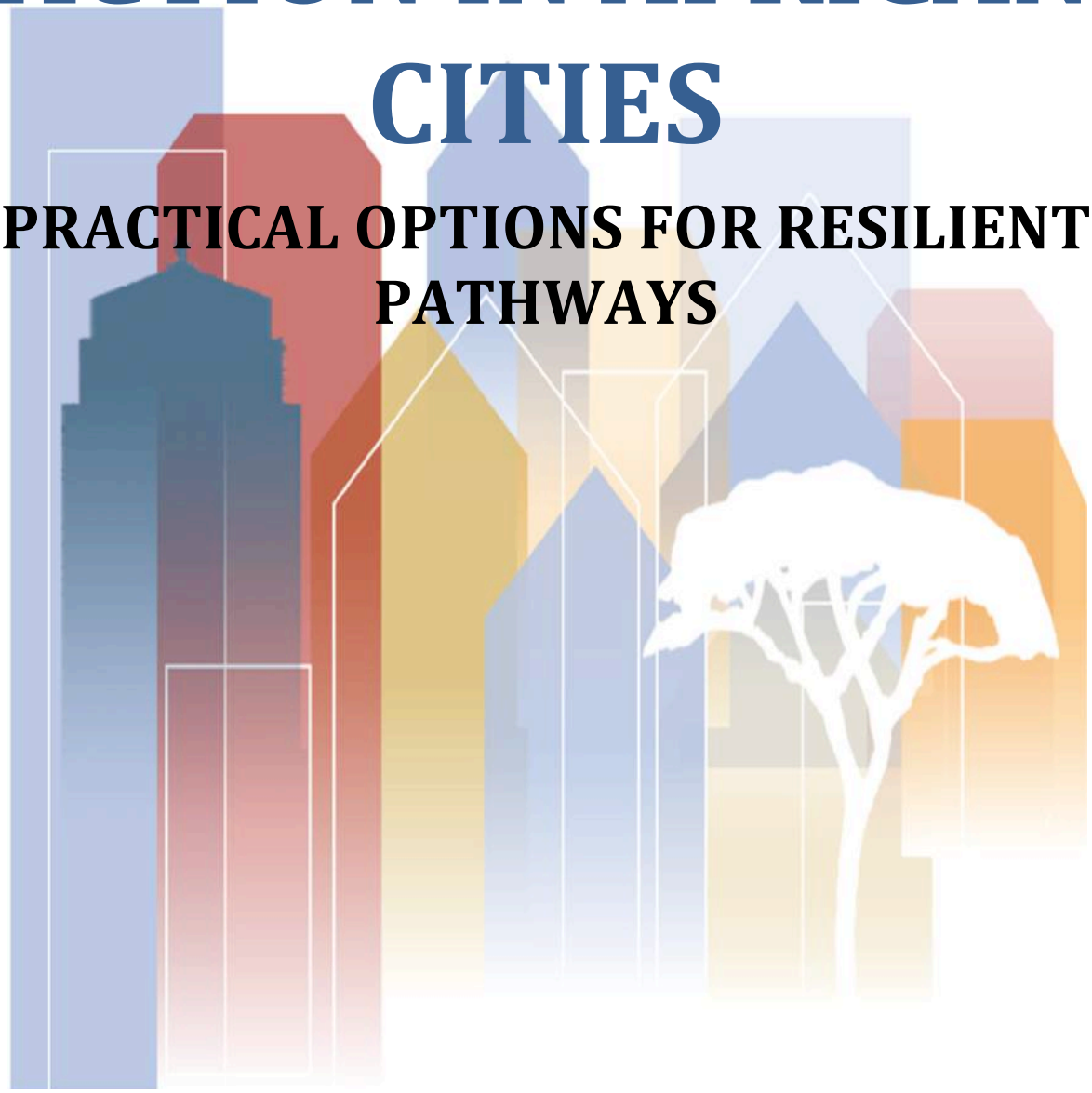
INSPIRING CLIMATE ACTION IN AFRICAN CITIES

PRACTICAL OPTIONS FOR RESILIENT PATHWAYS



FUTURE CLIMATE FOR AFRICA

FRACTAL
FUTURE RESILIENCE FOR AFRICAN CITIES AND LANDS

SEI

ICLEI
Local Governments for Sustainability

About FRACTAL working papers

This series is funded by the UK's Department For International Development (DFID) and the Natural Environment Research Council (NERC) through the Future Resilience for African Cities and Lands (FRACTAL) project, within the Future Climate For Africa (FCFA) multi-consortia programme. The overarching objective of FCFA is to generate fundamentally new climate science focused on Africa, and to ensure that this science has an impact on human development across the continent. FRACTAL's main aim is to advance scientific knowledge on regional climate responses to global change, and to enhance knowledge on how to integrate this information into decision making at the city-region scale in Southern Africa. These products have been developed to share initial findings from research in the hope of fostering dialogue, and eliciting feedback to strengthen the research. The opinions expressed are therefore the author(s) and are not necessarily shared by DFID, NERC or other programme partners.

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Citation: Butterfield, R.E., Coll Besa, M., Burmeister, H., Blair, K., Kavonic, J., Bharwani, S., Cullis, J., Spires, M. and Mwalukanga, B. (2017). Inspiring Climate Action in African Cities: Practical Options for Resilient Pathways. FRACTAL Working Paper 4. Stockholm Environment Institute Oxford Centre, Oxford, UK.

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Acknowledgements

The FRACTAL project is funded through the Future Climate for Africa (FCFA) programme. FCFA is an international research programme that supports research to better understand climate variability and change across sub-Saharan Africa. We would like to thank the joint funders of FRACTAL- the UK's Department for International Development (DFID) and the Natural Environment Research Council (NERC), and also the project coordinators - The Climate System Analysis Group at the University of Cape Town.

Acknowledgement is given for permission for inclusion of adaptation case studies for this FRACTAL Working Paper by the project partners and colleagues of authors at ICLEI - Local Governments for Sustainability, Aurecon, and the Stockholm Environment Institute. In particular, we would like to express our appreciation to Aliou Bakolado and researchers with CRES (Consortium pour la Recherche Economique et Sociale) for suggestions and photographs for the Live with Water project (case 17) and also Vanesa Castán Broto for edits to the Climate Compatible Development Maputo project (case 14). Please also see individual cases for case study contact points.

Acknowledgement is also given by the authors to internal FRACTAL reviewer Dianne Scott, and Karen Brandon (SEI Oxford Communications Officer) for editing and advice on the structure of the document.

Foreword

The need for climate change adaptation has been widely recognised among developing countries since the early 1990s. The 2015 Paris Agreement provided renewed impetus for addressing the issue; many countries included adaptation and mitigation commitments in their national climate plans. Despite significant advances in adaptation, and the increasing awareness of the importance of adaptation, knowledge remains in some respects incomplete. The scope of understanding is fragmented as the result of limited awareness of what and how adaptation projects and policies are being carried out, and because of the scant monitoring of the outcomes of these undertakings.

Humanity, the natural world, and the built environment across the globe are increasingly feeling the effects of climate change. Developing nations are believed to be particularly susceptible to the impacts of climate change, in part because of the dependence of livelihoods on climate-sensitive sectors such as agriculture, tourism, fisheries and forestry - and in part from the fragility of infrastructure in developing nations, where houses, buildings, municipal services and transportation networks often have limited capacity to cope with severe impacts that already have begun to occur.

'Inspiring Climate Action in African Cities' serves to highlight adaptation projects that have taken place in Africa - specifically in the urban and peri-urban settings that increasingly define the continent - and to highlight the Sustainable Development Goals that these efforts address. This working paper deliberately focuses on the African continent's *urban* adaptation – a subject in need of global attention, particularly in the context of climate change. The African continent will lead the world's population growth over the next 50 years, and 'the people of Africa will increasingly be city dwellers… This means that Africa will have some of the largest mega-cities in the world' (African Development Bank, 2014). While no continent is immune to the impact of climate change, the African continent, in general, and Sub-Saharan Africa, in particular, face a particularly broad array of issues. Vulnerabilities include: increased water stress, higher risk of coastal inundation, changes in river hydrology, increased exposure to infectious disease, and alterations to the magnitude and frequency of extreme events. 'Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change' (UNFCCC, 2007).

The projects in the working paper are intended to provide practical options to inspire national and municipal governments, city planners, NGOs, private companies, international institutions, and communities to take action to implement further adaptation projects on the continent. Readers of all backgrounds and from locations within and beyond Africa can and should learn from these case studies.

The term 'adaptation' encompasses a broad range of policies and interventions that changes the costs and consequences of climate change, including particularly urgent needs to aid health, water resources, ecosystems, agriculture, coastal zones, settlements and economic activities. With rapid urbanisation on the African continent and increasing demand for water and energy, cities are exploring a variety of technological and management innovations to reduce negative climate change impacts on urban water, food and energy resources.

Climate change, variability and associated increased disaster risks present additional challenges along the journey towards sustainable development, and towards achieving the Sustainable Development Goals in and beyond Africa. In reality, this is only a partial list of the many disturbances that impinge upon livelihoods and well-being in the developing world. Other issues - conflict, environmental degradation, colonialism and post-colonialism, demographic changes and disease, among them - are projected to be further aggravated by climate change, if action towards climate adaptation and mitigation are not undertaken.

Executive Summary

Workers tend to plants for the Buffelsdraai Community Reforestation Project in South Africa. (Photo courtesy of the project.)

'The community we are working with is the (poorest of the) poor, and with this project, it came to them to change their lives, and they used that opportunity…They now really understand what's going on'…

-Nondumiso Khumalo, a manager of the Buffelsdraai Community Reforestation Project in South Africa. The programme, initiated to provide a carbon offset for the 2010 World Cup in Durban, created a buffer zone for a landfill, planted native trees in former sugar cane fields, and created local jobs.[1]

Africa's cities and urban areas confront a multitude of interlinked and complex challenges as a result of climate change. The most pressing climate- and human-induced issues are:

- **Climate change itself.** People must contend with increased risk and uncertainty related to flooding, drought, extreme temperatures, sea level rise, and changes in seasonal rainfall patterns and intensity. These all have consequences for health, availability of food, water, shelter, livelihoods and security.
- **The effects and consequences of climate change.** On the African continent, the environmental repercussions are desertification, loss of biodiversity, deterioration and draining of wetlands, environmental degradation, and soil erosion. These forces increase the vulnerability of poor, rural communities – raising the likelihood that already high levels of rural-to-urban migration will continue to grow and increase pressure on cities.
- **The rapid pace of urban population growth.** At present, metropolitan growth is largely defined by the spread of so-called 'informal' settlements, substandard residential neighbourhoods. Piecemeal action on urban housing and infrastructure will not arrest the trend. Entire urban regions – not solely cities acting alone – must plan in truly multi-faceted ways. Cooperation and coordination must encompass both private and public sectors – and

[1] See case study 2, page 31.

the many layers and levels of governments and agencies that pursue sometimes conflicting goals.

- **The ongoing – and growing - challenges related to water delivery and wastewater removal.** Access to clean drinking water, and effective removal of wastewater take on new urgency in the face of longer-lasting droughts and more-severe flooding. Management of these services is often fragmented. Infrastructure is inadequate, poorly maintained, and prone to malfunctioning.
- **The lack of institutional capacity to adapt to new realities and to address new needs.** As the climate changes and risk rises, government capacity faces new and pressing tests of its resolve and resources - human, financial and administrative – to anticipate, prepare for, and respond to changing ecological and economic situations. The situation cries out for well-functioning early warning systems, reliable climate data, and functioning legislative frameworks.
- **The increased competition for scarce resources.** Water, energy and food sectors compete for the same resources that also bear the brunt of the increased stress from climate change. For instance, securing, treating and distributing potable water are energy-intensive functions, and can be affected by energy shortages and prices. Thus, the competition for water, land and soil presents a growing challenge, and rising source of tension.

Adapting to risks is essential to ensure sustainable development in Africa's cities. Therefore, this working paper aims to enhance scientific understanding, foster policy debate, and spur action towards promising adaptation pathways. The ultimate goal is to enhance urban areas' resilience, and to reduce the vulnerability of these regions to the challenges they face.

This paper contains 17 case studies, each providing a chronicle of creative ways that governments, institutions, NGOs, private enterprises, and communities have found to adapt to complex, interwoven climatic and social challenges. Their innovative approaches also address many of the United Nations' Sustainable Development Goals.

Each case offers its own, unique story - a singular combination of circumstances, players, challenges, ideas and solutions. Yet, ultimately, the cases share certain lessons - integral characteristics that offer important insights about adapting to climate change.

Key lessons include:

- **Build trust between different stakeholders** involved in the adaptation process to secure their buy-in, and to enhance the likelihood of a project's long-term sustainability.
- **Establish partnerships and collaborate across sectors.** A transdisciplinary team of stakeholders can add new perspectives on existing problems.
- **Capitalise on the capacities offered by women and youth.** They constitute a workforce with often untapped potential that can be used to catalyse adaptation activities.
- **Consider the knowledge, capacity and natural resources of local communities.** Community- and ecosystem-based approaches are often more feasible and potentially more enduring than high-tech solutions. These kinds of solutions are often easier and more affordable for vulnerable and poor communities to maintain. Moreover, these approaches can transform people's perspectives about their environment and about their own potential capacity - by making them aware of the benefits of protecting and sustainably using their own resources, and by making them aware of the role they can play in this.
- **Think about adaptation as a learning opportunity.** Couple adaptation and mitigation projects with education, training and awareness-raising programmes.
- **Build climate-resilient cities and infrastructure** by integrating sustainable and innovative solutions into land-use planning. For instance, creating and maintaining green spaces

reduces both the creation of 'heat islands' in cities, and the potential for flooding. At the same time, these green spaces provide spaces for recreation and urban farming.

- **Share lessons and knowledge** about (climate) risks, challenges and opportunities with similar projects to create synergies, and to avoid unnecessary duplication of effort. Actionable knowledge and measurable outcomes from projects should be shared with a wide array of constituents: governments at all levels, agencies, institutions, private companies, NGO's, researchers, community leaders, and residents who are struggling to adapt.
- **Capitalise on the potential of adaptation to lead to other benefits.** A project that addresses one Sustainable Development Goal often has a cascade effect, addressing aspects of other, sometimes seemingly unrelated goals. The promise of adaptation – along with other benefits, such as new businesses, new jobs, new community assets – may be enough to give a project needed momentum and backing.
- **Institutional and policy development.** Policies and regulations on national, regional and local levels are needed to ensure the long-term safety and sustainability of adaptation projects around Africa. Institutions, regional governments and municipalities benefit from the enforcement mechanisms that legislations and policies give them in pushing for adaptation action.

The challenges are formidable; they will require innovative thinking, and the collective will of people brought together through new, and perhaps unusual, collaborations. These 17 case studies offer insight into circumstances in which governments, institutions, researchers, private companies and communities rose to these challenges, and their stories may inspire others to do the same.

More clean water, treated at the Gorengab Water Reclamation Plan, makes its way to residents. (Photo courtesy of the plant.)

'If you look at the world, the pressing need is always in developing countries. It's a fast-changing environment, so, you always have to be innovative to try and stay a step ahead…An idea can be generated in a developing country that can actually inspire a similar trend in a developed country'.

- Pierre Van Rensburg, strategic executive, Department of Infrastructure, Water and Technical Services, City of Windhoek, Namibia, where the Gorengab Water Reclamation Plant turns sewage into potable water.[2]

[2] See case study 4, page 38.

About this working paper

This working paper is inspired by the two Adaptation Inspiration Books developed by European Commission projects: 'Adaptation Inspiration Book: 22 Implemented cases of local climate change adaptation to European citizens - Climate Impact Research and Response Coordination for a Larger Europe (CIRCLE 2)' (Pijnappels and Dietl, 2013); and 'BASE adaptation inspiration book: 23 European cases of climate change adaptation to inspire European decision-makers, practitioners and citizens' (Ng, Campos, and Penha-Lopes, 2016). Both books were coordinated by the Faculty of Sciences, University of Lisbon. Both books have a European focus. The aim of this working paper is to inspire decision-makers and practitioners from cities of the Global South, in particular African cities, with practical ideas and options for climate-resilient pathways at the city-region scale. This working paper is the result of a compilation of 17 diverse case studies that span administrative levels, geographic scales, sectors and disciplines. It showcases adaptation approaches, experiences and actions that address changing climate effects in growing African cities and peri-urban areas. The projects presented here deal with diverse challenges, spanning climatic risks such as droughts and flooding, and other stressors, such as internal conflicts and management of waste. Encompassing community-based adaptation, partnership-building and infrastructure solutions, each project has created its own inspiring and unique adaptation approach. The examples also provide linkages to the United Nation's Sustainable Development Goals, and, wherever possible, information about how the goals are addressed in each case study.

Resources allowing, the working paper will be converted into producing a 'live' online version of the paper. The cases will be available online to share the lessons more widely, and links will be added to new and emerging FRACTAL case studies.

Acronyms and abbreviations

BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CbA	Community-based Adaptation
CBO	Community Based Organisations
EbA	Ecosystem-based Adaptation
GCMs	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
ICLEI	Formerly: International Council for Local Environmental Initiatives, now known as: Local Governments for Sustainability
IDA	International Development Association
NEWMAP	Nigeria Erosion and Watershed Management Project
NGO	Non-Governmental Organisation
NGRP	New Goreangab Reclamation Plant
LEAP	Long-range Energy Alternatives Planning
SDG	Sustainable Development Goal
SEI	Stockholm Environment Institute
TSE	Treated Sewerage Effluent
UNA Rivers	Urban Natural Assets: Rivers for Life
UNDP	United Nations Environment Programme
WEAP	Water Evaluation and Planning
WEF	Water-Energy-Food
4PCCD	Public, Private, People partnerships for Climate Compatible Development

Location of case studies

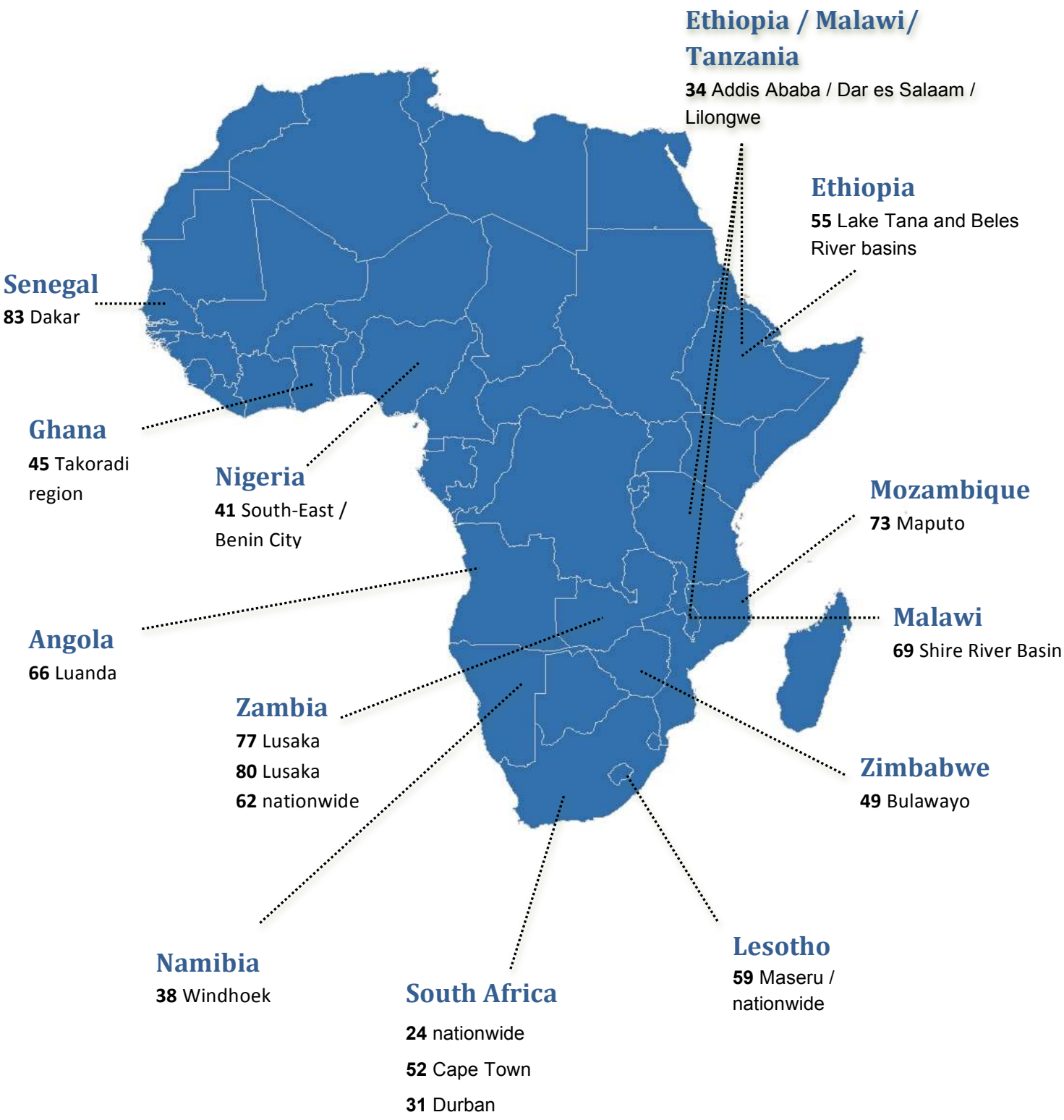


Figure 1 Map of featured case studies in Africa, indicating page number.

Introduction

'The community we are working with is the (poorest of the) poor, and with this project, it came to them to change their lives, and they used that opportunity…They now really understand what's going on…'

- *Nondumiso Khumalo, a manager of the Buffelsdraai Community Reforestation Project in South Africa. The programme, initiated to provide a carbon offset for the 2010 World Cup in Durban, created a buffer zone for a landfill, planted native trees in former sugar cane fields, and created jobs for local people.*[3]

Increasingly, international climate leaders are coming to accept that the world's agenda on climate change must expand its scope beyond mitigation to include adaptation. Increased adaptation efforts are equally important to enhance resilience to the effects of climate change. This is key, not only for reducing negative impacts, but also for turning climate-related challenges into opportunities to benefit humanity and the global environment. These efforts need to span local stakeholders, regional and national institutions, non-governmental bodies, private enterprises, and the international community to ensure a holistic approach to the problem, and the sustainability of solutions. Each small-scale success contributes to sustainable development on a global scale. With this in mind, we need to be aware of the variety of innovative approaches to bolster adaptation efforts, and to learn from one another about the possible transfer and scalability of approaches.

'Inspiring Climate Action in African Cities' has been developed to help with this mission. It focuses on the African continent's urban adaptation – a subject of in need of global attention, particularly in the context of climate change. The African continent will lead the world's population growth over the next 50 years, and 'the people of Africa will increasingly be city dwellers…This means that Africa will have some of the largest mega-cities in the world' (African Development Bank, 2014). While no continent is immune to the impact of climate change, the African continent faces a particularly broad array of issues that compounds the problem. 'Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change' (UNFCCC, 2007).

Against this backdrop, 'Inspiring Climate Action in African Cities' is intended to inspire adaptation action on various urban and peri-urban scales, involving a wide range of stakeholders. The working paper has been produced through sourcing examples from projects and initiatives driven by the many institutions that have been involved in writing the working paper. Additional input and assistance in the development of the working paper came from embedded researchers working in the Future Resilience for African Cities and Lands (FRACTAL) team.

The case studies in this working paper have been selected based on three general criteria. The first criterion was the location. All projects had to be located in African cities or metropolitan areas, or have some urban focus, e.g., being centred on urban rivers or catchments. Second, the focus of the projects had to align with the outcomes of the United Nations' Sustainable Development Goals (SDGs). We aimed to compile case studies that underline the transformative power of adaptation to create a sustainable future for everyone. The alignment with the SDGs shows how these African case studies also deliver on a broader basis by contributing to the globally agreed-upon, new development agenda. Third, the case studies had to respond to historic or ongoing climate challenges, and to address or include at least one of the following adaptation measures:

- **Employing Early Warning Systems -** to warn communities about imminent floods, storms and droughts, and to offer advice on how to protect people, assets and livelihoods.
- **Undertaking Disaster Risk Reduction -** to reduce the damage caused by natural hazards such as earthquakes, floods, droughts and cyclones and hurricanes through an ethic of prevention.

[3] See case study 2, page 31.

- **Climate-proofing the Built Environment -** to reinforce roads, houses and buildings (such as schools and clinics against storm damage) to improve community health, and to maintain access to vital services.
- **Promoting Climate-resilient Livelihoods -** to help people to make a living in such a way that they can cope with, and recover from, the effects of sudden or slow-onset changes in weather patterns.
- **Emphasising Community-Based Adaptation (CbA) -** to enhance the resiliency of local communities and/or the ecosystems on which they rely, to cope with climate change impacts by cultivating human resources and capacities within the community itself. This measure is intended to address a common situation: the communities likely to be the most severely affected by climate change impacts are frequently the least equipped to cope and adapt.
- **Promoting Ecosystem-based Adaptation (EbA) –** to use biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, regional, national and global levels.
- **Strengthening Institutions** – to bolster institutions that are vital to adaptation. Local communities, trade associations, local government agencies, kinship networks and traditional networks serve to limit, hedge and share risk. Municipal, national and international institutions provide extension services, weather and climate services, health services, early warning systems, training, disaster risk reduction services and information.
- **Securing Resources** – to obtain income and resources for needed activities. Most adaptations are occurring at the individual level with weak involvement of government stakeholders. Adaptation activities are more likely to occur in natural-resource sectors such as agriculture, fisheries and forestry, or the securing of food resources.
- **Building Partnerships** – to provide a bridge between adaptation and development actors and institutions. These efforts may require knowledge-sharing activities and legal or policy-making partnerships between national, municipal, civil and private actors. Strong partnerships are required when addressing a complex transdisciplinary problem with a science-society interface.
- **Promoting Awareness** - to inform policy making, and to provide buy-in for local projects. Training and knowledge sharing are required to expand understanding about climate, weather and hazards.
- **Enhancing Learning** - to foster new insights and to spread knowledge among multiple stakeholders. Adaptation is an on-going process of managing risks and changes. Social learning and training present ways to inform communities about challenges and options faced by their communities, and to support local projects and decisions.
- **Promoting Best Policy-making Practices: -** to provide guidance to policymakers through rigorous research and/or impact evaluations on the effectiveness of climate change interventions.

We note here that in selecting case studies we did not stipulate that adaptation measures had to be labelled as such. We liberally included measures so long as they led to a significant increase in the capacity to cope with climate change, or to a decrease in vulnerability to the adverse effects of climate variability and change. This dovetails nicely with a premise of adaptation principles: that actions should strive to be consistent with disaster risk reduction, development and broad climate change resilience.

Utlimately, our project aims to plant the seeds for action around opportunities to adapt and to mitigate the impacts of climate change and variability that are already visible and palpable around the African continent. Then, too, we aim to nurture the practices that will be required to see these seeds grow and flourish through sustainable, long-term actions. This working paper is thus designed to:

- Inform and inspire policy and action for minimising vulnerability to climate-related hazards.
- Foster transdisciplinary and collaborative work that requires original, imaginative and inspiring solutions.

- Address the urban nexus (water, food, energy) holistically at the city-region scale, where possible.
- Regard adaptation as a positive approach to face climate change by taking advantage of new opportunities where they exist.
- Share learning opportunities between cities in Africa and other urban areas facing similar problems worldwide.

'If you look at the world, the pressing need is always in developing countries. It's a fast-changing environment, so, you always have to be innovative to try and stay a step ahead…An idea can be generated in a developing country that can actually inspire a similar trend in a developed country'.

- Pierre Van Rensburg, strategic executive, Department of Infrastructure, Water and Technical Services, City of Windhoek, Namibia, where the Gorengab Water Reclamation Plant turns sewage into potable water.[4]

[4] See case study 4, page 38.

Navigating the case studies

'Inspiring climate action in African cities' compiled case studies covering a wide range of sectors: from typically urban concerns of water supply, energy, sanitation, transport, health, job security and infrastructure to universal concerns of agriculture, land use, food security, natural resource management, disaster and flood risk management. The working paper is organised into three broad chapters based on the most relevant sectors. These are:

Ecosystems and Biodiversity; Urban Water Resources, Agriculture and Energy; Infrastructure, Settlements and Waste Management.

The case studies in each of these chapters display a number of important key facts in a summary table at the beginning. The contents of this table are explained below.

Climate risks	*This section indicates the possible climate risks that the project has been confronted with throughout its realization or that will probably occur in the future. In this working paper, four principal climate risks have been identified: extreme temperatures (e.g. heat waves), flooding, droughts and sea level rise. Each of these climate risks is displayed with its specific icon. You can find a more detailed description of each of the main climate risks covered in this working paper as well as their icons on the pages 16 -18.*
SDGs	*This part of the summary table shows the links of the projects to the relevant SDGs by displaying their icons. Find more information on the variety of SDGs, their meaning as well as a summary table displaying all of the goals and their respective icons on the pages 19 – 20.*
Project location	*Here, the specific area of implementation of the project is indicated. The project location can either be a city, a peri-urban area or have an urban focus, being centred on urban rivers or river catchments.*
Adaptation type	*This section indicates the specific adaptation approach taken within the project.*
Keywords	*Identifies the main topics or areas of information covered in each case study.*
Sectors	*Provides information on the most relevant sectors of the case study, e.g. water, health, biodiversity...*
Stakeholders	*Indicates all the relevant implementing partners and institutions, beneficiaries of the project or other stakeholders involved; e.g. communities, the private sector etc.*
Project status	*The project status gives information on the project duration and whether the project is still ongoing.*
Contact point	*In case of further questions or interest in the project and its approach taken, this is the relevant contact point.*
Website	*Although not available for every project, the website can be consulted for further information and resources about the presented or other similar projects.*

Climate Risks

This section provides a short overview of the main climate risks felt on the African continent. As a result of climate change, the increased risk of extreme temperatures, more extreme weather, increased storm frequency with intense precipitation and flooding, plus uncertainty in changes to rainfall patterns puts increasing pressure on vulnerable systems. Those described below are relevant to the examples provided in this working paper.

Flooding

Increased storm frequency and intensity related to increased variability and climate change have been exacerbated by local factors particularly in urban settings such as the growing occupation of floodplains, increased runoff from hard surfaces, inadequate waste management and silted-up drainage. The result is that many of the urban poor in Africa face growing problems of severe flooding. One can distinguish five types of flooding in urban areas:

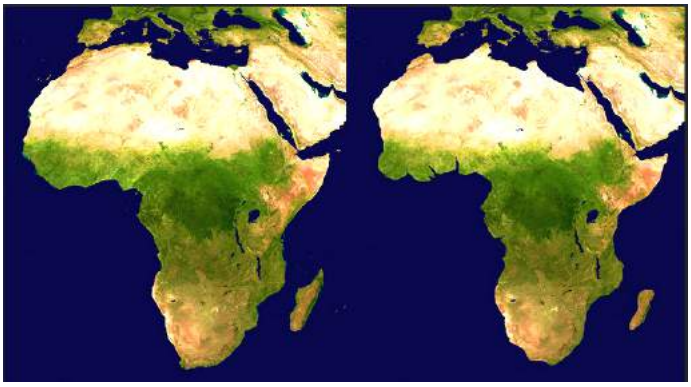
1. **River floods:** these occur when water levels rise over the top of the river banks due to excessive rainfall over the same area for extended periods of time.
2. **Coastal floods:** which are caused by a higher than average high tide and worsened by heavy rainfall and onshore winds.
3. **Storm surge:** which occurs as a result of an abnormal rise in water level in coastal areas, over and above the regular tides, these are caused by forces generated from a severe storm's wind, waves and low atmospheric pressure. Along the coast, storm surge is often the greatest threat to life and property from a cyclone.
4. **Inland flooding:** this occurs when moderate precipitation accumulates over several days, intense precipitation falls over a short period or a river overflows because of debris jam or dam failure.
5. **Flash flood:** this is caused by heavy or excessive rainfall in a short period of time, generally less than six hours (Jonkman, 2005).

Flooding, as a result of climate change, is the most prevalent concern in North Africa, the second most common in East, South and Central Africa, and the third most common in West Africa (Douglas et al., 2008). Clear motivations for adaptation can be found in the effects of the 2001 disastrous flood in northern Algeria which resulted in about 800 deaths and economic loss of about $400 million (African Water Development Report, 2006). In addition, the floods brought about by Cyclone Eline in Mozambique and parts of Limpopo Province (South Africa) (Thomas et al., 2007) in 2000 caused 800 deaths, displaced 329 000 people and destroyed agricultural production land (Moore, Eng and Daniel, 2003). An example of inland flooding of the streets of Accra in June 2016 is seen in Figure 1.

Downpours causing floods in the streets of Accra, Ghana. June, 2016.
Picture Credits: GhanaWeb

Sea level rise

Sea level can rise by two different mechanisms with respect to climate change. First, as the oceans warm due to an increasing global temperature, seawater expands - taking up more space in the ocean basin and causing a rise in water level. The second mechanism is the melting of ice over land, which then adds water to the ocean (Oceanservice, 2017). Brown, Kebede and Nicholls (2011) used an integrated biophysical and socio-economic impact global model to examine the potential impacts of sea-level rise in Africa. While risks are not well understood, some 320 coastal cities (with more than 100,000 people) and nearly 56 million people (2005 estimate) live in vulnerable, low elevation (<10m) coastal zones. Thus, this report highlights the potential magnitude of impacts and identifies countries which have a high absolute risk. Countries were ranked by their relative impacts and costs. In absolute terms, several countries consistently appear in the 'Top 10' rankings. The countries in which flooding and forced migration are likely to have the most severe effects on people are: Mozambique, Cameroon, Tanzania, Morocco and Egypt. For economic damages, the most profound consequences are likely to be suffered by Algeria, Egypt, Morocco, South Africa, Tunisia, Libya and Cameroon – all of which are estimated to face additional damages of more than US$1 billion per year under a mid-range scenario in 2100. In absolute terms, the highest adaptation costs are expected to occur in Mozambique, Guinea, Nigeria, Guinea-Bissau and South Africa.



Future projection of Africa's shoreline change due to climate change within the next 1000 years. Picture credit: Spooner, S. (2015).

On a longer timescale - within the next 1,000 years - the face of the African continent is set to alter drastically through two processes - desertification and rises in sea levels (Nicholls and Cazenave, 2010). Over the past century, global mean sea level has risen by 10 to 20cm. If we are to crudely assume this rate will continue, even though there is evidence that it is accelerating, by 3015 we will see a rise of between 1-2 metres (UNEP, 2014), drastically affecting the coastline, as seen in the map on this page. Left unmanaged, the effects of this rise could be devastating as it is estimated that at least 25% of Africa's population lives within 100km of a sea coast (Dasgupta et al., 2008). The low-lying islands of Seychelles, Mauritius, Sao Tome and Principe and Cape Verde could be submerged and a vast portion of Madagascar's coastline could also disappear (Church and White, 2006).

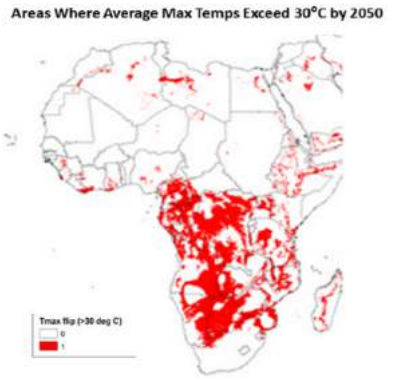
It is estimated that West Africa's Atlantic coastline will suffer. Senegal, The Gambia, Sierra Leone, Nigeria, Cameroon, Gabon, Angola all have low-lying lagoonal coasts that are susceptible to erosion and hence are highly threatened by sea-level rise. Consequently, major cities such as Lagos, Banjul, Abidjan, Tabaou, Grand Bassam, Nouakchott, Sassandra, San Pedro, Banjul, and Port Harcourt - all situated at sea level - would be underwater. Flooding due to sea level rise would likely be most severe in Lagos (home to 21 million people) because of its position at the southern end of the Gulf of Guinea where stronger tropical storms from the South Atlantic create storm surges (Spooner, 2015).

Furthermore, millions of people across the region rely on underground water that is already saline due to saltwater intrusion as a result of overexploitation of groundwater resources from aquifers. In that regard, sea level rise will pose an additional challenge to towns and cities whose water supply derives from underground sources (Nicholls, Hoozemans and Marchand, 1999).

Extreme temperatures

Extreme temperatures as a climate change risk will come largely in the form of heat waves. A heat wave normally is a sustained period of excessively hot weather. This may at times be accompanied by relatively higher levels of humidity, particularly in oceanic climate countries. It is normally measured relative to the usual weather of the given area and relative to the normal temperatures of that particular season.

The climate change risk of heat poses a major threat to both public health and food security (Patz et al., 2005). Droughts and heat stress due to climate change have led to a reduction in crop yields and livestock productivity. In addition to this, climate-sensitive diseases and health impacts can be high in poor countries that have minimal resources to treat and prevent illness (Haines et al., 2006). Examples of climate related health impacts include: frequent and severe heat stress linked to sustained increases in temperature, and the reduction in air quality that often accompanies a heat wave, which can lead to breathing problems and worsen respiratory diseases (McMichael, Woodruff and Hales, 2006).
The most vulnerable are normally babies, the elderly and the sick. Children and the elderly face graver risks due to susceptibility to infectious diseases, such as Malaria, limited mobility and reduced intake of food. The elderly face physical danger and even death due to heat stress. Children often die from starvation, malnutrition, diarrheal diseases, the impacts of which are compounded by heat stress (Haines, 2004).



Specific 'Hotspot' African regions identified as most vulnerable to heat as a public health and food security concern. Picture Credits: CGIAR Research Program on Climate Change, Agriculture and Food Security.

Drought

Drought induces severe environmental and social impacts including losses or destruction of fish and wildlife habitat, wind and water erosion of soils and poor soil quality. Health problems result from a wide variety of related issues, among them dust, low water flows, poor water quality and migration of people (from farms into cities, or from one city to another) (Field et al., 2014).

Africa has seen a decrease in rainfall over large parts of the Sahel and Southern Africa, and an increase in parts of Central Africa. Over the past 25 years, the number of weather-related disasters, including droughts, has doubled, resulting in Africa having a higher mortality rate from droughts than any other region (Meadows and Hoffman, 2003). Drought is often referred to as a "creeping phenomenon" and its impacts vary from region to region. Drought originates from a deficiency of precipitation over an extended period of time - usually a season or more- resulting in a water shortage for some activity, group, or environmental sector (Scholze et al., 2009). Its impacts result from the interplay between the natural event (less precipitation than expected) and the demand people place on water supply, and human activities can exacerbate the impacts of drought.

Although agriculture is typically the first and most affected sector by drought, many other sectors, including energy production, tourism and recreation, transportation, urban water supply, and the environment, have also experienced significant losses (Le Houérou, 1996). Furthermore, the economic impacts of drought could be debilitating for countries who are reliant on hydroelectric power. Citizens will have to pay more for power and because water companies may have to spend money on new or additional water supplies, people might have to pay more for water and food (Field et al., 2014).

Delareyville, South Africa experienced the worst drought for 23 years in July 2016. Farmers growing maize, soya beans and sunflowers were some of the worst affected. Photo credit: Climate Signals.

Sustainable Development Goals

What are the SDGs?

The 2030 Agenda for Sustainable Development, with its commitment to protect the planet from degradation and take urgent action on climate change, has developed The Sustainable Development Goals (SDGs) - a set of seventeen aspirational 'Global Goals'.

The SDGs have been spearheaded by the United Nations, through a deliberative process involving its 193 Member States, as well as global civil society, the goals are contained in paragraph 54 United Nations Resolution A/RES/70/1 of 25 September 2015. The Resolution is a broader intergovernmental agreement that, while acting as the Post 2015 Development Agenda (successor to the Millennium Development Goals), builds on the principles agreed upon under Resolution A/RES/66/288, popularly known as The Future We Want. Each SDG has a description plus a unique icon showing its number name and an illustration.

The examples showcased in this working paper provide the linkages to the Sustainable Development Goals and wherever possible, it highlights how the goals are addressed in each case study. Where possible, we have tried to frame the examples provided below in terms of both the climate risks that they target as well as the sustainable development goals to which they contribute.

Of particularly relevance to this work is the identification by the 2030 Agenda for Sustainable Development (UN General Assembly, 2015), in paragraph 14, of climate change as being 'one of the greatest challenges of our time'. Paragraph 14 furthermore states that 'its adverse impacts undermine the ability of all countries to achieve sustainable development. Increases in global temperature, sea level rise, ocean acidification and other climate change impacts are seriously affecting coastal areas and low-lying coastal countries, including many least developed countries and Small Island developing States. The survival of many societies, and of the biological support systems of the planet, is at risk'.

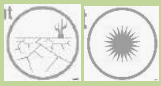
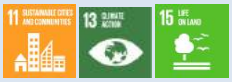
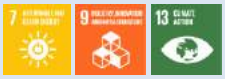
Sustainable Development Goal 13 aims to 'take urgent action to combat climate change and its impact' (UN General Assembly, 2015). More specifically, the associated targets of SDG 13 focus on the integration of climate change measures into national policies, the improvement of education, awareness-raising and institutional capacity on climate change mitigation, adaptation, impact reduction and early warnings. Many of these targets are also those of the adaptation projects presented.

Sustainable Development Goal 11 to 'Make cities and human settlements inclusive, safe, resilient and sustainable' includes targets related to implementation of policies to address mitigation, climate change adaptation and sustainable development and another that highlights reduction in deaths due to disasters (UN General Assembly, 2015). To follow the transdisciplinary nature of the FRACTAL project, in each case study selected, we have made links with the most relevant SDGs that the project or initiative in question addresses. These are just two examples relevant in the cases of how each SDG can tackle various global issues.

Table 1. Numbered sustainable development goals, with description and icon.

No	Goal	Icon
1	**End poverty** in all its forms everywhere	
2	**End hunger**, achieve food security and improved nutrition and promote sustainable agriculture	
3	**Ensure healthy lives and promote well-being** for all at all ages	
4	Ensure inclusive and **equitable quality education** and promote lifelong learning opportunities for all	
5	Achieve **gender equality** and empower all women and girls	
6	Ensure availability and sustainable management of **water and sanitation for all**	
7	Ensure access to affordable, reliable**, sustainable and modern energy** for all	
8	Promote sustained, inclusive and **sustainable economic growth**, full and productive employment and decent work for all	
9	Build **resilient infrastructure**, promote inclusive and sustainable industrialization and foster innovation	
10	**Reduce inequality** within and among countries	
11	Make cities and **human settlements** inclusive, safe, **resilient and sustainable**	
12	Ensure **sustainable consumption** and production patterns	
13	Take urgent action to **combat climate change** and its impacts*	
14	**Conserve and sustainably use the oceans**, seas and marine resources for sustainable development	
15	Protect, restore and **promote sustainable use of terrestrial ecosystems**, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
16	**Promote peaceful and inclusive societies** for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	
17	**Strengthen the means of implementation and revitalize the global partnership** for sustainable development	

Table 2. Project summary table showing chapter, project title, climate risk and relevant sustainable development goal icons.

Ecosystems and Biodiversity			
1	Ecological Infrastructure for Resilience and Job Creation in South Africa		
2	The Buffelsdraai Community Reforestation Project		
3	Mainstreaming Biodiversity and Ecosystem Services for Effective Management in Cities		
Urban water resources, agriculture and energy			
4	Africa's First Direct Water Reuse Plant in Windhoek, Namibia		
5	Tackling Soil Erosion and Improving Lives in South- Eastern Nigeria		
6	Off-Grid Power Generation Solutions in the Takoradi Region, Ghana		
7	Urban Agriculture: Improved Governance for Resilience in Bulawayo, Zimbabwe		
8	Applying an Integrated Approach to Catchment Management in Cape Town		
9	Meeting Ethiopia's Development Goals by Addressing Links between Water, Energy and Food		
10	Lesotho: Tackling Water Insecurity in a Changing Climate		
11	Reconciling Water, Energy and Agricultural Sector Demands in Zambia		
Infrastructure, waste management, settlements			

12	Building Happy and Integrated Neighbourhoods in Luanda, Angola		
13	Stakeholder-Based Development Planning of the Shire River Basin's Water and Natural Resources in Southern Malawi		
14	Maputo: Private-Public-People Networks for Climate Compatible Development		
15	Building Disaster Risk Reduction in the City of Lusaka, Zambia		
16	Improved Waste Management through Public-Private Partnerships in Lusaka		
17	Community-Based Action against Flood Risks in Dakar		

Ecosystems & Biodiversity

1. Ecological Infrastructure for Resilience and Job Creation in South Africa

Climate risks	
SDGs	
Project name	Working for Water, Working for Wetlands, Working on Fire
Project location	South Africa (nationwide)
Adaptation type	Community-based adaptation, ecosystem-based adaptation and disaster risk reduction
Keywords	Wetland health, remediation measures, erosion prevention, skills development, invasive alien species, rehabilitation, streamflow, South Africa, drought, integrated fire management.
Sectors	Public works infrastructure, non-governmental organisations, economic development, water, conservation
Stakeholders	South African Department of Water Affairs and Forestry; Department of Environmental Affairs; Departments of Environmental Affairs and Tourism, Agriculture, and Trade and Industry; Provincial Departments of Agriculture, Conservation and Environment
Project status	In progress
Contact point	Working for Water David le Maitre 021 888 2441 dlmaitre@csir.co.za Working for Wetlands Umesh Bahadur South African National Biodiversity Institute 012 843 5200 Working on Fire 013 741 6400 comms@wofire.co.za
Website	https://www.environment.gov.za/projectsprogrammes/workingfowetlands https://www.environment.gov.za/projectsprogrammes/wfw https://workingonfire.org/

1. Working for water

Project background

The fight against invasive alien plants is spearheaded by the Working for Water programme, launched in 1995, and administered previously through the Department of Water Affairs and Forestry, and now through the Department of Environmental Affairs in South Africa. This programme works in partnership with local communities, for whom it provides jobs; and also with national government departments, including the departments of Environmental Affairs and Tourism, Agriculture, and Trade and Industry; provincial departments including agriculture, conservation and environment; research foundations and private companies.

Since its inception, the programme has cleared more than one million hectares of invasive alien plants from both urban green belts and rural areas. The programme has provided jobs and training to approximately 20,000 people from among the most marginalized sectors of society per annum - of these, 52% are women.

Climate risks and other stressors

Invasive alien plants are plants, animals and microbes that are introduced into countries, and then out-compete the indigenous species. They intensify the impact of fires and floods and increase soil erosion. Both fires and floods are climate-based hazards which can be further aggravated by climate change. Invasive Alien Plants can divert enormous amounts of water from more productive uses, such as for washing or drinking. Invasive aquatic plants, such as the water hyacinth, affect agriculture, fisheries, transport, recreation and water supply.

Adaptation approach

Working for Water currently runs over 300 projects in all nine of South Africa's provinces. Scientists and field workers use a range of methods to control invasive alien plants. These include:

- Mechanical methods - felling, removing or burning invading alien plants;
- Chemical methods - using environmentally safe herbicides;
- Biological control - using species-specific insects and diseases from the alien plant's country of origin. To date, 76 bio-control agents have been released in South Africa against 40 weed species;
- Integrated control - combinations of the above three approaches. Often, an integrated approach is required in order to prevent enormous impacts;
- Developing an up-to-date Geographical Information System coverage of invasive alien plants in the catchments that comprise the Western Cape Water Supply System, and then using the latest monthly catchment models to estimate the invasive alien plants-related streamflow reduction impacts on the runoff simulated for these catchments.

Enhancing capacity and commitment to solve invasive alien plant problems through:

- The development of a combined environmental implementation and management plan;
- The establishment of a skills development programme;
- Co-ordinating policy, legislative and planning frameworks (national and international);
- Implementing an advocacy and awareness strategy.

Link to SDGs

The Working for Water project addresses SDGs 3, 8, 13 and 15. The Working for Water, Working for Wetlands and Working on Fire projects address Goal 3 of the Sustainable Development Goals as all projects are working towards healthy lives, prevention of diseases through flood control, and death due to fire. These projects work towards Goal 8 through providing decent work and educational opportunities to marginalised people in the population. They also relate to Goal 13 as they are are all around developing and supporting ecological infrastructure (refering to naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction) as a means of making the environment more adaptable to climate change. Finally, the three projects are fundamental in capacity building towards achieving Goal 15 (to sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss).

Challenges

Dealing with a multifaceted problem such as removing invasive alien plants and the integration and coordination of the various controls tied to that procedure is the most important, yet also most difficult part of the Working for Water programme. Only through effective communication and project management has Working for Water been able to sew together the various aspects of the programme such as biocontrol, social development, or value- adding industries (utilising the cleared biomass to create furniture). Working for Water also works closely with schools to incorporate teachers in the project to expose them and their students to the programme's work.

Benefits

The Working for Water projects enable urban, peri-urban and rural communities to work together towards healthy lives and prevention of diseases through flood control. The project also works to provide decent work and educational opportunities to marginalised people within the population. In addition to this, Working for Water and its various projects have been able to develop and support ecological infrastructure as a means of making the environment more adaptable to climate change risks such as flooding and fire. Working for Water also sustainably manages forests, combats desertification, halts land degradation and biodiversity loss.

Lessons

Fully involving all members of the local community or area in the planning and implementation of any Working for Water projects was key to the success seen by Working for Water. It is only through participation that communities acquire a sense of ownership and become motivated to operate and maintain the area.

The Working for Water team doing an incredible job of removing peri-urban alien vegetation. Photo provided by: Working for Water project

The Working for Water team removing alien vegetation. Alien plant removal occurs in both rural and semi-urban areas. Photo provided by: Working for Water project.

2. Working for Wetlands

Project background

Working for Wetlands is a joint initiative of the departments of Environmental Affairs, Water and Sanitation (previously known as Water Affairs), and Agriculture, Forestry and Fisheries of South Africa. The initiative works through models that emphasise cooperative governance and partnerships. The focus is on the rehabilitation, wise use and protection of wetlands in a manner that maximises employment creation, supports small businesses, and transfers relevant and marketable skills to beneficiaries.

Climate risks and other stressors

Climate risks and consequences of wetland loss include:

- Diminished water security;
- Desertification;
- Reduced food security;
- Reduction in biodiversity;
- Lost livelihoods;
- Increased vulnerability to natural disasters, especially floods and droughts. With climate change predicted to change rainfall patterns, wetlands will play a more important role than ever before in reducing the impacts of floods and droughts.

Adaptation approach

All rehabilitation interventions aim to improve the condition and functioning of the wetland ecosystem, and to address both causes and effects of degradation. Through these measures, urban and rural wetland ecosystems become more resilient to climate change.

Typical rehabilitation process activities include:

- Building concrete, earthen or gabion structures to arrest erosion, trap sediment, and re-saturate drained wetland areas;
- Plugging artificial drainage channels;
- Addressing other causes of degradation, such as poor agricultural practices and invasive alien plants;
- Propagating plants, and taking steps to facilitate vegetation and bio-engineering;
- Building boardwalks, bird hides and interpretive signboards to enhance the recreational, tourism and educational value of rehabilitated wetlands;
- Concluding contractual agreements with landowners to secure the rehabilitation work, prevent further degradation of wetlands, and influence land use practices; and
- Providing community members with part-time employment and training to monitor completed rehabilitation once the work is completed.

Link to SDGs

Please see ‘Link to SDGs’ section in ‘Working for Water’.

Challenges

Working for Wetlands faced practical challenges to its structural work caused by heavy rains that led to flooding and rendered some roads inaccessible; and temperatures surpassing 40 degrees Celsius. There were also challenges in accessing privately owned land, and the need to achieve 'buy in' from private landowners and communities with communal lands. The project also faced the difficulty of accommodating staff and the safe-keeping of rehabilitation material in distant locations.

Benefits

Wetlands can play an important role in helping to dampen the effect of climate extremes such as flooding and fires, which are predicted to increase with time due to climate change. The contribution that wetlands make to reduce the severity of floods by accommodating and slowing down flood waters has been well demonstrated. Coastal wetlands, particularly mangroves, also provide storm protection. For example, when a tsunami batters a coastline, those coastal sections with intact mangroves are generally much less severely affected than those coastal sections where mangroves have been cleared.

The function that wetlands play in storing water in the local landscape is well known; e.g. in dry periods, stored soil water can help to support the growth of native plants, which may be a critical source of food for livestock, and also cultivated crops for human consumption. In this way, a wetland can be a life-saving safety-net for poor, small-scale farmers.

Lessons

The design of the erosion-prevention infrastructure allowed for both 'hard' solutions (involving stone gabions, concrete and wire) as well as 'soft' solutions (involving vegetating banks, using saplings, geotextiles, armorflex and ecologs). This promoted labour-intensive construction and skills development within local communities and for unskilled workers.

Wetlands are brought to life in the Soweto township, South of Johannesburg. Photo provided by: Working for Wetlands project

Working for Wetlands has rehabilitated 500 wetlands throughout South Africa, and has employed 1,500 people. Photo provided by: Working for Wetlands project

3. Working on Fire

Project background

Working on Fire is a government-funded, job-creation programme focusing on implementing integrated fire management in South Africa. The programme employs more than 5,000 young men and women who are fully trained as wildfire firefighters and are stationed in more than 200 bases across South Africa; 94% of whom are youth, 31% are women (the highest level in any comparable fire service in the world), and 3% have disabilities. The Working on Fire firefighters are recruited from marginalised communities and trained in fire awareness and education, prevention and fire suppression skills.

Climate risks and other stressors

As a result of climate change, South Africa experiences higher temperatures and longer dry spells in summer. Projections show that these are likely to increase in frequency. As a result, increasing heat and droughts combine to exacerbate the incidence of fire risk, putting many lives at risk in both rural and urban South African environments.

Adaptation approach

Working on Fire is putting in place fire management activities that are adaptive to climate change by taking into account changes in fuel, vegetation type and burning conditions due to changes in climate. These activities are wide ranging. They include: prevention, early warning, detection, mobilization and suppression of unwanted and damaging fires. Working on Fire also addresses issues related to the appropriate use of natural- or human-caused fire in maintaining ecological values and integrity of certain ecosystems; using fire to reduce the accumulation of natural fuel and residues from commercial or non-commercial activities; and the rehabilitation of ecosystems damaged by or dependent on fire.

Link to SDGs

Please see ‘Link to SDGs’ section in ‘Working for Water’.

Challenges

Challenges faced by Working on Fire include finding effective ways to empower affected rural and urban communities, and recruiting fire fighters to fill needs in key areas. Working on Fire conducts outreach to enhance understanding about the benefits of, and potential harm caused by fire – a challenging mission it undertakes through advocating and assisting with the implementation of appropriate land-management strategies.

Benefits

One of the resulting benefits of the project is the creation of an awareness and education platform amongst land-users and the general public. Enhanced awareness of relevant laws, ordinances, by-laws, and compliance issues could be raised among partner groups and local communities. Preventing fires and limiting their spread produced many benefits in terms of protecting urban and ecological infrastructure, and human lives. Lastly, Working on Fire has enabled local job creation and skills development.

Lessons

Working on Fire started out as a training programme for firefighters and as a job-creation programme for people from disadvantaged backgrounds. However, Working on Fire quickly realised that success in managing fires not only lies in the preparation and training of firefighters, but in expanding awareness and education on the issue in vulnerable and high-density communities.

Working on Fire is a presence on the large dry green belts in Johannesburg. Photo provided by: Working on Fire project

A firefighter with Working on Fire puts out a roadside fire in Cape Town, South Africa. Photo provided by: Working on Fire project

2. The Buffelsdraai Community Reforestation Project

Climate risks	
SDGs	
Project name	EThekwini municipality's Buffelsdraai Community Reforestation Project
Project location	Buffelsdraai Landfill Site, north of the City of Durban, South Africa
Adaptation type	Community ecosystem-based adaptation (CEBA)
Keywords	Community reforestation, planting trees, ecosystem services, indigenous forests, landfill site, Durban
Sectors	Waste Disposal, Environmental Land Management
Stakeholders	Land use planners, waste managers, engineers, community members, environmentalists, community groups, funding agencies.
Project status	Active (2008 – present)
Contact point	Mr Errol Douwes Manager: Restoration Ecology EThekwini Municipality E: Errol.Douwes@durban.gov.za

Project Background

The Buffelsdraai Community Reforestation Project was initiated in 2008. The project aims to address the environmental risks associated with a landfill by increasing urban biodiversity, and by maintaining natural buffer zones – measures intended to foster adaptation to climate change, and to create more resilient community planning. (Douwes et al., 2015). As a co-benefit, the project has also successfully contributed to alleviating the climate change impacts associated with hosting elements of the 2010 FIFA World Cup. The total unavoidable carbon footprint of the event was estimated to be the equivalent of 307,208 tons carbon dioxide (CO_2). Reductions have been achieved by planting indigenous trees, and by restoring local natural habitat within the buffer zone around the Buffelsdraai Landfill site (situated in the north of Durban). The reforestation project, established as a natural carbon sink, aimed to offset the equivalent of approximately 42,000 tons CO_2. The total offset is expected to be achieved over a 20-year period. All reforested areas were previously lands that were infested with invasive alien plants, or were sugarcane farms with limited productive capacity. The project is conducted using a community ecosystem-based approach. This is intended to ensure that a range of socioeconomic co-benefits (such as sustainable job creation) would be produced to directly benefit the neighbouring community.

Climate risks and other stressors

Recurring drought presents a major challenge. In 2013, Durban experienced very hot and dry periods. During that time, the project's water pump also malfunctioned, which led to heat stress and, consequently, to increased tree mortality. The clearing of alien invasive plant species also presented participants of the reforestation project with challenges.

The Buffelsdraai Landfill is important for city waste disposal; but like all landfills, it also has environmental impacts. Odour, noise and the visual impact of the landfill count among other factors that impair the well-being and health of nearby residents.

Adaptation approach

The 'Indigenous trees for life' concept used in this adaptation example was developed by the Wildlands Conservation Trust, one of the partners of the project. Local community members ('tree-preneurs') are encouraged to grow indigenous tree seedlings in their 'home nurseries' (in the buffer zone around the landfill site) until these saplings reach a suitable height, and are ready to be traded. On collection of the trees, tree-preneurs are paid with credit notes. These credit notes can be used at 'tree stores' organised by Wildlands Conservation Trust to purchase groceries, bicycles, or building materials; or to pay for school fees or vehicle driving lessons. Collected trees are kept in a holding nursery at the project site, and are sorted according to size and species, ready to be hardened off prior to planting. The project's reach extends beyond Buffelsdraai to include the surrounding communities of Osindisweni, Buffelsdraai, Ndwedwe and KwaMashu. These communities can participate in the exchange of trees for goods. As a result, the neighbouring communities also benefit through sustainable job creation.

Workers prepare a site for the planting of trees at the Buffelsdraai Community Reforestation Site. Photo provided by: Ethekwini Municipality

Link to SDGs

Sustainable economic development, and the jobs that go with such development, hold the potential to lift some of the most vulnerable residents of Buffelsdraai out of poverty (SDG 1). The project also contributed to a more resilient community settlement (SDG 11) by adopting a community ecosystem-based approach, and by contributing to the restoration and protection of terrestrial ecosystems (SDG 15).

Challenges

Throughout the implementation of the project, the contested ownership of lands in the buffer zone presented an ongoing issue. Various activities – among them grazing cattle and goats, and arson fires – damaged trees. Other activities with indirect negative impacts include trespassing, illegal settlements, hunting and petty theft. Also, as soon as trees had been planted, follow-up steps had to be taken, including ongoing control of invasive alien plants, and the guarantee of the creation of firebreaks to prevent the spread of fires. Moreover, some community members were neither sufficiently aware of why the reforestation project was initiated, nor sufficiently informed about its potential benefits (UNFCCC, 2012).

Benefits

Wide-ranging benefits resulted from the implementation of the community reforestation project in Buffelsdraai. The region showed a marked increase in biodiversity (both fauna and flora). For instance, the number of tree species in the project areas has increased from zero to 124. The total number of bird species listed has increased from 91 to 145 over the five-year period in areas previously under sugar cane production. The project also led to the offsetting of 50,000 of the 307,208 tonnes of CO_2-equivalent emissions associated with the 2010 FIFA Soccer World Cup, which Durban hosted. Though viewed primarily as a 'carbon sequestration' initiative, the project also ensures the improved supply of a large number of other ecosystem services, such as water quality, flood attenuation, sediment regulation, biodiversity refuge conservation, and river flow regulation. Thus, the project contributes to enhanced resilience and adaptive capacity at the local level.

Furthermore, the programme produced significant socio-economic benefits to some of the most impoverished and vulnerable communities in Durban. Members of the pioneering, model 'tree-preneurs' received training to source and propagate indigenous seeds; this provided them with employment related to tree planting. A social impact assessment after the second year of the project implementation showed that education and food security had increased (Greater Capital, 2011). Schooling for children had been improved; project participants earned additional income to cover needs such as transportation. Access to adequate food supply in two of the project communities had increased by 40%.

Lessons

Engaging with communities from the onset of the project is essential. Community members need to see the value of the project. Otherwise, engagement, project ownership and project sustainability remain challenging. In addition, this project demonstrated a range of co-benefits, many of them the result of participation by local people. Planting trees and restoring natural ecosystems resulted in economic opportunities for the city and neighbouring communities. The project showed the participants that they can play an active role in adaptation to climate change.

The sustainability of the Buffelsdraai community reforestation project will need to take into account the longer-term transition of the project once the tree planting has been completed, so that the forest and its biodiversity can continue to improve, and so that community job creation can be sustained.

In conclusion, this pioneering model, which gave rise to the 'tree-preneur', shows how natural ecosystems support and protect human communities; and they show how human communities can support, restore and protect local ecosystems in return.

3. Mainstreaming Biodiversity and Ecosystem Services for Effective Management in Cities

Climate risks	
SDGs	
Project name	Urban Natural Assets for Africa: Rivers for Life (UNA Rivers)
Project location	Addis Ababa (Ethiopia), Dar es Salaam (Tanzania), Lilongwe (Malawi)
Adaptation type	Ecosystem-based adaptation, resource restoration, improved monitoring
Keywords	Biodiversity, ecosystem services, land use planning, local decision-making, riverine ecosystems, restoration, flooding, drought.
Sectors	Biodiversity (Environmental Management) and Planners (Engineers)
Stakeholders	City council, Research Academics, Private Sector, NGOs, Community members
Project status	Active (2016 - 2019)
Contact point	Jess Kavonic 021 202 0389 jessica.kavonic@iclei.org
Website	http://cbc.iclei.org/project/una-rivers/

Project background

The ecological components of urbanised environments, and the adaptation of these landscapes to meet human needs in city regions have long been a focal point of discussion for policymakers, urban planners and other relevant actors in these transformative processes. ICLEI – Local Governments for Sustainability Cities Biodiversity Center, together with project partners, designed the *Urban Natural Assets: Rivers for Life* (UNA Rivers) project to approach this issue with a special focus on urban river systems in three target cities: Addis Ababa, Dar es Salaam and Lilongwe. The goal is to mainstream biodiversity and ecosystem services (the processes by which the environment produces resources utlilised by humans such as clean air, water, food and materials) into land use planning and local government decision-making processes. The project also aims to contribute to an enhanced understanding of the socio-economic importance of biodiversity and ecosystem services, and to facilitate the use of new understanding into strategic climate change adaptation plans. Urban Natural Assets for Africa Rivers for Life (UNA Rivers) furthermore improves coordination and engagement within the project cities (between departments and key stakeholders: Community-based

Organisations (CBO's), NGOs, researchers, communities (inter alia) as well as between cities. Lastly, through locally appropriate, scalable project implementation (with a specific focus on community-based art and culture activation), the project successfully connects people living in urban communities to biodiversity and ecosystems within an urban river context, enhancing overall human well-being.

Illegal waste dumping on rivers in Lilongwe... Photo provided by: ICLEI Africa (2016)

… and Dar es Salaam. Photo provided by: ICLEI Africa (2016)

Climate risks and other stressors

Typical climate hazards associated with riverine ecosystems are the impacts of flooding and drought, both likely to deteriorate the existing biodiversity, and to threaten the livelihoods of the people living nearby. Building resilience at the local level by managing the natural asset base and restoring riverine ecosystems can help confront these natural hazards.

Adaptation approach

By sustainably managing and restoring rivers and riverine ecosystems in three African cities, this project aimed to protect natural ecosystems so that the natural asset base is maintained for cities to better adapt to climate change. UNA Rivers adopted certain measures with an ecosystem-based approach to attain their goals. This approach involved mapping the existing natural assets in the three target cities, and then sharing the capacity- building potential of the mapped information with key decision makers. As a result, land-use planning incorporated biodiversity and ecosystem services into the process, with the aim of better guiding policy and planning systems. In addition, on- the-ground engagement promoted coordination of key role-players in managing urban rivers. Pilot riverine ecosystem restoration measures were implemented.

Link to SDGs

This project primarily aligns with SDG Goal 15 through protecting, restoring and promoting the sustainable use of terrestrial ecosystems. Through better coordination and community-based activation, the project contributes to strengthening sustainability and resilience at the local level, thus enhancing human well-being and poverty alleviation (SDG 3).

Challenges

Through an intensive consultation during the planning phase of the project, important relationships were built that led to increased access to relevant information, and to enhanced understanding of the governance structures in the project cities. Understanding these structures proved crucial in mainstreaming information, and overcoming barriers.

Benefits

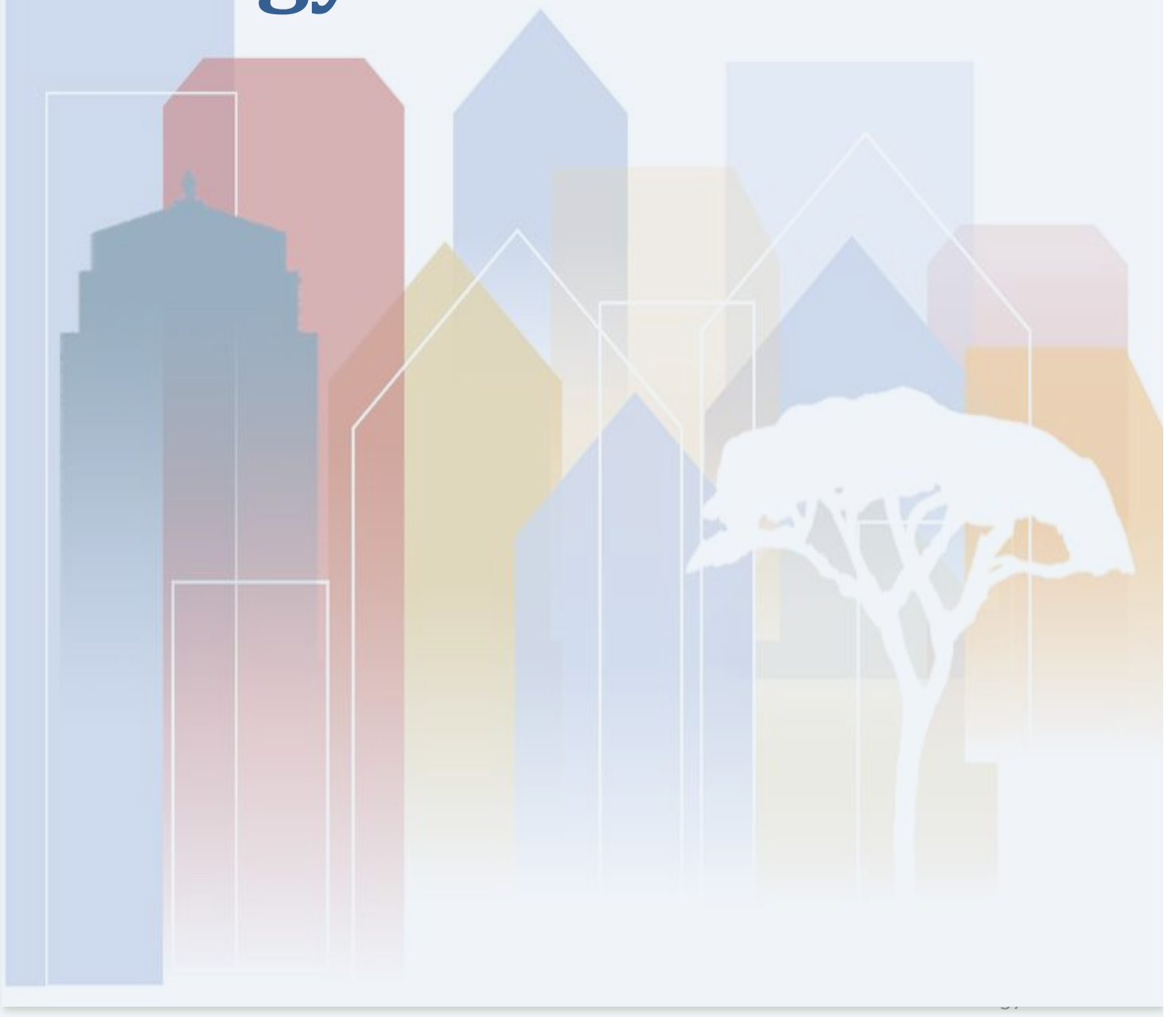
Substantial benefits can result from the ecosystem-based approach presented here. Through better coordination and community-based activation, resilience at the local level can be strengthened and human well-being can be enhanced. Understanding the decision-making processes in the project cities, and improving the co-ordination of key stakeholders are essential for transformation needed to build resilience. Improved information helps to provide much needed links between decisionmakers and technical officials in the cities, enabling cities to better protect and manage riverine environments.

Lessons

Several key lessons emerged from the implementation of the project. To identify entry points to mainstream information, it is important to understand the city context, the official and unofficial governance structure, and the roles played by key decisionmakers. There is still a major need for

implementation-oriented pilot projects that introduce innovative ideas, and push for a change in the use of urban ecosystems. Also, co-ordination of environmental protection interventions in African cities is still widely lacking. Improved coordination leads to knowledge and lesson-sharing, and therefore eventually accelerates adaptation activities. Projects should be aligned with city needs and policies, and to that end, projects should be co-produced with relevant decision makers, such as city officials.

Urban water resources, agriculture & energy



4. Africa's First Direct Water Reuse Plant in Windhoek, Namibia

Climate risks	
SDGs	
Project name	Goreangab Water Reclamation plant
Project location	Windhoek, Namibia
Adaptation type	Urban Adaptation, Climate resilient livelihoods, urban infrastructure
Keywords	wastewater treatment, potable water, drought, water reclamation system, City of Windhoek, drinking water supply
Sectors	National Department of Water Affairs, Aurecon Technical Consultants, Namibia City of Windhoek
Stakeholders	Namibia City of Windhoek, Design Engineers, Contracting Engineers
Project status	Completed
Contact point	Johan de Vos City of Windhoek +264 61 290 2346 joha.devos@windhoek.org.na
Website	http://www.wingoc.com.na/about.html

Project background

Namibia is the most arid country in Southern Africa. Windhoek, the capital of Namibia, has an average annual rainfall of around 370mm, while the average evaporation rate is 3400mm. In 1968, the Goreangab Water Reclamation plant was built by the City of Windhoek to reclaim water directly from domestic sewage effluent.

In 2002, a new, larger Goreangab Reclamation Plant was completed to replace the original plant, using the latest available, proven water-treatment technology. The ultimate aim of the project was to ensure the security of the potable water supply for the future. The plant was developed to ensure the total utilization of available effluent from domestic wastewater (from the Gammams Wastewater Treatment Works in Windhoek, built in 1965). The plant was designed based on extensive experience (30 years) and research conducted locally, and on input from international experts to assure compliance with the strictest water quality guidelines applied internationally.

Climate risks and other stressors

Regions such as Namibia are likely to face longer and more intense periods of drought as a result of climate change. Water recyling can save resources. The First Direct Water Reuse project demonstrated that wastewater should no longer be viewed as a waste product, but can be considered a special resource that can fill human needs through specialised treatment. (In this respect, wastewater may be considered in a category similar to seawater, which also requires specialised treatment for use as potable water.)

Water reuse provides one answer to the looming water shortages for arid regions in Southern Africa. This upgrade project also built and provided capacity to wastewater infrastructure that is needed to address large-scale public health concerns stemming from African cities' inability to provide the wastewater removal and treatment needed to keep pace with record levels of urbanisation. As the cost of cleaning and piping water increases, wastewater reuse offers an increasingly viable solution for communities seeking to cope with growth.

Bioreactor at Gammams water reclamation Plant. Photo provided by: City of Windhoek

The Water Reclamation Plant in Windhoek is internationally known as the first plant in the world to reclaim domestic sewage for potable use. Photo provided by: City of Windhoek

Adaptation approach

To mitigate future water stresses in the region, a water reclamation plant for the production of potable water for Windhoek, Namibia, has been upgraded. The capacity of the reclamation plant totals 21,000 m^3/d after the completion of the project. The raw water used consists of treated municipal wastewater. The municipal wastewater from the region is conditioned in the Gammans treatment plant (using a biological nutrient removal process), and polished in maturation ponds before being treated in an advanced multi-barrier system. This employs several barriers for all crucial contaminants, and thus guarantees outstanding drinking water quality. Since its start-up, all the relevant standards have been fulfilled without difficulty.

The different steps involved in the treatment process include:

- Oxidation and pre-ozonation
- Powdered activated carbon dosing
- Coagulation and flocculation
- Dissolved air flotation
- Dual media filtration
- Main ozonation

- Biological activated carbon filtration
- Granular activated carbon filtration
- Ultrafiltration
- Disinfection and stabilisation.

This plant was the first plant in the world to reclaim sewage for drinking water. The upgrade of the plant required pioneering technologies.

Link to SDGs

The Goreangab Water Reuse Plant was a technical project assisting with SDG Goal 3, ensuring people have clean and sufficient water to maintain health and reduce the chance for waterborne diseases to spread. It fed into SDG Goal 6, ensuring adequate clean water and sanitation for the people of Windhoek. It further addressed Goal 11 and 12, ensuring sutainable cities through effective use of waste in Windhoek and sutainable production production and consumption, and Goal 13 as this was an example of a climate resilient city implementation.

Challenges

The plant's upgrade required pioneering technologies, such as Biological Activated Carbon filtration and Granular Activated Carbon filtration.

The process needed to remove four major elements from the wastewater, including physical and organoleptic elements, macro elements, micro biological and disinfection by-products. The process design was one of a 'multiple barrier' process. Individual barriers were established for each of these four elements that needed to be removed. The challenge ultimately consisted in the ability of the plant to produce a clean, clear, pathogen-free effluent, with special emphasis on the removal of *Cryptospiridium* and *Giardia.*

Benefits

The water reclamation plant provides renewable water for the City of Windhoek in an increasingly arid Namibia. Also, the reuse of treated water allows for the conservation and allocation of freshwater and can enhance the restoration of streams, wetlands and ponds. The use of nutrient-rich treated wastewater for agriculture may lead to a reduction (or elimination) of fertilizer application, and/or increased productivity, and may therefore also contribute to food security.

Lessons

Three lessons emerged from the Windhoek experience. First, the 35-year-long project proved that augmenting drinking water supplies through direct reuse of water can be undertaken in a safe and responsible way. However, if geographical circumstances allow, the use of an indirect reclamation plan that, for example, allows reclaimed water to be stored in an aquifer is recommended

Second, a multi-disciplinary team approach was essential in ensuring that the proper installation and operation of the technologies employed. Additionally, proper monitoring was important to ensure that the produce is safe for its intended use.

Third, policies and regulations at national and local levels were needed for proper support to ensure the long-term safety and sustainability.

5. Tackling Soil Erosion and Improving Lives in South- Eastern Nigeria

Climate risks	
SDGs	
Project name	Nigeria Erosion and Watershed Management Project (NEWMAP)
Project location	Southeastern Nigeria (specific project in Benin City, Edo State)
Adaptation type	Disaster risk reduction, climate-proofing the built environment, climate-resilient livelihoods, community-Based adaptation
Keywords	Rainfall variability, bioremediation, watershed management, gully erosion, land degradation, resilience, slope stabilisation, Nigeria
Sectors	Agriculture, Forestry, Housing, Public Works
Stakeholders	Environmental Affairs, World Bank, Aurecon Consulting Engineers, Traditional Rulers, Women Leaders, Site Committee Members
Project status	In progress (2014 – 2020)
Contact point	John Adisa EDO-NEWMAP jadisa33@yahoo.com +2348023071085
Website	http://newmap.gov.ng/

Project background

The Federal Ministry of Environment, the World Bank and its partner agencies designed the Nigeria Erosion and Watershed Management Project (NEWMAP). NEWMAP is aimed at addressing gully erosion in southeastern Nigeria, as well as land degradation in northern Nigeria. The project is in line with the growth and resilience goals of Nigeria's Vision 20:2020.

The Edo State Project Management Unit appointed Aurecon in the engineering design and supervision of erosion-control sites over a three-year period. The aim of this specific project is to develop measures and install structures to mitigate the severe erosion gullies at sites in and around Benin City, in Edo State. This includes 13 sites for engineering design and supervision:

- Ibore gully erosion site in Esan (Central Local Government Area)
- Emu/Ohodua gully erosion in Esan (Southeast Local Government Area)
- Ewu Esan gully erosion (Central Local Government Area)
- Igbe quarters flood and gully erosion
- Urora
- Edo College gully erosion
- Ambrose Alli University
- Ogiso/Osunde flood and gully erosion site
- Fugar-Agenebode road flood and gully erosion
- Gapiona watershed catchment
- Oshiobugie gully erosion site
- Queen Ede gully erosion site
- Ekehuan road gully erosion site

Climate risks and other stressors

The rainfall changes associated with climate change, along with expected changes in temperature, solar radiation, and atmospheric CO_2 concentrations, will have significant impacts on an already extreme soil-erosion rate in Nigeria. The processes involved in the impact of climate change on soil erosion by water are complex, involving changes in precipitation amounts and intensities, including the number of days of precipitation, plant biomass production, plant residue decomposition rates, soil microbial activity, evapotranspiration rates, and shifts in land use necessary to accommodate a new climatic regime.

Soil erosion by water due to heavy rainfalls is a major environmental threat to the sustainability and productive capacity of agriculture in Nigeria. The effects of climate change on soil erosion go beyond rainfall to the more indirect effects on human life and livelihoods and critical infrastructure.

Besides oil, agriculture is important to the Edo State region in Nigeria - especially concerning major crops, including rubber, cocoa and palm tree derivatives. In line with this, the Edo State Government has undertaken this 13-site, 36-month project in an effort to improve soil erosion, as well as to manage public resources, and to improve the institutional and policy environment of the State.

Adaptation approach

NEWMAP takes an integrated watershed management approach to erosion, addressing the interlinked challenges of poverty, ecosystem services, climate change, disaster risk management, biodiversity, institutional capacity and governance.

Link to SDGs

The NEWMAP project addresses Goal 11, 13 and 15 by ensuring that the cities and towns in the Edo state are liveable and sustainable, geared towards climate change adaptations, and that natural systems are preserved from the scourge of soil erosion.

Challenges

The challenge is that solutions to drainage infrastructure problems such as those addressed by NEWMAP do not exist in a vacuum, they exist amongst a complicated network of environmental and human problems. This is amplified by the fact that Nigeria's ecological problems are unique in the sense that different geo-political zones are faced with specific environmental challenges. Major challenges that NEWMAP aims to improve include weak local participation, absence of land use planning, and insufficient attention to livelihood issues.

Further to this, a major challenge has been related to the use of land where people have already settled. As a result, compensation has been paid to people directly affected by the ongoing construction works in the initial 21 sites.

Benefits

Benefits to towns where NEWMAP has implemented infrastructure include:

- Reduced loss of infrastructure including roads, houses, markets, and other real estate;
- Reduced loss of agricultural land and productivity from soil loss caused by surface erosion;
- Enhanced sustainable development efforts;
- Increased incomes for rural households resulting from improved agriculture and agro forestry from the vegetative regeneration using an integrated watershed approach.

The Atakpa reclaimed site is a completed project of NEWMAP. Previously in this location water pulsed, unconstrained, down this hill creating mass erosion. Photo provided by: NEWMAP project

Disaster of soil erosion due to heavy rainfalls in the town of Gombe; NEWMAP is to start work in the town in 2017. Photo provided by: NEWMAP project

Lessons

(a) Watershed management, including gully restoration and prevention, is complex and must address a myriad of interactions among land, water and people. Successful approaches balance evidence-based planning with meaningful stakeholder involvement at an early stage.
(b) Begin watershed planning with a larger scale assessment, but also implement activities at a smaller scale appropriate for integrating communities into a participatory process. This approach can help internalize externalities in the watershed, connecting upstream and downstream users.
(c) It is important to adopt an integrated approach that addresses livelihoods and watershed management. Civil works and simple land management interventions can safeguard soil and water resources and reduce climate risk, while livelihoods interventions can reduce pressure on natural resources.
(d) With major gullies, it is important to first understand the causal factors, which often arise from poorly designed infrastructure, urban development and inappropriate agricultural practices. Prevention is usually more cost effective than remediating existing gullies. Measuring the success of gully restoration interventions often requires more than one indicator.
(e) There is a need for a balanced focus on information, institutions, and on-the-ground investments (combining structural, vegetative, and livelihoods).

(f) It is critical to sustain government commitment through a supportive network enabling the legal, policy, and institutional environments to invest at scale. It is important to establish and maintain transparent procurement and reporting systems, clear accountabilities, and good dialogue and coordination across sectoral and geographical boundaries.
(g) Successful watershed programs are characterised by openness to testing innovative approaches, while insisting on rigorous and locally appropriate civil engineering designs and monitoring.

Operational lessons:

(h) A robust and well-funded monitoring and evaluation system that addresses input-output, process and impact evaluation is required. It will also include appropriate application of new technologies such as remote sensing and Global Information Systems (GIS), with strong feedback to guide project implementation. A highly qualified firm can often provide significant technical support to implementing agencies, and arms-length reporting.
(i) The use of Global Environment Facility (GEF) resources should be fully integrated into International Development Association (IDA) financed operations, avoiding the common use of parallel implementation structures for GEF and IDA in Bank-financed Nigeria operations in the past.
(j) Local development planning should be more harmonised, as the experience of Bank-assisted Community Driven Development projects shows greater impact on poverty alleviation.

6. Off-Grid Power Generation Solutions in the Takoradi Region, Ghana

Climate risks	
SDGs	
Project name	The WestPark project
Project location	Takoradi Region, Ghana
Adaptation type	Disaster risk reduction, sustainable energy and development; protect/conserve (properties prone to flooding)
Keywords	Off-grid electric power generation, land-use zone, land infrastructure concept designs, industrial park, Ghana.
Sectors	Textile industry and business leaders, civil society, local communities, employees, employers, infrastructure, energy, agriculture, land use, disaster risk, flood management.
Stakeholders	Department of Trade and Industry, BlackIvy, Aurecon
Project status	Concept plan completed 2015
Contact point	Abena Amoah Blackivy Ghana Ltd +233244520208 abamoah@gmail.com

Project backround

The WestPark industrial development concept plan represents a unique opportunity towards providing much needed industrial space within the wider Takoradi-region in Ghana. The concept for WestPark was completed in 2015 and entailed the development of a master plan for the WestPark industrial park, including developing appropriate land-use zones, land infrastructure concept designs, and off-grid electric power generation solutions.

Next door to the oil and gas cities of Sekondi-Takoradi in Ghana's thriving Western region, WestPark now benefits from ready access to an uncongested deep-water port, Africa's largest thermal power park and a rail and road network undergoing major expansion.

WestPark is a development by BlackIvy, a company that builds and grows logistics and infrastructure solutions for emerging economies and businesses that serve the needs of the growing middle class (Aurecon, 2015).

The four core guiding principles for the project were

Integration and inclusivity: The concept was based on having mixed land users, making sure it was universally accessible, and integrating it with the surrounding environment and infrastructure.

Resilience: The WestPark development was envisioned to have resilient infrastructure, and to be financially sustainable with low operation and maintenance costs. Its design used a 'whole society' approach, whereby the public and private sectors work together to produce development solutions that are feasible over the long term

Liveability: The development concept design was based on creating a safe and secure development, using high-quality structures and infrastructure that offered convenience for people who work and live in the region. Planners also aimed to ensure a vibrant economy, affordable housing, protected open spaces, conveniently accessible community services, and a sustainable environment.

Resource Efficiency: The development was designed to be, as far as possible, a self-sufficient, green development that prioritises maintaining and creating a clean environment (Aurecon, 2015).

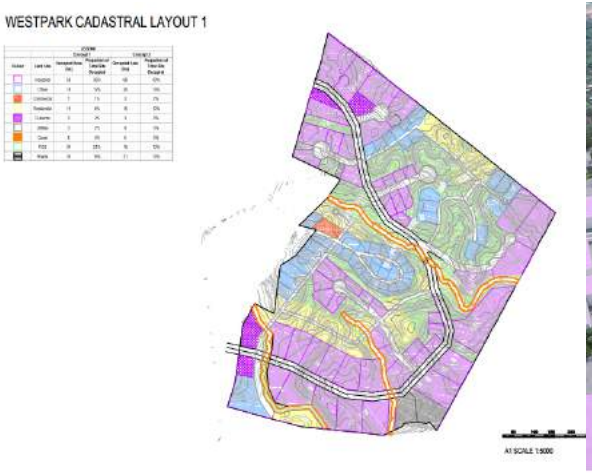
Climate risks and other stressors

Climate change impacts on natural hazard vulnerability in Ghana:

Floods and landslides: Ghana is exposed to floods, particularly in the northern Savannah belt. Landslides associated with these floods are also a growing concern. Extreme rainfall events have increased over the 1986-1995 period, including a high number of 24-hour maximum rainfall events—a trend that has continued in the last decade.

Coastal erosion: Further sea-level rises and storm surges are likely to affect coastal regions of Ghana, which already faces coastal erosion, especially along the eastern coastline.

Droughts: Climate extremes amplify food-security threats, and can severely affect economic development. Insufficient rainfall during the major cropping season in 1982-1983 affected more than 12 million people. More recently, in 2007, catastrophic floods in north Ghana occurred immediately after a period of drought, and damaged the maize harvest (World Bank, 2011).



Land use diagram for the Westpark industrial park. Photo provided by: BlackIvy

Rendering of how the park will look once constructed. Photo provided by: BlackIvy

Adaptation Approach

The planners of WestPark ensured that the industrial park was adapted for future climates by developing a land-use schedule for residential, business, commercial and industrial zones. Green belts were created to separate the residential and business areas from the commercial and industrial zones.

The current topography of the land earmarked for development is highly variable. As a result, the bulk earthworks of this project pose one of the highest concerns with regard to climate change-induced flooding. For this project, a specific bulk earthworks programme was proposed to:

- Provide free drainage of properties;
- Limit damage to property and areas prone to flooding;
- Reduce loss of goods and life due to limited flooding;
- Reduce the implementation cost of civil infrastructure elements such as roads, stormwater drainage, sewerage and water. Servicing each plot with the requisite utilities will now be technically achievable, whereas before there would have been various grade separation issues for connections of pipes, etc., for plot servicing;
- Provide maximum possible flexibility in urban plan layout changes for future modification, should the client wish to change certain elements/ land uses/ access;
- Eliminate the need for any type of retention structures throughout the site to maximise the potential for land development, and to reduce potential costs;
- Find the most effective alternative in terms of construction cost by achieving an approximate net balance between suitable cut material and required fills, considering the assumed amount of unsuitable excavated material to be spoiled off site (Aurecon, 2015)

Link to SDGs

The development of WestPark addresses SDGs 3, 9, 11, 13 and 15. It provides a space for economic development; it is an industrial space that has been designed with sustainability and climate change in mind. The green belts and layouts of the park are intended to boost health, and to provide heat control – measures that are designed to make this development resilient to climate change.

Challenges

Three types of challenges surfaced in the project. The first stemmed from the high variability in the topography of the land. The bulk earthworks devised to deal with the situation required additional planning, and added to costs.

The second related to the lack of an established textile industry. The project confronted initially low efficiency levels, and few ancillary supply industries (e.g., packaging).

The third related to needed infrastructure. Lack of direct access to the Cape Coast via the Takoradi Road is an issue. The presence of shallow groundwater will likely have implications in terms of the design for roads and drainage of sites in the future.

Benefits

The three following items stand out as climate change adaptation and mitigation benefits of the concept design:

- 12% of the land set aside for the industrial park has been allocated for public open space, which will allow for the channelling of surface water runoff, and for a recreation network (specifically for those living in the area).

- Two design elements have been proposed that speak to water-focused sustainability on the development: rainwater harvesting, and the potential reuse of the treated sewerage effluent (TSE).
- While not proposed as an initial power generation solution for WestPark, solar PV generation has been identified as a resource that could potentially be exploited in future design stages of the development. This is particularly relevant, given the significantly large roof areas that will be prevalent in an industrial park, and the potential to utilise these for the location of solar PV panels, and for net energy generation (Aurecon, 2015).

Lessons

Business interests and green zones are not necessarily mutually exclusive. Investments in basic infrastructure can be conceived to improve the business environment and the environment. WestPark accelerated the development of the Takoradi region by attracting investments in gas, power, port and rail infrastructure. These investments benefitted commercial and residential zones in the enclave through improved access to reliable power, water and transport, which are often challenges for sub-Saharan African regions. The building development company used the incentive of low wages in the Ghanaian textile industry to encourage businesses to relocate to Ghana, and to generate additional investments into WestPark, but the strategy drew criticism. This underscores how sensitive the debate can be over finding a balance between the costs and benefits of equitable growth. However, experience has also shown that seeking to combine economic development with elements that enhance adaptation to future climatic conditions can prove beneficial for the region and its people.

7. Urban Agriculture: Improved Governance for Resilience in Bulawayo, Zimbabwe

Climate risks	
SDGs	
Project name	Urban Agriculture Policy for the City of Bulawayo
Project location	City of Bulawayo, Zimbabwe
Adaptation type	Climate change adaptation policy intervention, disaster risk reduction, community-based adaptation.
Keywords	Urban agriculture, multi-stakeholder forum, food security, urban farming, local knowledge, Bulawayo.
Sectors	Agriculture, water management.
Stakeholders	National Government, City Council, Research and Academic Institutions, NGOS, CBOs and Community leaders.
Project status	Active (2007 – ongoing)
Contact point	ICLEI Africa 021 202 0389 biodiversity@iclei.org.za

Project background

In 2007, the City of Bulawayo developed an urban agricultural policy with support from the Resource Centres on Urban Agriculture and Food Security. The policy document promotes urban agriculture in an effort to provide the urban community with augmented food sources and nutrition in a socially inclusive and gender-sensitive manner. The policy encourages productive use of land by supporting sustainable practices, and promoting financial and educational resources for urban farmers. It creates zones in which different types of agriculture are permitted, and it outlines a leasing system in which residents pay the city a nominal fee to farm on public land. In addition, it encourages diversified crop systems, and increased access to financial support for farmers. One of the most important aspects of the policy is the establishment of the Urban Agriculture Multi-Stakeholder Forum, through which farmers, city officials, and relevant NGOs and agencies meet regularly to discuss and evaluate urban agriculture practices in Bulawayo. Urban farmers who are growing food for the city's residents are now helping to steer the decision-making process about the city's urban agricultural management.

Climate risks and other stressors

Bulawayo faces a number of risks related to urban agriculture. It is located in a dry region with inadequate supply of surface and underground water, creating a chronic water shortage for domestic and industrial use. The likelihood of increasing periods of drought will further exacerbate food insecurity caused by water shortages.

Another issue is access to land for urban agriculture. Though the City of Bulawayo Master Plan (2000–2015) revealed the presence of several thousand hectares of vacant land, a major portion belonged to private owners. As a result, farmers plant crops in more fragile areas (such as along stream banks or beside waterways), exposing these areas to soil erosion and other farm-related sources of environmental degradation. Other factors have impeded the implementation process for urban agriculture management. Prior to 2007, neither a legislative framework nor an institution dealt explicitly with urban agriculture in Zimbabwe. Financing of urban agricultural projects is difficult. Stakeholders have faced challenges in accessing loans, with funding going primarily to rural, resettlement and commercial farmers (City of Bulawayo, 2007).

Adaptation Approach

The Urban Agriculture Policy is an explicit policy intervention to encourage the productive use of land, and to provide better financial and training support for urban farmers. Through its participatory approach, the policy fosters sustainable, community-based adaptation to a changing agricultural environment. The approach relies on integrating local communities into the planning, and providing them with capacity-building and other assistance. The assistance comes through partnership initiatives with NGOs, the private sector and/or other stakeholders and through financial assistance and other measures. As the risk of climate-related disasters in the region will likely increase in the future, this policy furthermore addresses both the short and longer-term vulnerability of local communities.

Link to SDGs

As the policy aims to boost food security and sustainable agriculture in the region, this project primarily aligns with SDG 2. These measures in turn promote healthier lives and improved well-being (SDG3), and enhance local communities' resilience to changing climatic conditions (SDG 11). The policy also promotes a sustainable use of land by a sound management of terrestrial ecosystems (SDG 15).

Challenges

During the implementation of the policy, an array of challenges presented themselves. A first obstacle in the process was the difficulty in persuading community members to change their established farming practices. Attendance at the forum stakeholder meetings remained limited, which rendered the meetings less inclusive and, consequently, less effective. Power relations at play during these meetings further hampered the engagement. Enforcement of the policy continues to be a challenge. Relationship-building with key community members addressed these challenges. Improved relationships and open communication eventually led to increased willingness and engagement of the members to implement alternative agricultural practices. In addition, capacity-building measures for all relevant stakeholders led to a better uptake of the policy.

Urban Agricultural plot in Bulawayo. Photo provided by: global change SysTem for Analysis, Research & Training (START)

Benefits

Through the implemented policy, urban agriculture as a practice is becoming more institutionalised and increasingly accepted in Bulawayo. Urban agriculture is increasingly seen as a vehicle for self-empowerment of people, and as a way to sustainably use and manage of natural resources. Agricultural diversification fosters an increasingly resilient food system. This will improve the quality of life for everybody, but mostly for those living in poverty, the economically disadvantaged, and other vulnerable groups such as those living with HIV / AIDS. Multi-stakeholder forums led to enhanced communication between farmers, city officials, relevant NGOs and agencies – and to better coordination and improved partnerships. Lastly, through the leasing system, farmers' access to financial support improves.

Lessons

The engagement of different stakeholders with local communities led to several key lessons. The inclusion of local knowledge and the involvement of the people on the ground were crucial in order to draft a policy that could be implemented and enforced. Multi-stakeholder forums proved to be invaluable spaces for lesson sharing and coordination. Nevertheless, behavioural patterns on the ground proved very difficult to change. A key difficulty surfaced when trying to persuade individuals to quickly shift from planting crops that were different from the ones they are used to growing. Continuous communication and capacity building are vital to ensure that this behavioural shift is sustainable. In addition, steps need to be drafted so that policies and plans are effectively enforced.

8. Applying an Integrated Approach to Catchment Management in Cape Town

Climate risks	
SDGs	
Project name	The Source to Sea Project
Project location	Zandvlei Catchment within Cape Town, South Africa
Adaptation type	Ecosystem-based adaptation, building partnerships
Keywords	Urban rivers, integrated catchment management, river corridors, water quality, water quantity, Cape Town, urban biodiversity.
Sectors	Environmental Management, Stormwater and Sanitation and Biodiversity management.
Stakeholders	City Council, National government, NGOs (such as ICLEI), Civil Society (such as the Wildlife and Environment Society of South Africa, Working for Wetlands, Friends groups), Neighbouring Communities and the Private Sector.
Project status	Active (2006 - ongoing)
Contact point	Jess Kavonic 021 202 0389
Website	http://sourcetosea.org.za/

Project background

This project is currently being implemented by the City of Cape Town, and aims to coordinate the growing network of partners and stakeholders in Cape Town that are working towards the overarching goal of restoring river corridors in the region. The project partners manage river water quality and quantity to support the region's wealth of biodiversity, and to ensure optimal utilisation of river corridors for the sustained benefit of all users.

Source to Sea is a pilot project within the broader management of the Zandvlei catchment. Zandvlei is one of the most important catchments within the city of Cape Town from a biodiversity perspective. Local authorities, the national park and civil society organisations have done a significant amount of work to develop a cohesive management strategy that aims to rehabilitate and maintain the catchment, and Source to Sea aims to coordinate all the various projects occurring within the Zandvlei catchment to ensure an integrated approach to catchment management. The pilot project connects Table Mountain National Park, a nationally protected area, to Zandvlei, an important estuary and municipally protected area, via two primary river courses along the Diep and Prinskasteel / Keyers rivers. These corridors meander through high-, middle- and low-income areas, connecting residents, businesses, schools, sports clubs and faith institutions. As a result, the mission challenges many

stakeholders to be part of the transformative vision of restoring healthy ecosystems, creating jobs, building climate resilience, and offering substantial recreational and mobility benefits.

Climate risks and other stressors

One of the most important natural hazards in the region is the risk of river flooding. Additionally, river courses are often prone to becoming negative 'open spaces' facing many issues, among them concerns about high levels of pollution, the presence of invasive aquatic vegetation, and the adverse impact on values of nearby property as the result of potential flooding. Rivers face the constant threat of deteriorating water quality due to pressures of urbanisation and the exploitative use of river corridors in the case of mismanagement in such regions (Source to Sea, 2016).

Adaptation approach

Source to Sea takes an integrated adaptation approach to ensure that everybody involved or affected by the project's activities benefits in the long term. Firstly, through buffering zones (such as wetlands), the city is addressing its vulnerability to natural hazards (or consequences thereof) such as flooding and storm-water infrastructure damage. Secondly, the management and cleaning up of riverine environments ensure that catchment areas remain free of waste, and that infrastructure issues related to sanitation and waste are addressed. Biodiversity and waterways are protected within the area of Cape Town to make sure that these natural assets do not deteriorate as the result of, for example, invasive, non-native species.

Finally, the investment into ecological infrastructure promotes tourism and recreation. This in turn leads to the creation of jobs connected to activities and services along the multi-use trails, and connects high- and low-income areas along the course of the rivers. It also leads to increased property values for those living alongside the protected areas. In that way, economic and ecologic value is added to the entire Zandvlei catchment.

Link to SDGs

This project aligns strongly with SDG 6 as it ensures sustainable water management across a wide range of stakeholders. By investing in ecological infrastructure, which promotes tourism and related opportunities, Source to Sea creates sustainable economic growth for all (SDG 8). Furthermore, the integrated approach to catchment management promotes a sustainable use of terrestrial ecosystems, in alignment with SDG 15. The core of the project however aligns with SDG 11 as the Source to Sea vision is aimed at making cities safe, inclusive, resilient and sustainable.

Source to Sea catchment. Photo provided by: Bruce Sutherland (2014) (from the City of Cape Town)

Challenges

The lack of coordination between different stakeholders due to the absence of a central, driving force behind initial river restoration was one of the major issues during the implementation of the project. The absence of an integrated approach to catchment management led to a lack of prioritisation of various catchment activities. Another major challenge was the lack of budget for on-the-ground implementation.

In response to these challenges, the development and framing of the Source to Sea project have allowed for the development of a business case model for this project. A business case document outlines the need for a project manager, prioritises interventions, and outlines a budget. This document serves as a coordinating mechanism as well as a means to leverage additional funding/partnerships to overcome presented issues.

Benefits

As a result of the project's activities in the region, riverine environments are improving, and urban biodiversity is better protected. Through its management of water quality and quantity, Source to Sea takes measures which are beneficial in various ways. The project's measures confront climate hazards such as floods, but also create a safer, more inclusive and healthier environment for all parts of society.

Lessons

Urban rivers are incredibly important and essential to the aim of building resilience to climate change at the local level. An integrated catchment management plan is vital in order to consider all social, ecological and economic factors that can contribute to clean water systems, intact biodiversity, and a prosperous socio-economic future for all. One way to ensure an integrated approach is to develop coordinating mechanisms such as a project website and coordinated branding. The project website displays all work currently occurring in the catchment. It offers a vehicle to share lessons, and to begin to establish strategic partnership. In addition, it is essential to appoint a project manager/co-ordinator to ensure all activities are aligned and work towards a common goal. Multi-disciplinary teams ensure that knowledge from differing perspectives is incorporated into Source to Sea strategies. The development of stakeholder platforms (such as forums meeting quarterly) ensures that activities, resources, data and knowledge are disseminated properly.

9. Meeting Ethiopia's Development Goals by Addressing Links between Water, Energy and Food

Climate risks	
SDGs	
Project name	The Food, Energy and Environment (FEE) Nexus: a case study in Ethiopia
Project location	Upper Blue Nile - Lake Tana and Beles River basins, Ethiopia.
Adaptation type	Impact reduction, secure resources, build partnerships.
Keywords	irrigation dams, hydropower, Upper Blue Nile, development pathways, nexus, water, energy, food, Ethiopia
Sectors	Water, energy and agriculture.
Stakeholders	Government bureaus, private sector, research institutes and universities
Project status	2013-2014
Contact point	Louise Karlberg Centre Director, Senior Research Fellow. Stockholm Environment Institute louise.karlberg@sei-international.org
Further information	https://www.sei-international.org/ For more information on LEAP see: www.energycommunity.org. For more information on WEAP, see: www.weap21.org.

Project background

Ethiopia has committed itself to reaching middle-income status by 2025. Following a decade of strong agricultural growth, the targets in Ethiopia's Growth and Transformation Plans cover a wide range of sectors; spanning agricultural issues (including improved seeds, fertiliser, mechanisation, irrigation), energy production (e.g. hydropower), conservation and land reclamation. The Growth and Transformation Plan targets are ambitious, and it is not clear whether the possible conflicts and negative impacts of pursuing them have been considered. For instance, allocating additional water for irrigation may compromise hydroelectric power generation, and conflicts such as this can impact on human welfare and the local environment. In light of urbanisation, conflicting population needs are a particularly sensitive topic in the country. Ethiopia's Growth and Transformation Plan II (effective until 2019 / 2020) states that 'urban areas are the centres of economic development', that 'the population of urban areas has been increasing' and, consequently, that 'the demand for economic and social services has risen' (Federal Democratic Republic of Ethiopia, 2016). Ethiopia needs innovative ideas to reconcile these emerging (urban) demands with its ambitious development goals.

Therefore, the Stockholm Environment Institute applied a 'nexus approach[5]' to help policymakers and planners achieve Ethiopia's ambitious national policies by improving agricultural and energy security while, at the same time, sustainably managing the country's resources, and reducing negative environmental impacts. The nexus approach can show how management decisions regarding one resource or sector affects others, and it can quantify those interactions. It identifies externalities, feedbacks, and potential trade-offs at different scales. It can highlight where sectoral plans are incompatible, and can help to identify mutually beneficial solutions. The aim was to improve food and energy security and environmental sustainability in Ethiopia by assessing the impact of different development pathways on the food, energy and environment nexus.

The collaborative project was undertaken in the Lake Tana and Beles River basins of the upper Blue Nile in Ethiopia (Karlberg et al., 2014). It assessed different development pathways on the food, energy and environment nexus by applying the SEI WEAP-LEAP toolkit (explained further below). The Lake Tana / Beles basins illustrate many of the trade-offs of Ethiopia's national targets. Four large irrigation dams are in various stages of construction in highland areas where farmers practice small-scale, rain-fed farming. A large hydropower plant recently constructed using Lake Tana as a reservoir redirects the water downstream to the Beles River. The lake itself supports fishing and tourism, and there are plans to designate it as a United Nations Biosphere Reserve because of its unique bird life and fish species (zur Heide, 2012). Objectives for managing local land and watersheds include reducing soil erosion, land degradation, and siltation of watercourses and reservoirs; increasing local storage of water for small-scale irrigation purposes and livestock; and maintaining wetlands and other ecosystems. Examining how all these various targets could possibly be reconciled, was subject of the methodology applied by SEI.

Climate risks and other stressors

Ethiopia is one of the world's most drought-prone countries. The country faces various development challenges that exacerbate its vulnerability to climate change, including high levels of food insecurity, ongoing conflicts over natural resources, and severe problems of food shortages, notably due to unpredictable rains. Importantly, 73% of the population are employed in the agricultural sector and 80% live in rural areas. Rural livelihood systems such as crop cultivation, pastoralism and agro-pastoralism are highly sensitive to climate. Food insecurity patterns are linked to seasonal rainfall patterns, with hunger declining significantly after the rainy seasons (USAID, 2016). Among the key impacts of climate change on the agricultural sector are declines in soil moisture and reduced yields and / or crop failure. Also, a lack of water resources and increased evapotranspiration will place even greater stress on agricultural production.

Estimates suggest climate change may reduce Ethiopia's GDP by up to 10% by 2045, with agricultural productivity suffering the largest losses. Future climate projections suggest an increase in temperature of 1ºC to 2ºC by 2050. In addition, erratic rainfall and increased unpredictability of seasonal rains will likely lead to increased incidence of drought and other extreme events. Limited water quantity and quality will lead to the drying of wetlands and freshwater sources and to the possible disruption of hydropower generation. Interlinked water and feed stresses will lead livestock to suffer from increased incidence of pests and diseases. As a consequence, livestock mortality is likely to increase. However, human health will also be affected – for instance from changing rates in vector-borne diseases, and an increased risk of water-borne diseases.

Adaptation approach

SEI and project partners began applying the nexus approach in the Lake Tana / Beles area to develop and analyse the outcomes of different development scenarios, representing three development pathways from 2010 until 2030. To this end, a story-and-simulation approach was used, in which narratives developed with stakeholders were translated into quantitative data and

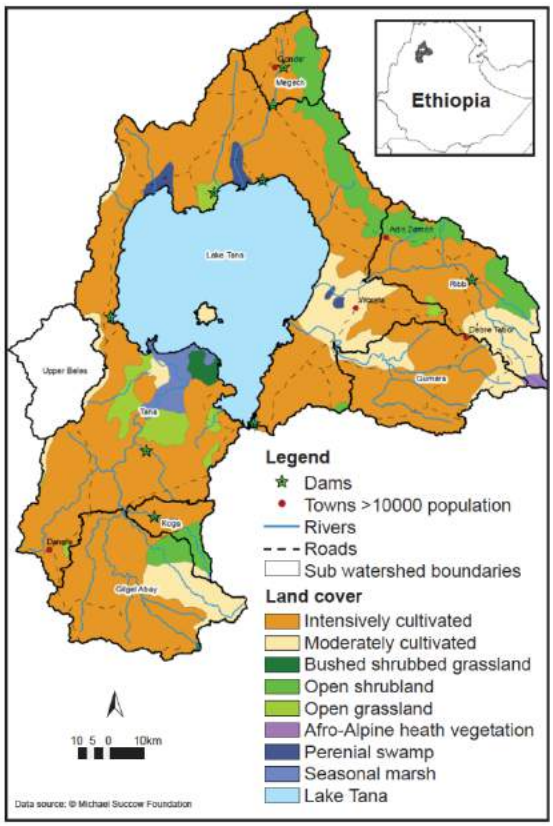
[5] The nexus concept emphasises the interlinkages among and between the environment (natural resources and ecosystems) and human development (food, energy and water security) and the need for coordination, integrated management and governance across sectors.

incorporated into SEI's nexus toolkit. The goals were to identify links between sectors (e.g. energy requirements for agriculture), and to carry out stakeholder reviews of assumptions and data use until the participants could deem that the results were credible. The SEI toolkit consists of two software tools: the Water Evaluation and Planning (WEAP) system (Yates et al. 2005a, 2005b), and the Long-range Energy Alternatives Planning (LEAP) system (Heaps 2012).

The project analysed three scenarios: 1) the business-as-usual scenario, which projected forward on the basis of today's patterns of land and water use and management; 2) the national plans scenario (which meets Ethiopia's Growth and Transformation Plan targets), which gave highest priority to water for food production and energy generation. It assumed that domestic energy demand per capita would fall as a result of the introduction of more-efficient stoves, and increases in connectivity to the national grid. Cattle would be replaced by tractors, reducing livestock production; 3) the nexus scenario (which meets the Growth and Transformation Plan targets, but also resolves outstanding conflicts between sectors), rendering the maintenance of the water level of Lake Tana the highest water-related priority. Under this scenario, only sustainable amounts of crop residues are used for energy; fodder is produced only as a by-product of crops produced for food and other purposes; and a bold electrification scheme reduces biomass demand in the energy sector.

Food and energy production and related environmental impacts differ substantially between the three development scenarios. Continuing along a business-as-usual path reduces per capita food production compared to current levels because of rapid population growth. The national plans scenario describes an intermediate level of food production coupled with high hydropower output from the Tana Beles station, which would seriously compromise the target to maintain water levels in Lake Tana.

The nexus scenario maximises food production and prioritises maintaining Lake Tana's water levels; hydropower production is substantially lower than under the other two scenarios. The process underscored key differences in the three scenarios. Total production of food and energy varies under each scenario. Resource-use efficiency in the production of the commodities also varies. Broadly, the nexus scenario receives a high rating for the indicators of the toolkit compared with the other two scenarios, except in terms of hydropower production and crop energy productivity.



Land-use map of Lake Tana (Upper Beles) sub-basin (from Karlberg et al., 2014, Photo provided by: Michael Succow Foundation)

Link to SDGs

The nexus approach links several SDGs through its innovative approach: Water and energy resources are used in a more sustainable way (SDG 6 and 7). The infrastructure of water, energy and agricultural sectors will become more resilient by taking limited resources and possible climatic hazards into account (SDG 9). Thus, the approach also confronts the impacts of climate change (SDG 13).

Challenges

SEI's analyses conclude that national policies in the Lake Tana / Beles region hold certain trade-offs. For instance, increased water withdrawals for irrigation upstream may reduce water availability for hydropower generation and environmental requirements downstream. Agricultural and energy challenges are interlinked, indicating that the region has hit a biomass ceiling where the demand for biomass for fuel, fodder and food is in the same order of magnitude as the annual increment of biomass production. The implication of this is an urgent need to reduce both fodder and fuel needs from biomass. The widespread use of traditional biomass for cooking leads to large-scale loss of

organic matter and nutrients from agricultural soils, which hinders productivity improvements. Shifting away from traditional biomass – by producing modern bioenergy on croplands or through other local energy innovations – could thus be important for transforming agriculture. Creating incentives for the livestock sector to reduce the number of animals raised, or to plant fodder on current croplands could be alternative options to respond to the biomass shortage.

Benefits

The water (WEAP) and long-term energy (LEAP) planning toolkits enabled joint learning between stakeholders from the agriculture, energy, water and environment sectors. The nexus toolkit revealed and analysed interlinkages between these sectors, resource allocations, and environmental impacts. Potential benefits and opportunities were furthermore uncovered: for instance, improved management practices requiring only small changes in hydropower dam operation rules would meet both environmental flow requirements and energy production goals, albeit with slightly larger inter-annual variation in energy production. Moreover, if upstream irrigation dams allow for higher downstream flows during the dry season, the result would benefit hydropower production, and ensure that environmental flow requirements are met.

Lessons

The SEI nexus toolkit helps planners at national and basin levels to better understand the complex relationships between different resource sectors. But it has also shown how some easily implemented measures could yield major win-win outcomes for agriculture, energy and environmental planning. To achieve Ethiopia's planned transformation in the agricultural sector, and to support energy transitions, several resource-use issues need to be tackled. The nexus approach and the nexus toolkit provide insights that can empower Ethiopia's planners to achieve their sustainability objectives as the country progresses towards its economic development vision. And it can provide answers to allocation questions beyond the project region of the Laka Tana and Beles River Basins, but for Ethiopia's entire growing population and urbanising environment.

10. Tackling Water Insecurity in a Changing Climate in Lesotho

Climate risks	
SDGs	
Project name	Lesotho Climate Change and Water Resources Impact Analyses Project
Project location	Lesotho (nationwide and including of city of Maseru)
Adaptation type	Secure energy resources and water for domestic use, hydropower, irrigation and transfer to South Africa
Keywords	Infrastructure development, robust decision-making, water, hydropower, Orange-Senqui River basin, Lesotho
Sectors	Water, Energy and infrastructure
Stakeholders	Government agencies
Project status	2015 - ongoing
Contact point	Annette Huber-Lee, Senior Scientist annette.huber-lee@sei-international.org

Project background

Water is one of Lesotho's most valuable resources. The country's water-rich highlands enable the water sector to contribute about 8-10% to the nation's Gross Domestic Product (GDP). One of Africa's most economically important rivers, the Orange-Senqu River, begins in the highlands of Lesotho and flows for more than 2,300 km across South Africa and Botswana.

Lesotho's altitude, water quantity, and its proximity to demand centres in southern Africa have enabled it to generate revenues through regional transfer schemes. One example of this is the Lesotho Highlands Water Project, a multi-phase and binational infrastructure project between South Africa and Lesotho. It enables the transfer of Orange-Senqu River water from Lesotho to Gauteng, South Africa, through a series of dams, tunnels and associated infrastructure. It also provides opportunities to supply electricity to Lesotho through associated hydropower development. Lesotho set up the Lesotho Lowlands Water Supply Scheme to ensure access of all households to clean water, and to meet agricultural, industrial and commercial demands for water.

The Stockholm Environment Institute (SEI) and the World Bank Group conducted an assessment of Lesotho's water management system to explore the important role that water plays for the socio-economic and climatic future of Lesotho, and to analyse possible vulnerabilities of its macro-economic development through to 2050 (World Bank, 2016, and Huber Lee et al., 2016). The aims of the project were to enable the government of Lesotho to better account for risks to water resources associated

with climate change, and to help to ensure that investments in infrastructure and overall development will be resilient to future shocks.

Climate risks and other stressors

Despite its abundant water resources, Lesotho remains vulnerable to the impacts associated with regular and recurrent floods and droughts, and large natural climatic variations. The country's agriculture is almost entirely rainfed and thus, highly vulnerable to changes in precipitation. Agricultural productivity is low and declining, in part due to the effects of climatic variability. Lesotho is highly dependent on its water resources to ensure continued water transfers and exports, but also to improve domestic levels of access, and enhance economic growth to eradicate extreme poverty. Increases in the urban population and commercial activity will place even greater stress on the demand for water resources and supply facilities.

The Katse Dam, on the Malibamat'so River in Lesotho, was completed in 2009, as the centrepiece of the Phase 1 of the LHWP. Photo provided by: Amada44 / Wikimedia Commons

Most of Lesotho's agriculture is rainfed, with low productivity. Another 12,000 ha of irrigated land could boost production by as much as 50%. Photo provided by: John Hogg / World Bank / Flickr

Adaptation approach

SEI used its Water Evaluation and Planning (WEAP) methodology to conduct the analysis of the performance of Lesotho's water management system and to find adaptation strategies across a range of potential future climatic models.

WEAP considers climate, hydrological and water management systems together to examine key uncertainties, and evaluate how different strategies might affect the reliability of the water supply for each key sector (in this case, the water transfers from Lesotho to South Africa). The modelling process was embedded in a robust decision-making framework to ensure that investments in infrastructure will be resilient to future shocks. Different adaptation options were identified in close consultation with stakeholders. These options were then analysed against the range of climate models to find out which future scenario would achieve the most robust performance. The analysis also highlighted trade-offs.

First, the assessment analysed the possible scenarios if no further infrastructure were developed. All of the future scenarios show that the demands of urban domestic and industrial sectors in Lesotho would not be reliably met. Meeting water delivery commitments to South Africa would also become increasingly difficult over time in the absence of further development of the Lesotho Highlands Water Project, and with demand increasing significantly after 2025.

In addition to the baseline strategy, four other strategies were considered for infrastructure construction and water prioritisation that can support the country's development. Two strategies were considered individually: the construction of the Polihali Dam under Phase 2 of the Lesotho Highlands Water Project: and the full development of all future phases of the project (including the Polihali Dam). In addition, three combinations were considered: First, the full development of both the highlands and lowlands projects; second, the full development of both the highlands and lowlands projects, with the development of irrigation to support 12,000 ha of agricultural production; and third, development of the Polihali Dam, the lowland project, plus the development of irrigation to support 12,000ha of agriculture production.

The vast majority of water resources are allocated to transfers under the highlands project. Still, the transfer commitments can be met while still supporting development of domestic services provision. The analysis shows that continuing to build out the highlands project – particularly the development of the Polihali Dam under Phase 2 – reduces the risk of failing to meet water delivery commitments to South Africa. Transfer deficits occur in only 13% of the climate scenarios. Hydropower production is also mostly robust. The development of the lowlands project would dramatically improve the resilience of the domestic sector throughout most of Lesotho, particularly in urban areas. Unmet water demands currently exist in every climate scenario – even the wet scenarios – due to a lack of provision of basic water access. Unmet water demands would be near zero in all but the driest climates (among more than 120 climate projections), and also would not affect the reliability of transfers to South Africa.

Link to SDGs

By exploring the role of water and energy in the face of uncertainty related to climate change, this project relates to SDG 13. The project's contribution to the development of hydropower in Lesotho addresses SDG 7 in ensuring access to affordable, reliable, sustainable and modern energy for all. Through the water transferred within the Orange-Senqu River Basin and the series of dams, tunnels and associated infrastructure developed alongside electricity supply, the project aims to build a resilient and sustainable infrastructure - goals in line with SDG 9.

Challenges

The challenge is to balance the opportunities afforded by the highlands project with the need to secure water for domestic, agricultural, industrial and commercial use, particularly in the face of uncertainties related to climate change. These interconnected issues have profound implications for the structure of the economy and future development.

To achieve the government's goal of 100% access to clean water by 2020, Lesotho will need major investments in urban water and sanitation services, particularly in the lowlands, which are home to 75% of the people.

Benefits

The analyses presented here provide decision makers in Lesotho with highly valuable information on how different strategies would affect water availability for different sectors under a wide range of possible future conditions. The results show how different strategies are likely to perform. Therefore, the process provides the tools to empower stakeholders to act with more confidence in the face of uncertainty.

Lessons

The analysis shows that climate change has significant implications for Lesotho's future economic development. Domestic and industrial water security is highly vulnerable even under current climate conditions, but implementation of the lowlands project and other potable water supply infrastructure investments, along with the Polihali Dam, can reduce these vulnerabilities. Agriculture will remain vulnerable to variations in precipitation in the absence of investments into the development of irrigation infrastructure. However, projected development targets can be met without significantly reducing the reliability of transfers to South Africa. The analysis also shows that the highlands project can continue to reliably meet transfers to South Africa unless the climatic conditions become drier by 5% or more. Building the Polihali Dam will increase the potential transfers, and improve reliability. Full development of the highlands project will increase the transfer capacity, and would also support development of water supply and irrigation schemes in the lowlands. Continued development of the lowlands project is critical for the domestic and industrial sectors. Exploring the interconnections between the highlands project and the lowlands bulk water supply scheme could enhance resilience and balance the opportunities afforded through the regional transfer of water with national priorities.

The assessment suggests that transfers to both South Africa and Botswana could be reliably met under future scenarios in which the climate is about the same as, or wetter than, historical trends. Under drier climates, there would be a trade-off between meeting the transfer targets for Botswana and South Africa.

11. Reconciling Water, Energy and Agricultural Sector Demands in Zambia

Climate risks	
SDGs	
Project name	A Water-Energy-Food (WEF) Nexus Approach to Attain the National Development Goals in Zambia
Project location	Zambia (national level)
Adaptation type	Climate change adaptation policy intervention; secure water resources (for agriculture and energy production)
Keywords	Water, energy, food, nexus, policy framework, Zambia, water demand, energy security, food production
Sectors	Water, Energy, Agriculture, Mining, Natural resources
Stakeholders	Public Sector, NGOs
Project status	Study started and completed in 2015
Contact point	Stockholm Environment Institute Louise Karlberg: louise.karlberg@sei-international.org Nina Weitz: nina.weitz@sei-international.org
Website	https://www.sei-international.org/publications?pid=3005

Project background

Zambia aims to become a mid-level economy by 2030. This goal is partly underpinned by a transformation of the agriculture sector to boost productivity to meet domestic food demands, and to generate income from exports. At the same time, the energy sector is undergoing a transition from being predominantly biomass based to meeting growing demands for modern energy sources for industry, agriculture and domestic use. Rural electrification remains a challenge in a sparsely populated country. Despite the country´s generally rich endowment of natural resources, degradation of these resources hampers development, and threatens sustainability. Food and energy security remain pertinent issues. Water demands for irrigation and hydropower generation are increasing, while undermining environmental flow requirements in regulated rivers and lakes. Moreover, deforestation rates are high, driven by expanding agriculture, as well as by the need for charcoal for cooking purposes.

The Water-Energy-Food (WEF) nexus concept addresses these inter-connected water, energy and food development challenges at different levels, to enable decisionmakers to work together to meet human aspirations. Quantitative assessments of current and new policy frameworks and

mechanisms, which take into account interdependencies between food, energy, water and environment, can support decision-making processes, investment planning, and administrative procedures to promote a more holistic socio-economic and ecological development.

GFA Consulting Group and the Stockholm Environment Institute (SEI) joined forces in the pilot study presented here to assess the WEF nexus in Zambia from a governance and bio-physical perspective, emphasising interdependencies between the environment (natural resources and ecosystems) and human development (food, energy and water security). Issues defined by stakeholders provided the entry point. The objectives were to explore whether a nexus perspective could add value to the implementation of the current policy framework, and to guide new policy development in Zambia (zur Heide et al., 2015).

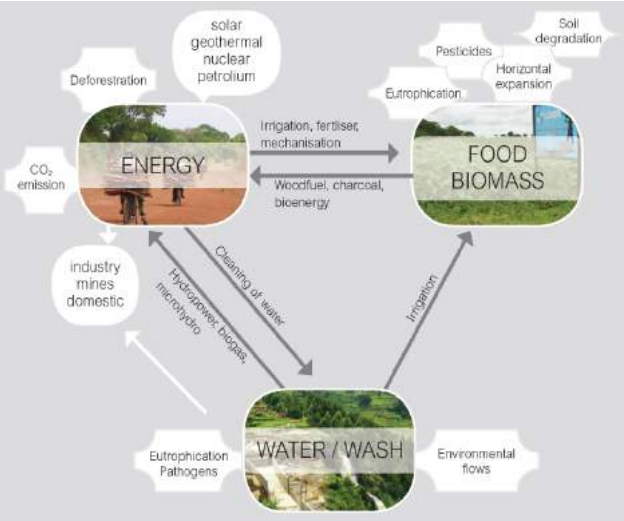
Climate risks and other risks

Zambia depends heavily on its natural resources. Climatic hazards such as droughts and floods threaten the wellbeing of its physical and biological systems. This puts considerable stress on the development of sensitive sectors – including agriculture and food security, wildlife, forestry, water and energy, and human health. These sectors also affect the economic, social, and environmental dimensions of Zambia's sustainable development.

The primary concern of the government is to protect its people, infrastructure, and other national assets against disasters and climatic hazards. Therefore, in order to respond to disasters at the national level, the government established the National Disaster Management Policy and the Disaster Management and Mitigation Unit under the Office of the Vice President. The government is also committed to ensuring that vulnerable communities receive needed support with safety-net initiatives, which will enhance their adaptive capacity, and reduce their vulnerabilities.

Adaptation Approach

The objectives of the WEF nexus study were to explore whether a nexus perspective could add value to the implementation of the current policy framework, and to guide new policy development in Zambia. The specific objectives of the study were: First, to develop and test a methodological tool for a rapid appraisal of the WEF nexus. This methodology consisted of a desk study of current policy frameworks, stakeholder interviews and an indicative, quantitative assessment of inter-sectoral dependencies. Second, potential nexus issues in Zambia and inconsistencies and implementation gaps in the current policy framework pertaining to the WEF nexus were identified. Third, the project assessed the demand of key stakeholders for policy advice and a more in-depth (quantitative) nexus assessment. Potential entry points for policy advice were identified. The general findings can be found in the section 'Challenges'.



Nexus diagram for Zambia (reproduced from zur Heide et al., 2015). Photo provided by: GFA and SEI.

Link to SDGs

The implementation of a nexus perspective would address the subjects of food, water and energy security (SDGs 2, 6 and 7) for all in an innovative manner (SDG 9) and at the same time meet the uncertainties under a changing climate, building resilience of communities to climate-related hazards (SDG 13).

Challenges

Despite positive economic development in recent years, food and energy security for all remain two of the main challenges facing Zambia. To tackle these issues, Zambia has embarked on an ambitious development trajectory to become a 'prosperous middle income nation by the year 2030' as described

in ‘Vision 2030’ (Republic of Zambia, 2006). A growing population (from the current 14.5 million people to an expected 25 million people in 2030), and an expanding urban middle class increase the demand for food, energy and water, and subsequently the pressure on natural resources. For instance, deforestation and unmet environmental flow requirements are two examples of current unsustainable resource exploitation in Zambia. Climate change is exacerbating these already difficult and complex issues.

Each of the three sectors examined in further depth in this study exhibited several challenges. Meeting the water demand of the Zambian population and the sector in general requires big investments into storage for water for irrigation and hydropower generation. Future expansion of irrigated agriculture and hydropower production will most likely lead to conflicting interests between the agriculture and water sectors, in particular during the dry season (March/April) when water demands peak.

With regard to energy security, the analysis suggests that only parts of the future energy demand can sustainably be met by hydropower, suggesting that biomass will continue to play a major role in the energy sector. Future development of the energy sector depends on the direction taken by other sectors, such as agriculture, which is a user of energy, a competitor for water, and a potential supplier of feedstock for bioenergy production.

Food security remains a challenging issue in many parts of Zambia. The current agriculture sector predominantly consists of small-scale, low-yielding farms, and a few large-scale, input-intensive commercial farm enterprises. With a growing urban middle class and increasing agricultural exports, Zambia’s demand for food is rising. As a response, agriculture is gradually intensifying (e.g., maize, sugar cane, tobacco and wheat) and expanding into forestlands, while the government recently started a programme to build commercial farm blocks to attract large-scale investment.

First estimates of future resource demands for the agriculture sector show a growing competition for water with the energy sector, higher energy needs, and large scope for improving production on current croplands to meet the domestic food demand, and to sustain a growing export industry. While the demand for water and land for the energy sector for bioenergy and hydropower production is far greater than that of the agriculture sector, it is not possible for the agriculture sector to substitute these resources to produce food. The energy sector has the option of exploring other development pathways which would be less land and water intensive, such as solar and wind power, for instance.

Benefits

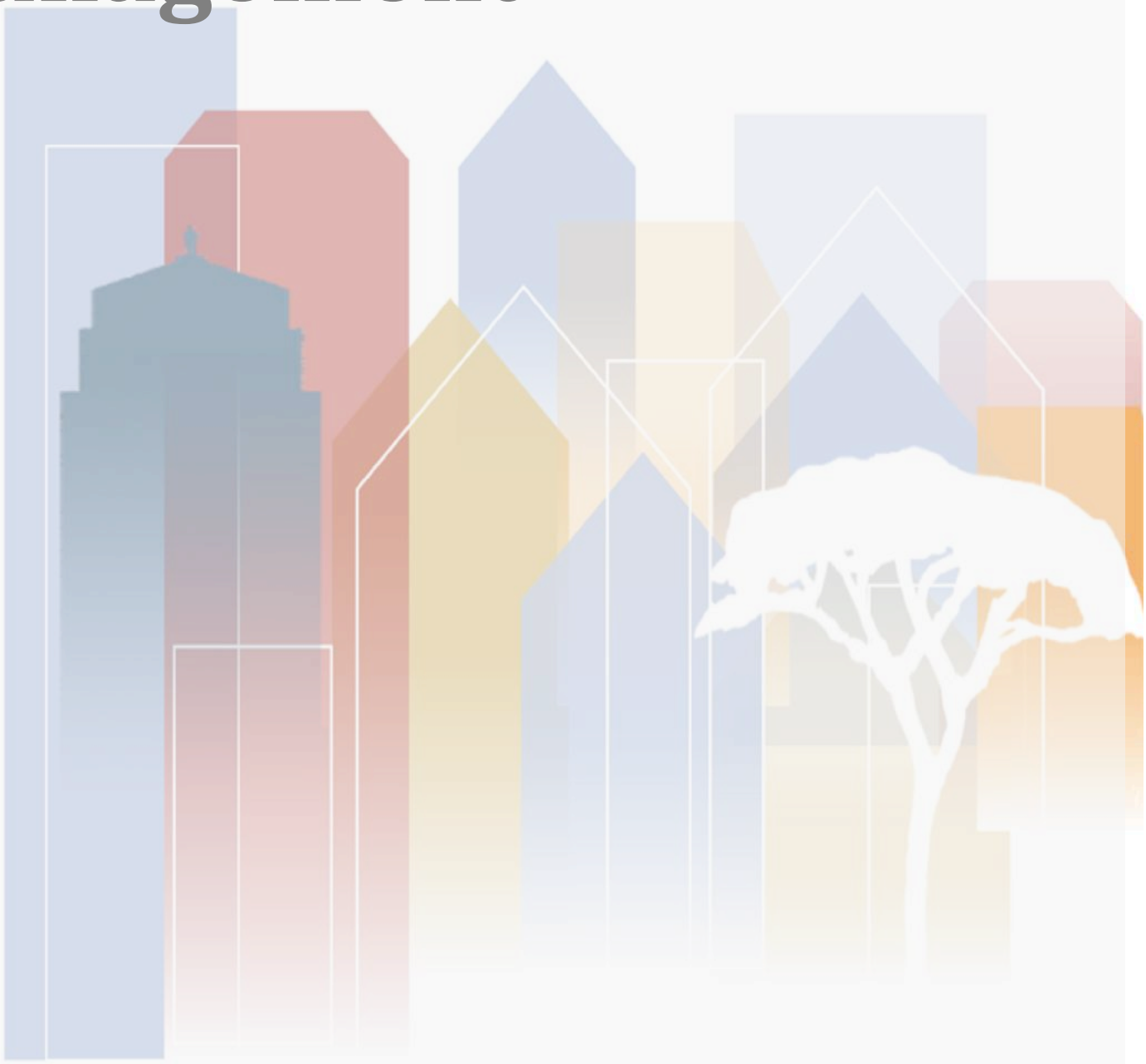
The Food-Energy-Water nexus study highlighted the interdependencies of these different sectors in the face of climate change. However, it also showed that these interdependencies can contribute to a sustainable development trajectory of Zambia if decision-makers on a regional and national level can make informed decisions that capitalise on the most promising pathways. The study provides policy makers with a holistic quantitative assessment that shows possible pathways, but also trade-offs of adaptive measures and different strategies.

Lessons

The study showed that agricultural transformation and energy transition are interdependent and partly also compete for the same resources, e.g. water and biomass. Increasing agricultural intensification also results in increasing energy demand. However, there is potential to increase the production of energy by using biomass from croplands for bioenergy (biofuels, crop residues). Nevertheless, the future development goals for the country (which are outlined in the current national policy framework) show conflicting sector policies. For example, intensified agricultural systems may be in conflict with sustainable water use. To attain the envisioned development trajectories, integrated quantitative assessments need to be conducted to account for cross-sectoral interlinkages and the competing demand for resources.

It also became evident that the Sector Advisory Groups meetings need to take a more proactive approach towards new implementation projects. Cross-sector strategic planning, underpinned by rigorous quantitative assessments of resources use and cross-sector linkages, is lacking. The planning of future irrigation and hydropower projects does not account for the strategic use of limited water resources.

Infrastructure, settlements & waste management



12. Building Happy and Integrated Neighbourhoods in Luanda, Angola

Climate risks	
SDGs	
Project name	Nova Vida Housing Development
Project location	Luanda, Angola
Adaptation type	Climate proofing the built environment; reduce climate risk; secure resources
Keywords	Urban development planning, green spaces, flood management, infrastructure development, residential housing, innovation, Nova Vida, Luanda
Sectors	Housing, Public Works Infrastructure.
Stakeholders	Ministry of Public Works, Construction Subconsultants, Urban Planners.
Project Status	Phase 2 ongoing
Contact point	Nico de Almeida Ministry of Public Works and Urbanisation +92 442 394 474

Project background

Luanda, the Capital of Angola, is home to 21% of the population of Angola. Rapid urbanisation and the scourge of a 27-year long civil war have resulted in dramatic housing shortages in Luanda. The government has responded by appointing Chinese contractors to build high density housing. As these housing developments are normally just 'bedroom estates' and not fully functional multifaceted urban organisms, they have shown to be inappropriate for the climatic and socio-economic reality in Angola (Bednarski, 2015).

The Nova Vida Housing Development is a large housing development project undertaken for the Angolan government, in an attempt to improve on the 'bedroom estates'. The Nova Vida Master Plan outlines the additions and expansion of 440 hectares of housing development for Angolan government employees. The Nova Park Development is an example of how eco-town planning can create environmentally and socially resilient communities. The services provided by this project include: integrated transport planning, handling of stormwater, bulk supply requirements and electrical reticulation. Further expansions to the project included municipal services such as a sewer network, pumping stations, pipe upgrades as well as a sewage treatment facility.

Climate risks and other stressors

Years of war in Angola drove large numbers of people from conflict-affected inland areas to the relative safety of coastal cities. Many of them eventually settled in informal communities on marginal, environmentally fragile and low-cost land prone to flooding and landslides in Luanda. Climate change is exacerbating these hazards by increasing average temperatures, shortening drought cycles, and leading to concentrated periods of higher rainfalls. This variability is further heightened in coastal areas, which are subject to isolated and extreme storm events releasing large volumes of rain.

These storms have particularly severe consequences for the vulnerable populations living in these areas. Up to an estimated 10% of residents are at risk of losing their homes due to flooding and erosion. Climate variability and its associated risks also damage urban infrastructure, and can impede provision of government services. Currently, almost 50% of households have neither piped water nor adequate sanitation. Scarce and poor-quality water contributes to the prevalence of malaria, cholera, and diarrhoea.

Adaptation approach

The Nova Vida urban park in Luanda, Angola, is a flagship project for the integration of green spaces into urban development planning for Africa. It can be described as an adaptation approach that is climate-proofing the built environment. The park provides a total of 6,000 residential units and 400,000m^2 of retail and office space. The green spaces included in the plan function both as recreational areas and as areas of small-scale cultivation, which reduces the climate risk to the park. These spaces enhance the natural beauty and environmental quality of the park, and they have positive effects on runoff and flood management.

Nova Vida Housing DevelopmentPhoto provided by: Aurecon

Constructed part of the Park. Photo provided by: Aurecon

Links to SDGs

The Nova Vida Park aligns with Goals 2, 3, 11, and 13 of the SDGs. Through the use of spatial planning, the park has specifically designed green belts that allow for urban farming (of crops such as maize or cassava, etc.) addressing Goal 2. In addition, the green belts assist with the drainage in the housing development, ensuring that people in Luanda can cope with highly variable rainfalls. Safe, well-built housing with sanitation and water quality assists with Goal 3 on good health and well-being. In addition, the Nova Vida Park has generated a local economy with various shopping activities developing in and around the park, which contribute to Goal 11 in developing economically, environmentally and socially sustainable cities and communities. The people centred development addresses climate change impacts through its flood management.

Challenges

This project faced four challenges. First, negotiation with the Angolan Government was required to promote the eco-town approach and describe the benefits of planning which supports resilient communities. Second, sourcing and transport of durable and suitable materials for the project proved difficult. Third, language proved to be an issue, with a multinational and multilingual workforce; designers of Nova Vida spoke a different language than the contractor, for instance. Fourth, the relatively unskilled local workforce required on-site skills training and mentoring.

Benefits

Trees, green spaces and areas of water can significantly cool the built environment and save energy. They can also have health benefits for the Nova Vida communities, and provide a space for urban farming and cultivation. In this way, the design of the park encourages the interlacing of housing and subsistence food production, enabling food security for the resident community.

The Nova Vida Park provides housing for 30,000 people. The park's infrastructure facilities also provide room for: future community facilities, parks, schools, churches, technical colleges, a university, clinics, shopping centres, a retail complex, office accommodation, light industrial stands, and town management offices. Furthermore, a primary school, police station, a convention centre and sports centre were constructed under separate contracts during phase 1.

Lessons

Nova Vida offers a prime example of what can be achieved, in collaboration between government and consultants, through innovation in addressing future climate risks and the practical needs of the client, in this case the Angolan government. The government of Angola's vision for 2018-2025 (Ministério da Energia e Águas, 2016), with the ambition of 'transforming Angola into a prosperous, modern, poverty free country...', sets a precedent for similar, future developments throughout the country and elsewhere in Africa.

13. Stakeholder-Based Development Planning of the Shire River Basin's Water and Natural Resources in Southern Malawi

Climate risks	
SDGs	
Project name	Shire River Basin Management Programme
Project Location	Shire River Basin, Malawi
Adaptation type	Early warning system, Disaster risk reduction, Climate resilient livelihoods, Community- Based Adaptation, enhance learning
Keywords	River basin management, land and water management, ecosystem and livelihood benefits, integrated catchment management, floods, dry spells, disasters, Malawi.
Sectors	Local community leaders, Members of local government from the Department of Agriculture
Stakeholders	Local community leaders, Contract managers, environmental managers, environmental scientists, funders (Kuwait Fund for Arab Economic Development and the Global Environment Facility).
Project Status	Completed 2016
Contact point	Dyce Kapumula Nkhoma Department of Disaster Management Affairs Lilongwe dycenkhoma@gmail.com +2651788648
Website	http://www.catchmentguidelines.org.mw/sites/default/files/training-material/training_workbook.pdf

Project background

The overall objective of the Shire River Basin Management Programme is to increase sustainable social, economic and environmental benefits by effectively and collaboratively planning, developing and managing the basin's natural resources. The program's first-phase Project Development Objective and the Global Environmental Objective are to develop the Shire River Basin planning

framework to improve land and water management for ecosystem and livelihood benefits in target areas (Aurecongroup.com, 2017).

Phase One of the Shire River Basin Management Programme Phase was implemented by the Government of Malawi, and supported by the World Bank and the Global Fund for the Environment. It aims to transform the now largely sectoral planning approaches in the Shire River Basin into inclusive, stakeholder-based development planning and management of the basin's water and related natural resources to generate sustainable social, economic and environmental benefits (World Bank, 2016).

Climate risks and other stressors

Floods and prolonged dry spells are recurrent phenomena in Malawi. The Department of Disaster Management Affairs recorded 23 major flood events in the 29 years between 1979 and 2008. These floods affected an estimated 1.9 million people (UN Economic Commission for Africa, 2015) through loss of life, damage of public infrastructure and private homes, crop loss and consequential food insecurity, and impacts on public health through the increased occurrence of diarrhoea and malaria, and outbreaks of cholera.

Such disasters appear to be increasing in intensity and frequency. The number of people affected by such disasters also appears to be increasing - a trend that can be attributed mainly to population growth and environmental degradation. The Chikwawa and Nsanje districts (UNDP, 2010), located in the lower Shire Basin, are among the most-affected areas in the country. Two-thirds of the economically active population is engaged in subsistence farming, which is severely affected by floods or prolonged dry spells on a nearly annual basis. Consequently, these districts are among the poorest in the country. According to a flood damage assessment, the main direct losses from flooding include damage to homes, local infrastructure, and agricultural crops. The average total annual flood related loss in the southern region of Malawi is USD 26 million, out of which non-agricultural losses constitute USD 5.85 million. At least 50% of the non-agricultural losses in southern Malawi are attributed to the Chikwawa and Nsanje districts (Pangapanga, 2012).

Population is also a concern - according to Malawi's vision 2020, the country has a very high population growth rate with a fertility rate of 6.7%. Coupled with the search of income earning opportunities for this rapidly increasing number of people, this has led to migration from rural to urban areas and exacerbated the problem of unplanned settlements and squatters (Malawi SDNP, 2003). Consequently, the country needs to adapt to a growing number of urbanised settlements and the ever-present risk of flooding.

Adaptation approach

The aims of this project were to address the interlinked challenges of poverty and a deteriorating natural resource base (Aurecongroup.com, 2017). As seen in the section on Climate risks, areas which are situated within the project's direct scope – the Shire River Basin – are also areas which suffer most heavily from flood risk. The Chikwawa and Nsanje districts, located in the lower Shire Basin, are in need of adaptation measures to confront increasing disaster risk due to flooding, which is endangering the livelihoods of the population that has settled there. However, Aurecon not only aimed to take measures to improve people's adaptive capacity in the villages, tomns and district cities of the Chickwawa and Nsanje district, but also in Malawi as a whole.

Key activities of the project included:

- Development of national guidelines for community-based flood risk management;
- Facilitating the planning and implementation of flood mitigation and adaptation measures;

- Supporting the roll-out and connectivity of a basin-wide flood forecasting and early warning system at the community level;
- Improving the capability to provide early warnings for and emergency response to flooding by securing for and providing equipment to and strengthening the capacity of the civil protection committees at district, area and community levels (Ministry of Agriculture, Irrigation and Water Development, 2016).

A suite of enabling activities relating to stakeholder engagement and participation as well as capacity development and communication supports the key activities. These follow a structured approach and are coordinated with related activities carried out under other programme components.

Over 200 extension workers in various districts around the country received training. The extension workers will now provide support to their villages in developing Village-Level Action Plans. These plans not only incorporate natural resource rehabilitation, prevention and management activities, but also livelihood improvement and social issues such as health and education. The plans also support other district development and safety net plans.

The success of these training workshops led to requests for from other community organisations for additional training across the country during 2016. Ten Youtube-style videos were produced in the scope of the project to provide visual guidelines on some of the key guidelines. Aurecon collaborated with ICLEI (Local Governments for Sustainability) to provide an additional training session and to develop a mobile Android application called Thrive, which enables the guidelines to be accessible via mobile devices (Ministry of Agriculture, Irrigation and Water Development, 2016).

The village of Mitware was used as a positive example of catchment management during the training courses. In return, Aurecon sponsored a tree-planting workshop in this village as a way of thanking the villagers for their cooperation. Additionally, trees planted during the workshop offset Aurecon's carbon emissions from the project.

Guidelines, videos, training documents and other useful references are available on the project website: http://www.catchmentguidelines.org.mw/

Board games and theatre were some of the education tools used for rural flood risk management in Malawi. Photo provided by: Aurecon.

Advertisement for the mobile application 'Thrive' accompanying the Guidelines. Photo provided by: Aurecon

Links to SDGs

Preparation of National Integrated Catchment Management and Rural Infrastructure Development Guidelines assisted with Malawi's journey towards SDGs 2, 3, 9, 10, 11, 13, 15. This project is highly community centred. The guidelines address a host of concerns for rural Malawians from food security (Goal 2), ensuring a healthy and happy lifestyle and home (Goal 3), improving local infrastructure (Goal 9), improving education and poverty cycles linked to natural disasters in poor rural areas (Goal

10), as well as through addressing Goal 13 and Goal 15 ensuring climate resilient and sustainable towns, human development and ecosystem protection and enhancement.

Challenges

The key challenges faced by this project were: the effective integration of local knowledge and technical knowledge, gaining leverage with the affected communities, and understanding the role of key players in the community.

Other challenges related to the broader regulatory framework that the Shire River Basin Agency had to work within:

- The National Water Resources Act, enacted in 2013, established Catchment Management Committees, but not the basin organization;
- The catchment committees' functions, as reflected in the act, do not match with the standard functions of the river basin organization;
- Establishing the Shire River Basin Agency as a regional office for the National Water Resource Act proved difficult because the agency does not have the regulatory mandate.

Benefits

- These guidelines address a host of concerns for rural Malawians: food security, ensuring a healthy and happy lifestyle and home, improving ecological and local infrastructure, improving education, halting poverty cycles linked to natural disasters in poor rural areas, ensuring sustainable towns, enhancing human development, and improving ecological protection.
- The guidelines led to a greater understanding on how to manage flooding at a subsistence level, and to increasing levels of education about flooding and its effects;
- The guidelines provide a framework for local and larger-scale, hard infrastructure and ecological infrastructure;
- The information presented in these guidelines empowers subsistence communities, and assists NGOs, governments and people to become more educated and able to adapt to climate change (Ministry of Agriculture, Irrigation and Water Development, 2016).

Lessons

The regulatory structure of the water resources proved challenging. Lack of legal provisions in the 2013 water resources legislation led to hampering of the establishment of Shire River Basin Agency. As a result, the Agency was established as a prototype organisation on the premise of learning by doing. The Shire River Basin Management Programme took responsibility for managing the Shire River Basin Agency because of its mandate described above.

14. Private-Public-People Networks for Climate Compatible Development in Maputo

Climate risks	
SDGs	
Project name	A Public-Private People Partnership for climate compatible development in Maputo (4PCCD)
Project Location	Chamanculo C bairro, Maputo, Mozambique
Adaptation type	Community based adaptation, disaster risk reduction, build partnerships
Keywords	Local citizens, informal settlements, Mozambique, Chamanculo, Climate Compatible development, partnerships, participatory planning, local capacity, knowledge, local government.
Sectors	Water and Sanitation; Waste Management; Emergency Response to Flooding.
Stakeholders	Ministry of Environment, Maputo Municipality, Private and Civil Society Organisations, the Mozambican Recycling Association, the Local Development Association, Chamanculo C. Community
Project Status	2011 - 2013
Contact point	Vanesa Castán Broto M: +44 207 679 11 11 v.castanbroto@ucl.ac.uk

Project background

Local communities are often capable and eager to take action to improve the quality of their lifes. They may organize themselves through non-governmental organisations (NGOs) and local associations, or in a more informal manner through what are called 'below-the-radar organisations' (e.g. groups that are capable of undertaking collective initiatives). To be useful, however, knowledge and local capacity need to be recognized by the local government and formal institutions. Lack of recognition may impede local progress. Moreover, communities may benefit from the enabling role that formal organisations play, by supporting their networks, facilitating access to knowledge and resources, and legitimizing their actions (Castán Broto et al., 2015).

The action research project "Public, Private, People partnerships for Climate Compatible Development (4PCCD)" was aware of the possible benefits that recognition of local knowledge and capacity by formal institutions could hold. Therefore, the project developed a participatory planning method to foster partnerships between public, private and civil actors (Castán Broto, 2014; Castán Broto et al., 2015). These partnerships tried to tackle climate change through actions in specific

locations in Maputo, but at the same time address the concerns of local citizens living in vulnerable urban areas (Castán Broto et al., 2015). This case study focuses on the informal settlements of Chamanculo C in Maputo, Mozambique. It was a partnership between academics from the Universities of York, Reading and University College London (in the UK), the governmental institution National Fund for the Environment of Mozambique and local communities of Chamanulo C.

Two children play around a household in Chamanculo C., Maputo. Photo provided by: Charlotte Allen

Climate risks and other stressors

The coastal location of Maputo ensures it suffers severe climate risks, such as flooding, cyclones and sea level rise. Flooding in particular constitutes a severe threat to Maputo's bairros (administrative subdivisions of urban districts). Water covers roads and properties, and the deficient drainage, which is often blocked by uncontrolled waste, prolongs the impact of floods. These impacts have a heavy negative impact on residents. In addition, 44 per cent of the population lives in poverty (Castán Broto et al., 2015). Access to services and other infrastructure is low. Heightened environmental risks are compounded with high vulnerabilities to these risks (UNFCCC, 2014). Vulnerability to the adverse effects of climate change therefore became a focal issue for local residents.

Adaptation approach

The approach taken by 4PCCD brought together municipal and national actions to jointly build strategies for climate resilience that benefit urban poor communities (building partnerships). It focused on producing local plans and engaging municipal and national government institutions, which are developing strategies to tackle climate change (Castán Broto et al., 2015). 4PCCD also got citizens involved in decisions that affect their resilience to climate change and the future sustainability of their neighbourhoods (enhancing awareness and learning, reducing climate risk) (Castán Broto et al., 2015).

4PCCD used a multi-stage urban planning tool to examine the question of how local views can be represented fairly in national and municipal planning process through a participatory approach. This

approach recognised the capacity of local citizens to develop a vision for the future of their neighbourhood in a changing climate.

As a first step, 4PCCD used a participatory planning methodology called Participatory Action Plan Development to address climate change in an urban context. To this end, relevant climate change knowledge had to be made accessible for and understandable to the community of Chamanculo C. General Circulation Models (GCMs) were downscaled to make climate change information available at the local level; urban climate studies and indicators as well as expert consultations were used to complement the information. Uncertainties and gaps of information were conveyed to the community and the climate information was related to specific impacts at the local scale and the community's previous experiences of cyclones and flooding in Maputo (Castán Broto, 2014; Castán Broto et al., 2015). In a process of knowledge co-production, the expert analyses were incorporated in the community's contextual understanding of vulnerability factors (Castán Broto et al., 2015). Thereby, potential courses of action could be developed in a joint process, linking the development of Maputo's community and local climate change priorities.

Secondly, 4PCCD aimed to provide a platform for partnership-building for long-term collaboration between the various stakeholders involved in the project. A governmental institution called National Fund for the Environment of Mozambique teamed up with academics from University College London, Reading University and the University of York to devise a participatory planning project that could build relationships between key stakeholders (Castán Broto, 2014; Castán Broto et al., 2015). Actor mapping was used to understand the key players who were delivering climate change interventions in Chamanculo C. and Maputo. The focus was on actors in Maputo who held the potential to work together over the long term. A clear understanding of the interests of different actors was important to enable constructive forms of dialogue. To that end, neighbourhood leaders were consulted to provide access to the target communities. Residents identified particularly vulnerable groups in the neighbourhood and ensured that their concerns were discussed. This allowed close consideration of multiple priorities. Apart from members of the community, other stakeholders also helped in the actor mapping. Representatives of international development agencies including UN-HABITAT were enrolled to ensure appropriate links to the existing interventions for climate change in the city (Castán Broto et al., 2015). Civil society organisations with extensive expertise in development interventions in Chamanculo C. participated as well. Finally, other actors that communities wanted to work with were identified and enrolled. External university-based facilitators, who knew the global debates and could grasp the local context, played a key role both in connecting communities with governmental and business actors and maintaining enthusiasm across the board.

Thirdly, a Community Plan for Climate Change Adaptation was developed based on confronting local climate challenges. The project facilitators provided check points but the communities developed proposals, wrote the plan, presented it to other actors and made follow-up approaches to institutions for further support. In order to do so, a Climate Planning Committee was established that represented and acted in place of the Chamanculo C's community. This process showed how local residents can engage with climate change information, and how they can use climate change as a theme to foster local debate and generate partnerships around their key development concerns, particularly in relation to their safety and health. Local proposals concentrated on improving drainage and infrastructure to increase the capacity to deal with floods. Residents of Chamanculo C proposed measures to improve the bairro's waste management and drainage through community organization, repairing networks to improve the water supply, and improve waste management through a recycling centre (Castán Broto et al., 2015). They also suggested the promotion of environmental education to, for example, learn about waste management and emergency responses to flooding. However, they rejected the option of relocation because they believed it would have an unbearable impact on their livelihoods.

Link to SDGs

Partnerships between different institutions including governments, private sector and civil society organisations are crucial for sustainable development in Maputo (SDG 17). Likewise, a well-designed and efficient city infrastructure is integral to ensure resilient communities, cities and urban areas (SDG 11, 13). Waste collection and recycling as well as water provision are key to maintaining good health and well-being and providing clean water and sanitation in urban areas (SDG 3, 6).

Challenges

The future challenge for both the National Fund for the Environment of Mozambique and local residents will be to implement the project proposals, demonstrating that participatory planning can improve the capacity of residents in Chamanculo C to respond to flooding events (Castán Broto, 2014). Development of large-scale participatory planning processes for climate compatible development can be resource- and time-consuming. It requires the buy-in of the community, their belief that the process will contribute to the improvement of their city and neighbourhood, and their certainty that their visions for the city's future will be recognised and considered by city managers (Castán Broto et al., 2015).

Benefits

Participatory planning offers different methods that can help to unpick the community's vulnerabilities and empower them to achieve both representation and recognition of their concerns and latent capacities. With a small amount of external support for facilitation and access to networks, community members are able to communicate their own interests and demands for climate compatible development. In this way, the Climate Planning Committee could identify key actors who could support them or who were responsible for delivering some of the proposed adaptation interventions (Castán Broto, 2014). This raised interest among different institutions that could intervene in the climate change sphere. The Committee met with each of these actors, creating new networks, some of which have maintained discussions beyond the project lifetime. Residents have also been able to mobilise external funding for their proposals and move towards implementation. This has accelerated a process of institutional development and mobilization around climate change in the community; now there is a dedicated climate change team working within the community (Castán Broto et al., 2015).

Lessons

Through the implementation of 4PCCD, it became evident that Participatory Action Plan Development methodologies have the potential to develop institutions for climate change governance at the local level and to establish channels of communication among different stakeholders from government, business and civil society. For instance, the participatory planning approach had a clear impact in terms of facilitating community organization, and strengthening their representation through the establishment of a Climate Planning Committee (Castán Broto et al., 2015).

4PCCD gave communities a forum in which they could present their plans to a wider audience of institutional representatives and policy-makers. This created expectations about what the communities could achieve, and local residents became confident in their perspectives. The project created a shift away from passive participation in neighbourhood planning to active leadership and meditation (Climate & Development Knowledge Network, 2014). Following this project, the municipality has embarked on deeper climate change planning processes. The National Fund's staff received training to further implement participatory methods for said processes and gained confidence in the way such methods can involve local residents.

Partnerships are a key strategy to build networks that can address climate change risks and initiate interventions for the sustainable use of resources. These partnerships emerge when actors with apparently different interests identify a common objective and work together towards achieving it. Initiatives which build partnerships for climate change in cities help to create linkages across different types of knowledge. A key question that remains is the extent to which partnerships can deliver forms of pro-poor planning that address climate change risks in cities in Africa.

15. Building Disaster Risk Reduction in the City of Lusaka, Zambia

Climate risks	
SDGs	
Project name	Building disaster risk reduction in the city of Lusaka
Project Location	Kanyama, city of Lusaka, Zambia
Adaptation type	Disaster risk reduction, emergency response.
Keywords	Water, health, Lusaka, drainage, sanitation, water borne diseases, flash flooding, disaster preparedness,
Sectors	Water and Health Sectors
Stakeholders	UNDP, UN-Habitat, Engineers, Planners, Disaster Management and Mitigation Unit Program Officer, Researchers
Project Status	2014- 2017
Contact point	Jonathan Mwanza, District Planning officer District planning unit, City Planning Department, Lusaka city council.mwanzajonathan@yhoo.co.uk +260977641683, Brenda Mwalukanga, Embedded Researcher, lunela2004@gmail.com, +260977926743
Website	https://www.lcc.gov.zm/, +260250077

Project Background

The majority of the population of Lusaka lives in peri-urban areas which are of an unplanned nature, densely populated and lack most of the basic infrastructure. Flooding is a regular climate risk. Damage to property, loss of lives and increase in water borne diseases and health risks have become inevitable and regular.

Emergency responses to flooding through the disaster-management-and-mitigation unit lacked a viable long-term strategy and implementation plan. Poorly coordinated institutional responses often resulted in inefficient and sometimes duplicated efforts. In 2010, the Lusaka city council received support to improve the drainage systems in Kanyama, an area of the city that is

Drainage for priority intervention in Kanyama. Photo provided by: People's Process on Housing and Poverty in Zambia (from Progress Report July-October 2016).

most prone to flooding, and has the highest incidence of water-borne diseases (such as cholera). The funding came from CARE International Zambia, which hired Rankin Engineering to design 120 kilometres of surface drains of various sizes. However, due to insufficient funds, the drains were never installed. Against this background, the need for a coordinated response strategy within the city emerged. The United Nations Development Programme, Lusaka city council and UN-Habitat developed a project with two aims. The first aim was to create a city-wide strategy that would enhance responses to and management of disaster risk. The second goal was to carry out demonstration activities in a flood-prone area in order to build the disaster-resilience capacity of the city of Lusaka. This case study focuses on the demonstraton activities that arose from the 'building disaster risk reduction and resilience in the city of Lusaka' strategy. The strategy is designed as a long-term plan. To improve coordination, and to avoid duplication, the plan took into account previous work by Rankin Engineering (funded by CARE).

Community volunteers working on the drainage. Pictures provided by: People's Process on Housing and Poverty in Zambia

Construction of the drainage. Pictures provided by: People's Process on Housing and Poverty in Zambia

Climate risks and other stressors

Topographic features make Kanyama prone to flooding. For instance, water does not seep through the impermeable surface geology of Kanyama easily, and this causes pools of water to collect. Also, a general lack of drainage systems makes these areas even more prone to flooding. Hence, flash floods and torrential rains constitute especially hazardous events for Kanyama. Where drainage systems do exist, flooding is sometimes caused by blockages caused by indiscriminate disposal of solid waste into the drains, or by unplanned and unauthorised construction on drainage reserves (e.g. properties that are constructed over existing drains). At the same time, Kanyama has to cope with the inadequate supply of potable water, which leads to high numbers of water-borne diseases.

Adaptation approach

The strategy had several overarching approaches to address the goals of disaster risk reduction: improving institutional coordination, building capacity for early warning and preparedness of the city, improving awareness, communication and risk identification as well as strengthening vulnerability and capacity assessment.

The project used a trans-disciplinary approach. UN-Habitat provided technical support through the provision of a geographic information system (GIS) expert, who conducted site visits, and received input from the community to identify flood-prone spots. The GIS expert then mapped the area. UN-Habitat also provided financial assistance to engage a consultant to carry out community-based works related to the construction of the drainage. The Lusaka city council provided technical support through the employment of a land surveyor, a civil engineer and planners. UN-Habitat financed the construction of 3 kilometres of drains; and a participatory process by the representatives of Kanyama. The resident representatives of Kanyama participated in mapping out the flood-prone areas, identifed the priority drains to be constructed, and provided labour for the actual construction of the drain.

Links to SDGs

Upgrading the drainage systems leads to an overall improvement of basic services such as water and sanitation (SDG 6) and thereby promotes healthy lives and enhanced well-being (SDG 3). By improving the drainage, Kamyana contributes to a system that is more resilient to the impacts of climate change (SDG 13). The described measures will furthermore contribute to a more resilient Kamyana (SDG 11) and to an alleviation of poverty of the people living there (SDG 1). Partnerships between the different institutions involved in the project also contribute to the sustainable development of the city at large (SDG 17).

Concrete lining of the drainage.

Challenges

The community was to volunteer in the construction of the drainage, but some of the people involved believed that they should be paid. Though 200 people initially attended recruitment sessions, only only 95 people registered after it was emphasised that the work would be voluntary. The project experienced delays in the procurement and branding of the construction tools to be used. Blasting for the drainage lines damaged some nearby properties; a wall fence fell and windows were broken at a house.

Excavation of the drainage.

Benefits

Kanyama reduced its disaster risk from flooding by completing this project. The 3 km long drainage system was constructed by community volunteers, which created a sense of ownership within the community, and is likely to reduce the potential for vandalism of the drainage system. At the same time, the use of volunteers reduced the cost of the project. The improved flow of water reduces the risk of water-borne diseases in the Kanyama.

Lessons

Wide stakeholder consultation is necessary to ensure that the strategy documents can be accepted and implemented. Participatory approaches to climate change adaptation produce the best outputs when key decisions are made by those who are most affected and who have a strong interest in contributing to an improvement of their situation. However, this approach also means that participating groups, responsible institutions and the city itself are willing to change their strategy of adaptation. The process needs a robust, inclusive plan to promote sustainable adaptation. Disaster risk reduction is the responsibility of all, including those most vulnerable to it.

Pictures provided by: People's Process on Housing and Poverty in Zambia

16. Improved Waste Management through Public-Private Partnerships in Lusaka

Climate risks	
SDGs	
Project name	The Manja Pamodzi Project
Project location	Peri-urban areas (Matero, George compound, Mtendere) in the city of Lusaka
Adaptation type	Community-based adaptation, disaster risk reduction, increase awareness and learning.
Keywords	Lusaka, Zambia, sanitation, water, drainage, community, waste, infrastructure, pollution, health, solid waste,
Sectors	Health, Water, Energy, Sanitation
Stakeholders	Researchers, Breweries, Lusaka City Council, Community Members
Project Status	2015 – ongoing
Contact point	Waste management Unit, Zambia Breweries, Lusaka city council edmuch2000@yahoo.co.uk +260977601260
Website	https://www.lcc.gov.zm/

Project Background

With more than 2 million residents living on 360 square kilometres of land, Lusaka in Zambia is among the fastest-growing capitals in Africa. The city confronts continued migration from rural areas, and the resulting increase in residential density. Poorly planned construction of property and other infrastructure on rocky terrain or near natural drains or streams leaves many communities prone to flooding. This climatic risk is exacerbated by indiscriminate disposal of waste in the drains. As a result, water not only accumulates in drains, but also in the streams and in the streets (Lusaka Times, 2015 and 2017). The amount of waste dumped into drains naturally increases due to population growth, and the increasing amount of waste again heightens the chance of blocked drains and the exposure of the communities to the risk of flooding, especially in peri-urban areas – and so a vicious circle grows in magnitude.

Historically waste management has not been handled efficiently. Local authorities lacked the resources to collect waste; local citizens had become accustomed to disposing waste indiscriminately, and poor city dwellers could not afford to pay for waste collection services. Flooding stemmed both from planning issues and from human activities. To stop indiscriminate waste disposal, local authorities stepped up enforcement of penalties and drainage policies, and undertook routine clear-

ups, but these steps did not work. Collection and recycling proved to be expensive for local authorities. Waste continued to accumulate in the drains and streams, and air pollution and diseases due to poor sanitation became more commonplace. Stakeholders living in the city recognised that the issue of waste collection required a holistic approach. The perception of waste needed to shift.

Waste in the drains of Lusaka. Picture provided by: Lusaka Times

The Manja Pamodzi (which means hands together) project is a public-private partnership project that aimed to achieve sustainable development in Lusaka by changing the practices of citizens and supporting them to become paid waste collectors. The project was devised to reduce the amount of waste being dumped on the streets and in drains of Lusaka, and it aimed to bring together the community, local authorities and the potential beneficiaries of recycled products. Zambian breweries, local researchers and the waste department at the Lusaka City Council spearheaded the project. In one year, 160 collectors had been registered and 195 tonnes of waste had been collected; two aggregation sites are currently operating in Ng'ombe and Chawama; and five clean-up exercises have taken place in Ng'ombe, Chawama, Matero, Kamwala and Lilanda (Zambia Daily Nation, 2016; Zambia Daily Mail, 2016).

Climate risks and other stressors

In Lusaka, climate change exacerbates long-standing flooding problems. Flooding is commonplace, the result of blockage of drains due to waste and unplanned construction. Indiscriminate waste disposal also emits greenhouse gases, specifically methane and produces bad odours. Water contamination and malfunctioning sanitary facilities are amongst the most serious consequences arising from current waste disposal practices of the poor communities in Lusaka. Unsanitary conditions and air and water pollution lead to the increased spread of diseases. Respiratory problems adversely affect the health of the people living in the city and its settlements.

Adaptation approach

To encourage behavioural change, health education campaigns were held in communities that had large amounts of indiscriminately disposed waste. After the health education campaigns, suitable collectors of solid waste amongst the community members were identified. These collectors were subsequently given an incentive to take the waste to an aggregator, where it was sorted for recycling and sent for reuse or composting.

Community aggregators who sell collected waste. Credit: Lusaka Times

It was recognised that the idea of recycling would be successful if people realised the value of the waste. Many people living in the peri-urban areas are unemployed, and therefore the collection, sorting and aggregation of waste could provide them with a source of income. The local authority also received support in clearing waste from the communities, which became cleaner and

showed reduced exposure to unsanitary conditions. Furthermore, producers of beverages and other products were able to purchase discarded bottles and papers, ultimately reducing the cost of their production.

Links to SDGs

Poor households improve their economic situation through the income generated by waste collection (SDG 1). Waste disposal from the drains improve overall health and well-being (SDG 3) as well as water quality and sanitation (SDG 6). By reducing the vulnerability of the community to flooding, the Manja Pamodzi project also contributes to a more resilient community (SDG 11).

Challenges

Even though the project has contributed to a large share of waste being collected and recycled, many local residents continue to indiscriminately dispose of their waste in streams and drains. Very few community members are aware of the potential economic benefits of recycling and reusing waste, and the resulting value chain. Therefore, these people don't have an incentive to change their behaviour.

Benefits

The Manja Pamodzi project led to a cleaner community, which improved health and well-being of the residents. Solid waste is cleared and disposed of; the recipient steward companies reduce their cost of production by recycling bottles and other products. Waste collectors – a number of whom are from very poor households – earn income from the collection and selling of waste to aggregators. Clearing the drainages from bottles and plastics has reduced the risk of flooding in the communities, allowing the free flow of storm water during and after intense rainfall.

Lessons

Solid waste management holds economic benefits for communities. Waste management programmes can present local people in need of work with business opportunities and incomes because they receive compensation for collected waste. Waste management and the value-chain concept should be encouraged and incorporated into local authority mechanisms. Involving business partners such as Zambian breweries offers advantages in helping such programmes to gain traction. By recycling and reusing bottles collected from the communities after consumption, these breweries claim product stewardship throughout the whole consumption cycle of these products.

Paper containers of Chibuku collected for recycling. Credit: Lusaka Times

Ecological benefits are just as important to the economic benefits. Through the recycling of waste, the risk of blocked drainages in cities and settlements and the related disaster risks of flooding can be reduced. This is a crucial point, as flooding and the risk it poses for developing countries may be amplified by indiscriminate waste disposal or unplanned construction in natural drains. In addition, the aesthetics of the surroundings and cleanliness of the community is enhanced, and the potential for disease is reduced.

17. Community-Based Action against Flood Risks in Dakar

Climate risks	
SDGs (Sustainable Development Goals)	
Project name	Vivre avec l'eau / Live with water
Project location	Pikine, Dakar, Guediawaye, Rufisque, departments of the city of Dakar, Senegal
Adaptation type	Community-based adaptation, building partnerships
Keywords	Women, adaptation and mitigation synergies, Senegal, community, flooding, infrastructure, disaster risk reduction
Sectors	Water, flood risk management, emergency response, capacity building, research, waste management, knowledge management, gender
Stakeholders	Government (flood response programme) and municipal advisors, local community, local flood committee, beneficiaries
Project Status	2015 - 2017
Contact point	cres@cres-sn.org, mdiasse@cres-sn.org

Project Background

'Vivre avec l'eau/ ('Live with water') is a partnership under the umbrella of Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED). BRACED (2015a, b) is a funding scheme from the UK Department for International Development; it was set up to support non-governmental organisations (NGOs) that help to enhance resilience of people facing extreme climate events in selected countries in the Sahel, sub-Saharan Africa and South Asia.

The 'Vivre avec l'eau' project builds resilience to flooding for 860,000 vulnerable people in ten communes of Pikine, Guediawaye, Dakar, and Rufisque, the four departments of Dakar in Senegal. It applies an innovative, integrated and community-based approach. This approach incorporates interventions in three fields: 1) infrastructure (floodwater evacuation, solid waste management, urban gardening and greening); 2) policy (district flood contingency plans and national policy advice); and 3) capacity building (training and awareness building for beneficiaries and key stakeholders, with a special focus on empowering women). These interventions are explained further in the section 'Adaptation approach'.

Mamadou Ndiaye, *délégué de quartier* of Bene Baraque sitting on a design bench. Benches made from recycled materials are arranged around the basins to improve the living environment of the neighbouring districts. Credit: Consortium pour la Recherche Economique et Sociale (CRES)

Many flood-affected communities in urban Senegal are distinguished by the high level of community action and self-organisation in the face of the challenges posed by the annual floodwaters. There is also a strong partnership between the key stakeholders who are committed to transforming and improving the current situation in flood-afflicted communities. For instance, in Yeumbeul Nord, a commune of Pikine, the community contributed to the identification of flood prone locations; helped to develop an urban management plan and also a local contingency plan. Meanwhile the Senegalese government has also implemented a number of national flood response plans. 'Vivre avec l'eau' tries to build on these regional and national efforts already in place, by designing a community flood response plan.

Climate risks and other stressors

In Senegal, urban flooding in the rainy season causes major damage to public and private infrastructure, and poses considerable social, economic and health-related risks to the human population, in particular the poorest. Poor drainage systems mean that rainwater floods the whole neighbourhood, paralysing transport, economic activities and posing health and safety risks due to stagnation and contamination (e.g. increase in water-borne diseases). Common conflicts with regards to how to deal with flooding often arise between households. Some attempts made in the past in Pikine to evacuate flood water have failed even with the help of firefighters.

Adaptation approach

First and foremost, the 'Vivre avec l'eau' project builds on its community-based approach. The project was initiated and is continuously driven by activities, experiences and know-how that the communities in Senegal show in the face of the challenges posed by the annual floodwaters. The driving force for an integrated response to urban flooding initially came from representatives from flood-afflicted areas. The community-based approach also entails a strong capacity-building component for the affected people. Key components of capacity-building activities are community workshops, which raise awareness of key aspects of flood prevention such as waste management and recycling. Technical workshops provide the training necessary to ensure the effective and sustainable implementation of the infrastructure and to promote flood-resilient urban planning. Policy workshops ensure that the learning and best practices from the project are integrated into policy at all government levels (e.g. through flood-contingency plans). The capacity-building component seeks to address broader issues of empowerment, public participation, leadership and knowledge management. Beneficiaries of the project will be involved in the project from the earliest planning stages to the final evaluation to ensure community ownership.

As the focus of this project lies on the poorest and most vulnerable people, special emphasis is put on the empowerment of women. They suffer from a disproportionate loss of income due to flooding because they are more active in small businesses such as laundry, selling used clothing or house services; moreover, women are more affected than men by water-borne diseases. At the same time, women are key actors to create lasting change and resilience. Therefore, they are especially encouraged to participate in resilience building activities prior to disasters caused by climate extremes and to actively respond in case of emergency.

Secondly, the project incorporates an integrated infrastructure approach as it deploys technological interventions to mitigate the physical effects of flooding whilst also responding to the social and political aspects of the problem. Interrelated flood-prevention practices and technologies are training session for young people in waste management collect water for use through an innovative urban

One of the five market gardens developed by the project for the women of the municipality of Yeumbeul Nord. Credit: CRES

Construction of the school wall with ecobrics (bottles filled with solid waste). Credit: CRES

space-management concept involving urban greening and gardening, converting the damaging floodwaters into a public good. A recycling and waste management programme is implemented to reduce the amount of waste in the districts, ensuring there is a sustainable source of revenue for members of the community, and ensuring that the infrastructure operates effectively.

Thirdly, the integrated infrastructure is based on the special needs of the particular districts. These needs will be addressed through the development of local flood contingency plans, incorporating the results from topographic and geographic information system (GIS) analyses of the terrain, and the expertise of the local beneficiaries and district stakeholders. As a result, problem areas can be identified in advance and necessary preparations can be made by local community residents; chains of responses to flooding can be developed, and responsible contact persons can be identified. Flood contingency plans will streamline communication between levels of government and the different organisations active in the flood-response field, building on existing flood- response systems in order to make local communities, policymakers and national emergency-response bodies better able to plan for and respond to urban flooding. Beyond the project-intervention areas, the use of low-technology solutions combined with training for engineers and urban planners from Senegal and other countries in West Africa will allow the uptake of these integrated infrastructure solutions on a larger scale.

Links to SDGs

Through the construction of resilient drainage infrastructure (SDG 9), the implementation of 'Vivre avec l'eau' contributes to a more sustainable city (SDG 11) that combats the impacts of flooding on affected communities (SDG 13). Also, the project puts special emphasis on gender equality through the empowerment of women throughout the project implementation (SDG 5).

Challenges

Land ownership is a major aspect that can hinder project implementation. When not foreseen and taken care of, is likely to be a source of conflict between the project and the community. It is important that the status of the land where the project activity is implemented is formally clarified.

Benefits

Results began to be seen in the first year of work. In Dakar, Senegal, very heavy rainfall resulted in urban flash flooding in Ben Barak (Yeumbeul Nord, Pikine), where the 'Vivre avec l'eau' project piloted urban flood capture infrastructure. Following the August 2015 event, a visit to the project site revealed that the infrastructure was able to drain the water quickly, while adjacent streets remained flooded several days later. As a result of the Year 2 activities implementation in Yeumbeul Nord, the areas have been provided with rainwater evacuation infrastructure, approximately 90 tons of solid waste have been taken out, the areas have been embellished with urban furniture made of waste and communities started urban gardening activities. Women have benefited from capacity building training and are strongly involved in local management committees. The project also supported the implementation of income generating activities related to waste management, compost making and selling etc. The youths have been trained as resilience champions, and spread the key resilience messages and practises to their relatives.

Lessons

Economic viability is an important factor in the sustainability of a project. Infrastructure solutions that are economically feasible and profitable are welcomed by community members because they are easier to organise, own and maintain.

Participation and collaboration in the form of inclusion and sharing of diverse know-how and expertise are crucial. Knowledge sharing can take the form of collaborative expert meetings or participatory community processes. It ensures that developed solutions are tailor-made and adapted to context and recipients. This also strengthens financial sustainability, e.g. when community members identify and prioritise feasible approaches to flood prevention, or when professional experts from different disciplines share knowledge, and create innovative solutions. In relation to this point, the building of strong partnerships is key to allow the participation and integration of the whole range of stakeholders

Training session for young people in waste management Credit: CRES

involved in the project. This multitude and diversity of stakeholders ensures integration of everybody's needs and capacities, and the building of synergies. In the case of conflict, strong partnerships also help to resolve a conflict more efficiently.

Active empowerment and involvement of women are important. Women's associations will not only strengthen a project's impact, but at the same time will ensure both equity and sustainability of the project. Women are amongst the most vulnerable groups. However, they are also potentially resilience-increasing stakeholders because they play an important role in the community, and can help to solve issues more effectively on the quartier level, e.g. regarding logistics or in case of conflicts between the project's stakeholders and communities.

Finally, context-sensitivity is a key factor for success. Strategies and technologies should be tailored to the respective community situation and conditions. This ensures that these are adapted to people's needs, and can be sustained beyond the duration of the project. Iterative project planning throughout appraisal, monitoring and evaluation process helps to cater for the whole project cycle.

Lessons

Climate change creates complex and interwoven challenges for Africa's cities and urban regions.

Major climate hazards

The 17 case studies featured in this report underscore the challenges Africa's cities and urban areas face due to the emergence and the increasingly adverse effects of climate change. The most important and imminent climate hazards facing the African continent are flooding, extreme temperatures, drought and sea level rise.

Multiple stresses

Alone, climate hazards such as flooding, drought or sea level rise pose severe threats to the integrity of African urban areas, the health of their citizens, and the safety and security of their surroundings. However, these hazards also lead to repercussions that are equally serious in scope, or that amplify the adverse effects humans already have had on their environment. As 'Ecological Infrastructure for Resilience and Job Creation in South Africa' (case 1) shows, the deterioration of wetlands in South Africa hampers the ability of these ecosystems to reduce the severe effects of flooding and fires - thus, leading to higher vulnerability of the local dwellers. Changes in rainfall and evapotranspiration have led to soil erosion in Nigeria (case 5), which impairs soil productivity and agriculture in the country. These are just two examples of the multi-faceted effects climate change can have.

Resource conflicts

Sectors increasingly compete for resources. This holds especially true for the water, energy and agricultural sectors. Water is essential to the production of nearly all types of energy (coal, geothermal, hydro, oil and gas, and nuclear power), but crop irrigation in agricultural production is also a heavy user. Energy is the dominant cost factor in the provision of water and wastewater services (extracting and conveying water, treating water, distributing water, using water and collecting and treating wastewater). As a consequence, these three sectors are sensitive to change and subject to resource conflicts. These are illustrated in a number of case studies, including 'Meeting Ethiopia's Development Goals by Addressing Links between Water, Energy and Food' (case 9) and 'Reconciling Water, Energy and Agricultural Demands in Zambia' (case 11).

Settlements and sprawl

Rapid population growth - and the lack of financial and institutional capacities to provide for urban housing and infrastructure - has led to sprawl and unsanitory, 'informal' settlements in many urban areas. Sanitary infrastructure, sewerage systems and adequate waste management are not prioritised and are often not effectively regulated. The projects 'Private-Public-People Networks for Climate Compatible Development in Maputo' (case 14) and 'Improved Waste Management through Public-Prviate Partnerships in Lusaka' (case 16) demonstrate how a lack of regulatory precautions and infrastructure negatively affect human health, water quality, flood risk and wildlife.

Governance and policy limitations

In theory, institutions and governments provide the necessary structures and means to implement adaptation projects, and to enforce underlying mechanisms that are needed - be it on the local, regional or national level. However, in many African countries, policy instruments and legislative frameworks are still in development or in need of reform. 'Urban Agriculture: Improved Governance for Resilience in Bulawayo, Zimbabwe' (case 7) provides an example of how an existing policy framework can be improved by taking into account possible changing climatic, economic, and ecological conditions in the future. A number of other projects presented in this paper involve government ministries, sub-national bodies, planners and municipal governments in implementation issues to ensure that regional and national planning units effectively adapt to climate change.

Adaptation requires change and collaboration.

Build trust and cross-sectoral partnerships

Trust is an essential ingredient and an important precondition for the success of a project – particularly when stakeholders from many backgrounds and differing perspectives create partnerships. A multi-stakeholder approach can be vital to build networks that are motivated by a common objective to reach a solution to a problem - as shown in the 'Private-Public-People Networks for Climate Compatible Development in Maputo' project (case 14). Through the use of participatory approaches (involving public, private and civil society actors), project managers are able to assemble all relevant and affected stakeholders to produce viable and holistic results. Having diverse backgrounds and different views on project challenges helps to ensure that actors comply with legislation, that projects fit into planning frameworks, and that technological solutions are properly installed and operative. 'Africa's First Direct Water Reuse Plant in Windhoek, Namibia' (case 4) provides one example.

Collaboration can add new perspectives to existing problems. Cross-sectoral collaboration is especially important in areas of conflicting interests and policies, and with limited resources, such as the Water-Food-Energy Nexus. In these areas, partnerships can help people to understand possible trade-offs and impacts of policies linked to climate change, which can help decision-makers and guide investments. 'Meeting Ethiopia's Development Goals by Addressing Links between Water, Energy and Food' (case 9) and 'Tackling Water Insecurity in a Changing Climate in Lesotho' (case 10) offer examples of this.

Empower local communities

Adaptation to climate change is not only about changing actions, but also about changing strategies. It often signals a new approach, involving both those affected by climate change, and the institutions responsible for mitigation and development in the city. At its best, the process involves a robust, all-inclusive response that promotes sustainable adaptation. Therefore, active community participation should be one of the main targets when implementing a project on the ground. This leads to longer-term success of projects. It also gives local people the opportunity to communicate their wishes (to municipalities, the private sectors and/or the national government), and to contribute to strategic decisions during the project implementation. The best outcomes address specific needs of the people who are most affected by changing climate conditions, and who have the highest stake in the possible benefits of adaptation. 'Community-Based Action against Flood Risks in Dakar' (case 17) and the 'Buffelsdraai Community Reforestation Project' (case 2) rely on strategies and technologies tailored to individual community situations and conditions.

Focus on women and youth

Women and youth are often among the most vulnerable and marginalised people in a community. A special focus on their empowerment is therefore vital to assure a holistic, societal capacity development. 'Community-Based Action against Flood Risks in Dakar' (case 17) demonstrates how the inclusion of women in the planning of resilience building and response activities prior to disasters led to their active empowerment. 'Ecological Infrastructure for Resilience and Job Creation in South Africa' (case 1) trained marginalised and disadvantaged groups in South Africa to become firefighters to confront the increased hazard of fires pose in regions facing longer periods of drought and higher temperatures. All of these newly trained firefighters are young people, and one-third are women.

Enhance learning

Training and education on adaptation and mitigation activities can amplify the effects of participatory approaches. Projects that are coupled with training programmes and capacity building are often more effective, and they have longer-lasting impacts in improving environmental, social and economic conditions. The training of extension workers in the project 'Stakeholder-Based Development Planning of the Shire River's Basin's Water and Natural Resources in Southern Malawi' (case 13) serves as a good example.

Build climate-resilient infrastructure, and create low-tech solutions when possible

Low-technological adaptation solutions that can be supported by the local community may be the most transferable situations throughout Africa. Moreover, they may offer the greatest potential to empower the most vulnerable. Ecosystem-based and community-based approaches are easier to implement, and they are more cost-effective to maintain than high-technology solutions that require expert knowledge and advanced education. Searching for low-technological solutions is also a viable approach for build climate-proofed infrastructure. 'Building Happy and Integrated Neighbourhoods in Luanda, Angola' (case 12) addresses these issues. The green space included in its housing development project proved to be a simple solution with multiple gains for the community and the environment. Planning for green spaces in towns and housing projects contributes both to reducing the risk of flooding and the health concerns caused by extreme heat. Green areas also provide communal spaces for recreation and urban farming - allowing for a range of climate change adaptations. The Luanda project offers an important lesson for growing African cities searching for ways to make growth sustainable – and for ways to involve residents in the process. The opportunities are enticing: much of Africa's urban environment is still to be built. This presents a real change to anticipate ongoing climate-change risks by developing adequate adaptation solutions within urban infrastructure plans.

Implement projects that raise awareness and have multiple benefits

'Applying an Integrated Approach to Catchment Management in Cape Town' (case 8) and the 'Buffelsdraai Community Reforestation Project' (case 2) in South Africa restored and preserved biodiversity and ecosystems in their respective project areas – and created local employment opportunities in the process. This not only benefitted the local environment, but also local people. Such approaches can transform people's perspective on their environment by making them aware of the benefits of protecting and sustainably using their own resources. Projects that are able to integrate public participation and job creation are also more likely to attract political support and international funding - as shown by 'Tackling Soil Erosion and Improving Lives in South-Eastern Nigeria' (case 5). Achieving a range of benefits through innovative approaches improves the chances of catalysed adaptation activities, and often helps to build resilience at the local level.

Invest in institutional and policy development

In 2007, the city of Bulawayo developed its first comprehensive agricultural policy (case 7) for sustainable and productive land use and the creation of zones for different types of agriculture. Lusaka (Zambia) developed a citywide disaster risk reduction strategy to confront the threats of flooding with a coordinated policy response (case 15). These two case studies provide examples of areas of possible intervention. African policymakers, and national and regional development planning can fill many similar gaps. Policies and regulations on national and local levels are needed to ensure the long-term safety and sustainability of adaptation projects around Africa. It should be noted that institutions, regional governments and municipalities benefit from the enforcement mechanisms that legislations and policies give them in pushing for adaptation action. To take these steps, decision-makers need to understand the value of such activities.

Share lessons and knowledge

A major challenge in African cities is the need for better coordination of projects and stakeholders. Despite an array of exemplar work, very little knowledge exchange and learning takes place to allow model projects to learn from each other and scale across sectors, locations and geographical scales. The same mistakes repeat themselves in new interventions that are similar to existing projects. 'Mainstreaming Biodiversity and Ecosystem Services for Effective Management in Cities' (case 3), implemented in Addis Ababa, Dar es Salaam and Lilongwe, showed how city coordination can lead to shared understanding about the problems of mainstreaming biodiversity considerations into land use planning. The project illustrates how improved coordination as a best adaptation practice in projects can unlock opportunities. It is therefore crucial to create links and synergies and avoid duplicating research efforts wherever possible.

Addressing the SDGs

Each case study and the multi-faceted benefits it brings about are in line with multiple Sustainable Development Goals. The 'Buffelsdraai Community Reforestation Project' (case 2) in Durban, South Africa, aimed to restore natural ecosystems and biodiversity around a landfill by planting indigenous trees and freeing this urban area from Invasive Alien Plants. This adaptation method simultaneously led to the creation of jobs (through the planting and trading of trees) and to an alleviation of poverty for local dwellers. It also rendered these settlements more sustainable and resilient by enhancing the community's awareness for environmental hazards and for the benefits and economic opportunities of intact ecosystems. Through its innovative approach, the ecosystem-based project at once addresses SDG 1 ('no poverty'), SDG 11 ('sustainable cities and settlements') and SDG 15 ('life on land').

'Meeting Ethiopia's Development Goals by Addressing Links between Water, Energy and Food' (case 9) is another inspirational example for simultaneously addressing multiple SDGs. The project discusses the challenge of managing sensitive sectors (water, energy and agriculture) through allocation scenarios that showcase the necessary resources for the subsistence of each sector. It also examines the infrastructure needed for a sufficient supply of water, energy and agriculture - especially facing the increasing demands of urbanization and the adverse effects of ever stronger and devastating natural disasters in the advent of climate change. Planning ahead for various sectors and climate scenarios, the project touches upon SDG 6 ('Clean water and sanitation'), SDG 7 ('Affordable and clean energy'), SDG 9 ('Industry, innovation and infrastructure') and SDG 13 ('Climate action').

These two original examples are just two of the 17 case studies in this working paper, which all succeed in integrating the SDGs into their planning. Therefore, every project not only inspires on a local basis, but also more broadly by addressing globally agreed-on development goals.

Conclusion

This working paper addressed climate change adaptation in African cities and urban areas by presenting and analysing lessons from 17 case studies. Although this working paper reflects lessons and conclusions available in collected cases, rather than from in-depth reviews, it amply illustrates the complexity of the situation facing the continent. The biophysical and socioeconomic issues the continent faces are multi-layered and interwoven; they go beyond traditional climate hazards, such as sea level rise or the risk of flooding. Add to this the ambition of many African nations to make the transition from threshold to emerging and advanced economies; the continuing migration of rural people into cities; and the institutional capacity that is inadequate to contemporary need, let alone to the magnified challenges that lie ahead if change does not take place. The challenges are profound. Residents in municipalities that fail to rise to these challenges will suffer, and the effects will fall disproportionately on the poorest communities. Therefore, capacity development and financing for resilience need to be enhanced and allocated more equitably among the African urban population. The roles of women and young people, in particular, are worth underscoring in this context. They often suffer disproportionate effects from climate change-inflicted problems. (For example, although the overall need to collect water is lower in urban areas than in rural ones, girls and women in urban settings take proportionally more responsibility than boys or men for collecting household water – tasks that may lead them to bear the brunt of flooding or other impacts that affect the neighbourhood). At the same time, vulnerable women and young people offer largely untapped human capital and vitality – assets that can and should be mobilised in resilience-building efforts.

Africa's urban areas and cities are in need of special attention. They are the hotspots of human demand for food, water, energy and other resources. The African Development Bank estimates that Africa will lead the world's population growth over the next 50 years, and that 'the people of Africa will increasingly be city dwellers'. Africa will have some of the largest mega-cities in the world' (African Development Bank, 2014).

The diminishing security of basic sectors such as water, food and energy will likely lead to increasingly conflicting demands in the next decades. Simultaneously, urban areas and cities in Africa often lack effective institutional and policy regulation to steer overall sustainable development. This leads to adverse effects that cause hardship and impact severely on human health for residents in the cityscape: illegal settlements, sprawl, mismanagement of waste, dysfunctional sanitary systems and erratic access to drinking water.

Complex problems require multi-layered and innovative responses. The cases presented in this working paper reveal the manifold, multi-beneficial approaches to adaptation that are possible within Africa's cities and urban areas. These case studies span approaches, among them ecosystem-based adaptation, policy intervention to change existent agricultural practices, and establishing water-reuse systems to address urgent population needs. A great number of the projects successfully pursued a multi-stakeholder approach involving all relevant stakeholders, and employing project managers with a broad range of disciplinary backgrounds to ensure a holistic approach to the adaptation challenge. Many involve community-based projects that focus on enhancing the resilience and capacity of local citizens in the face of diverse climate risks, such as extreme temperatures and degradation of ecosystems. The creation of partnerships such as the ones highlighted here deserves special emphasis. Creating partnerships between communities, government, the public sector and other relevant stakeholders proved to be a useful and powerful tool, both to generate trust, and to ensure a more sustainable implementation of the project. The studies underline that projects operating on the basis of low-technology solutions are generally more feasible, since they are easier to maintain for local citizens. Furthermore, they show that positive spill-over effects can be created by implementing projects with multiple benefits: This can be an urban green space that mitigates the risks of flooding and, simultaneously, creates public space for recreation and improved air quality. Or it can mean a

job creation and training project for disadvantaged community members that, simultaneously restores wetlands and enhances biodiversity.

Innovative implementation projects and creative solutions such as these are an inspiration for adaptation activities in urban Africa. Their successes and outcomes should be celebrated and shared. 'Inspiring Climate Action in African Cities' is intended to do exactly that – to share these stories, learn from them and inspire decision makers to facilitate the urban environment and urban dwellers to adapt.

The power of providing inspiration, and successes worth emulating, is difficult to measure, but should not be underestimated. This is the message expressed by Pierre Van Rensburg, the strategic executive with the Department of Infrastructure, Water and Technical Services, which oversees the Gorengab Water Reclamation Plant (case 4).

'If you look at the world, the pressing need is always in developing countries. It's a fast-changing environment, so, you always have to be innovative to try and stay a step ahead', he said. 'An idea can be generated in a developing country that can actually inspire a similar trend in a developed country'.[6]

[6] See case study 4, page 38.

Glossary

Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2014).
Capacity building	The practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society, or organization to respond to change (IPCC, 2014).
Community-based Adaptation	Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency, and preferences of communities as strengths (IPCC, 2014).
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.”The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC, 2014).
Climate variability	Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC, 2014).
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2014).

Ecosystem-based Adaptation	The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase the resilience and reduce the vulnerability of ecosystems and people in the face of the adverse effects of climate change. Ecosystem-based adaptation is most appropriately integrated into broader adaptation and development strategies (Convention on Biological Diversity, 2009).
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. (IPCC, 2014).
Mitigation (of climate change)	Mitigation (of climate change) A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2014).
Mitigation (of disaster risk and disaster)	The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability (IPCC, 2014).
Resilience	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation (IPCC, 2014).
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014).
Water- energy-food nexus	The link between food, energy and water systems, where the use of and pressure on one can affect the other. e.g. a drought can lead to increasing food prices, or to shutting of power plants, which need water.

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