC, 2010) states that "more than half the world's population lives in [the smaller] urban centres, not cities" and UN-Habitat (2010) also notes that the most rapid population growth is occurring in smaller urban centres, relative to the large cities. Both cities and smaller urban areas equally attract new residents. However, it is important to note that there is still a pattern of population's eventual, but stepwise, concentration in a primary city, which has resulted in much of the global research and assistance being concentrated on these cities rather than the smaller urban centres, which also require a measure of investigation.

People migrating from rural areas to cities usually have a small town as an intervening staging post. There are several reasons for this: 1) living costs are higher in the major cities and new immigrants arrive without much wealth and 2) possibly the cultural difference between moving from a small town to city is smaller than moving

directly from a rural area into a large city (UN-Habitat, 2010). However, there is also a migration from larger cities to smaller towns for similar reasons – to lower the costs of living and take advantages of different lifestyles available. In some parts of the developing world migration to urban areas occurs as a result of changes occurring in rural areas, which includes mechanisation and other changes to farming practices (Hasan and Raza, 2009) and better economic and social opportunities in the urban areas (provision of health services, education and others). This suggests that investment in climate change-resilient urban infrastructure should be guided more by a long-term economic logic than short-term needs. Actions should also focus not only on large cities but on the whole continuum of settlements, from rural through small towns and to cities.

Recent research also suggests that focusing on climate challenges should include those of the smaller urban centres (UN Habitat, 2008). It is significant that the IFRC's 2010 World Disasters Report focused on urban risk. It debunks certain myths about urban centres, including that 'more than half the world's population lives in large cities'.

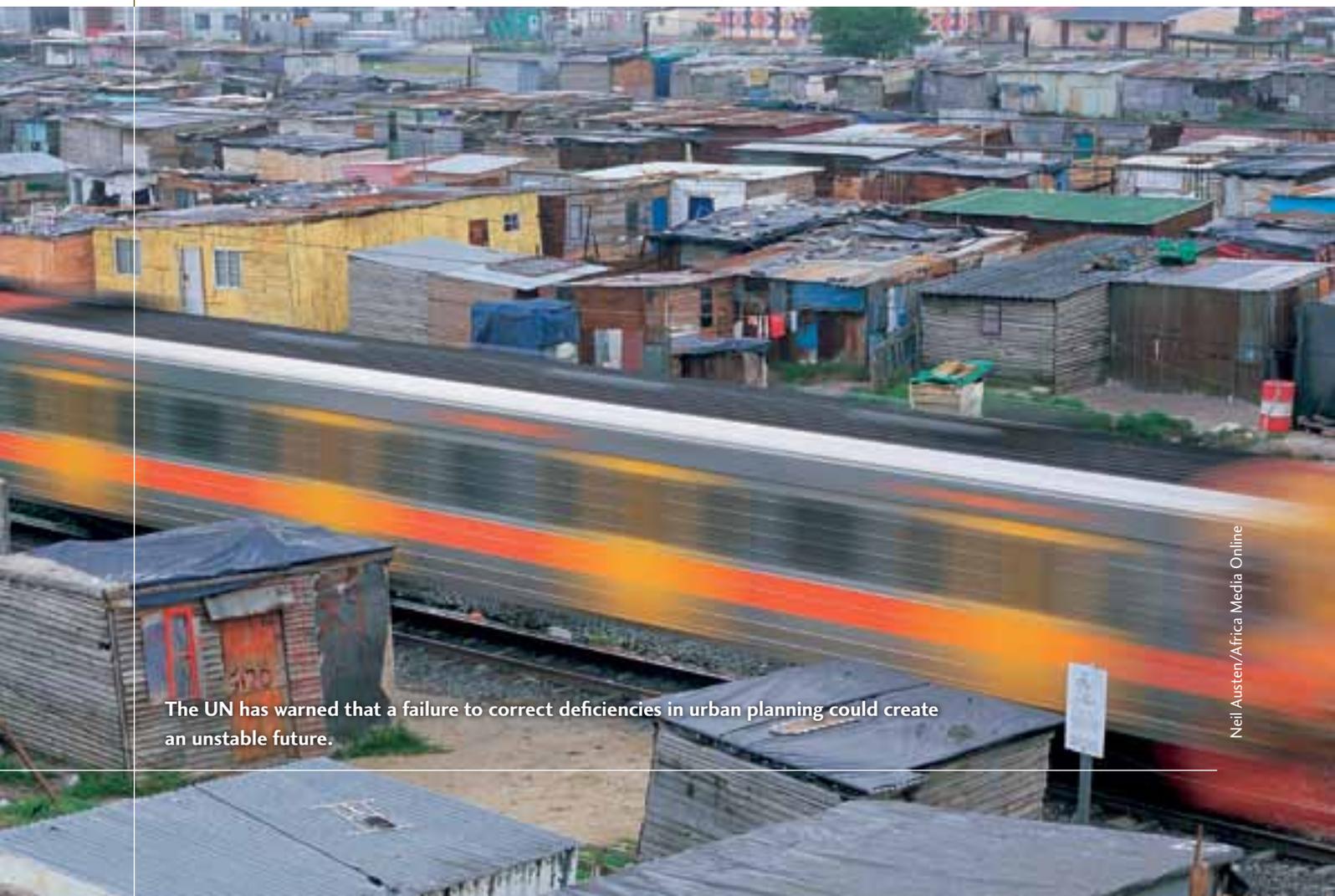
2.4 Informalisation of urban centres

Urban growth in southern Africa is largely associated with high levels of informality: 62% of urban inhabitants in southern Africa live in informal areas, and this percentage is increasing. UN-Habitat (2008) has further disaggregated this statistic into types of deprivations associated with slum areas: overcrowding, informal housing, lack of access to water and sanitation and

insecurity of tenure. This increases the inhabitants' vulnerability to climate-related threats, exacerbated by the fact that many informal settlements are on marginal land such as flood plains and steep slopes. In addition, the poor are most likely to be affected by less dramatic environmental disasters such as polluted water sources, lack of adequate sanitation and solid waste disposal, lack of services such as potable water, roads and stormwater, communication networks and electricity (as evidenced in the case studies – Section 3.2). This is as a result of their lack of assets and political voice (IFRC, 2010).

2.5 Governance

Urban centres have a particular form of governance within the spheres of government. On the one hand, they are largely dependent on central governments for revenue, as well as policy direction and determination of mandates/devolution of functions. On the other hand, they are expected to raise their own revenue and exercise jurisdiction over devolved functions within their legislated geographical boundaries. Their actions are often restrained by their physical boundaries, as well as by limited or decreasing revenues relative to increasing mandates and populations. Added to this is the often limited ability of local government to perform its functions, let alone improve its capabilities. Climate change then becomes an added stressor to an already dysfunctional system, making urban areas particularly vulnerable to any climate-related (or other) disaster. Local government is the sphere of government which is 'closest to community', and the opportunity is greatest at this level for government-civil society cooperation and coordination.



The UN has warned that a failure to correct deficiencies in urban planning could create an unstable future.

3. Climate hazards and climate change in southern Africa

Projections are that southern Africa will become significantly warmer, more than 3.5°C on average in the continental areas (Christensen *et al.*, 2007). While the western areas of the continent are projected to become largely drier, the eastern areas are likely to become wetter. Increases in rainfall are likely to be experienced through greater intensity and variability of rainfall. Both these scenarios may cause agricultural decline, health and flooding problems, which may lead to further movements of people, and will need to be planned for.

Hydroclimatological disasters in Africa are already increasing and becoming more intense (CRED, 2012). This may be explained in part by the increase in population, and therefore the number of people exposed to hydroclimatological hazards, as well as the change in frequency and intensity of extreme weather. The ability of urban centres to establish effective early warning systems, disaster management and disaster recovery and reconstruction will be tested, and requires a concerted, coordinated effort from a variety of stakeholders: national government, local government, the private sector, civil society and financiers. Other RCCP research has already shown that despite the presence of early warning systems for extreme weather in the region, it is the ‘last mile’ of impending extreme weather warnings and adaptive responses that are not implemented well, with negative consequences for citizens.

3.1 Temperature increases

Mean annual temperatures have increased by about 1.2°C since 1960 (McSweeney, 2008). Mean annual temperatures are projected to continue increasing by a further 1–3.1°C by 2060 and more than 4°C by 2090. Much of the warming will be experienced in the June–July–August (JJA) cool dry season. The number of hot days and hot nights has increased by 20–35% respectively since 1960, with the strongest warming experienced in the JJA months (McSweeney, 2008). Likewise, the number of cold days and cold nights has reduced by 5–11% over the same time period, most change occurring in the September–October–November (SON) quarter. These trends are expected to continue – multimodel simulations give a consistent view of warming across the region.

3.2 Rainfall

Seasonal rainfall over much of southern Africa is controlled by the position of the Inter-tropical Convergence Zone (ITCZ) over parts of southern Africa during the southern hemisphere summer. The amount of rainfall received is broadly correlated to how far south in

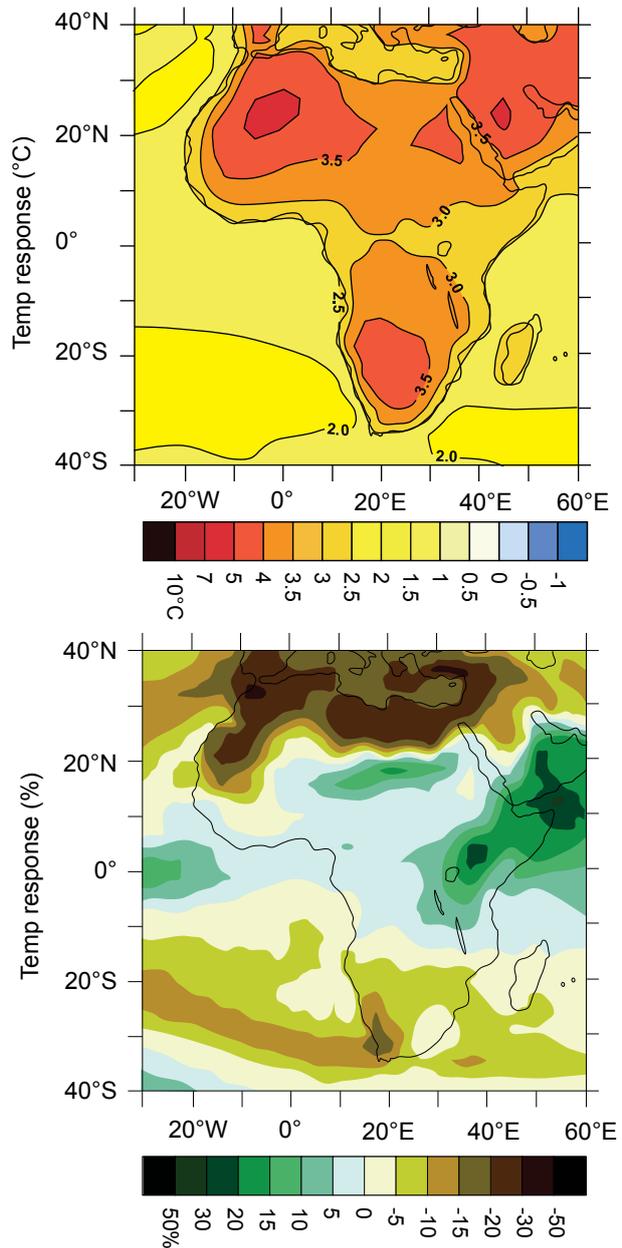


Figure 2. Multimodel aggregation of likely temperature and rainfall changes

Source: Christensen *et al.*, 2007

the subcontinent the ITCZ penetrates. The position of the ITCZ is in turn influenced by the phases of the El Niño Southern Oscillation (ENSO) sea surface temperature atmosphere dynamics in the Pacific Ocean, as well as a similar system in the Indian Ocean, called the Indian Ocean Dipole (IOD). During El Niño years, the region



Inland flooding may result in standing water, which soon becomes a health risk in unserviced informal settlements.

tends to receive less than its average rainfall and drought is usually associated with a strong El Niño. The converse is also true and during the La Niña component of ENSO, the region tends to receive higher than normal rainfalls and this phase is often characterised by regional floods. The frequency and intensity of future ENSO phases is likely to be influenced by the amount of warming in the Pacific Ocean. Global circulation models (GCMs) do not however give consistent views or projections of ENSO trends (Christensen *et al.*, 2007). It is the frequency of the wet and dry phases which gives effect to the most important part of the climate change signal. Nevertheless, a multimodel aggregation of likely rainfall changes for the region is given by Christensen *et al.* (2007) (Figure 2).

What is more certain is that the warming of the atmosphere will create more intense convection storms (see Trenberth *et al.*, 2003 for an explanation of the mechanism). This effect has already been observed over southern Africa (New, 2006; Kruger, 2006), where the intensity of 1-day rainfalls has increased in inland areas. This translates into a greater frequency of localised flooding and increased duration of dry periods (Trenberth *et al.*, 2003). A continuation of this trend can be expected with a warming atmosphere. It is likely therefore that the southern African region will experience an increase in rainfall variability, as well as an increase in the intensity of extreme weather.

3.3 Cyclones, storm surge and flooding

The south-eastern seaboard of southern Africa is exposed to the impacts of tropical cyclones in the Indian Ocean, from the Mozambican northern border to Richard's Bay in South Africa. These, and sub-tropical and temperate latitude cyclones (also cut-off low pressure systems), are storms that also have oceanic-terrestrial interactions. They have a severe impact, firstly by creating the conditions for storm surge, and secondly by generating large quantities of precipitation, creating floods inland. A storm surge arises from a dome of water created as the sea surface responds to strong winds piling up water against the land surface, assisted by the low atmospheric pressure of the storm (which occurs through strong circular atmospheric convection). Both effects can combine to lift the local sea level by as much as 1–2 m. These conditions can be exacerbated by a strong wave run-up, caused by a highly energetic wave climate generated by strong winds.

The combined effects cause flooding at river mouths, which when coinciding with severe storm surge, creates a double jeopardy in that stormwater rises are higher than would be created by a flood inland or storm surge separately. Human habitation tends also to be located at these places, for economic and aesthetic reasons.

If we assume that the key climate change signal will be a change in the frequency and intensity of extreme weather, then the number of people in these exposed areas will increase with climate change, both because the populations in these areas are increasing and because of the changing nature of the climate. The United Nations State of Cities Report (2010) also notes that 25% of Africa's one billion people live within 100 km of the coast and large numbers of people who live immediately adjacent to the coastline are exposed to the risks of sea level rise. The impact of severe storms is likely to be worse when imposed on top of the expected sea level rise. The IPCC (Nichols *et al.*, 2007) expects sea level rises from 0.4 m to more than 1 m by 2100. With increasingly powerful storms at sea (Webster *et al.*, 2005; Christensen *et al.*, 2007), severe coastal erosion and flooding can be expected, especially along the eastern and southern coastlines of southern Africa. The Indian Ocean islands are likely to be similarly affected.

4. Other causes of vulnerability to climate change in urban centres

Urban poverty and disaster are often closely related (IFRC, 2010). Urban poverty and poor (unplanned) settlement location is a powerful multiplier of exposure to dangerous conditions through lack of risk-reducing infrastructure. Overcrowding in an area where there is an absence of drainage can, and does, turn regular seasonal heavy rainfalls into frequently harmful floods (IFRC, 2010).

Migration has been, and still is, strongly driven by the search for economic opportunities. The increase in female migrants is a feature of southern African migration characteristics (UN-Habitat, 2008). This is especially noted in the case of women traders and workers who work across borders, and the trend is linked to the informalisation of economies. Women have tended to fare better than men in the informal service sectors (UN-Habitat, 2008). High levels of unemployment coupled with inadequate housing and services for incumbent populations has made migrants particular targets of crime and violence, on top of already high background levels of these social pathologies. Anti-immigrant attitudes have become prevalent, especially in South Africa but also Botswana, Zimbabwe and Zambia, with the competition for economic opportunities and resources (UN-Habitat, 2008).

Rapid expansion of southern African cities has mostly taken place without a parallel expansion in the capacity and reach of waterborne sewer networks (with the exception of the more wealthy southern and western countries – South Africa, Namibia and Botswana) (UN-Habitat, 2008). This has predisposed the majority of the inhabitants of urban centres, at least in the developing countries, to exposure to waterborne disease during flooding.

4.1 Health

HIV/AIDS, tuberculosis (TB), malaria and cholera are the major diseases prevalent in overcrowded urban areas. HIV/AIDS has a very indirect link to climate change – primarily it is one in which the HIV/AIDS epidemic has so overwhelmed the health issues of southern Africa that the impacts of climate change have largely been ignored (van Hasselt and Chapman, 2012). TB, as an airborne disease, spreads far more rapidly through densely populated areas, and especially so where a large number of people are already immuno-compromised (WHO, 2011). Multi-drug resistant strains have emerged recently. The world's TB epidemic is centred in southern Africa where tuberculosis is closely linked to over-crowding and malnutrition – making it primarily a disease of poverty. The prevalence of coinfections by HIV/AIDS and TB globally has its strongest relationships in southern Africa (WHO, 2011). The prevalence of these two diseases is likely to be the

strongest in the overcrowded urban and peri-urban areas of southern Africa.

Malaria can and does increase in urban and peri-urban areas where drainage and drain maintenance is poor and there are frequent occurrences of stagnant water. Cholera is bacterial in nature and the disease spreads most easily in those areas where there is poor hygiene and a lack of water supply and good sanitation. Other diarrhoeal diseases are also prevalent in urban areas of poor sanitation (WHO/ UNICEF, 2009).

With respect to the neglected tropical diseases, there are strong differences between rural and urban areas in the possibilities of contracting African trypanosomiasis (sleeping sickness). The tsetse fly vector is only found in rural areas where it is strongly associated with vegetation cover. Leishmaniasis (a protozoal disease spread by female sandflies) is however an increasing problem in expanding informal settlements, particularly because coinfection of the disease with HIV is an emerging problem (WHO, 2010). The case fatality rate of coinfection is high (WHO, 2010). Housing and settlement clustering is a significant risk factor, especially where buildings are poorly constructed and have highly porous walls. Poverty is another major underlying determinant of the disease. Migration is also a cause of outbreaks in new areas and migration due to regional famine has been shown around the world to be a factor in new infections.

Air quality is slowly becoming more of a problem in southern African cities in localised urban areas – with increasing vehicular emissions, smoke from unventilated cooking fires and burning biofuels for heating in winter. This situation is exacerbated by the lack of availability of electricity to poorer households, as well as the intermittent nature of power supplies in some southern African countries. The links between climate changes in this region and declining air quality have not yet been established.

4.2 Food security

Because of the poverty-driven rural-urban migration, newly arrived migrants (and often those who have been urbanised for a while) have few income-generating or employment opportunities. Their lack of cash means they are also often food insecure. Food insecurity is strongly propelled by the incidence of disease, particularly HIV/AIDS (Crush *et al.*, 2007). The burden of disease is a co-factor of poverty and hunger. Food security related initiatives such as the Regional Hunger and Vulnerability Programme (RHVP), Famine Warning Systems Network (FEWSNET), Vulnerability Assessment Committees (VACs)



Greg Mainovich/Africa Media Online

Cholera spreads most easily where there is a lack of good sanitation. Residents of Sebokeng, South Africa, negotiate a street flooded with sewerage.

and Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS), which are all funded by donors, have been primarily focused on rural areas (Crush and Frayne, 2010a). There are no pointers in how increasing rural food production of smallholders will increase the food security of urban dwellers. The Regional Indicative Strategic Development Plan of SADC, as indicated by Crush and Frayne (2010a), does not pay much attention to the trends of urbanisation. Regional development strategies in southern Africa need to take a much stronger view on accommodating the strong urbanisation trend and dealing with the social pathologies which are emerging from that – overcrowding, malnutrition, health issues related to hygiene, poor quality water supplies, expensive water, compared against even lower levels of sanitation, etc. Issues of urbanisation need to be addressed specifically.

Crush *et al.*, (2010b) argue that urban food insecurity is the emerging development issue of this century and that the food security strategies of the urban poor is the controlling factor of the stability and quality of life in African cities. Ironically, the urban poor are more vulnerable to high food prices than are the rural poor (Crush *et al.*, 2010b). One envisaged solution is the support of the rural smallholder, but this has not taken the realities of urban or rural economic conditions into account. Crush *et al.*, (2010b) also argue against the image of food security as a ‘rural production problem’, and state that the issue of food insecurity is more of an urban problem. The increases in wages in urban areas have not kept track with the increases in food prices, pushing more people into poverty, hunger and exposure to diseases and strengthening the link between poverty, hunger and ill

health in urban areas (Kalipeni, 2000).

Climate-induced food price shocks have a big impact on food-insecure people in urban areas. Because of the global connectedness of the grain trade, drought-induced losses of wheat yield in Argentina and Russia in 2007–2008 have been anecdotally linked to the food riots in Maputo in 2010 as global prices rose dramatically (Warshawsky, 2011). With rising food prices, the urban poor are more severely affected than the rural poor, who can use other, but less valuable, resources (Wodon and Zaman, 2008).

4.3 Other vulnerabilities

The Mozambican NAPA notes the severity of erosion of the coastline is most severe near coastal urban centres and that while this is a response to natural forces, human causes also play a part, including the use of sand as a raw material (MICOA, 2007). They also note that most of the countries’ urban centres are vulnerable in one way or another to environmental hazards that result from haphazard settlement and ineffective land-use planning and management. Tourism development on coastal dunes is having an especially negative effect on coastal stability.

The Zambian NAPA (2007) specifically mentions climate-proofing sanitation in urban areas. Through its associated human health vulnerability assessment, it was demonstrated that it is the urban areas that are most vulnerable to diarrhoeal diseases from comparisons of clinical cases of diarrhoea along the Copperbelt (MTENR, 2007). An important source of disease is the annual flooding of pit latrines during heavy rainfall and the contamination of surface water sources (MTENR, 2007).

5. Lessons from three southern African cities

5.1 Beira

Beira is a tropical east African city that serves as a port terminus of transport corridors to Malawi, Zimbabwe, Zambia and as far as the south-eastern parts of the Democratic Republic of the Congo. It is heavily dependent on the trade and economies of these countries. It is Mozambique's second largest city and has a population of half a million people, but is growing rapidly. Recent oil and gas finds on the offshore continental shelf, as well as mining development near Tete and Moatize (coal), is creating the push factor of an increasing attractiveness for economic prospects and therefore in-migration.

5.1.1 Migration and change

Influxes of people into the Beira environs occurred in waves, picking up after the end of colonial rule in the 1970s as people moved to towns for economic reasons (Table 2). An additional factor was the civil war in Mozambique, with people moving into the towns as a measure to increase personal security. This was given extra impetus by the added hazard of intense drought, which resulted in famine and the deaths of more than 100 000 people in 1981 in Mozambique (CRED, 2012). Many people settled in unplanned and unserviced low-lying areas, less than 5 m above mean sea level, which are highly prone to flooding.

Table 2: Population growth in the Port of Beira, Mozambique

Year	Population	Type	Source
1970	113 770	Census	secondary
1980	230 744	Census	secondary
1997	412 588	Census	official
2007	436 240	Census	official
2012	441 723	Calculation	

Source: World Gazetteer, 2012

5.1.2 Water supply and sanitation

About half of inhabitants have access to clean municipal water supplies (JMP, 2010). Water services can be intermittent; however, improvements have brought supplies up to nearly continuous operation to those who have connections (World Bank, 2010). Use of groundwater is unfeasible because of the low ground level and the dangers of saline intrusion, apart from the risks of fecal contamination of groundwater. About 27% of inhabitants have access to modern sanitation services (World Bank, 2010), which will increase significantly after a new

project is completed in 2012, funded by the European Development Fund. The system is complex because of the shallow water table. Substantial investment is still required to increase sanitation coverage even further.

5.1.3 Health profile

Living in a tropical area with a high poverty rate, people are exposed to a particular suite of diseases. Malaria is the top cause of death in children under the age of five (WHO, 2006). Other communicable diseases include HIV/AIDS (12% of the population) and tuberculosis. Cases of cholera in Mozambique increased markedly from the late 1970s and the country contributed between a third and a fifth of all notified cases in Africa in the years of 1992, 1993, 1998, 1999 and 2004 (WHO, 2006). Beira has been an important source of infection, especially since 1998 (WHO, 2006). Case numbers decline along with diminishing seasonal rainfall, indicating a contaminated surface water link. Other diarrhoeal diseases include dysentery, which sometimes occurs at the same time as cholera outbreaks (Aragón *et al.*, 1998)

5.1.4 Impact of climate change and variability

Beira is located at the estuary mouth and confluence of the Pungwe and Buzi rivers in a narrow embayment with a large and shallow continental shelf. High waters in these rivers contribute to the flooding hazards in the built areas. Sedimentation in the estuary and shifting sandbars make navigation hazardous. The town is highly exposed to tropical cyclones in the Mozambique channel. Storm surge from a severe tropical cyclone moving into the bay zone is likely to raise mean sea level more than 1.5 m (according to results from the SLOSH model – World Bank, 2010). Added to this hazard is the wave run-up, as well as the possibility of backwater flooding from high waters.

The chief climate change threat is the change in the frequency of intense tropical cyclones and storms in the south-western Indian Ocean, in conjunction with sea level rise (see, for example, Webster *et al.*, 2005). The National Institute for Disaster Management (INGC) has also tracked these cyclones and also shows a significant increase in the number and intensity of storms in the past decade. The INGC has made significant progress in developing effective early warning systems at national level, but also down to the level of the four most vulnerable neighbourhoods in Beira (comprising 18% of Beira's population).

Sea level rise is a particular concern as storm surges already have an impact on the city and peri-urban environs, as well as the port. Disaster management is therefore



Beira, Mozambique's second-largest city, has a population of 500 000, and is growing rapidly.

a top priority for immediate response during extreme weather. The INGC is responsible for 'proposing policies and strategies to government for the prevention and mitigation of disasters.' In addition, in partnership with the municipality and with the support of local committees, they take control of natural disaster management such as cyclones and floods.

Climate changes that increase the intensity of tropical cyclones and storm intensity in this part of the world will exacerbate the situation, especially in the poorer and low-lying peri-urban areas. The Mozambican NAPA has little to say about future climate projections, however.

5.1.5 Disaster management

The municipality and the INGC (and others) have established local committees for risk and disaster management, early warning systems, coastal protection, sanitation (under construction), opening and cleaning of drainage channels, mangrove reforestation, plantation of adequate species to absorb excess water and repositioning of vegetation on the dunes. The disaster management system could further improve its coordination to reduce inefficiencies, according to the Beira research Focus Group. The sea wall protecting the part of the city north of the port was damaged in August 2010 by a spring high tide (Figure 2). The road directly adjacent to it is vulnerable to flooding and sand inundation. The Swiss Government is assisting in its restoration.

5.1.6 Strategic planning and action

Medium- to long-term city planning can be an effective tool to avoid climate hazards by controlling land uses. However, these will only be effective if implemented and enforced. The municipality of Beira has a strategic development plan and a climate change draft concept note for Beira city which supports the strategic plan. The Railways Company has an environmental department, and there is a Coastal and Harbour Strategic Protection Plan. However, the necessary resources for carrying out these strategies are not readily available.



Figure 2: A sea wall in Beira, destroyed during storms and not reconstructed (increasing inland risk)

5.1.7 Role of local government

The Beira Focus Group (see Section 1 for a brief description of these entities and the appendix for a list of institutional members) asserted that a number of factors are hindering the effective provision of basic services. The *internal factors* are human capacity and the need for appropriate technology; lack of effective tax collection and the complexity of the city. *External factors* include the rate of growth of informal settlements; the lack of public/private partnerships and inter-sectoral collaboration.

Municipal laws and taxes are seen as the most effective existing mechanisms for improving service levels and many suggestions were made for new mechanisms, including:

- institutional: decentralisation of competencies, involvement of local committees in the urbanisation, waste management, bags distribution and depots allocation; improvement of the community organisations;
- financial: increase in number of tax payers; and
- attitudinal: campaigns to change behaviour; clean-up campaigns.



Dar es Salaam is a low-lying coastal city with over three million inhabitants.

A view of the city from the Kigamboni peninsula.

This city also faces some important and difficult governmental decisions regarding the political economy at national level. With the discovery and exploitation of large mineral resources inland and seawards, the focus on Beira as an economic hub will take on greater importance in the Mozambican economy. The urban centre was located there for historical reasons, without a view to its possible future economic importance or to its future climactic vulnerability.

5.2 Dar es Salaam

Dar es Salaam is a tropical city on the east coast of Africa with a population of about 3+ million people (see Table 3). The conurbation is located over the watersheds and catchments of four rivers. Lowland wetlands include mangroves, near to which unplanned habitation is tightly packed and which is vulnerable to flooding through storms in the catchments or flooding from the seaward side, where intense oceanic storms increase seawater surges. Rainfall averages about 1 000 mm per year and temperatures are tropical and humid. Tropical diseases are an ongoing concern, including malaria and dengue. The inhabitants located in the lowland and wetlands have long-standing difficulties with sanitation, waste disposal as well as general services such as water and road infrastructure. Years of unplanned urbanisation has lead to an urban sprawl of singly storey (or double at the most) structures, creating large suburban areas such as Mbagala, Chirambe, Kigamboni, Mburahati, Segerea, Tandale, Makumbusho. Satellite photographs show that absolutely no allowance has been made to preserve riparian and flood zones that would be expected within a well planned city (Figure 3).

Table 3: Population growth in Dar es Salaam, Tanzania

Year	Population	Type	Source
1978	769,445	census	secondary
1988	1,205,443	census	secondary
2002	2,345,424	census	official
2010	3,212,040	calculation	

Source: World Gazetteer, 2012



Figure 3: Peri-urban living in the Dar es Salaam suburb of Tandale, adjacent to water courses with no provision made for storm runoff and flooding

Current levels of access to the services usually required for a well-functioning urban area are highly inadequate. The most inadequate basic services are water provision, energy, sanitation and safe land for housing and development, all of which have public health implications. A cursory examination of household density shows individual households that contain 4–6 individuals on every 180m².

5.2.1 Water supply and sanitation

The Water Sector Development Programme (WSDP) of the Ministry of Water anticipates that by 2015, 65% of Tanzanians should have access to clean and safe water. The Dar es Salaam research Focus Group reports that poor access to potable water, especially in the slums, has badly affected the public health situation. Further, the natural drainage systems in Dar es Salaam, such as the Sinza, Mlalakuwa and Mbezi rivers, have been blocked by industry dumping effluent and solid waste there, meaning there is no adherence and policing of by-laws. If the natural drainage systems were revived in terms of competence to carry floods, flooding in Dar es Salaam would be greatly reduced. Studies have shown that 60–70% of water from the Ruvu River (which is the main source of tap water for

Dar es Salaam) is lost on the way to the city; this has been identified as an important intervention. The Ministry of Water is also working with the Energy and Water Utilities Regulatory Authority (EWURA) to help in developing the necessary regulatory tools. The big national water consumers, such as companies Tanzania Breweries and Coca-Cola, have initiated activities aimed at securing water futures in collaboration with World Wide Fund for Nature (WWF). Other large water consumers are showing an interest in similar collaboration.

Currently, people living in those areas with no access to water must meet their needs through buying from water vendors, neighbours with connections, constructing illegal connections from the main water pipes and using boreholes – especially in those areas in which the water table is high (where unlined pit latrines pose severe risks to water quality through contamination).

About 15% of people living in the city have access to waterborne sewerage; the remaining 85% rely on pit latrines and most of these are unlined (Dodman *et al.*, 2011). Apparently there is a local practice of using seasonal floodwaters to flush these pit latrines and consequently cholera outbreaks are frequent, with a high case of mortality. Disposal of solid wastes also remains an enormous problem. Cholera incidence appears to be closely related to the density of informal and unplanned settlements because of the inadequate water supply and sanitation facilities, proximity to health facilities and income level (Penrose *et al.*, 2010).

5.2.2 Energy

Statistics indicate that only 10% of Tanzanians have access to electricity; only about 0.3% of people in Dar es Salaam depend on electricity as their sole domestic energy source. The Focus Group further reported that the main utilisation of electricity in Tanzania is for lighting and industrial activities. The alternative sources of energy are charcoal, firewood, kerosene and fuel generators. The NGO Tanzania Traditional Energy Development Organisation (TaTEDO) believes that charcoal and firewood will remain the main source of cooking energy. TaTEDO promotes efficient use of charcoal and wood stoves. The Focus Group participants reported that approximately 3.4 tonnes of carbon per household per year could be saved through the use of efficient firewood stoves.

The organisation is also engaged in capacity-building activities on efficient ways of making charcoal, which is a source of household income for many rural families. There are ongoing efforts to implement new energy technologies, such as biogas from animal dung and household waste, and the making and use of organic briquettes. Public buildings like schools and prisons are being targeted for biogas technology: so far six bio-latrines are expected to be built in prisons, starting in 2011.

5.2.3 Safe land for housing and development

About 70% of the population of Dar es Salaam lives in poor quality housing in unplanned settlements. The layout of the city is highly inefficient, poorly serviced by road infrastructure and/or service servitudes. Studies have shown that with proper planning the current population

of Dar es Salaam could be accommodated on one third of the land. Because of the failure to plan and service areas, the poor have no option but to settle in new, unplanned settlements without adequate services, resulting in increased living costs as residents have to acquire these privately.

5.2.4 Impacts of climate change and variability

Flooding in the informal areas of Dar es Salaam is one of the most visible and high-impact effects of extreme weather. As recently as late December 2011, more than 20 people died as floods ripped through the flood-prone, low-lying but inhabited areas of the city. More than 60 000 people living in 6 000 houses are liable to flooding in some parts of the inhabited area (Lusugga Kirronde, 2006). Lack of maintenance of the existing drainage systems creates the highly suitable conditions for mosquitoes to complete their life cycles; consequently malaria and dengue are severe health issues.

There are predictions that the semi-arid areas in Tanzania will receive less rainfall. The Ruvu River depends on rivers originating from these arid areas, which implies that availability of water in Dar es Salaam is insecure: the city is already experiencing water stresses, with frequent seasonal shortages. Decreased rainfall due to climate change will also impact on the electricity supply, which is dependent on hydroelectric power – for example, the main supplier of electricity in the country, TANESCO, relies on hydroelectric power generation produced by the Mtera Falls dam. The company is trying to adapt to climate change by finding ways of producing power with less water. The current strategies include strengthening the capacity for hydropower generation, as well as investigating and promoting alternatives such as wind and geothermal power generation. It also includes working with the private sector as potential power producers.

The impacts of sea level rise on coastal stability are significant. Annual maximum storm surge has been calculated at about 2.8m and the 1:100 year storm at more than 3m (Linguisti and Vonortas, 2011). Annual storms are contributing increasingly to coastal erosion and projected sea level rises will increase the potential for damage dramatically, such that the annual maximum storm surge plus projected sea level of 1m by 2100 will result in the 1:100 year return period surge becoming closer to the 1 to 5 year maximum surge. This type of change will overwhelm existing sea defenses and result in very significant coastal erosion.

5.2.5 Adaptations

Climate-related disasters

The Prime Minister's Office (Division of Disaster Management) is responsible for coordinating disaster management activities in the country. It consists of a Disaster Management Committee with members at regional, district and village levels. The disaster committee includes stakeholders from all ministries. At a local level, the Ilala Municipal Council, Environment and Water Sanitation Department, has an emergency preparedness plan. In case of any disaster, the office communicates

The impacts of sea level rise on coastal stability are significant. Fishing boats offload at the Kivukoni fish market.

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with other responsible stakeholders to deal with the impacts. The Focus Group noted that at present, disaster preparedness and management is largely the responsibility of the individual. While the institutional arrangements have been put into place, they have not been put into operation or made effective. This implies the need for more leadership and action at local government levels.

Urban and development planning

The Tanzanian National Adaptation Plan of Action (NAPA) provides a guideline for adaptation priorities and plans. The programme recognises water, energy, agriculture and forests as the sectors most impacted by climate change, and they are thus prioritised in adaptation actions rather than impacts in urban areas. Lack of funds hinders implementation of development plans. For instance, the city council has set up some urban development plans, but lacks funds to implement these schemes. The Disaster Management and Training Centre (DMTC) at Ardhi University is advocating mainstreaming risk reduction in urban planning. The research showed that while inadequate planning can be a recipe for disaster, good planning can reduce risk.

The National Water Sector Development Strategy (NWSDS) has led to the formulation of the National Water Resource Management Act and the National Water Supply and Sanitation Act. The Water Sector Reform Project under this strategy (lead by the Ministry of Water and supported by GTZ) is enhancing water access to poor communities, as well as facilitating water supply and sanitation activities. One strategy is the establishment of water kiosks, another is capacity building. The project is also involved in the development of concepts and guidelines on how commercialisation can improve water services.

Role of local government

Dar es Salaam city council is responsible for coordinating the powers and functions of the three municipal authorities, preparing a coherent city-wide framework for enhancing sustainable development, promoting cooperation between the city council and local government authorities, and providing security and emergency services. With respect to climate change, the council restricts people from encroaching on areas prone to climate change impacts. Examples of such restricted areas are Mbezi and Msimbazi river valleys. The council is also running a number of development projects. These include:

- infrastructure upgrading;
- 'safe cities', which is also involved in provision of entrepreneurship education to rural youth so as to reduce rural urban migration; and
- 'cities without slums' in which sustainable land management forms its focal point.

The local government was reported by the Focus Group to have failed in providing the basic services. The factors given were:

- political interference in prioritising service provision;
- poor governance (it was raised that the local government has shown limited governing capacity);
- corruption, reported to be interfering with most of the development plans;
- lack of accountability: some political leaders are not accountable – for example, some are not paying their water tariffs. Attempts to disconnect the service is usually accompanied by threats from these leaders; and
- inadequate infrastructure systems: these were said to be poor and deficient.



Environmental Protection and Management Services (EMPS) is also involved in a study on “Challenges of climate change on shelter provision and poor settlements”. The findings show that there is a poor link between local government systems, community organisations and municipalities. A change of attitude is needed towards urbanisation. Currently the rural immigrants are blamed for problems in the urban areas, while much of the problem is simply the basic poor institutional capacity and funding to plan and deliver services. Planners and decision-makers need to plan for growing populations, a state of affairs that is highly evident in Dar es Salaam. However, some still felt that the only way to address urbanisation was to stem it through improving agriculture and services in the rural areas.

5.3 Lusaka

Lusaka is the capital city of Zambia, with an estimated population of more than 1.4 million in 2010 (see Table 4) and growing at about 4% per year at that time. The city covers an area of 375 km² and is located at 1 280 m above sea level on a watershed, in typical major southern African city style, without the benefit of being a major port (Gauteng, the major industrial region of South Africa, Harare and Dodoma also fit this description). Government administration and the services sector (domestic, commercial and financial) provide the most paid employment.

Table 4: Population growth in Lusaka, Zambia

Year	Population	Type	Source
1980	498,837	census	official
1990	769,353	census	secondary
2000	1,084,703	census	official
2010	1,451,145	calculation	

Source: World Gazetteer, 2012

Lusaka has extensive slums due to a lack of housing provision and poor planning, and no policy implementation (Lulenga, 2003). The city quadrupled in size in the

period 1963–1980, growing at more than 6% per year. The absence of statutory building standards caused a series of housing crises and expansion of unauthorised settlements at the urban edge (Lulenga, 2003). At present, about 70% of the city’s population lives in unplanned and unserved informal settlements where average monthly household income is about ZMK 370 000 (\$100 USD), compared with the ZMK 2 million (\$560 USD) received by inhabitants in planned settlements (Pegasys, 2011). The cause of the high proportion of informal settlement has been the speed of change (rate of immigration) and the unavailability of low cost housing during those times of greatest migration flux (MLGH, LCC and JICA, Volume 1, 2009). The small urban centre of Sesheke has a current annual growth rate of about 9.2% (World Gazetteer, 2011).

About half or more of Zambia’s live in urban and peri-urban areas, in unplanned informal settlements. Zambia’s population is expected to grow to 14 million by 2015. This most likely means more unplanned settlements in urban centres and larger peri-urban areas. The World Gazetteer also shows that growth in some Zambian urban centres such as Sesheke achieved 10% per year recently (World Gazetteer, 2012), although it needs to be emphasised that this is not the norm.

5.3.1 Policies and politics of urbanisation

Restrictive policies limiting rural-urban migration existed in colonial times – however, little support is now forthcoming from national or local (rural or urban) government to manage urbanisation, despite policies and acts focused on the matter. Urbanisation is not viewed favourably, in general, citing increased pressure on local government to provide services (in peri-urban areas); unemployment and other ‘vices’; stress on family structures; disease and rural poverty as reasons (Lusaka Focus Group). The Focus Group felt that government should support rural development through infrastructure development and agricultural support, and urban areas through creating an enabling environment for investors, including positive political will, coordination and the decentralisation of funds. Existing private ownership,



Paul Weinberg/Africa Media Online

Informal traders in an informal settlement in Lusaka. Most working people in Zambia are in the informal sector, and 70% of Zambians live in unserviced informal settlements.

cumbersome land acquisition processes and political interference restrict access to land (especially by the poor) (Lusaka Focus Group). This results in poor people settling on flood-prone land, exposed to flood hazards. The UN report makes the point that what is needed is the sustainable provision of infrastructure and essential services including sanitation (Lulenga, 2003). The provision of education also lags.

5.3.2 Water supply and sanitation

Access to clean water is deficient as a general rule and legislation regarding city planning and management is outdated and obsolete. Lusaka suffers particular water supply and sanitation deficiencies. Water demand currently outstrips supply of 260 000 m³/day. No major improvements in supply have taken place for 30 years (LWSC, 2010). While groundwater resources exist in the underlying dolomites, these are being rapidly polluted by pit latrines and completely overburdened and poorly performing waterborne sewage systems (Pegasys, 2011). Only 28% of the population had access to flushing toilets by 2006 and there has been little change since.

The Focus Group indicated that 86% of the population in urban areas has access to clean water, compared to 50% in the peri-urban areas (ZWP-MEWD, 2008). However, in the city water supplies are intermittent and potable water from water kiosks is expensive, while the common mindset is that water should be free. While the Lusaka Water and Sewerage Company (LWSC) is rolling out new infrastructure in Libala South, this is a response to crisis rather than a proactive decision.

Boreholes are the common response in areas where infrastructure is poor or services are unreliable. The increased number of boreholes leads to over-extraction in dry seasons, which could lead to the collapse of underground caverns (sinkholes) in the dolomitic terrain. Sinkhole development has taken place in parts of Lusaka and is known elsewhere in southern Africa (Johannesburg and Pretoria) where water extraction has caused a loss of buoyancy and support of the ground surface. This creates significant problems for municipal management because

it becomes hard to police and maintain open ground that is unsafe. Individual initiatives such as boreholes are not regulated.

Only 25% of Lusaka's residents (32% of the area) are on the central sewerage system, which is not fully functional. 75% of residents use onsite sanitation such as pit latrines and septic tanks. More than 40% of people are peri-urban (WSUP, 2009) and about 90% of these use pit latrines. Poor drainage and poor waste management lead to a high groundwater table, periodic flooding during the rainy season (Figure 6) and pollution (Nyambe and Maseka, 2000). Pits fill up with waste and need relocation – itself a problem where space for new structures is limited. Some laws and regulations mitigate against adaptations (e.g. the laws on moving human waste – Water Supply for the Urban Poor (WSUP)). Existing initiatives around the supply of sanitation include the LWSC, with WSUP, (an NGO) seeking funding partners to spend £2 000 000 per year for five years on improved sanitation provision, including Ecosan toilet systems (Pegasys, 2011).

Climate change is expected to increase the frequency of urban flooding and adequate drainage systems (stormwater) are a necessity that remains to be addressed. Vulnerability of the population in the peri-urban area is heightened by part of the city underlain by limestone/dolomite, which contains high quantities of water which may be contaminated by the use of pit latrines (Nyambe and Maseka, 2000). The capacity of Ecosan latrines is too low to cope with demand. Sanitation is also not a popular service in which to be involved, so tends to be neglected (Lusaka Focus Group).

5.3.3 Food security

Growth in the city continues to outpace growth in social services and increasing food insecurity in the peri-urban centres appears to be a growing issue. Major health problems within the peri-urban areas of Lusaka include protein energy malnutrition (PEM) as is iron deficiency (anaemia) and Vitamin A deficiency (Pegasys, 2011). Urban agriculture is negligible in places because of the lack of space and water for irrigation. It is evident elsewhere that

during crises urban agriculture expands rapidly – this is very evident in Harare at present. There are essentially four types of urban agriculture: gardening for food, semi-commercial gardening, commercial gardening and rainy season agriculture (Drescher, 1997). Women have an extremely important role in urban agriculture – they produce most of the food. Gathering (from biodiversity sources) is still an activity but has declined substantially because of the diminished resources (Drescher, 1997).

5.3.4 Energy services

In the peri-urban areas the major sources of energy are charcoal, petroleum (for generators) and the formal electricity supply. Zambia is chronically short of electricity. However, access to electricity is low (20% in urban areas), and so is access to charcoal (the implication of this is accelerated deforestation to supply the higher demand). Deforestation is a major issue in Zambia and it has one of the highest rates of deforestation anywhere. Solar and wind power utilisation is very low because of the extremely high initial costs of solar units. Adoption of biogas as an energy source is limited. There are difficulties with large-scale adoption of alternative, ‘high-tech’ solutions because the capacity for technological ‘deepening and servicing’ just doesn’t exist.

5.3.5 Transport and markets

Road infrastructure in general is inadequate and under pressure, and road construction is not well regulated. Traffic congestion on roads, combined with floods resulting from heavy rainfall, is leading to the degradation of the road infrastructure (Pegasys, 2011). Roads in the peri-urban areas are unplanned and defined by homesteaders’ needs. The quality of the transport infrastructure has a direct effect on the types of economic activity that can take place. Markets are therefore also predominantly small-scale traders located opportunistically. As an example of adaptation and socioeconomic development, markets could become more efficient if there were a ‘cold chain’ from harvesting to selling, reducing wastage (remembering that food insecurity is a developing issue in peri-urban areas of Lusaka). This seems far removed from the modern conveniences that are developing in central Lusaka.

5.3.6 Drainage systems

The city is built on a plateau that is the headwater catchments of three small rivers which mostly flow to the north-east (Pegasys, 2011). Much of the land in the western part of the city is flat, but located on shallow soils, and the underlying rock creates difficulties for construction. Pooling of water is common in the summer rainfall season and the drainage infrastructure to prevent this does not exist. The inadequate solid waste removal and waste management exacerbates the health impacts of the inadequate drainage through increased contamination of surface waters with chemical and pathogenic pollutants (Pegasys, 2011). In Lusaka, cholera is closely related to the occurrence of heavy rainfall (based on WHO data), with the potential for climate change to result in an

increased frequency of heavy rainfall. Groundwater is also affected, as contaminated water percolates into the water table. Floods also displace populations and destroy infrastructure, including communications.

5.3.7 Impact of climate change and variability

While local belief is that climate change will result in some drying in the region of Lusaka, increasing the chances of drought, IPCC (2007) multimodels indicate a possibility of wetting. An increasing variability of rainfall seasons has been recorded (McSweeney, 2010) and this trend is expected to continue. New *et al.*, (2006) also show an increase in the frequency of intense 1-day rainfalls. More intense rainfall will have an undoubted effect on increasing the incidence of local flooding, with a knock-on effect on human health (cholera, dysentery) and loss of assets. McSweeney (2010) indicates a highly likely increase in the number of hot days and hot nights and this could have a notable effect on health issues, particularly relating to the incidences of malaria.

5.3.8 Disaster management

The city’s experience of frequent flooding has strengthened its response structures (“experience is the best teacher”) according to local disaster management authorities. Early warning systems are being established, under the Disaster Management and Mitigation Unit (DMMU), which has a 3-tier management system that includes provincial and local or district management structures. The early warning system is still weak and a proactive risk mitigation approach should be adopted, rather than being reactive to disasters after the event (Lusaka Focus Group). The following attributes still require implementation: improved coordination between those with differing responsibilities, increased integrated planning, and the mainstreaming of climate change and vulnerability into planning activities. A particular focus on reducing vulnerability and/or exposure to climate hazards at local authority level is required, on top of improved management of the disaster.

5.3.9 Strategic planning and action

The development of a master plan for Lusaka is underway but already the Focus Group anticipates problems with its implementation. They feel that improved town planning and its implementation are needed, including a deliberate housing policy. An alternative to strong political influence is required as a way of creating the necessary diversity of opinion on how management should respond. It was noted that the Sixth National Development Plan (SNDP) has added a chapter on climate change which should give some focus to the issues in urban areas. However, local government is hindered in playing its role by: financial and human resource constraints; possibly a lack of political will – especially in managing the settlement of migrants; the lack of capacity to enforce local laws and the inadequate involvement of stakeholders in planning. Finally, the scale of the problem appears overwhelming.

6. Discussion

6.1 Common themes

The lack of preparation of areas for settlement (i.e. supplied with basic services including water, sanitation and stormwater management) is the prime factor causing vulnerability to the impacts of climate change, especially that of extreme weather. Principally, these include the poor state (or total lack) of stormwater drainage and water supply and sanitation services. In a properly functioning urban area, settlement would not be tolerated in low-lying, poorly drained areas. In all case studies flooding during and after heavy rainfall remains one of the most visible and frequently experienced climate-induced hazards.

From the literature and as demonstrated by the three case studies, and indeed to implement any kind of spatial growth plan which takes into account the basics of good planning and safety, it is apparent that urban centres struggle to service their rapidly growing populations with basic infrastructure. This creates the context for the high impact of extreme weather-related disasters. Those who are most affected are the urban poor, because of resultant health threats and inefficiencies (for example, the poor are paying more, per unit of water from water vendors, than are those serviced by the municipal system). None of the NAPAs of southern African nations prioritise change in the urban centres in any meaningful way, except the Zambian NAPA, which concerns itself specifically with flooding. The continuing view that urbanisation is a temporary and reversible phenomenon seems to be prevalent across southern Africa and this stance continues to be an inhibiting factor in developing a more resilient urban habitat.

6.1.1 Urban planning and basic services

Bulk urban services for water and sanitation in the formal parts of the cities are decaying, and local governments need assistance to upgrade these, in terms of capital investments and capacities to maintain services, if not upgrade them, over time. One of the most significant outcomes of the rapid urbanisation in southern Africa has been the low levels of attention to water management, which includes potable water supply, waste water transport and treatment, and stormwater management and disposal. Even large private sector bulk users of water are realising that they either need to access independent water supplies, or assist the municipalities to increase supply to meet their needs. Efficient energy use options, as well as health, transport and education services are also not in place and need to be implemented.

Addressing the inefficient layout of these cities – where new settlements are low density (or high density, low rise), peripheral and unserved – is a challenge which overwhelms management capacity. Bulk urban services for old and new areas need to be rehabilitated and/or new ones provided in more efficient layouts. The lack of provisioning of basic services will continue to be a public health threat, exacerbated by climate stressors. A more proactive approach needs to be taken therefore, with an improved spatial growth strategy that includes rapid release of serviced land pre-empts some of the combined effects of peri-urban settlement and the effects of increasingly difficult environmental conditions.

6.1.2 Food security

Food insecurity is widespread in southern African cities and urban areas, primarily because of poverty. However, people are vulnerable to climate shocks through the impact of climate on agricultural yields at global scales. In South Africa it has been shown that the introduction of government grants and welfare has led to the reduction in urban food production (Warshawsky, 2011). Food supplies are mostly adequate at city level in southern Africa but it is the poverty and lack of cash that creates the high levels of food insecurity. Agribusiness food chains are the answer to food security, not necessarily small farmers (Crush *et al.*, 2010) – but elsewhere, they show that the urban poor are well served by the informal food markets selling food on the street. The solution to food insecurity in urban areas is to create the means of spreading and increasing income, which requires investment, good governance, improved infrastructure (especially energy infrastructure and supply), education, telecoms and transport. There is no short-term sustainable fix. Also, the analysis of whole cities becoming less food secure as a result of increasing aridity in traditional food source areas is not addressed in this document, but is an area for further research.

One solution to the urban food crisis that has been posed is one in which the urban poor produce their own food (Crush *et al.*, 2010). This solution faces difficulties in many areas because of the very crowded nature of informal settlements. Other issues include the availability of suitable land, gender biases in asset ownership and the availability of labour in female-headed households (of which there are many)(Crush *et al.*, 2010). Another option is food banking, which involves a substantial donor commitment (Warshawsky, 2011). This is not sustainable however, due to the dangers of increased dependency of recipients on food parcels and regular handouts,

combined with the unreliability of donors who tire of continuing obligations.

6.1.3 Health

The major diseases of HIV/AIDS, malaria, cholera and TB are common themes of most urban areas in the LDCs. TB however has become more widespread even in the wealthier of southern African countries and this is related to the HIV/AIDS pandemic, which is accelerated by widespread conditions of poverty and food insecurity. Elements of poor health that are strongly related to climate, such as malaria and cholera (as well as other diarrhoeal diseases), are highly prevalent in poorly serviced and managed peri-urban areas, where the close proximity of vulnerable populations provides ready pathways for infection.

Breaking the chain of infection of cholera and other diarrhoeal diseases requires substantial improvements in water supply and sanitation, Malaria incidence can be reduced by improved maintenance of drainage systems, through spraying programmes and works that reduce the incidence of stagnant water. The lack of good planning, in the way it affects layout of urban zones and the exposure to hydroclimatological hazards, as well as infrastructure, are among the most important causes of poor health in the urban centres of many of the LDCs.

6.1.4 Disaster management

It has been shown repeatedly that 'experience is the best teacher'. Municipalities are becoming more adept at disaster management and early warning systems, with Mozambican urban centres being the most prepared (they have been affected the most by tropical cyclones): they could provide valuable lessons to other parts of the region. While good institutional arrangements for disaster management may exist on paper, however, there are problems with functional coordination between different departments, and between different levels of government, as well as community level and disaster aid agencies. Much can be done with minimal resources: the willingness to cooperate is the key resource. In addition, these cities identified the need to manage forests and river courses in their hinterland, to enable them to meet the cities' ecosystem services needs and reduce the possibility of a degrading environment contributing to disaster outcomes.

6.1.5 Urbanisation

A negative perception towards urbanisation persists widely, because city and urban zone managers are unable to cope with the migration pressure. Various strategic approaches are implicit in the response to this trend: a 'do nothing' option; a strong anti-urbanisation approach, and a strong pro-urbanisation approach. Different approaches may be appropriate in different regions/countries, depending on whether the rural population has reached the carrying capacity of the land. However, it is unlikely that even strong anti-settlement approaches will work and all urban centres need to try to meet the demand with the greatest efficiencies possible.

Whichever approach is adopted, proactive mechanisms to ensure the availability of well-located, secure land for new urban settlement are required, to accommodate natural urban growth; and national adaptation plans need to be translated into plans that are locally relevant. A scenario-building, strategic approach to the consequences of different policies may be useful to envision safer, efficient and effective outcomes.

6.1.6 Local government

The trend in southern African countries is for the responsibilities of management to be devolved to local level. However, these often come without the additional funding needed, and local governments struggle to raise sufficient local revenue that is needed to meet the demands of building even the most essential of basic services. On the other hand, the rapid growth of urban areas is a stimulus to the urban economies, and while this may not be easily measured as it is largely in the informal sector, it does indicate the role that urban areas can play in mitigating against a range of human security threats. More effective local governance which addresses institutional weaknesses and appropriate (national and local) funding sources is an obvious need. Research has noted the need to develop economic infrastructure (e.g. Pegasys, 2011), and with improved economic performance will come the improved access to capital necessary to undertake the required investments, operation and maintenance of infrastructure.

It should be noted that donor or funding organisations who are less familiar with the poor state of planning and the growth of slums might think that a small number of interventions are all that is necessary to impart a greater level of protection against climate hazards. However vulnerability is a lot more fundamental, with huge humanitarian implications for the future if urban growth continues unmanaged and without anticipation. The report by the IFRC (2010) is recommended for a more in-depth discussion of some of these issues.

To summarise, institutional deficiencies in the different urban centres and their lack of capacity to carry out planning and management provisions remains at the core of urban and peri-urban vulnerabilities and sensitivity to extreme weather. These problems can be expected in LDCs. Since a greater incidence of extreme weather is likely to result from global warming and climate change, urban and peri-urban communities can be expected to face increasing climate-mediated risks.

7. Recommended adaptations

In line with international experience, urban centres should be zones of reduced vulnerability and sensitivity to extreme weather. Physical infrastructure should be protective and emergency services be able to respond relatively efficiently. Formal settlements on the periphery of southern African cities are often the focus of disaster management and health authorities. This indicates that they are vulnerable and sensitive to severe weather. Well planned urban areas with the necessary infrastructure are not only economically efficient but should also offer more protection against climate hazards.

National governments should review the predominant view that urbanisation needs to be resisted. Nations with large, efficient cities that are economically active tend to be wealthier than those that are less urbanised and have less installed economic infrastructure. Adaptive capacity of those urban dwellers who are not ultra-poor is probably considerably higher than their rural equivalents, with more diverse climate-insensitive livelihood opportunities; much better access to services (health care, education, markets, quicker emergency response times) and more cost-effective systems.

Improvement of basic services is the first priority of increasing climate resilience. Economic growth in some southern African countries is creating investment opportunities for improvement of basic services. Urbanisation, supported by appropriate services and well located, is an appropriate climate change adaptation strategy. In many urban centres, while local institutions are still required to carry out their service roles, capacity is still disconnected from mandate. Improvement of basic services that rely on 'preferred, cheaper options', are often under-designed and under-specified for the intensity of use they experience (e.g. pit latrines in Lusaka). Thus improvements can become ineffective as a service option if the scale of investment is not large enough. Poverty also remains a major factor of vulnerability. Improving resilience will only take place when there is increased economic activity and increased distribution of income. Therefore investments in the economic infrastructure of cities will have an important but indirect effect on resilience to climate change impacts.

While there are many existing initiatives in the major urban centres to improve governance, urban planning and to improve the lives of people living in slums, a key intervention would be to invest in making these investments more 'climate smart'. The investments need to align with desirable climate change adaptation outcomes.

Key targets for investment which will particularly increase adaptive capacity in many southern African

urban centres include:

- **Water supply and sanitation:** The reduction in the potential for diarrhoeal diseases is one of the most important objectives of increasing climate resilience. Cost-benefit analyses of the opportunity costs of water supply (what are the economic and social costs of being sick and dying against the costs of installation and maintenance) show that the benefits of water treatment outweigh the costs (Hutton and Haller, 2004). Elsewhere (e.g. van Hasselt and Chapman, 2012) it has been noted that diarrhoeal diseases, including cholera, have a strong climate link and are a high priority health intervention target. Cholera outbreaks in Beira, Dar es Salaam and Lusaka are far more common during heavy rainfalls that result in flooding in urban areas. This relationship holds for other southern African cities such as Maputo. Contamination of surface waters by faecal matter is the primary route of infection in these cases.
- **Stormwater drainage:** Most southern African urban centres in least developed countries suffer from flooding problems. All of the urban centres in the case studies have stormwater drainage problems. Existing stormwater drainage systems need to be rehabilitated. Properly functioning drainage systems to remove stormwater rapidly and safely from an urban area are a necessity. New drainage capacity needs to be constructed.
- **Provision of modern public health services:** This includes not only the response to individuals contracting infectious diseases, but also the preventative measures to ensure the minimum possibility of being exposed to malaria and dengue, diarrhoeal diseases (including cholera – see above) and emerging and neglected tropical diseases. Public health professionals need to work with their infrastructure and maintenance counterparts in municipal services to undertake activities that result in the disruption of disease pathways and vectors.
- **Disaster risk and response:** Each municipality should have a well-planned and efficiently functioning disaster risk and response (DDR) strategy. While DRR plans and strategies exist in many urban areas, there is often very little capacity to undertake the specified actions.
- **Food security:** The problem of food availability and affordability is not easily addressed by directed investments. While urban agriculture has been proposed as one approach, theft of crop yield is an unsolvable problem. Probably the most sustainable solution is to invest in the economic infrastructure

A crowded street in Bukavu, DR Congo. Population displacement resulting from conflict in the eastern parts of the country places strain on the resources of recipient towns and cities.



Lori Wasechuk/Africa Media Online

and economic efficiency, with the objective of increased employment opportunities and income of inhabitants. A mix of solutions may improve the situation, which could also include ‘food banking’ (Warszawsky, 2011), but this needs to focus only on emergency situations or dependencies could easily be established.

Key recommendations are for greater support for developing the capabilities of the institutions responsible for undertaking the required planning and the installation of services. Primarily this means improvements in city and smaller urban centre governance capability. How local governments will go about reducing risk by withdrawing inhabited areas from dangerous zones is not known at present. However, it is clear that significant storms in some areas, such as some suburban parts of Dar es Salaam and especially those areas threatened by high water in Beira, create very significant risks. Enforcement of planning provisions is one necessity that needs to be achieved as soon as possible.

Opportunities exist to build institutional capacity to self-finance. Building resilience is a long-term process.

It includes the decentralisation of management and activities by the local governments, improved bottom-up planning and stakeholder awareness and sensitisation. The ability to self-finance for predictable and continuous funding will allow sustainable and streamlined development. Donor funding is often project based and variable, creating difficulties for maintaining revenue after donor sponsorship ends. Institutional capacity must also improve in order to: a) prevent unplanned settlements occurring; b) increase the delivery of essential services, and c) manage services sustainably so as to ensure continuity of supply. This requires strengthening of financial sustainability and human resources.

Continuous engagement by government and the private sector will yield results. Other parties have a role to play. Proactive mechanisms to ensure the availability of well-located, secure land for new urban settlement is required to accommodate natural urban growth; and National Adaptation Plans of Action should be translated into locally-relevant plans and funded into reality. There are also opportunities for significant private sector input, such as large bulk water users assisting municipalities to increase their supplies of good quality water.

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Acronyms and abbreviations

DFID	Department for International Development (UK)		Disaster Management, Mozambique
DMTC	Disaster Management Training Centre (Ardhi University, Tanzania)	ITCZ	Inter-tropical Convergence Zone
ENSO	El Niño Southern Oscillation	IOD	Indian Ocean Diapole
EPMS	Environmental Protection and Management Services (Tanzania)	LDCs	Least developed countries
EWURA	Energy and Water Utilities Regulatory Authority (Tanzania)	LWSC	Lusaka Water Sewerage Company
FAO	Food and Agricultural Organisation	MEWD	Ministry of Energy and Water Development
FEWSNET	Famine Early Warning Systems Network	NAPA	National Adaptation Plan of Action
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems	RCCP	Regional Climate Change Programme
GDP	Gross domestic product	RHVP	Regional Hunger and Vulnerability Programme
IDRC	International Development Research Centre of the Canadian Government	SADC	Southern Africa Development Community
ICLEI	Council for Local Environmental Initiatives (an international association of local governments focusing on sustainability)	SNDP	Sixth National Development Plan (of Zambia)
IFRC	International Federation for Red Cross and Red Crescent Societies	TaTEDO	Tanzania Traditional Energy Development Organisation (an NGO)
INGC	Instituto Nacional de Gestao de Calamidades/National Institute for	VACs	Vulnerability Assessment Committees
		WSDP	Water Sector Development Programme (Tanzania)
		WSUP	Water and Sanitation for the Urban Poor
		WWF	World Wide Fund for Nature
		ZWP	Zambia Water Partnership

Appendix: Institutional members of the in-country Focus Groups

Institutional participants in the Beira, Mozambique, Focus Group

- Caminhos de Ferro de Mocambique (Centro) (State railways company)
- Cimentos de Moçambique (cement manufacturer)
- Direcção Provincial de Coordenação da Acção Ambienta de Sofala (Provincial Directorate for the Coordination of Poverty and the Environment)
- Direcção Provincial de Obras Públicas e Habitação/ Provincial Directorate of Public Works and Housing
- GTZ
- Instituto Nacional de Meteorologia
- Notícias Da Beira
- PRO-GRC Institutionalization of Disaster Risk Management in Mozambique
- Saneamento e Águas da Beira (Municipal Water Supply and Sanitation)

Institutional participants in the Dar es Salaam, Tanzania, Focus Group

- Ardhi University
- Dar es salaam City Council
- Disaster Management and Training Centre, Ardhi University
- Environment Protection and Management Services
- GTZ-Water
- Ilala Municipal Council
- Ministry of Lands and Human Settlements
- Ministry of Health and Social Welfare
- Ministry of Water
- National Environment Management Council (NEMC)
- National Land Use Planning
- Prime Ministers Office, Division of Disaster Management
- TANESCO (Tanzania Electric Supply Company)
- Tanzania Red Cross Society
- Tanzania Tradition Energy Development Organization (TaTEDO)

Institutional participants in the Lusaka, Zambia Focus Group

- Ministry of Health
- UNZA IWRM (University of Zambia, Institute for Water Resource Management)
- Chainama College
- Zambia Electricity Supply Commission
- Ministry of Energy and Water Development – Department of Water Affairs
- National Institute for Scientific and Industrial Research
- OneWorld/RCCP
- Kanyama Health Centre
- Water and Sanitation Association of Zambia
- Water Resources Action Programme
- Zambia Daily Mail
- Ward Development Committee Chaisa
- Ward 20 Chaisa
- UNICEF
- Ward Development Committee Kanyama
- Ministry of Agriculture and Cooperatives
- Ministry of Health
- Danida
- Ministry of Local Government and Housing
- Lusaka City Council
- Environmental Council of Zambia
- Ministry of Health
- Zambia Meteorological Department
- Wateraid
- Disaster Management and Mitigation Unit

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The maps on pages 16 and 17 were produced by Rob Davies of Habitat Info Ltd.

Series Editor: Andy Mason

Typesetting: Ink Design

Cover photograph: Khayelitsha, South Africa.

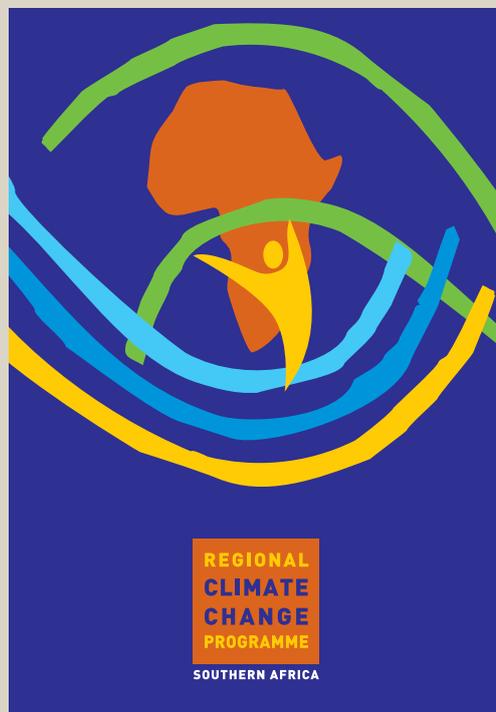
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