C40 CITIES FINANCE FACILITY

Flooding in East Africa

The impacts on and implications for cities in East Africa, with a case study of Dar es Salaam

Contents

About the C40 Cities Finance Facility:

The C40 Cities Finance Facility (CFF) is a collaboration of the C40 Cities Climate Leadership Group and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The CFF supports cities in developing and emerging economies to develop finance-ready projects to reduce emissions to limit the global temperature rise to 1.5°C and strengthen resilience against the impacts of a warming climate. The CFF is funded by the German Federal Ministry for Economic Development and Cooperation (BMZ), the Children's Investment Fund Foundation (CIFF), the Government of the United Kingdom (Department for Business, Energy and Industrial Strategy) and the United States Agency for International Development (USAID).

About the CFF in Dar es Salaam:

The Climate-Smart Solid Waste Management Project aims to reduce Dar es Salaam's vulnerability to climate change-induced flooding. The CFF is assisting Dar es Salaam City Council in identifying appropriate flood attenuation measures, as well as adaptation and community-based solid-waste management interventions for the middle Msimbazi River catchment (from Kawawa Road Bridge to Pugu Hills and the surrounding settlements of the Msimbazi floodplain). The CFF further supports Dar es Salaam City Council in the project preparation process for technically feasible interventions.

Assessments of potential flood attenuation and adaptation measures and community-based waste-management interventions are being made through a series of specialist studies and a multi-stakeholder consultation process. The specialist studies include a waste-management study, flood modelling and a flood-management feasibility study.

Section 1. Introduction

African cities are among the fastest growing globally. Mass migration and the resultant urban sprawl have created cities that are vulnerable to the impacts of climate change. One of the primary climate-related risks they face is the destruction and harm caused by flooding. Growing populations, a lack of infrastructure and limited vegetation leads to increased flood risk.

The cost of such flooding grows ever year and the effects are felt by all citizens to varying degrees. Vulnerable populations are particularly at risk, as their homes are often built on available land in flood plains and they have limited financial resources to recover from disasters.

If flood risk is not addressed, it will continue to drain cities' financial resources and endanger lives and livelihoods.

This report examines the different types of flood and their current and future impacts on East African megacities, taking Dar es Salaam as a case study. The report explores links to other issues and introduces the concept of an Integrated Flood Management approach.

What is the purpose of this report?

Cities are vulnerable to natural hazards, due primarily to their high concentration of people, infrastructure and economic assets. Megacities and emerging megacities in low- and middle-income countries, in particular, face unique threats from climate change, as vulnerable populations tend to be focused in high-risk areas. In such cities, upwards of 70% of the population may be living in informal settlements – and this number continues to grow with rapid urbanisation. Newcomers and migrants face housing shortages and outdated residential planning requirements, often from a past colonial era. Infrastructure growth is not keeping pace with the rate of urbanisation, leading to bottlenecks in the supply of housing and other basic services. Settling in an open expanse of land on a floodplain is often the only option.

However, these populations may also be excluded from the formal economy, leaving them more at risk when there are shocks and stresses in the economic system, and more vulnerable to floods because of their location.

Indeed, one of the main climate-related risks these cities face is the destruction and harm caused by flooding. Climate change will only compound these risks in the future as rainfall patterns become more unpredictable and more intense and sea levels rise, causing more coastal flooding. Broader variations in climate will also translate into more frequent and/or severe storms, rain, flooding and drought cycles (IPCC, 2018).

Around the world, policymakers, city officials and technical experts are already responding to climate change. To make informed decisions, these stakeholders need to understand the causes, likelihood and severity of climate change impacts and the range, cost and efficacy of the various options to limit or adapt to them.

The issue is complex and, to create effective programmes to combat the myriad risks, city officials and experts need to understand the entire system.

Only then can they can make informed decisions, increase the resilience of their cities and citizens and be prepared in the event of a flood.

This report is aimed primarily at policymakers in emerging megacities, where the population is set to reach more than 3 million by 2050, but also at practitioners and other interested parties. It is the first in a two-part series on the flooding issues faced by East Africa, aimed at deepening city officials' and planning departments' understanding of the long-term sectoral impacts of flooding. The objective is to inform on and raise awareness of climate change issues, specifically, flooding in emerging megacities in East Africa.

The report begins with an introduction to the concept of flooding in an emerging megacity, reviewing the types of flood experienced and the growing issue of flooding overall. We then undertake a case study of Dar es Salaam and conclude with a link to integrated risk management. The second report in this series will look at current flood-related projects in Dar es Salaam and the CFF's activities in the city, it will be published in early 2021. This report is accompanied by an infographic, which offers a visual representation of the information with a view to engage new constituencies (National Research Council, 2010).

Section 2. Flooding in East African megacities

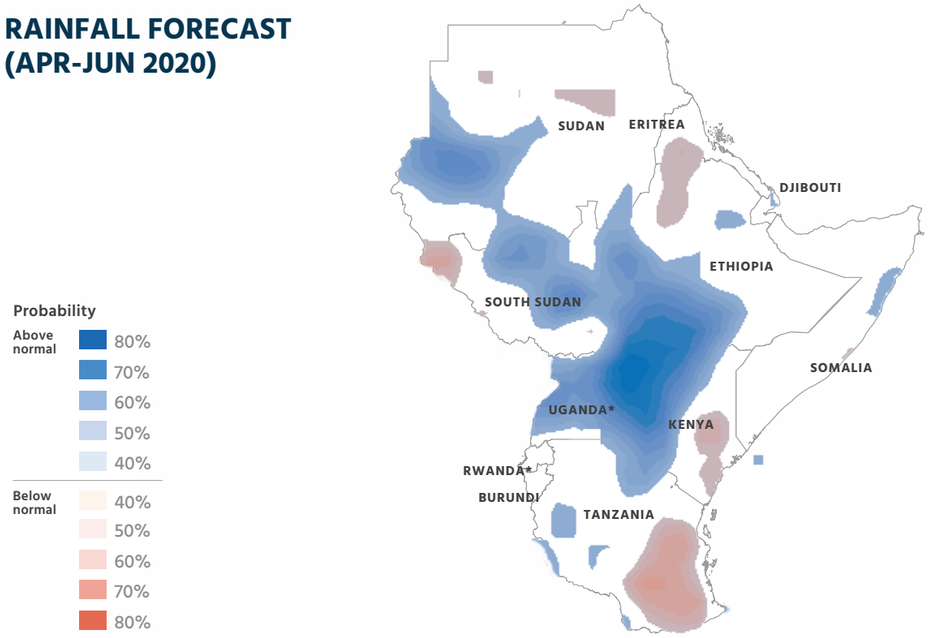
Flooding is one of the most destructive natural hazards. Records suggest that both flood frequency and severity are on the rise and likely to worsen in the face of climate change (Dewan, 2013). At the same time, the world's rural inhabitants are migrating to its cities on a massive scale. The speed and magnitude of urbanisation has created sprawling cities, with burgeoning informal settlements and slums. In unplanned urban environments that continue to grow, infrastructure is often minimal to non-existent and residents are exposed to the dangers of flooding (Wamsler et al., 2020).

East Africa is burdened by the dual pressures of climate change and the rapid, uncontrolled transformation of its cities into megacities. For the purposes of this report, we will define East Africa as Kenya, Tanzania, Uganda and the Horn of Africa, comprising Somalia, Djibouti, Eritrea and Ethiopia. East Africa is a region in which emergencies tend to be protracted and extensive, resulting in significant displacement, among other things (OCHA, 2020).

Since the beginning of the 'long rains' season in March 2020 alone, more than 1.3 million people have been affected by flooding in East Africa, with at least 481,000 of them displaced (OCHA, 2020). During the same period, almost 200 people have lost their lives to overflowing rivers and mudslides in Kenya, while 40,000 have been displaced (Jones, 2020). The water levels of Lake Victoria reached their highest point since records began 120 years ago, displacing thousands of people, flooding homes and businesses, damaging infrastructure, and destroying roads. In Uganda, numerous flash-flooding incidents have caused people to flee to higher ground.

Aftermath of flooding in Dar es Salaam. Source: Shutterstock.

RAINFALL FORECAST (APR-JUN 2020)



FLOOD-AFFECTED AREAS

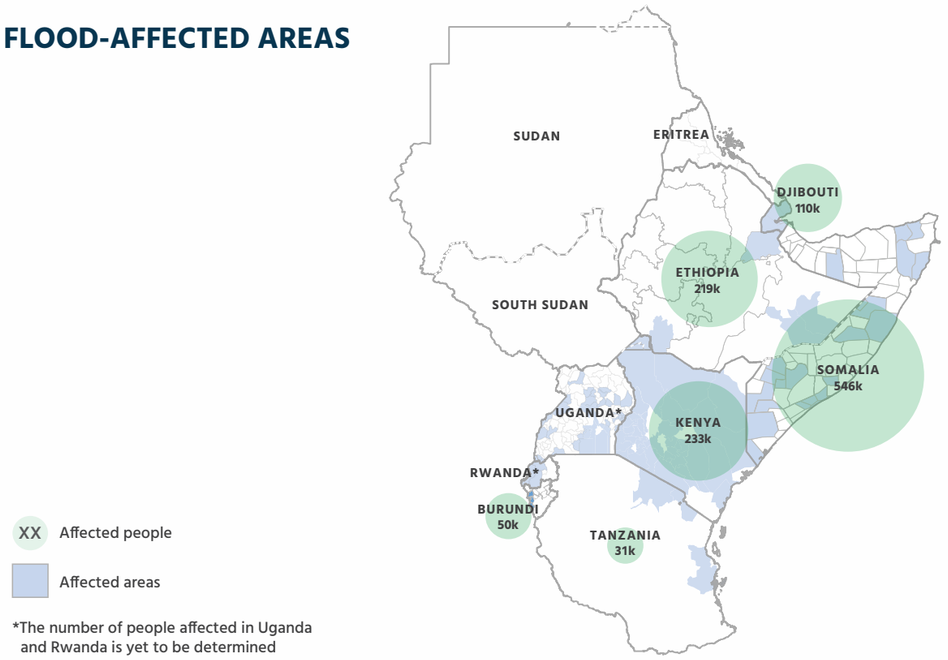


Figure 1: Snapshot of flooding in East Africa **Source:** OCHA (2020)

2.1 Flooding impacts

The impacts of climatic hazards are unevenly split among urban populations. Lower-income communities tend to live in marginalised areas that face greater risk of climate disaster more generally (floods, landslides and earthquakes, for instance), but also in flood-prone areas with insufficient sewage and drainage systems.

Overflowing pit latrines and clogged sewers and drains due to improper waste disposal and untamed vegetation pose widespread health risks to poor residents. These conditions lead to such areas becoming breeding grounds for disease vectors, contaminate wells and springs, and result in water becoming unsafe for household use (START, 2011). Diseases such as cholera, malaria, diarrhoea and measles spread easily among displaced people living in unsanitary conditions with limited access to clean water. Their capacity to respond to flood events is also lower, as they have less access to information, scant resources to withstand adverse impacts and fewer safety nets. With little assurance that their homes and belongings will be safe in an evacuation, many can be reluctant to leave (START, 2011).

Flooding also is estimated to be the costliest hazard at national level globally, responsible for 62% of all economic losses from natural disasters from 1990 to 2014 (World Bank, 2019b). The most vulnerable populations bear the brunt of this impact. They may be restricted from going to work, or work in the informal sector, which provides little in the way of sick pay or time off.

Flooding in the streets of Addis Ababa (Ethiopia) after heavy rain.
Source: iStock

Tree and riverbank loss and landslides.

Widespread health risks due to stress and the spread of vector-borne diseases.

Loss of life.

Damage to public property – schools, roads, business, agricultural land and livestock.

Interruptions to schooling.

Population displacement.

Economic loss due to the disruption of traffic, public transport and business.

Damage to private property – homes, businesses, agricultural land and livestock.

Loss of food reserves and limited access to clean water.

2.2 Types of flooding

To plan for flooding in a megacity, it is essential to understand the type (or types) of flood it may face. Floods differ in how they occur, how they are forecast and the damage they incur. Although they can vary in scope and severity, most cities experience a combination of the three main flood types – coastal, fluvial and pluvial (Maddox, 2014; Zurich Insurance, 2019).

Manyara, Tanzania. The catastrophic mudflow destroyed a road between national parks Manyara and Ngorongoro
Source: Shutterstock

Coastal (surge flood)

Coastal flooding occurs when low-lying, normally dry land is flooded by seawater. It is typically the result of extreme tidal conditions caused by severe weather. Storm surges are the leading cause of coastal flooding and are formed when high winds push water onshore. Seawater can cause significant damage and disruption to communities, often requiring them to retreat further inland. With the salt in seawater causing further damage to buildings and permeating the groundwater supply, coastal flooding is a serious issue that must be addressed with appropriate flood defences.

The Eastern African coastal zone is heavily populated and continues to attract more people. It is estimated that 13% of the 62 million people in East Africa reside along the coast, due to the rapid development of coastal activities, such as fishing, sea ports for imports and exports, coastal tourism and industry (Hinkel, 2012). Flooding on the East African coast can hinder port activity and damage the mangrove forests that help prevent erosion, while salinity can affect the productivity of nearby agricultural lands (Hinkel, 2012). In the Kunduchi Beach area of northern Dar es Salaam, the coastline has retreated by about 200m over the last 50 years, destroying residential houses, public services (including a mosque), tourism facilities (such as hotels), the historical fish market (constructed in the 1970s) and a seawall constructed to protect Ocean Road (Casmiri, 2008).

Fluvial (river flood)

Fluvial, or riverine flooding, is one of the most common types of flooding. It occurs when water levels in a river, lake or stream rise and overflow onto the surrounding banks, shores and land. The damage from a river flood can be widespread, as the overflow affects smaller and bigger rivers downstream, often causing dams and dykes to break and overflow into nearby areas.

In May 2020, Lake Victoria, which is shared by Kenya, Tanzania and Uganda, saw its highest water levels on record. Due to heavy cumulative rainfall (more than 100mm during the month), the water level rose to 13.45 metres, causing widespread flooding in many areas (Anami, 2020). In Uganda, fluvial flooding displaced communities living close to the shoreline and created challenges for the country's hydropower infrastructure. In Western Tanzania, a further 180 houses, home to 1,655 people, were affected by floodwaters from Lake Tanganyika (Anami, 2020). What's more, Tanzania depends on hydropower for more than 60% of its electricity, so was left with huge power deficits as a result of the flooding, necessitating rationing during the dry season and increased spending on alternative sources, including diesel generators.

Pluvial (surface flood)

A pluvial, or surface-water flood, is caused when heavy rainfall creates a flood event independent of an overflowing water body. One of the common misconceptions about flood risk is that one must be near a body of water to be at risk. Pluvial flooding can happen in any urban area, however, even in elevated areas that lie above coastal and river floodplains.

There are two types of pluvial flood: surface-water and flash floods. Surface-water floods occur when the urban drainage system is overwhelmed and water floods onto the streets. These occur slowly and the water level is rarely more that 1m deep. Flash floods are torrents of water triggered by intense rainfall or a sudden release of water from a levee or dam. They are very destructive because of the debris that is often swept along with the flow of water.

January 2020 saw heavy rainfall in south-eastern Tanzania, resulting in flash floods that led to fatalities and major damage. More than 18,000 people were affected, 13 people died, 5 were reported missing, 1,746 houses were completely destroyed and 1,074 latrines collapsed (Relief Web, 2020). The flash floods caused major damage to local infrastructure, such as schools, roads and bridges, to 495 acres of farmland and to personal property, destroying thousands of livelihoods (Relief Web, 2020).

In northern Dar es Salaam, the coastline has retreated by about 200m over the last 50 years, destroying residential houses, public services (including a mosque), tourism facilities (such as hotels), the historical fish market (constructed in the 1970s) and a seawall

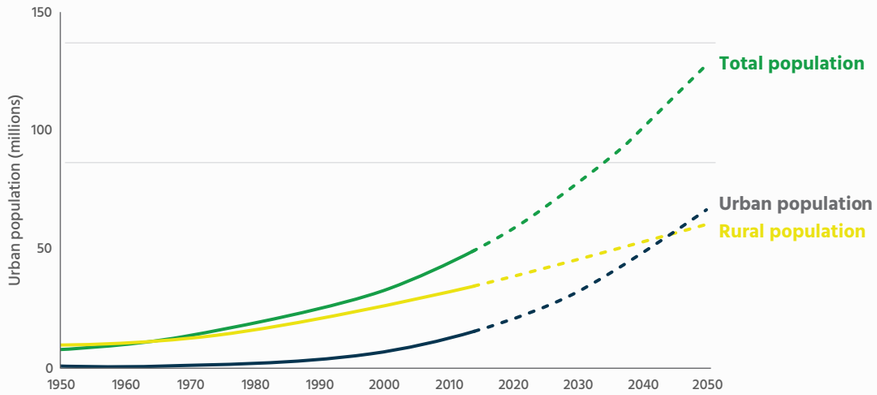
Section 3. Case Study – Dar Es Salaam

3.1 City context

Dar es Salaam is a major city in Tanzania, located on the east coast of Africa. It is the country's commercial and financial hub and home to Tanzania's arts, fashion, media, music, film and television industries. Urban growth is ballooning, as rural residents flock to the city for better opportunities. More and more international residents are also settling there as the economy improves. Dar es Salaam is the second-fastest growing city in Africa, with a population of more than 6 million as of 2018 (UNDESA, 2018). With population growth at a brisk 5.6% a year, the city is estimated to reach 10 million inhabitants by 2030 (UNDESA, 2018) catapulting it into the ranks of the global megacities.

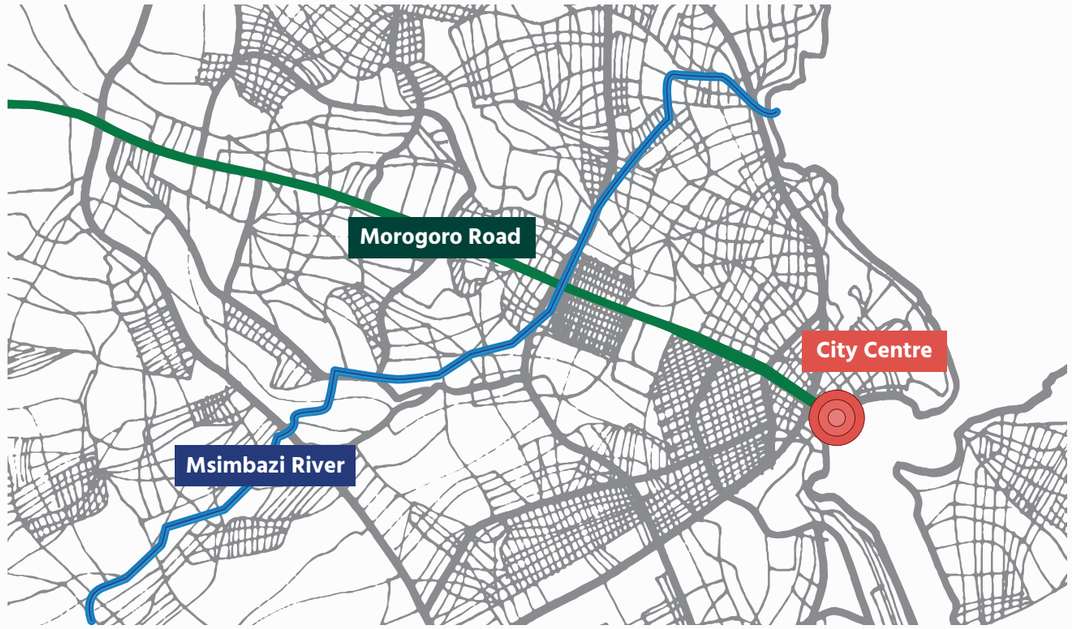
Dar es Salaam is characterised by urban sprawl and large informal settlements. The city faces a combination of poor infrastructure, a lack of housing and inadequate planning, which will only intensify as urbanisation continues apace and the population pressure grows. Seventy percent of the city's population already lives in unplanned settlements (START, 2011), largely out of need. Formal planning regulations in Dar es Salaam hark back to the country's colonial days, when a property had to be at least 400–500 square metres in size, preventing most people from gaining planning permission (Rasmussen, 2013). Thus, they live on smaller plots with vague tenure and legal status. Thus, many people live in settlements tend to be in the low-lying flood plains and eroding coastal zones, where land is available and close to employment.

Figure 2. Tanzania's total, rural and urban populations (millions), 1950-2050



Source: Worrall et al. (2017)

Dar es Salaam



The Msimbazi Catchment

The environmentally degraded Msimbazi Basin covers an area of 271 square kilometres in the heart of Dar es Salaam and houses nearly a third of the city's population. Historically, the river served as an important water source and the fertile floodplain provided prime land for agriculture and animal grazing. However, with time and a changing climate, the riverbed is no longer perennial, but seasonal. This means that for much of the year, the river is completely dry. When the rain comes, it is unable to absorb the sudden influx of water, causing flash floods along its banks and tributaries. The river valley is where the city's most severe flooding takes place every year.

The settlements in Msimbazi Valley are the fastest growing in the city, despite their undesirable location. Easy access to unregulated farming and building plots, proximity to the city centre, low levels of awareness, poor enforcement of regulations on land use and the availability of low-cost housing have spurred the influx of people (START, 2011). The valley areas are overpopulated, exposing residents to life-threatening floods and flood-related health problems.

Flooding in the Msimbazi Valley also impacts life in other areas of the city. The Morogoro Road is vital to the city, as it connects the business district to residential areas. However, the road intersects the Msimbazi River and, as it is raised only a few metres above the water level, it is subject to frequent flooding, paralysing the city. Dar es Salaam's rapid transport system is also built along the road and billions have been spent on repeated repairs (The Guardian, 2020).

3.2 A history of flooding

The combination of highly informal infrastructure and climate hazards makes flood risk a critical challenge for sustainable urban growth and public health in Dar es Salaam (START, 2011). Heavy rainfall frequently causes fluvial and pluvial flooding, particularly in the unplanned settlements of high-risk flood areas.

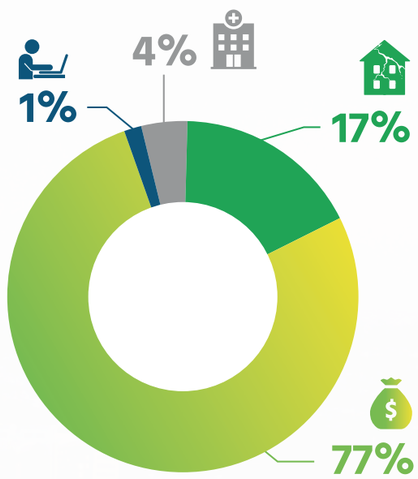
The city is also subject to coastal flooding. About 8% of Dar es Salaam lies in a low-elevation coastal zone that is more than 10m below sea level.

In 2005, models put the number of people exposed to a 100-year coastal flood event in Dar es Salaam at 30,000, with potential asset losses of USD 35 million (Kebede and Nicholls, 2012; World Bank, 2019b). That figure is now more than 210,000 people (at risk of a 100-year event by 2070), at a potential asset cost of USD 10 billion (Kebede, 2012).

In April 2018, Dar es Salaam was hit by some of the worst flooding in its history, with 81.8mm of rain falling on 14-15 April and 99.6 mm in the 24 hours that followed. Fifteen people died and 11 were severely injured. The city's Multi-Agency Emergency Response Team and the Tanzanian Red Cross estimated that 2,151 households were displaced, 42 houses and 21 latrines destroyed, and 342 houses severely damaged - though the World Bank (2019b) estimates that the actual loss of life and property may have been far worse.

In May 2019, the city was again inundated, in yet another reminder of the urgent need to tackle the country's flooding issues. On 5-7 May alone, Dar es Salaam saw 144mm of rain, close to the average for the entire month, leading to flooding and road closures. Later that month, the flooding that followed a week of torrential rain in Kyela District in the south of the country killed five and left 2,500 people homeless (World Bank, 2019b).

Figure 3. Losses experienced by households in the 2018 flood in Dar es Salaam



- Asset losses*
- Health monetary losses
- Housing repairs
- Missed days of work

*A resource owned by an individual that provides present or future value. Examples: vehicles, animals, cash, homes.

Source: [World Bank (2019b)]

3.3 The economic and health cost

It is important to note that although Dar es Salaam receives a lot of rainfall, the flooding in unplanned settlements is largely a function of inadequately maintained stormwater drains and poor waste-disposal practices. In fact, some settlements in the Msimbazi Valley flood even in the absence of rainfall, due to clogging and structural interferences along the Msimbazi River (START, 2011).

Economic cost

Flooding in Dar es Salaam affects all citizens. The World Bank estimates that the April 2018 flood cost residents between USD 107 million and USD 227 million in economic losses, or between 2% and 4% of the city's gross domestic product (GDP).

On average, affected households lost 23% of their annual expenditure, equating to 84 days of typical household spending (World Bank, 2019[b]).

Furthermore, poorer households are less likely to recover from flood exposure, leaving them more vulnerable to other climate-related hazards. USAID estimates that USD 5.3 billion in public and private assets are currently at risk from flooding and sea level rise in Dar es Salaam (Cusick, 2018).

As temperatures rise and rainfall becomes more unpredictable and concentrated, the net economic costs to Dar es Salaam of climate change could rise by 2–3% of GDP per year by 2030 (World Bank, 2019).

Health impacts

Only 13% of the city's residents are served by adequate sewerage systems and only 37% of solid waste is properly collected (World Bank, 2019). This is caused by the city's lack of a coordinated stormwater drainage system, inadequate housing development and the blockage of water streams by the careless dumping of solid waste (World Bank, 2019). When asked about their experience of flooding, affected households said their biggest concern was their health and that of their family (Bird, 2019). As many as 1.7 million people were affected by the April 2018 flood alone, with 47% reporting health impacts such as cholera, diarrhoea, malaria, fungal infections, skin infections and mental-health disorders. That is almost 20% of the city's population experiencing adverse health effects from a single flood event, not to mention the associated healthcare costs and high levels of stress and discomfort (Bird, 2019; World Bank, 2019b).

Section 4. The outlook

4.1 What does the future hold for Dar es Salaam?

In future, severe flood events and droughts will be more common in Dar es Salaam. Its residents, particularly the poor and vulnerable, are unlikely to be able to cope. Average temperatures in Dar es Salaam have risen over the past few decades and are projected to rise even more in the coming years. Combined with heavier rainfall, this may raise humidity levels, with implications for health and environmental conditions (START, 2011). A rise in average temperature also leads to putrid waters (as sewage-contaminated waters heat up due to higher temperatures).

Flooding will be exacerbated by:

- → Increasingly heavy seasonal rainfall caused by climate change.
- → Increasing land use change in the upper catchment.
- → A decline in urban green cover.
- → A rise in the city's impermeable surface area.
- → A lack of water-body management, resulting in compromised ecosystem services.
- → Growing pressure on overwhelmed sewage infrastructure and stormwater drainage.
- → Further unplanned urban expansion, exposing more households.
- → Poor urban planning.
- → Rapid population growth to a projected 10 million people by 2030.
- → A siloed approach to climate change.

4.2 Links to other issues

Flooding in a large urban centre is a complex issue and often tied to many other problems a city faces. Many of the coastal cities in East Africa, such as Mombasa and Mogadishu, have developed along river lines. Settlement patterns follow the rivers inland, meaning riverbanks are often the most populous areas.

Flooding is not just an issue of excess rainwater, it is connected to waste management, infrastructure, land use, health and other concerns. It is important that flood prevention programmes provide integrated solutions that take into account the entire city and its population, not a siloed approach. One example of this is the Integrated Flood Management concept, which encourages the holistic use of river basin resources, employing strategies to maintain or augment the productivity of floodplains, while at the same time providing protective measures against losses due to flooding.

Details on this approach can be found at https://www.floodmanagement.info/

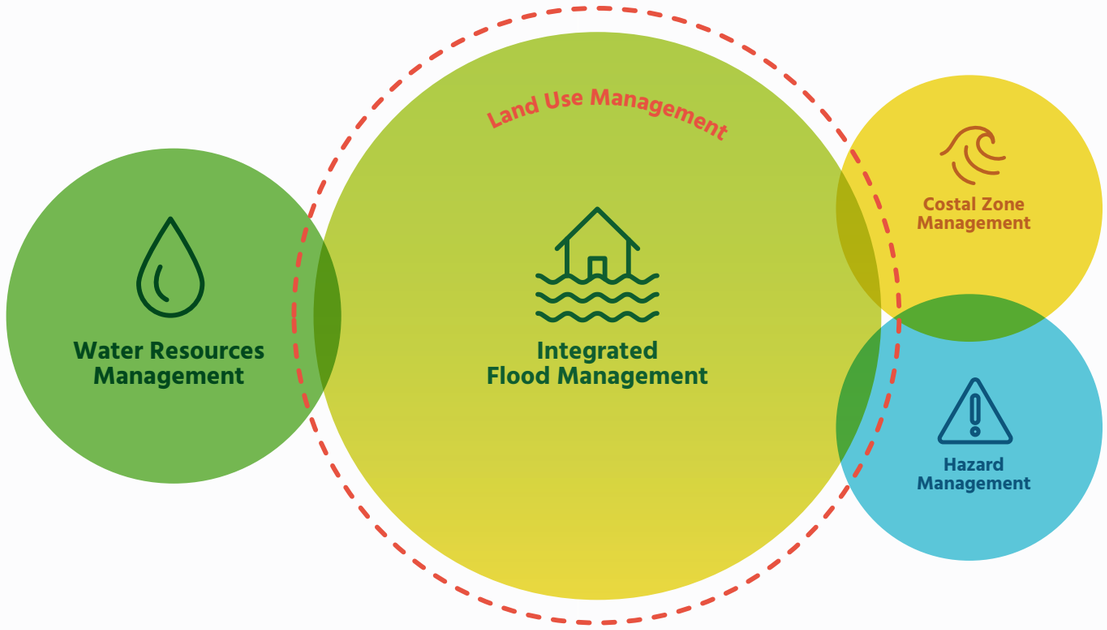


Figure 4. Integrated Flood Management.

Deforestation and urban green space

Green spaces are increasingly regarded as essential urban infrastructure that can provide diverse ecosystem functions, services and benefits. Indeed, green space is now increasingly seen as instrumental in mitigating the effects of climate change, including urban heat islands and flooding, and as a biodiversity refuge (Boulton, 2020). The importance of vegetation in reducing floods is long known. Vegetation, particularly trees, helps prevent floods in a number of ways: it intercepts direct rainfall, absorbs more water by promoting high soil infiltration rates, prevents excess runoff and stabilises riverbanks to prevent mud slides (European Environment Agency, 2019). In addition, trees can release water in the dry season and help mitigate the effects of drought (European Environment Agency, 2019). In emerging megacities, however, the immediate monetary value of the land as living space outweighs its green value, resulting in very little urban green space. With many of the cities in East Africa undergoing rapid urbanisation, new urban dwellers will need land to be converted from vegetation to housing. The decreasing amount of green space will only add to the flood risk and exacerbate the damage when floods do occur.

Wastewater systems

In most developing countries, urban authorities are responsible for waste management. Waste management is one of the most visible urban services, and its effectiveness and sustainability serve as an indicator of good local governance, sound municipal management and successful urban reform. In other words, it is a very good indicator of how a municipality is performing (Okot-Okumu, 2012). In many East African cities, waste-management and sewage systems have become a major problem. Waste generation in Dar es Salaam has tripled over the past 16 years and 60% of the waste the city generates remains uncontrolled (Palfreman, 2014). Excess waste ends up in storm drains, contributing to water pollution, the spread of disease and worsening annual flood events. There is also a large amount of littering, which ends up blocking storm drains, intensifying floods and health hazards.

Climate change

As the climate changes rapidly and greenhouse gases continue to be emitted into the environment, weather patterns will become more unpredictable and extreme. There is a strong correlation between global warming and future flood risk, so land cover and ecosystems are likely to be negatively impacted, particularly near rivers and in floodplains, resulting in increased surface flooding and soil erosion, greater plant water stress and reduced water security.

Although many cities in East Africa regularly suffer from flooding, the increase in magnitude of flood events means that new areas with no history of flooding are also being severely affected. And in rapidly growing urban centres, the problem will only get worse. Increased surface-water runoff will lead to a greater likelihood of flooding, especially as rainfall intensity is set to increase (IPCC, 2018). Hotter temperatures will create urban heat islands in cities, fuelling disease levels and water-borne illnesses. Cities that are near the sea will experience the effects of higher sea levels in the form of more frequent and severe floods.

All of these impacts will create a negative feedback loop, whereby more intense rainfall, fewer permeable surfaces and faster erosion will fuel more frequent flooding. The increase in flooding will only drive more people into cities to seek shelter in informal settlements (START, 2011).

4.2 Conclusion

Dar es Salaam is just one of East Africa's emerging megacities dealing with the consequences of urban sprawl and mass migration. Its burgeoning population, lack of urban green space, deteriorating infrastructure and climate change have brought flooding and flood risk to an all-time high – at significant human and financial cost. If these risks are not addressed, the city will end up throwing its limited financial resources at never-ending recovery and reconstruction efforts. The flood risk needs to be addressed in an integrated manner that involves stakeholders from all city departments, if it is to be successful.

Further research

Further research could be conducted to quantify ecosystem services in Dar es Salaam, as well as the urban development plans of emerging megacities. It would also be interesting to explore the changes in landscape over the last 30–50 years and look at how this could be linked to flooding in East African cities.

Dar es Salaam's burgeoning population, lack of urban green space, deteriorating infrastructure and climate change have brought flooding and flood risk to an all-time high

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