WORLD BANK GROUP

Greening Africa's Cities:

Enhancing the relationship between urbanization, environmental assets and ecosystem services

URBANIZATION, THE ENVIRONMENT AND GREEN URBAN DEVELOPMENT IN AFRICA

Roland White
Jane Turpie
Gwyneth Letley

Korea Green Growth Trust Fund
The Nature Conservancy

Design and production by Zephyr
www.wearezephyr.com

WORLD BANK GROUP

Korea Green Growth Trust Fund

The Nature Conservancy

Greening Africa's Cities:

Enhancing the relationship between urbanization, environmental assets and ecosystem services

URBANIZATION, THE ENVIRONMENT AND GREEN URBAN DEVELOPMENT IN AFRICA

Roland White
Jane Turpie
Gwyneth Letley

PREFACE AND ACKNOWLEDGEMENTS

This report is based on a suite of eight research exercises undertaken over the period 2015-2017, all of which – together with accompanying datasets – are available on-line:

- **A regional desk-study** which examines and synthesizes available material, providing an overview of the key situational dynamics and trends in the natural environment in Africa's main cities;
- **Detailed urban environmental profiles** of three case study cities of Durban, Kampala and Dar es Salaam developed using the "Rapid Urban Environmental Assessment" (RUEA) methodology;
- **Ecosystem Services Valuation (ESV) studies** which provide a valuation of urban natural capital and ecosystem services and the identification, quantification and valuation of the costs and benefits associated with specific development interventions in the three cities of Durban, Kampala and Dar es Salaam. Drawing on TEEB (The Economics of Ecosystems and Biodiversity) methodologies, these studies were conducted through a number of key steps involving both extensive technical work and intensive stakeholder dialogue;
- **A toolkit** of policy measures, instruments, and planning and management strategies taken largely from both developed and developing country experience which can be adapted and utilized by city and national governments to address the sorts of environmental externalities and ecosystem services impacts identified in the environmental profiles and ESV studies.

Many people contributed to the overall study: Dr Timm Kroeger, Dr Raffaele de Risi, Dr Francesco de Paola, Chris Roed, Dr Dambala Gelo, Dr Liz Day, Dr Robynne Chrystal, Prof. Derek Stretch, Dr Stef Corbella, Kat Forsythe, Chyi-Yun Huang, John Bachmann, Diane Dale, Brian Goldberg, Jennifer Black, Petrina Rowcroft and Maritza Pechin all made valuable contributions to the production of the regional desk study, the detailed urban environmental profiles, the three city case studies and the urban environmental toolkit.

We are grateful to Dr Jeffrey Wielgus, Mike Toman, Sanjay Strivastava, Urvashi Narain, Glen-Marie Lange, Elizabeth Tellman, Rob McDonald, Stephane Hallegatte, Steve Hammer, Kavita Sharma and Daniel Auerbach who contributed invaluable technical insights, critical review, and guidance.

Thanks to Jonathan Schroeder, Robert Pretorius, Chivashni Bachen, Dr David Kyamboto, Amy Faust, Nancy Lorenzo Garcia, Mary Bitekerezo, Herbert Oule, Najib Lukooya Bateganya, Susan Namaalwa and Stephen Tumwebaze who provided data, assisted with data collation, and provided other useful inputs and city-specific advice.

We are also grateful to the relevant municipal staff in eThekwini (Durban), Dar es Salaam and Kampala for their interest and support of the research projects conducted in their cities over the two year period.

A

INTRODUCTION: BACKGROUND AND OBJECTIVES

Africa is urbanizing late but fast. This brings many benefits but, as this report shows:

- Thus far, urbanization in Africa, unique in a number of respects, is having deleterious and largely unchecked impacts on the natural environment;
- The degradation of natural assets and ecosystems within African cities carries tangible economic, fiscal and social costs;
- There are important opportunities to change the current environmental trajectory of African cities so that they move towards a more harmonious relationship between their natural and built environments. For this to happen, focused action is necessary.

URBANIZATION, THE ENVIRONMENT AND GREEN URBAN DEVELOPMENT IN AFRICA

In this context, the lack of an adequate understanding of the natural environment and the extent of urban environmental degradation in Africa, its economic and human costs, and the complex interplay between urban development, natural asset decline, and the value of ecosystem services provision is becoming increasingly problematic. National and city governments are unable to make well-informed, cost-effective urban planning, land-use, budgetary and investment decisions regarding the development of urban areas, and lack the tools to mitigate negative environmental externalities. Moreover, there is a significant risk that African cities may become locked into a "grow dirty now, clean up later" development path which is potentially costly, inefficient and welfare-reducing (World Bank 2012). Thus far, with one or two exceptions (de Wit et al., 2011) very little systematic analytic work has been done on these issues in Africa and little attention has been paid to the development of instruments, strategies and approaches which can improve cities' capacities to improve their decision-making capabilities and enable them to respond effectively to the erosion of the value of their environmental assets.

This report, and the suite of eight research studies which underlie it (see Preface), is directed at addressing part of this knowledge deficit. An improved understanding of urbanization's impacts on the environment, and the proper valuation of the costs and benefits associated with interventions that alter the natural capital base and ecosystem services provision, can allow public agencies to make more cost-effective and responsible urban development decisions, balance the trade-offs between natural capital conservation and other land-uses, and inform approaches to developing urban land and the nature of the associated investments (TEEB 2010). It is particularly important that knowledge and technical capacity gaps in this area are addressed sooner rather than later: once ecosystems are severely degraded or destroyed it becomes very difficult, or impossible, to restore them and the value of the services they provide may be irreversibly lost.

"There is a significant risk that African cities may become locked into a "grow dirty now, clean up later" development path.

B

THE RELATIONSHIP BETWEEN CITY GROWTH AND THE NATURAL ENVIRONMENT

How urban activities affect the environment

Urbanization entails the growth and spatial concentration of population, economic production, and consumption. This involves three types of activity which affect the natural environment:

- The expanded use and consumption of natural resources;
- The transformation of the natural environment into the built environment as residences, economic enterprises, and infrastructure are established;
- The generation of waste including atmospheric emissions, wastewater and solid waste.

In any urban space, these activities exist in complex interaction with one another and have mutually compounding effects. Broadly speaking, however, they impact the natural environment in three ways:

i. They affect the natural asset base of the city, e.g. they may reduce the amount of freshwater available and diminish its quality. The rate of natural resource consumption is determined by a combination of demographic and economic drivers: population growth, increases in wealth and living standards, and growth in economic output.

ii. They affect the ecosystems of the city and the volume and value of the services these systems generate. For instance, the conversion of wetlands to agriculture or hard surfaces reduces the value of the water cleansing services that wetlands often provide;

iii. They affect the biodiversity of the cities in that species may be eliminated.

Why this matters

To a significant extent, such impacts are intrinsic to the urbanization process and insofar as urbanization is inevitable, these impacts are also inevitable. They are also beneficial. Natural resource consumption, for example, is a precondition of economic production, hence of improvements in human welfare. But it is important to recognize that deterioration in environmental quality also invariably has negative economic, fiscal and welfare consequences for cities. Such consequences may be felt at the level of the household or firm; they are more or less measurable; they may be more or less severe; and they may be experienced in a variety of ways: increasing costs of water production; deteriorating human health (and the costs of addressing this); damage to infrastructure (and the costs of addressing this); reduced property values; loss of recreation and tourism value; and so on.

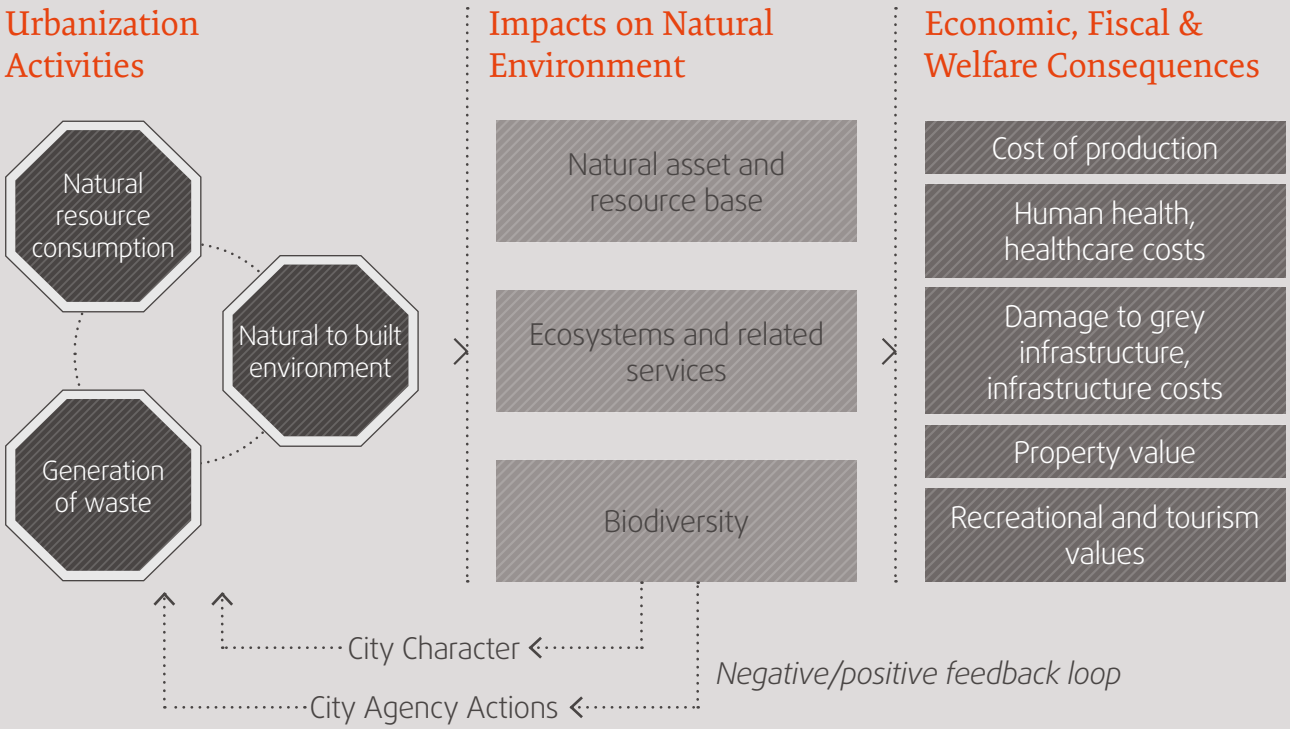
Trends are self-reinforcing

Thus, while urbanization impacts the natural environment, the natural environment impacts cities. Environmental assets can enhance city resilience to disasters such as floods, and ecosystems can reduce the costs of service-delivery. In other words, there is a feedback loop between urban development and the quality of the natural environment which may be either positively or negatively reinforcing.

In any city, the way in which urban growth affects the natural environment, and the nature of the feedback loop,

Figure 1:

Urbanization-natural environment impact chain



are determined by both the character of the city (economic, demographic and spatial) and any measures affecting environmental quality taken by city institutions. Such measures range from those which target environmental assets directly to those which do not focus on the environment specifically but which may have significant positive environmental impacts. It should be noted that non-targeted measures may often be more important in their environmental consequences than targeted measures. For example, city-wide sanitation programmes undertaken primarily to enhance liveability may improve water resource quality more than liquid waste control programmes directed at industrial and commercial enterprises.

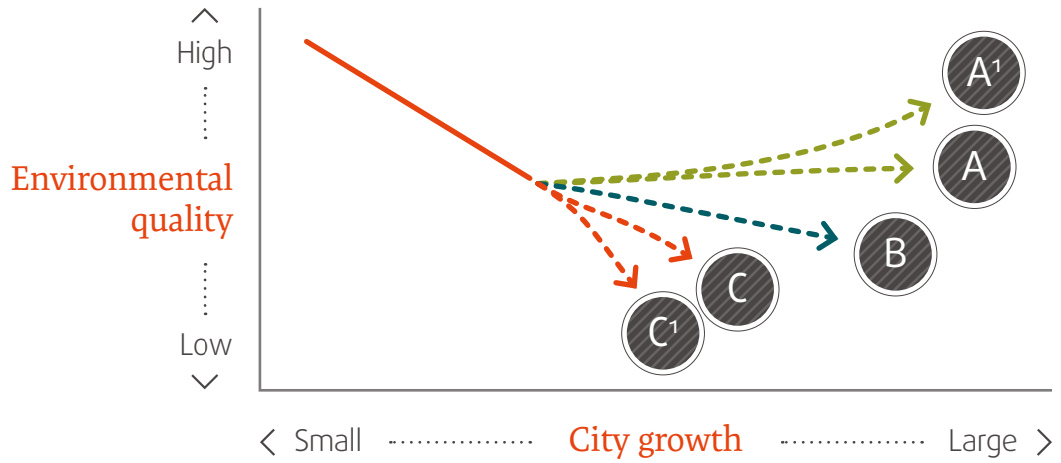
Figure 1 illustrates the basic relationships in the **"general impact chain"** outlined above. Typically, as urbanization progresses and cities grow, urbanization activities have large, negative environmental impacts and few measures to address these impacts are taken, either directly or indirectly. As illustrated in Figure 2 below, the city thus progresses rapidly from top to bottom along the vertical axis, and is characterized by a rapid deterioration in environmental condition. As the consequences and costs of this deterioration become evident, direct and indirect measures may be undertaken and the city may begin to move increasingly up the vertical axis. At a certain point, at least as regards some natural assets and ecosystems, a positively reinforcing feedback cycle between environmental quality and environmental interventions may set in (the better the base condition of the environment gets, the greater the positive impacts of any set of environmentally targeted actions), and the city may begin to reverse its direction of travel (environmental conditions may actually improve).

Cities may be on negative or positive trajectories
For any given city, or group of cities within a country or region, a range of different scenarios from A to C is possible:

- Under A, a city is able to arrest and reverse the impact of urbanization-activities on its natural asset base, ecosystems and species (see Box 1). A1 presents a scenario in which a positive feedback cycle has emerged and an improvement in environmental quality is becoming increasingly rapid;
- Under B, the city slows but does not stop environmental deterioration;
- Under C, deterioration continues largely unchecked. A negative feedback cycle emerges under C1, and the deterioration in environmental quality becomes increasingly rapid.

It should be stressed that, as with many other aspects of city development, natural environment impacts can be highly path-dependent and may be more or less difficult to reverse. For example, ecosystems that have been built on are lost, but deforested areas and degraded wetlands can be restored. The problem is that this restoration can be very difficult and too costly to be feasible. Once ecosystems such as wetlands in urban areas have become severely impacted, they are often effectively eradicated, as is the stream of services they can provide to support economic production and human well-being (Box 2; Turpie et al., 2016). However, with appropriate policy and sufficient resources it is possible to significantly improve the quality of a deteriorated urban river system, or city atmosphere, within a reasonable period of time. Choices like these can have important consequences for a city's economic and fiscal future.

Figure 2:
Relationship between urban growth and natural environment quality over time



Box 1:

Cities can intervene to improve the environment and its benefits to people

Mexico City and London provide examples of how cities can utilize different measures to reduce their impact on the environment, and at the same time, benefit their citizens with improved environmental quality.

In the early 1990s, the United Nations declared Mexico City's air quality as the lowest in the world. Through a series of actions that have included replacing old cars, removing lead from gasoline, adopting the use of natural gas in transportation, and expanding public transportation, the city has been able to reduce the health impacts of air pollution drastically. Although the city still has a long way to go in improving its air quality (such as dealing with high levels of ozone and fine suspended particles), the average concentration of lead (which can cause neurological effects in children) has dropped by approximately 90% (from 1.30 µg/m3 to 0.13 µg/m3), and the concentration of sulphur dioxide (which can cause respiratory problems) by approximately 91% (from 58 ppb to 5 ppb). Carbon monoxide and other pollutants have also been reduced.

Meanwhile, London has been able to reverse the city's impact on the watershed of the Thames River. In the 1950s, pollution from the city caused oxygen levels in the river to be so low that the river was declared biologically dead. With the implementation of strict regulations that prevent the dumping of pollutants, better treatment and diversion of sewage from the city, and the rebuilding of mud banks and other habitat, the river has made an impressive comeback. The combined effect of these interventions has resulted in a swift resurgence of riverine fauna, and today, more than 100 species of fish inhabit the river and wading birds have become a common sight.

In an urban context, the core insight of the "sustainable development" thesis is that while in the short term human welfare gains may be compatible with paths B and C, in the long term these paths will erode the natural assets and ecosystems on which economic production and human life rest. It is thus important that, directly and indirectly, measures are consistently undertaken to bend the trajectory of urban development from B or C to A, or cities will become increasingly costly, less productive and less liveable.

Influencing the trajectory requires understanding the nature of urbanization

Sub-Saharan Africa (SSA) is no different than any other region in that its urban and environmental futures are interlocked and will ultimately either be virtuously or viciously correlated. And, like other regions, the specific features of Africa's urbanization will affect the character of the cities that emerge, and hence their environmental impacts. It is thus important to understand the nature of the urbanization process in Africa; how this process is shaping SSA cities; how city development is, in turn, affecting the natural environment and the feedback loop between the environment, urban character and environmental measures. It also needs to be recognized that the dynamics of political economy (such as immediate demands for housing; the influence of powerful developers over environmental decisions) and fiscal and institutional constraints determine and circumscribe the priorities and limits to action. A consideration of such factors in any given context is necessary to inform what measures may or may not be possible at any time, and the design of feasible environmental instruments.

Box 2:

Lessons from Kampala's Nakivubo wetland

(Source: Turpie et al., 2016a)

The Nakivubo wetland, one of several large wetland systems that are found within and around the city of Kampala, is severely degraded. Polluted water from the city passes through the wetland before entering Inner Murchison Bay.

In the late 1990s, it was ascertained that the water treatment service performed by the wetland yielded a significant cost saving for the nearby Ggaba Water Treatment Works. However, as the city has continued to grow, pollution flows into the wetland have increased significantly, while the size and assimilative capacity of the wetland has decreased. As a result the nearby water treatment works has been upgraded twice and new treatment works have been sited far from the city. Fisheries in Inner Murchison Bay have also all but collapsed, and the wetland itself has become the site of slum development. These concerns, as well as the increasing shortage of public open space areas in the city that are available for recreation, have led to the city's consideration of the rehabilitation of the Nakivubo wetland, both to restore its functioning and to create the opportunity for a recreational area with associated possibilities for economic development.

In this study, a sequential set of interventions was identified to restore the wetland to a level where economic benefits could be realized. This "treatment train" included improved sanitation infrastructure and measures, extending and upgrading the waste water treatment works, wetland rehabilitation, conservation measures, and investment in recreational facilities. Excluding some of the required sanitation work which is already underway, the proposed fix would incur an initial cost of US$53 million, with ongoing maintenance and operating costs of US$3.6 million per year.

Benefits of the project would include water treatment cost savings of US$1 million (limited because of sunk costs) and recreational benefits exceeding US$22 million per year. The net present value of the project over 15 years would be in the order of US$80 million (-US$24 to US$220 million), and the internal rate of return would be in the range of 20% (4% to 34%), depending on assumptions. The restoration would also enhance the feasibility of creating a waterfront development next to the wetland. Nevertheless, the initial capital costs are high, and such a project may well not be undertaken due to financial constraints and political intractability.

There are important lessons to be learned from this study. Considerable environmental, economic and fiscal costs have been incurred by allowing the built environment to encroach on and largely eradicate a crucial part of the city's natural capital endowment. A green urban planning paradigm (see Section F) would have yielded the sustained flow of benefits outlined above. Now it is too costly and, from a political point of view, impractical to restore the wetland to a state where these benefits can be achieved. This lesson holds for the many additional wetland areas that could become engulfed as Kampala continues to grow. Most wetlands within the existing urban area have already been effectively lost. Without proactive interventions, the wetlands outside of the present urban core will also be destroyed and the cumulative impacts on Murchison Bay and any economic activities around the bay, including the viability of a future waterfront development, could be significant.

> "Recreational benefits would exceed US$22 million per year.

One of the main challenges in achieving such interventions will be institutional. Greater Kampala extends well beyond the boundaries of the Kampala Capital City Authority (KCCA), which originally encompassed the entire city. Unless the KCCA area is adjusted accordingly (as has been done in other countries), the problems that will arise in a growing city will be in areas under multiple other jurisdictions.

C

THE KEY CHARACTERISTICS OF AFRICA'S URBANIZATION

Four key features of the urbanization process in Africa appear to have significant impacts on the way in which city growth is affecting the natural environment.

- Late but rapid urbanization
- Low levels of wealth, fiscal resource and service delivery
- Low levels of industrialization, motorization and technology
- Institutions and systems are weak

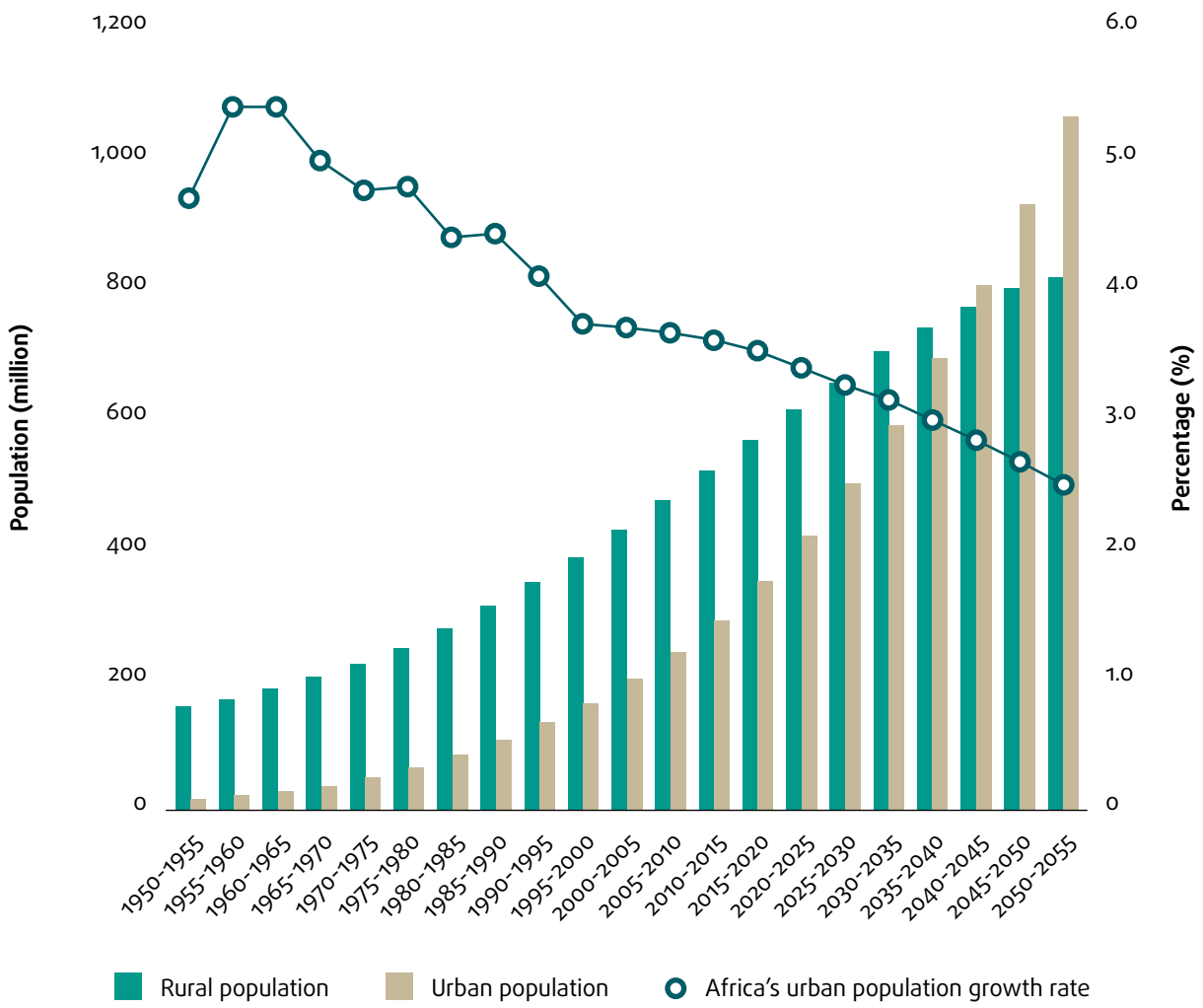
Late but rapid urbanization

Africa is urbanizing late but fast. Urbanization in Africa began later than in any other global region and, at a level of about approximately 40%, Africa remains the least urbanized region in the world. However, as indicated in Figure 3, this is rapidly changing: SSA's cities have grown at an average rate of close to 4.0% per year over the past twenty years, and are projected to grow between 2.5% and 3.5% annually from 2015 to 2055 (Figure 3). By contrast, globally the average annual urban population growth rate is projected to be between 1.44% and 1.84% from 2015 to 2030 (WHO 2015).

From an environmental perspective, this has two important implications. On the one hand, most of Africa's urban space has yet to emerge. Much of the area which will eventually be covered by the built environment has not yet been constructed and populated. Crucial natural assets – and significant biodiversity – thus remain intact in areas to which cities will eventually spread. On the other hand, this is changing quickly: pressures on the natural environment in and around cities are escalating steadily and these assets are increasingly under serious threat.

Figure 3:

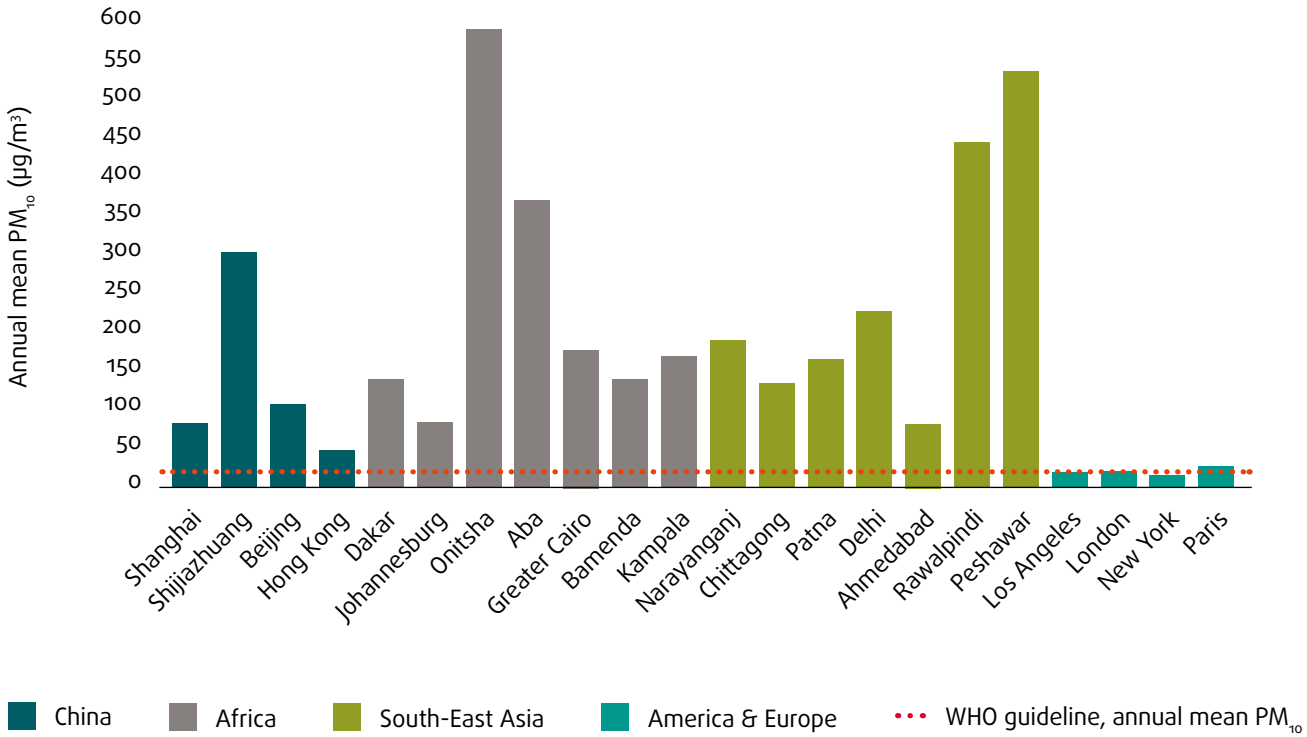
Rural and urban population growth in Africa and the average rate of urban population growth (1950 – 2055)
(Source: WHO 2015)



Low levels of industrialization, motorization and technology
Africa is urbanizing at relatively low levels of industrialization (Lall et al., 2017), motorization and technology. For example, at levels of 42, 25 and 39 per 1,000 population, respectively, motorization levels in Nairobi, Dar es Salaam and Dakar are low by international standards (Behrens et al, 2016; CETUD, 2015). This has varying effects on the urban environment. For example, while atmospheric emissions related to transportation and manufacturing are relatively low, heavy reliance on biomass fuels in African cities tends to generate high levels of fine and small particulate matter ($PM_{2.5}$ and PM_{10})[1] relative to other regions (Figure 4).

Low levels of wealth, fiscal resource and service delivery
Africa is urbanizing at substantially lower levels of wealth than other regions (Figure 5). This is aggravated by low proportions of overall capital investment (infrastructure, housing and office building) which remains at around 20% of GDP. In contrast, capital investment in China rose from 35% to 48% of GDP at the time that its urbanization level rose from 18% to 52% of the population (1978-2012), and capital investment in East Asia as a whole remained above 40% over this period (Lall et al., 2017).

Figure 4:
Average annual small particulate matter (PM_{10}) concentrations for cities in SSA and other regions
(Source: WHO 2016)

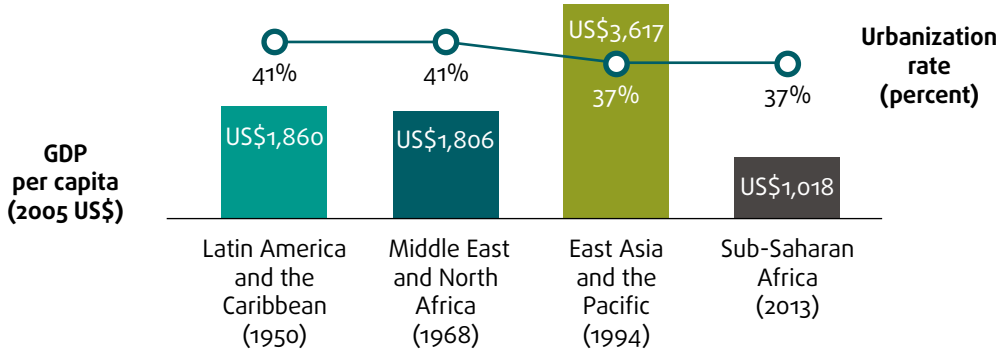


1 Small and fine particulate matter (PM10 and PM2.5) include pollutants such as sulphates, nitrates, black carbon, and dust which penetrate deep into the lungs and cardiovascular system, posing the greatest risks to human health (WHO 2016)

Figure 5:

GFP per capita of different regions, at Sub-Saharan Africa's current urbanization level

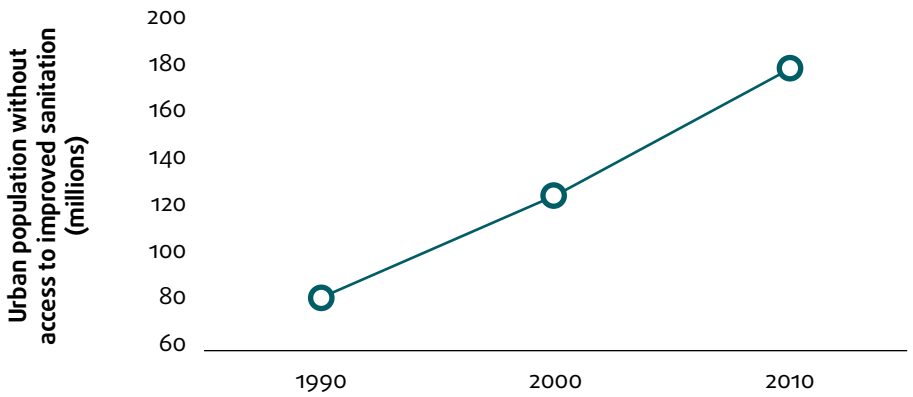
(Source: Lall et al., 2017)



In the context of rapid urbanization, and in combination with other factors (such as weak planning and institutional capacity), this has had three important and interrelated impacts. First, relative to city size, fiscal resources are extremely limited. This is reflected in exceedingly low public expenditures on urban infrastructure which (outside of South Africa) are normally in a range of less than US$1 per capita per year to around US$15 per capita per year.[2] Second, household resources for investment in housing and payment of service charges are also very limited, one reason for the very high proportion (at 70% by far the highest in the world) of the urban population living in informal settlement, which is characterized by poor levels of infrastructure and service delivery. Third, in the context of social and political pressures which tend to emphasize the delivery of services focused on access and immediate human consumption (water, roads and so on), infrastructure and services which deal with waste are deprioritized and receive little of the scarce resources that are available. Thus, the urban population without access to improved sanitation has grown steadily over the past 2-3 decades from 89 million in 1990 to 189 million in 2010 (Figure 6; AMCOW 2012). For the entire region the proportion of urban residents with access to sanitation was estimated to be only 37% in 2010.[3]

Figure 6:

Urban population without access to improved sanitation in Sub-Saharan Africa (1990-2010)



2 World Bank staff calculations drawing on various data sources

3 World Bank staff calculations drawing on various data sources

Solid waste coverage also remains very limited with collection rates for many African cities at below 50% (Table 1). The upshot is that African cities appear to be doing less to manage the waste that their urban populations and enterprises generate than most other cities in the world.

Institutions and systems are weak

Institutions and systems which are cardinal to effective urban development and management are weak. There are two respects in which this has important implications for the natural environment. First, it is clear – for example – from evidence assembled by the World Bank in the course of undertaking Urbanization Reviews in ten African countries in recent years,[3] that the organizations which are responsible for planning, managing and governing African cities tend to be jurisdictionally fractured, weakly empowered and poorly capacitated. Most metropoles traverse numerous jurisdictions, managed by different elected bodies, local government structures and agencies, many of which have fragmented and/or overlapping planning and regulatory authority which restricts effective urban environmental management. Even in cities widely regarded as amongst the urban management leaders on the continent (such as Durban), tectonic faults impose severe effectiveness constraints (see Box 3 below).

Second, institutional systems pertaining to the administration of assets which are critical to the nature of urban development suffer from severe deficiencies. As regards land, for example, cities struggle with overlapping and contradictory property systems, in which rights are often unclear and administrative systems function poorly. In West Africa, for example, only 2-3% of land is held with a government registered title. In addition, across the continent, planning regulations are often anachronistic, restrictive and impracticable from an enforcement point of view (Lall et al., 2017).

Table 1:

Percent of municipal solid waste collected in selected cities of Sub-Saharan Africa (SSA), East Asia and South Asia

(Source: Hoornweg & Bhada-Tata 2012)

Country (Data source)	City	Year	Urban Population	Solid waste collection coverage (%)
Benin (UNSD 2009)	Paralou	2002	148,450	10
Burkino Faso (UNSD 2009)	Ouagadougou	1995	876,200	51
Cameroon (Parrot et al., 2009)	Yaounde	2005	1,720,000	43
Chad (Parrot et al., 2009)	Ndjamena	2003	800,000	15-20
Cote d'Ivoire (Parrot et al., 2009)	Abidjan	2002	2,777,000	30-40
Guinea (UNSD 2009)	Conakry	2007	3,000,000	76
Kenya (Parrot et al., 2009)	Nairobi	2006	2,312,000	30-45
Mauritania (Parrot et al., 2009)	Noualchott	N/A	611,883	20-30
Senegal (Parrot et al., 2009)	Dakar	2003	1,708,000	30-40
Tanzania (Parrot et al., 2009)	Dar es Salaam	N/A	2,500,000	48
Togo (Parrot et al., 2009)	Lome	2002	1,000,000	42
Zambia (UNSD 2009)	Lusaka	2005	1,300,000	18
Zimbabwe (UNSD 2009)	Harare	2007	2,500,000	99
China, Hong Kong SAR (UNSD 2009)	Hong Kong	2007	6,926,000	100
China, Macao SAR (UNSD 2009)	Macao	2007	525,760	100
Indonesia (UNSD 2009)	Jakarta	2004	8,962,000	86
Philippines (UNSD 2009)	Manila	2007	1,660,714	95
Nepal (Asian Development Bank 2013)	Kathmandu	2003	738,173	86
Sri Lanka (UNSD 2009)	Dehiwala-Mount Lavinia	2007	206,787	96
	Moratuwa	2007	189,790	90

3 These countries include Ethiopia, Kenya, Ghana, Senegal, Malawi, Cote d'Ivoire, Nigeria and (forthcoming) Tanzania, South Africa and Mozambique

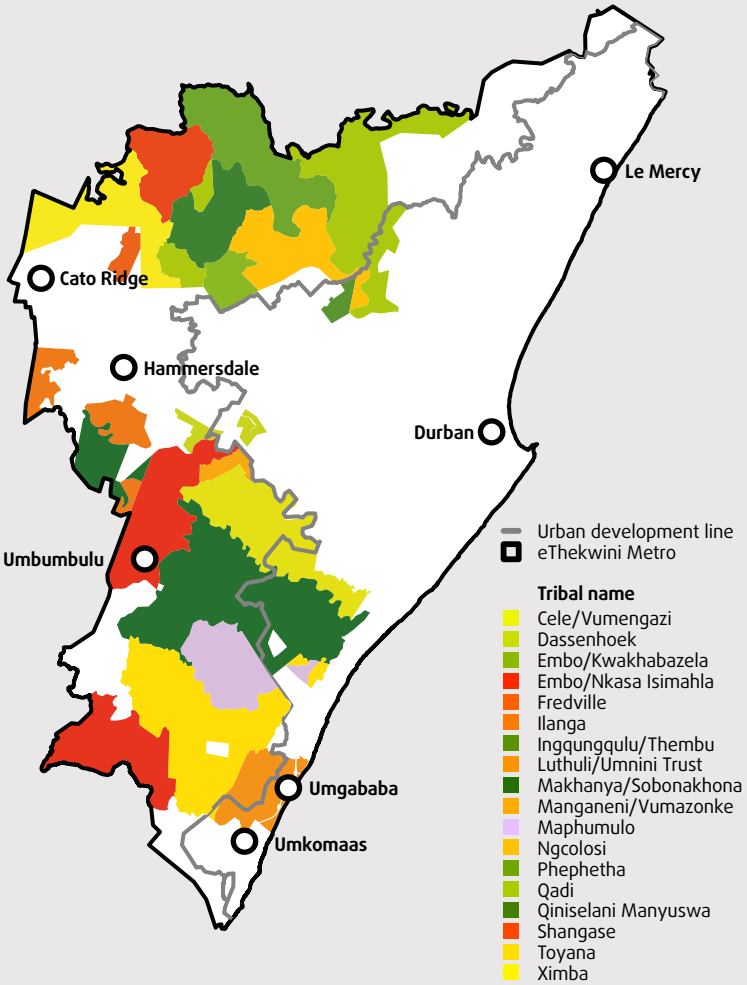
Box 3:

Challenges of managing environmental assets under overlapping jurisdictions

Durban, South Africa, faces challenges in environmental management due to two parallel structures that govern land within the eThekwini municipality's boundaries.

Approximately 36% of the municipality is controlled by the eThekwini Municipal Authority, while 37% falls within traditional authority areas administered by the Ingonyama Trust Board, which is under the national-level administration by the Minister for Rural Development and Land Reform. While the eThekwini government has developed an ecosystem management and protection program for green open spaces throughout the city, a large part of this land lies within traditional authority areas, limiting the eThekwini government's authority to administer green open spaces.

Dar es Salaam, Tanzania, has a complex and fragmented institutional structure comprised of three municipalities: Ilala, Kinondoni and Temeki, in addition to a central coordinating entity called the Dar es Salaam City Council. Each municipality is governed by its own mayor and municipal council and has its own individual departments, often lacking staff dedicated to environmental management. Both of the municipalities as well as ministries and agencies of the national government manage key environmental functions including water supply and sewerage, transport and traffic management and urban planning. This fragmented structure inhibits comprehensive and effective environmental management of the city's aquatic and terrestrial assets.



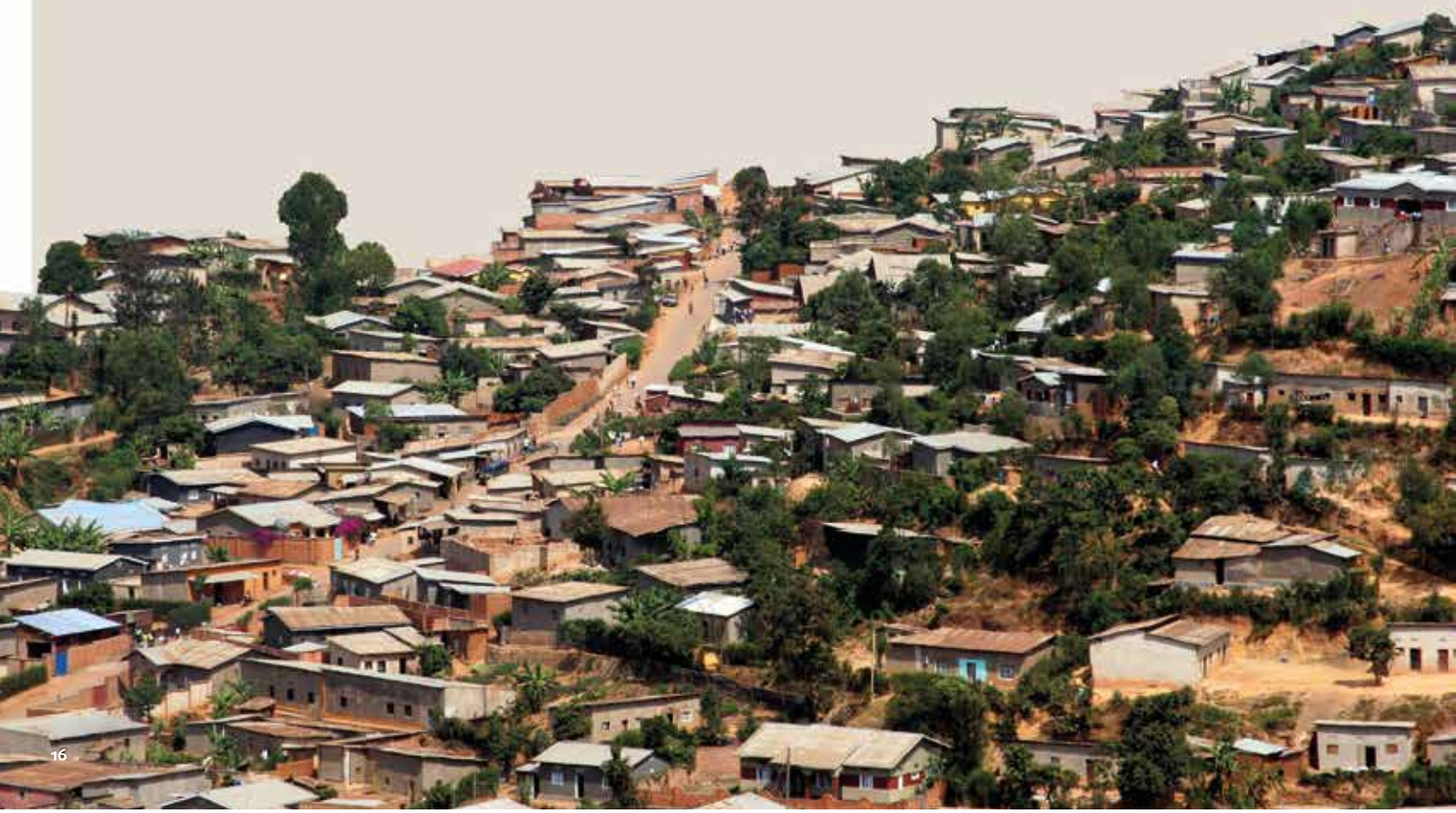
Traditional Authority Areas within eThekwini Municipality
(Source: Corporate GIS, eThekwini Municipality)

From an environmental perspective, these institutional realities have two key impacts. First, with very few exceptions, cities are unable to grow in a manner which conserves and enhances key environmental assets. While African cities are not necessarily more fragmented than cities in other regions, their development takes place in an ad hoc, unplanned manner with little regard for the importance of environmental assets and ecosystems and the benefits that derive therefrom. Second, urban management institutions in Africa are largely unable to take effective environmentally directed actions. With the possible exception of some South African cities, the research undertaken for this report was unable to discover any effective or sustained programmes or actions currently being undertaken by African cities to protect or restore ecosystems. In short, African cities lack the institutional capacity and resources to initiate actions which could arrest the development of an increasingly negative feedback loop and begin shifting their development from path C and B towards path A.

D

ENVIRONMENTAL TRENDS IN AFRICAN CITIES

Although urban areas cover a relatively small proportion of the Earth's surface, their expansion drives global environmental change (Seto et al., 2012). Rapid urbanization, coupled with low levels of wealth and technology and weak institutions, have had a combined effect on the environment that has been particularly severe in Africa. Poor and ineffective planning has led to the transformation of valuable ecosystems and other open space areas in and around cities, while a growing backlog in infrastructure investment and service delivery has led to major problems of pollution, flooding and overconsumption of resources. All of these problems, along with a lack of protection from invasive alien species, have had major impacts on ecosystems and biodiversity. These problems, discussed in more detail below, will be exacerbated by the effects of global climate change while also contributing to the problem.



Urban encroachment on natural ecosystems

There is often very little green open space remaining within African cities, particularly the poorer cities. The amount of all public parks, recreation areas, greenways, water ways and other protected areas accessible to the public is estimated to be below 1 m^2 per inhabitant in some African cities, such as Luanda, Cairo and Alexandria (African Green City Index 2011). This is well below the 9 and 30 m^2 per capita recommended by the World Health Organization and United Nations, respectively.

In Dakar, Senegal, the amount of green open space within the city decreased by approximately 34% over a twenty year period between 1988 and 2008 (World Bank 2009). In Addis Ababa, Ethiopia, most of the urban trees have been cleared for housing purposes and it is estimated that vegetation coverage, including trees in private yards, cover 7,900 ha or just less than 15% of the total city land area (Dubbale et al., 2010). Rapid urbanization has also been identified as the major cause of the depletion of green space in the city of Kumasi in Ghana, once known as the "Garden City of West Africa" (Mensah 2014a, b). Many of the parks and garden spaces within the city that were once in a good condition have been degraded or encroached, and green open space now covers only 10% of the total land area (Mensah 2014a, b). In South Africa, the Durban Bay estuary has been reduced by about 57% and only 14% of the original tidal flats, 3% of the mangrove forest and 4% of the natural shoreline habitat remain (ERM & MER 2011). Other estuaries in Durban have lost more than 70% of their original fish habitat (Forbes & Demetriades 2010).

Access to public parks, recreation areas, greenways, water ways and other protected areas is below 1m^2 per capita in some African cities.

The transformation of open space areas within African cities has come about through both formal and informal development. Due to the strong demand for housing close to the city centre for access to employment and transport, suitable open space areas tend to be developed in these areas first, leaving only wetlands and river floodplains. As the alternatives for informal settlement become increasingly distant from the city centre, so the demand for these central floodplain areas increases, in spite of the high risks of flooding. Examples of this are seen in most African cities, including relatively high income cities such as Durban. This pattern can be expected to radiate outwards over time. Indeed, there are many African cities in which high risk areas are under informal settlement even at some distance from the city centre.

In Dar es Salaam, for example, thousands of informal dwellings are situated along river banks and floodplains of the Msimbazi River system, with densities increasing downstream towards the city centre (Figure 7, Turpie et al., 2016b). While there is provision for a 60 m protected River Reserve on either side of all rivers in the city (as outlined in the Environmental Management Act of 2004), this post-dates much of the settlement and has been difficult to enforce. As a result, there are frequent episodes of flooding and loss of human life.

Figure 7:

Msimbazi River flowing through dense residential area in Dar es Salaam showing informal structures erected in the floodplain
(Source: Google Earth)

Wetlands are also attractive for settlement as they provide opportunities for alternative income sources such as harvesting resources, farming and brick making (Vermeiren et al., 2012). In Kampala, where over 60% of the population live in informal settlements, encroachment into the city's wetlands has been extensive, and only about 8% of the remaining wetland area within the city boundaries is still highly functional (Figure 8, Isunju et al., 2013, KCCA 2014). The wetlands have been encroached by transport infrastructure, industry and informal settlements as well as being drained for small-scale agriculture. Despite legislation preventing development of these areas, this has been facilitated by the unscrupulous creation of title deeds as well as lack of enforcement. The functional area of Nakivubo Wetland, centrally located between the city centre and Lake Victoria, shrunk from its original extent of 500 ha to 400 ha by 1955, 280 ha by 1990 and 90 ha in 2015; an 82% reduction in wetland area (Turpie et al., 2016a). Each year the numbers of rural poor living in slums within or adjacent to wetland areas increases, resulting in the subsequent degradation or loss of wetland habitat surrounding the city along the northern shores of Lake Victoria. This has had major impacts on water quality, fisheries and human health as well as biodiversity (see Box 2).

Figure 8:

Informal households situated in four wetlands (Nakivubo, Kinawataka, Kansanga and Kyetinda/Ggaba) that drain into Murchison Bay of Lake Victoria

(Source: Isunju et al., 2016)

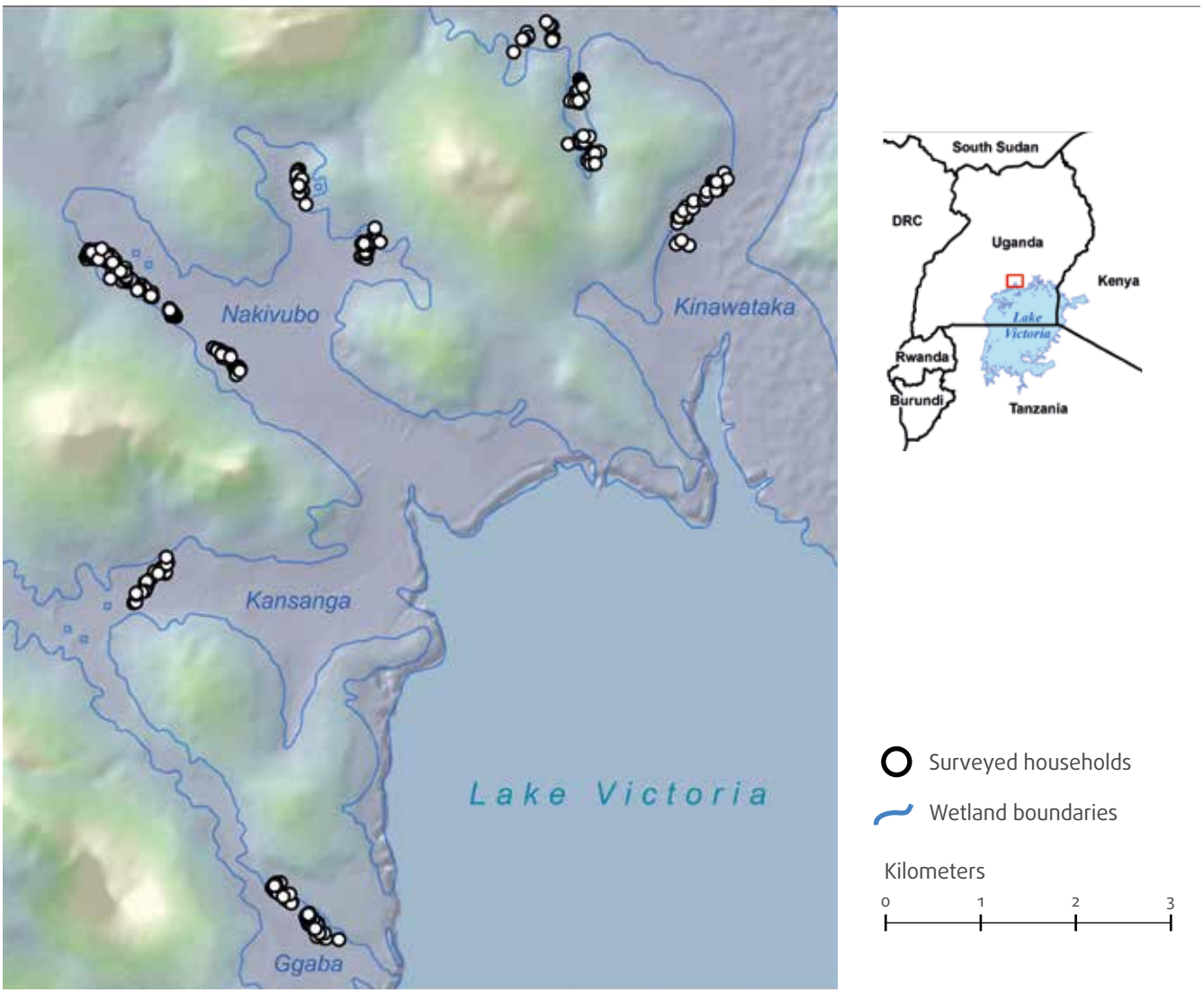
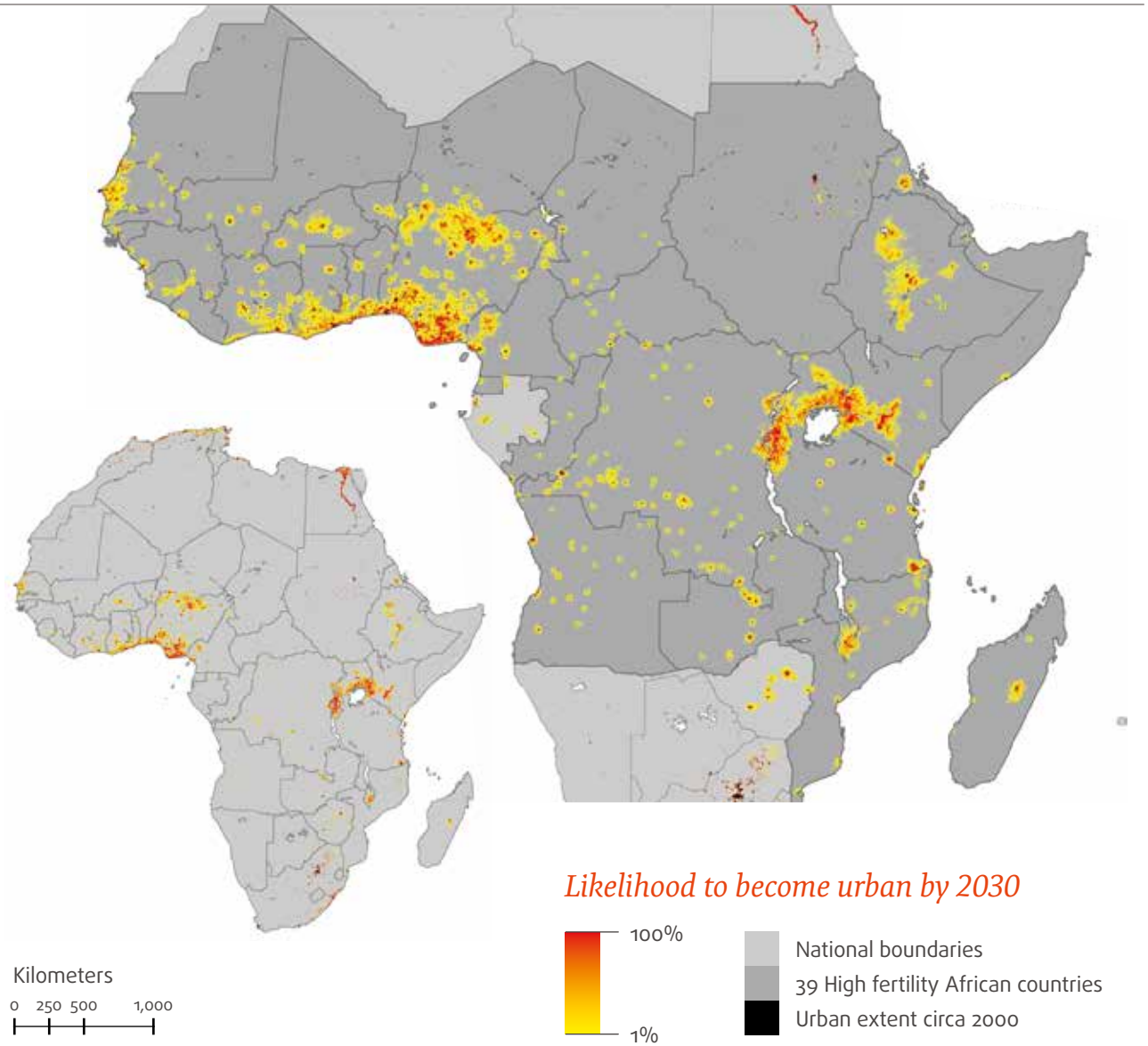


Figure 9:

Probability of urban expansion in 39 high fertility African countries, 2030

(Source: Seto et al., 2012)



As well as the transformation of habitats within cities, all cities expand over time and invariably adjacent lands become incorporated into the urban fabric. Seto et al., (2012) have predicted that by 2030 more than 5.87 million km² of land will be converted to urban areas globally. Based on present and projected regional urban populations, population densities and GDP values, they also predicted that the rate of increase in urban land cover will be highest in Africa, increasing to almost six times the 2,000 urban land cover levels (Figure 9). This growth is estimated to be concentrated in five main regions: the Nile River in Egypt; the coast of West Africa on the Gulf of Guinea; the northern shores of Lake Victoria in Kenya and Uganda and extending into Rwanda and Burundi; the Kano region in northern Nigeria; and greater Addis Ababa, Ethiopia (Seto et al., 2012, Figure 9). The results show that there is, in fact, a high probability that the northern shores of Lake Victoria, from Kampala, Uganda to Kisumu, Kenya, will become one contiguous built-up area (Seto et al., 2012).

Whereas neither the rate of growth nor the horizontal extent of this growth is unusual in African cities, it is the unplanned nature of this growth that is of particular concern. While well-planned growth might minimize the costs of expansion and capitalize on the potential services offered by maintaining selected natural systems, uncontrolled growth can incur disproportionately high costs through indiscriminate degradation and loss of natural systems. Uncontrolled expansion leaves peripheral city areas without the benefits of green open space areas. This is particularly pertinent in African cities, where the majority of urban poor live in informal settlements and may be more dependent on natural systems to meet their basic needs, particularly in peri-urban areas (Boon et al., 2016).

The city of Kampala is one of the fastest-growing African cities (Vermeiren et al., 2012). During the last two decades the city has expanded in all directions beyond the administrative city boundary, incorporating satellite towns and transforming surrounding agricultural and natural land. Between 1989 and 2010 the total urban area increased exponentially from 71 km^2 to 386 km^2 (Vermeiren et al., 2012). This is expected to increase to 653 km^2 in 2020 and up to almost 1,000 km^2 by 2030 (Figure 18, Vermeiren et al., 2012), and if uncontrolled could result in significant losses in surrounding forest and wetland habitats and associated ecosystem goods and services.

Most of the population growth in Dar es Salaam over the last few decades has been in informally-developed settlements, with new settlements swelling at the urban periphery. Between 1982 and 2002, more than 15,500 ha of open space or agricultural land was transformed into urban land uses with more than 75% of these new developments being classified as informal. While much of the influx of people is to informal settlements near the city centre, population growth is also rapid at the periphery, with peripheral municipal wards accounting for 42% of the total population increase between 2002 and 2012 (World Bank 2015a). While continued influx into the city centre leads to increasing densities, the densities tend to decrease outwards from the city centre (Congedo & Munafo 2013), with the peripheral areas grading into rural

Figure 10:

Growth of Lagos city over the last 50 years. Green open space areas in the city cover less than 3% of the total land area
(Source: Sawyer 2013)

agricultural homesteads. Pressure on the remaining natural resources in these areas is intense, and these peri-urban inhabitants mostly exist in highly degraded landscapes.

In 2008/09, 49% of the eThekwini (Durban) municipal area was classified as "transformed" (i.e. converted for development), and by 2014/15, this had risen to 53% (EPCPD 2015). The municipality encompasses a significant amount of rural and peri-urban land as well as the city of Durban. Much of this area falls under traditional authorities which lack formal planning schemes to regulate land use activities (see Box 3). Land here falls under traditional tenure and allocation systems and the relative ease of acquisition by in-migrants appears to have had a spatially distortionary impact on the development of the city. Despite their relatively remote location, these areas have seen significant increases in population, resulting in loss of important biodiversity areas (Boon et al., 2016).

Rapid urbanization has caused substantial loss of habitat in a number of West African cities (e.g. Lagos, Ibadan, Kano, Kaduna, Sokoto, Dakar, Freetown, Abidjan, Accra, Kumasi and Tema) (see Figure 10), with open space and peri-urban forests being transformed for housing or converted into dumping sites (Fuwape & Onyekwelu 2010, Mensah 2014).

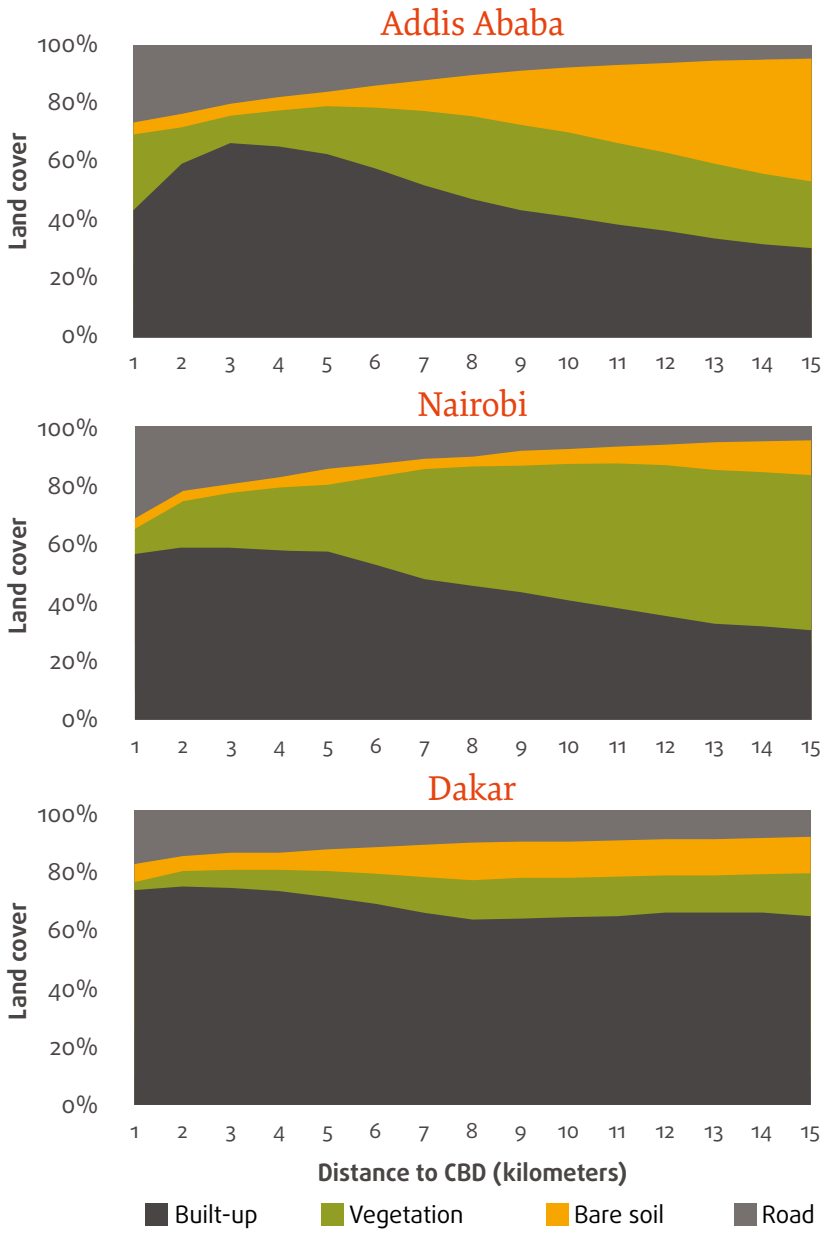
Examination of land use patterns in three African cities illustrates both the challenges and the opportunities surrounding the relationship between the natural and built environments within these settlements. In Addis Ababa, Ethiopia (urbanization level around 18%), significant areas of well-located open space remain close to the city centre, but these have largely been denuded of vegetation and the quality of terrestrial assets has declined (Figure 11). In other words, the structure of the city still permits for the development of a more harmonious relationship between natural and built environments, but much more active steps will need to be taken to manage the remaining natural assets well if they are to contribute effectively to the health of the city.

In Nairobi, Kenya (urbanization level approximately 25%), key vegetated and relatively high-quality natural assets (such as the Nairobi National Park, located about 7 km from the Central Business District (CBD) remain close to the city centre (Figure 11). Increasingly, however, these are under threat and a combination of proactive planning measures to secure a potentially green city structure and assertive management steps to preserve and enhance the quality of natural assets within this structure will need to be taken to avoid the fate of Dakar, Senegal (urbanization level 45%), where the pattern of growth of the city has effectively eradicated almost all natural assets up to a distance of 15 km from the CBD.

Figure 11:

Urban land cover in Addis Ababa, Nairobi and Dakar ca. 2010 (work done for study based on satellite image analysis)

(World Bank 2015c)



Supply and consumption of natural resources
When people move to cities, their resource demands may change to some extent. For some, the direct dependence on natural resources may decrease as a result of increased income opportunities. Many, however, remain reliant on agriculture and natural resources, leading to the conversion of open space areas described above, as well as the depletion of local forestry and fishery resources. In general, however, the growth of city populations and incomes leads to increased rates of consumption which increase the footprint of cities, or the amount of resources that have to be provided from other areas. The combined effect of a growing urban population and a higher per capita demand for resources, has resulted in a significant increase in the amount of pressure being placed on ecological resources both in and around cities (Giljum et al., 2009, WWF 2016). These include fuelwood, charcoal and water, the excessive use of which is harmful to surrounding environments from which they are sourced, as well as leading to localised problems of environmental degradation.

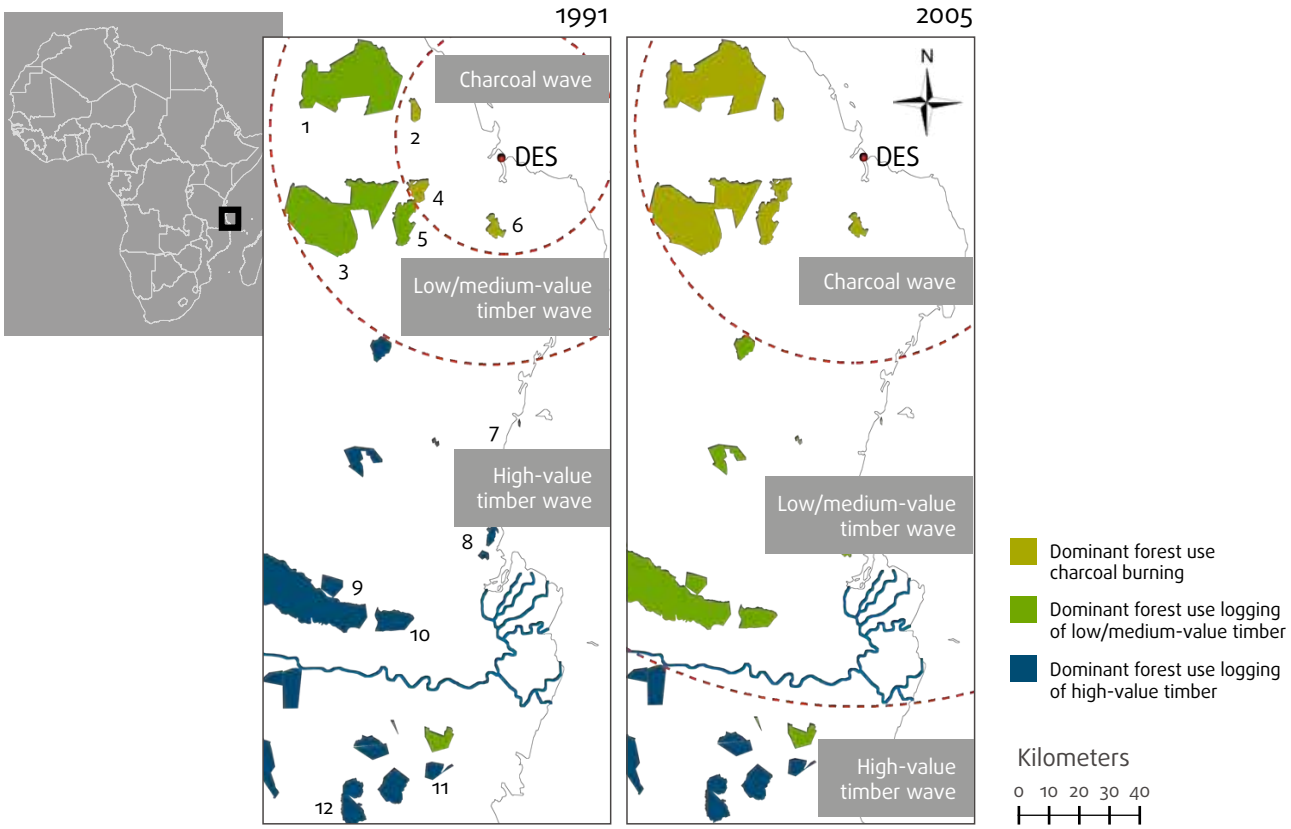
In African cities, constrained access to, and relatively high costs of electricity and Liquid Petroleum Gas (LPG) has resulted in urban consumers relying on biomass fuel, which degrades forests, produces high particulate matter concentrations and high carbon emissions. In Sub-Saharan Africa, 73% of the urban population uses biomass fuels (wood, charcoal, manure, crop residues) as the main source of energy for cooking and heating (Ezzati 2010), with charcoal being the most common choice in most cities (Zulu & Richardson 2013, Sedano et al., 2016). Charcoal production for urban energy consumption is a main driver of forest degradation in Sub-Saharan Africa (Sedano et al., 2016).

For example, there have been three distinct waves of forest degradation emanating from Dar es Salaam (Ahrends et al., 2010, Figure 12), for high-value timber, medium-value timber and then charcoal. Between 1991 and 2005 the zone of impact of these activities extended significantly (Figure 12). In 2005 charcoal production had become the dominant use up to 50 km from the city and extended as far as 170 km from Dar es Salaam, with the outer boundary of the area where charcoal production was the dominant use having moved 30 km (i.e. 2 km per year). The forest reserves close to Dar es Salaam have also been impacted, with a loss of more than 30% of forest cover (World Bank 2015a).

Figure 12:

Map of the degradation waves of dominant forest use in the study area in 1991 and 2005

(Source: Ahrends et al., 2010)



1 Ruvu North FR; 2 Pande GR; 3 Ruvu South FR; 4 Pugu FR; 5 Kazimzumbwi FR; 6 Vikindu FR; 7 Kisiju; 8 Mchungu FR; 9 Ngulakula FR; 10 Ngumburuni FR; 11 Namakutwa; 12 Kiwengoma

In Durban, the influx of poor households into its peripheral traditional authority areas has increased the demand for natural resources in these areas. With increased development, unauthorized activities such as sand mining have become more prominent causing habitat degradation, infilling, bank erosion and the subsequent loss of sand to the coastal environment. The eThekwini Municipality systematic conservation assessment has shown that by 2012, about half of the natural vegetation in the eThekwini Municipality (Durban) was degraded (Mclean et al., 2016). A significant proportion of the remaining open space area in Durban is located on tribal land, requiring proactive management and coordination between local government and tribal authorities to prevent further environmental degradation.

Much of the urbanization in Africa has occurred in coastal areas (Small & Nicholls 2003, Seto et al., 2011, Neumann et al., 2015). Given the dependence on natural resources as a low-input option for many poor households, this has led to concentrated pressures on coastal mangrove and fishery resources. Due to poor management and lack of enforcement, this has had heavy effects on resource stocks. Without action, these pressures will only get worse, as the highest rates of population growth and urbanization are also expected to be in the coastal zone, particularly in Egypt, and in Sub-Saharan countries in western and eastern Africa (Seto et al., 2011, Neumann et al., 2015).

Urbanization also leads to increasing per capita demands for water, and provision of adequate, safe water supplies is a major concern in most cities. This is creating challenges in many cities since much of the continent is arid or semi-arid, and 41% of African countries are water-stressed (WWF 2016). Many African cities have relied on large-scale inter-basin water transfers to meet demand thus far. Water supply problems are exacerbated by the increasing anthropogenic inputs of nutrients and eroded sediments from catchment areas that increase the cost of water treatment, coupled with the loss of loss of natural capital assets such as riparian forests and wetlands that play a role in the amelioration of these effects. In coastal cities, excessive pumping of aquifers has resulted in the contamination of groundwater resources. In Dar es Salaam, water samples from Mikocheni, Oyster Bay, Msasani, Masaki, and the central areas of the city show elevated chloride, sulphate and sodium concentrations, and over 50% of the samples were brackish (Mitoni 2010). These problems will be further exacerbated by climate change.

Pollution

Most African cities are characterized by high levels of pollution. Air pollution is linked to the large proportion of households that rely on wood fuels for energy, as well as industrial emissions, fertilizer use in urban and peri-urban agriculture, transportation and congestion. Water pollution is linked to inadequate sanitation as well as industrial effluents and agro-chemicals. Solid waste problems are linked to low investments in waste collection services. Most of these problems are exacerbated by a lack of enforcement of existing regulations.

Because of the rapid growth of informal settlements, fiscal constraints, and weak institutions, Africa has made limited progress in providing residents with access to basic sanitation (see section C). For example, in Kampala it is estimated that only 5% of the population is connected to the sewer network, with 95% of the population having access to basic on-site, mostly shared, sanitation (NWSC 2014). This has resulted in significant degradation of surrounding wetland areas. The volumes of flows entering wetland channels have increased significantly with increased contaminated runoff from informal areas and the generation of large volumes of partially-treated wastewater from the overburdened sewage works. Current levels of pollution in the Nakivubo Wetland are hazardous to human health, with high levels of human excreta, patristic nematodes and faecal bacteria being recorded (Turpie et al., 2016a). This has significant negative impacts on wetland and lake ecological function and impacts on the cost of water supply to the city from Lake Victoria's Inner Murchison Bay (see Box 2). In Kinshasa, Democratic Republic of the Congo, the expansion of informal settlements has also been found to contribute to the costs of water supply (UNEP 2011).

While it has many benefits, urban agriculture also contributes to pollution. Fertilizer use in crop fields can be a major contributor to ammonia emissions which react with other chemicals in the atmosphere, increasing PM2.5 levels (World Bank 2016). Moreover, as illustrated by the Nakivubo example (see Box 2), conversion of green assets delivering public benefits - such as wetlands which filter water runoff or mangroves which protect against flood-surge – to agricultural uses in which benefits accrue to private interests can accumulate significant problems for cities.

The combination of sewage and poorly managed industrial effluents and agricultural return-flows has led to critical levels of pollution in many urban river systems, to the point of being hazardous to human health. For example, the Little and Great Akaki rivers in Addis Ababa, Ethiopia suffer from multiple pollution stresses and their water is badly polluted with trace metals and high concentrations of E. coli bacteria (Gebre & Van Rooijen 2009). Similar conditions occur in the Msimbazi River and its tributaries, which course through highly urbanized areas of Dar es Salaam. Coliform bacteria counts at the mouth of the river in the Indian Ocean are approximately 1000 times greater than the levels considered safe for swimming (UNEP-NEMC 2014). The Msimbazi also has high concentrations of heavy metals, such as lead, that exceed WHO drinking water standards (Mwegoha & Kihampa 2010). In Dakar, Senegal, biological contamination of groundwater is a major concern, as 87% of sites within one area of the city were found to contain water that is below WHO standards for human use (Niang et al., 2007 as cited in UNEP 2014). In Lagos, Nigeria, the Lagos Lagoon is heavily impacted by solid waste, sewage and industrial effluents that flow untreated into the lagoon (Amaeze et al., 2012). The fish fauna has changed in favour of species that are tolerant of polluted and low oxygen waters, such as tilapia and catfish, and the reduction in fish diversity and numbers has been

widely observed by local Lagos fishing communities (Amaeze et al., 2012). In Durban, South Africa, seven of the sixteen estuaries within the municipality are highly degraded, with overall estuarine functionality reduced to 35% of the natural condition (Turpie et al., 2017a). Contaminated runoff from informal settlements, poorly treated sewage effluent and dams that restrict freshwater flows are some of the drivers of Durban's declining estuarine health.

In 2013 air pollution was ranked as the fourth leading fatal health risk, with an estimated 5.5 million premature deaths attributable to air pollution worldwide (World Bank 2016). Air quality in most African countries has deteriorated, with few cities having formal air pollution regulations or adequate capacity to monitor and enforce emissions. Increasing industrialisation, growing ownership of private motor vehicles, burning of household waste, and the continued use of charcoal and wood as a primary household energy sources has raised air pollution levels significantly across the continent, with the latter being the main feature of air pollution in African cities. According to the latest urban air quality database released by the World Health Organization, 98% of the cities in low- and middle-income countries with more than 100,000 inhabitants do not meet WHO air quality guidelines (see Figure 4 and Figure 13).

The situation is particularly bad in Nigeria where four of the worst cities in the world for air pollution are located (Figure 13). According to WHO, Onitsha in Nigeria is the world's most polluted city when measuring small particulate matter (PM10) concentrations, with concentrations being 30 times higher than the WHO recommended levels (WHO 2016). The poorest segments of society are affected disproportionately by air pollution impacts, with the poor more likely to work and live in polluted environments (World Bank 2016). The disproportionate health burden felt by the poor is due to higher exposure to air pollution, low resistance to illness, and a lack of basic services such as sanitation (World Bank 2016).

Given the high percentages of urban populations that are reliant on charcoal for cooking and heating (e.g. 75% in Kampala), the high air pollution levels in African cities are probably driven more by household burning of biofuels than by industry and motor vehicles. This is the main cause of respiratory illness in women and children in informal settlements in Sub-Saharan Africa (UN-HABITAT 2008). In Africa as a whole, the death toll from indoor air pollution has grown concurrently with the growth in the size of the urban population (Roy 2016). Among the risk factors to human health in Africa, air pollution (household and ambient) is the only factor whose contribution to premature deaths has continued to increase over the past two decades (Table 2).

Figure 13:

Annual mean concentration of particulate matter in 13 African cities

(Source: WHO 2016)

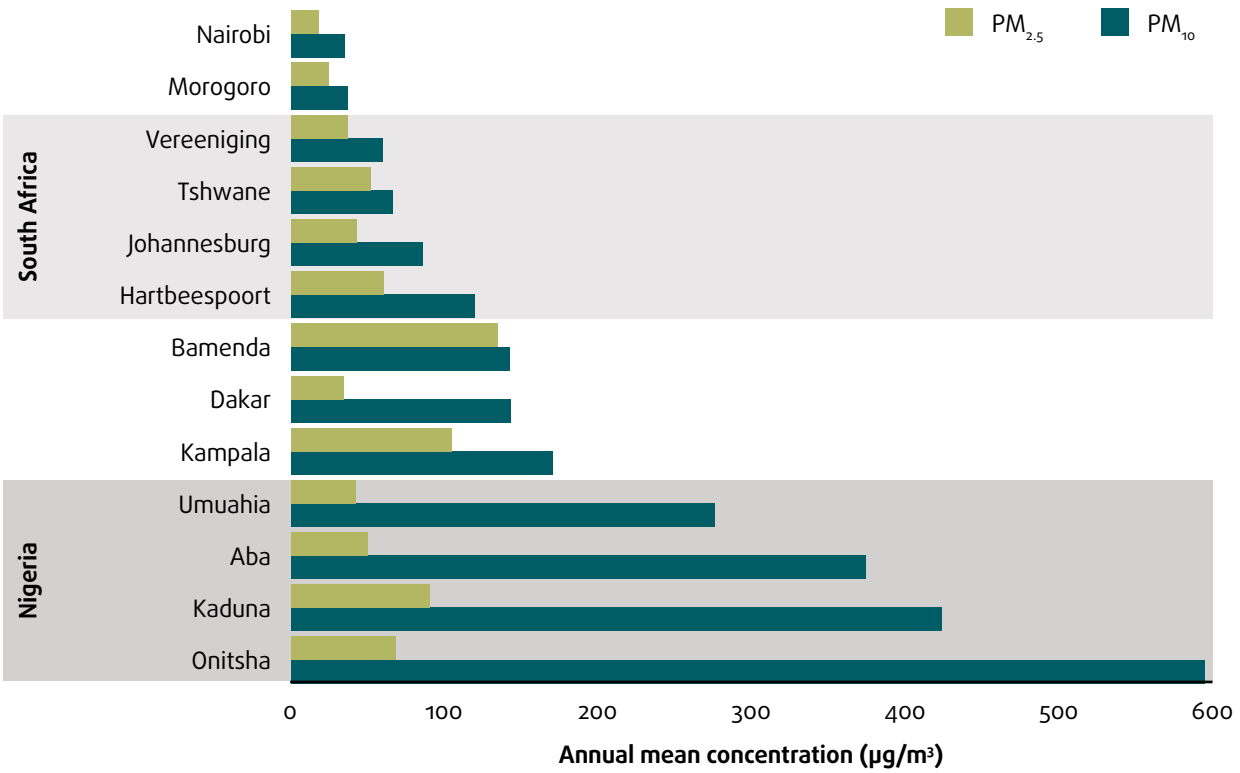


Table 2:
Premature deaths from selected major risk factors in Africa
(Source: Roy 2016)

Risk Factors	1990	1995	2000	2005	2010	2013
Unsafe water	837,702	780,095	751,892	644,136	561,342	542,855
Unsafe sanitation	615,540	573,084	551,948	468,815	407,092	391,656
Childhood underweight	474,819	467,921	420,606	309,945	273,294	275,813
Household air pollution	396,094	422,895	436,463	429,199	450,969	466,079
Ambient PM pollution	181,291	190,933	200,854	213,429	227,428	246,403

Traffic congestion also plays an important role. The number of vehicles in Dar es Salaam increased from 24,600 in 1979 to 705,000 in 2011 and it is projected that there will be about one million vehicles by 2030 (World Bank 2015a). The numbers of motorcycles and tricycles have also increased, contributing to significant increases in emissions.

Solid waste problems arise from a lack of policy and service provision. Waste policies, such as overall waste management strategies and environmental standards for waste landfills, are seriously lacking in most African cities (African Green City Index 2011). From a group of 28 cities of over 300,000 people for which there is solid waste management information, none had guidelines for the management of sanitary landfills, and only Ouagadougou, in Burkino Faso, has regulations that mandate the segregation of waste. Solid waste collection is also low in Sub-Saharan cities (Table 1), particularly in informal settlements where garbage piles up along walkways and roads, and in gutters, drains and waterways. In Dar es Salaam 18% (767 tons per day) of uncollected waste is controlled on-site by burning. Much of the rest ends up in stormwater drains, contributing to runoff pollution into rivers and coastal waters and exacerbating annual flooding events and health problems (World Bank 2015a).

Hydrological changes
Buildings, roads, roofs, paved areas, and other hard surfaces in the built environment prevent rainfall from infiltrating into the soil, increasing the rate and volume of run-off during any given rainfall event. This has two main impacts. First, existing river channels become eroded downwards or laterally, which impacts habitat integrity and creates problems for property owners and city managers. Second, flood inundation areas increase, putting more people at risk.

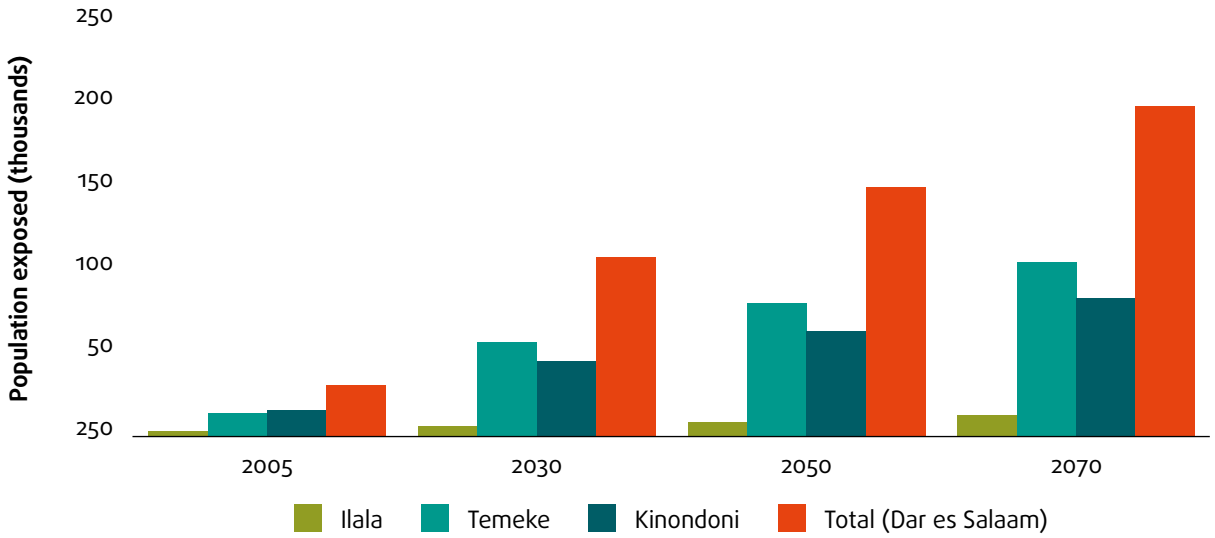
These effects are magnified as cities expand and densify. In Kampala, the construction of unregulated structures in informal settlements has reduced infiltration of rainfall significantly, increasing runoff to six times more than what would occur on natural terrain (ActionAid 2006). While some of the increase is likely due to climate change, this is largely the direct result of land cover change. As a result even moderate storms produce high flows, with floods increasing in size and frequency and exposing inhabitants to increasing flood hazards (ActionAid 2006, Satterthwaite 2008). This is made all the more problematic by the increasing numbers of people exposed to flood risk as a result of development of informal settlements in floodplain areas. In Dar es Salaam, flooding is a major problem which frequently brings the city to a standstill. This is caused by increased development in the catchment leading to higher runoff, inadequate drainage, and a lack of solid waste management which leads to blocked waterways. Frequent floods not only result in damages to property and direct loss of life, but also disrupt traffic and expose people to health risks as a result of exposure to sewage, industrial wastes and waterborne disease (World Bank 2015a). These risks will increase over time as a result of further urbanization (Figure 14), and will also be exacerbated by climate change.

> "Buildings, roads, roofs, paved areas, and other hard surfaces in the built environment prevent rainfall from infiltrating into the soil, increasing the rate and volume of run-off during any given rainfall event.

Figure 14:

Exposed population in Dar es Salaam to a 1 in 100 year flood event, 2005-2070

(Source: Watkiss et al., 2011)



In addition, the importation of water from surrounding catchments to meet urban water demands adds to the problem of increased flows within cities. Much of this water is channelled through sewage works, which pump a continual stream of treated effluent into rivers. In Cape Town, South Africa, the additional water brought into the city has led to the transformation of naturally ephemeral wetlands and rivers into permanent reed-choked systems, as well as the radical modification of most of its estuaries (Brown & Magoba, 2009).

Introduction and proliferation of invasive species

Invasive alien species are animals, pathogens and plants that are intentionally or unintentionally introduced from other areas, and which are able to spread and multiply in the absence of their natural predators or other limiting factors, causing damage to the environment, economy and human health. They pose a serious threat to biodiversity and are a growing driver of species extinction (EPCPD 2015). In particular, they cause the declines or elimination of indigenous species through competition, predation, transmission of pathogens, and the disruption of ecosystem functioning.

Global trade and travel have reduced geographical barriers, facilitating ease of movement of species around the world. Urban areas, and in particular port cities, are extremely vulnerable to the introduction of alien invasive species (van Ham et al., 2013, Zari 2014). In addition, the planting of exotic plants in urban parks and private gardens contributes to the release and spread of alien invasive species into the already fragmented urban ecosystems (Zari 2014). These species have a range of impacts, including loss of biodiversity and disruption of ecosystem functioning, interfering with water supply and increasing the risk of fire and floods.

Durban, located within a global biodiversity hotspot, has been invaded by at least 130 alien plant species. For example, Spanish Reed (*Arundo donax*) introduced from the Mediterranean has had a major impact on rivers and streams. These reeds are easily dislodged during floods and as a result cause severe blockages of waterways and culverts, increasing flood damage. In Harare, Zimbabwe, the reservoir that supplies 77% of the city's potable water is clogged with the invasive water hyacinth (*Eichhornia crassipes*) and spaghetti weed (*Hydrocotyle ranunculoide*), increasing evapotranspiration and threatening water supply (Nhapi 2007). In Cape Town, situated within the Cape Floristic Region, invasive Australian acacias not only threaten the unique floral diversity, they also impact on water supply and dramatically increase the severity of fires in the city (Richardson & van Wilgen 2004).

Biodiversity loss

Biodiversity, a precondition for life on Earth, plays a major role in maintaining ecosystem integrity and resilience. Biodiversity includes ecosystem, genetic and cultural diversity, and the connections between these and all species, including humans (EPCPD 2015). Global biodiversity losses have reached unprecedented levels. Monitored species population abundance declined by 58% between 1970 and 2012 (WWF 2016). The continued degradation of ecosystems

and loss of biodiversity can have significant impacts on human well-being and economic productivity (TEEB 2010). When ecosystems are degraded and biodiversity is lost, the biocapacity of the planet to support species populations and to regenerate natural resources is considerably reduced, leading to the loss of vital ecosystem services (Zari 2014, WWF 2016).

Human activities are accelerating ecosystem degradation and biodiversity loss at unprecedented rates as a result of habitat transformation, overexploitation of resources, hydrological alteration, introductions of invasive alien species and pollution. These pressures are particularly severe in African urban environments, as discussed above, and will be further exacerbated by climate change. Biodiversity is also affected by the approach taken to greening cities. In Addis Ababa, Ethiopia, only 10 – 40% of trees planted have been indigenous tree species (Shikur 2011), compared to Durban where 97% were indigenous, 2.7% were fruit trees and only 0.3% were exotic (EPCPD 2015).

Cities can harbor a surprising amount of biodiversity. With the transformation of both rural and urban environments, cities can even provide important refugia for some species. Many cities are situated within global biodiversity hotspots, including Durban, Cape Town, and several cities along the Indian Ocean and West African coasts (Figure 15). In these cities urbanization's effect on biodiversity has global consequences. Irrespective of its global significance, the loss of biodiversity within cities also has particular relevance for its inhabitants, since urban biodiversity has considerable amenity and tourism value (Turpie et al., 2017a).

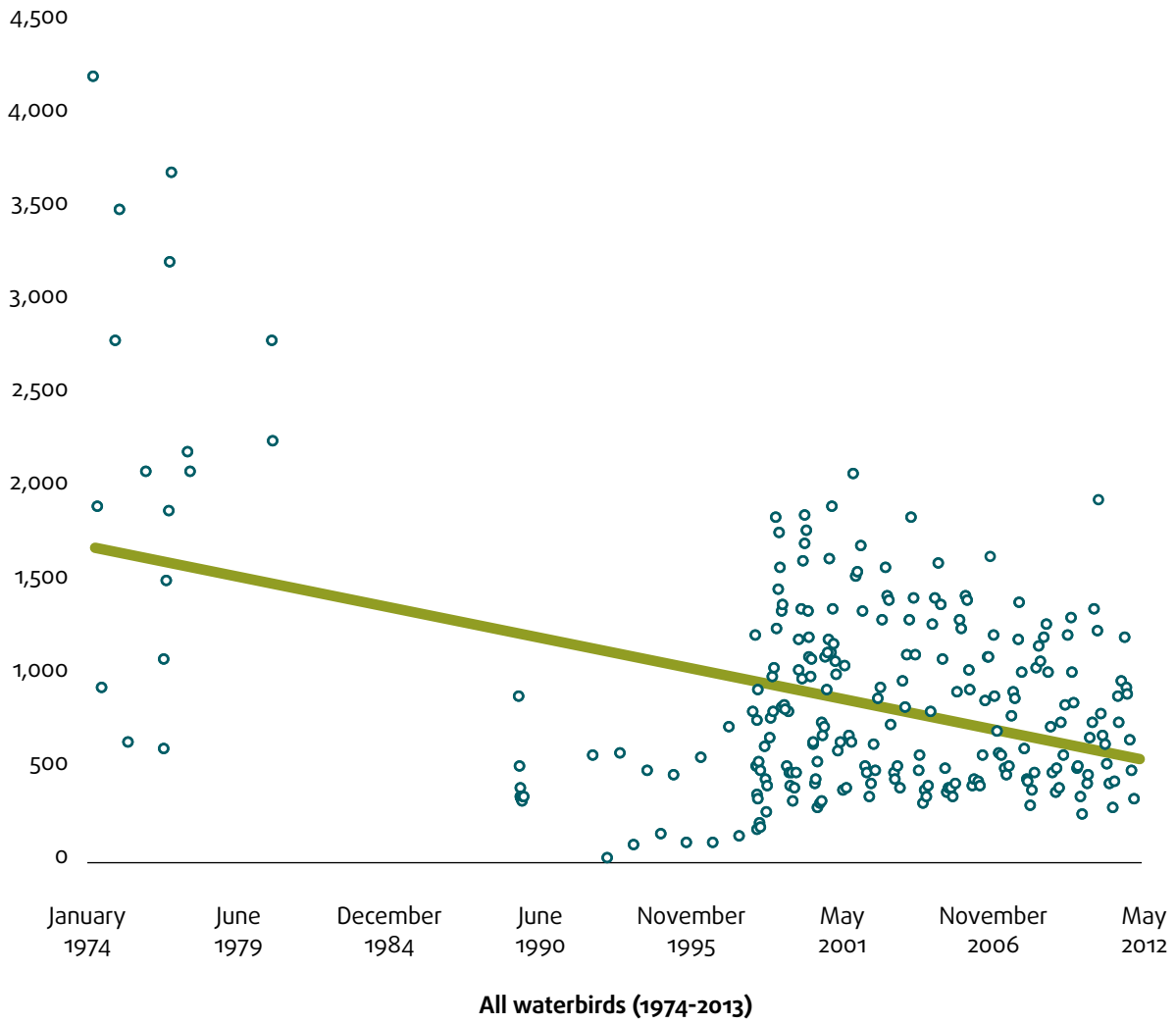
Figure 15:
Global biodiversity hotspots
(Source: SCBD 2012)

In Durban, only about 10% of the open space area is under formal protection, and much of the remaining biodiversity is in private hands or in communal lands on the city's periphery. With more than 2% loss per year, Durban's terrestrial vegetation faces significant extinction threat. Loss of biodiversity is also evident in Durban's estuaries, due to loss of habitat and changes in hydrodynamics and water quality. These impacts, along with international declines in migratory bird numbers, have contributed to the dramatic decline in numbers of waterbirds in Durban Bay harbor (Figure 16). Similarly, in Cape Town, also located within a global biodiversity hotspot, 13 plant species have become extinct and 319 species are threatened by extinction as a result of urbanization; this represents 18% of the threatened Red List species in South Africa (Rebelo et al., 2011). The losses in other African cities may be comparable but have not been quantified.

Figure 16:

Total numbers of waterbirds counted in Durban Harbor during counts from 1974 to 2012.

(Source: Allan 2012)



Increasing vulnerability to climate change

Global climate change is manifest in increasing temperatures, changes in rainfall pattern, rising sea levels, and increased incidence of storms. These changes, which are already observed, are expected to lead to changes in biodiversity and ecosystem functioning, changes in water availability, increased severity of droughts and floods, increases in heat-related illness, and impacts on agriculture and energy production (IPCC 2007). This will affect economies and human well-being on a global scale, but more so in developing countries that are more reliant on land and natural resources (Tol 2012).

Cities are particularly vulnerable to many of these effects because of the large number of people, buildings and infrastructure potentially exposed to natural disasters such as floods and more intense coastal storms in combination with higher sea levels, the potential exacerbation of existing heat-island effects, and the fact that their biodiversity is fragmented, leaving little room for natural adaptation. Supplying urban water demands will also become increasingly difficult under climate change.

The degradation of environmental assets, such as forests, rivers, coastal habitats, and wetlands, reduces a city's resilience to climate change, undermining the well-being of residents and future economic prospects. Climate change exacerbates resource scarcity and places vulnerable communities at risk from sea level rise and more frequent and intense storms, under which the likelihood of extreme flooding events is expected to increase. Developing countries already tend to be less resilient to natural disasters because of fragile economies, poverty, lack of risk awareness, and a lack of coping capacity in urban communities (De Risi et al., 2013, Jalayer et al., 2015). Loss of forest areas and wetlands in urban catchments increase the risk of flooding. In Dar es Salaam, Tanzania, and Doula, Cameroon, the degradation and loss of mangrove forests has increased the vulnerability of coastal areas to damages from coastal storm surges (Ellison & Zouh 2012).

In a sample of 30 African countries, it was found that two-thirds are warming faster than the world as a whole (AGI 2017). This trend is expected to continue, placing challenges on both current and future development progress in African cities, especially given that Africa contains seven of the ten countries that are considered the most threatened by climate change globally: Sierra Leone, South Sudan, Nigeria, Chad, Ethiopia, the Central African Republic, and Eritrea (AGI 2017). The cities most at risk are those where extreme events are already common and have already caused serious damage and disruption (Satterthwaite 2008), and where levels of environmental degradation are high and institutions and policies are weak.

Superimposing the climate trajectory on Figure 2 begs the question as to whether the impacts of climate change will outstrip the ability of city or regional authorities in Africa to take action, keeping success (path A or A1) consistently out of reach. Increasing frequency of disaster events will potentially put even greater pressures on fiscal resources. It is not so much that climate change will increase environmental degradation (it will, to some extent, through direct pressures on ecosystems for example), but that ecosystems will become more critical to buffer the impacts of more extreme temperatures and storm events. This ramps up the urgency with which cities need to ensure the protection of these critical natural areas in catchments, along rivers and along the coast to protect from flooding, and maintaining tree canopies within city centres to protect from temperature rise (as well as pollution).

In a sample of 30 African countries, it was found that two-thirds are warming faster than the world as a whole (AGI 2017).

"

The degradation of environmental assets, such as forests, rivers, coastal habitats, and wetlands, reduces a city's resilience to climate change.

E

COSTS AND CONSEQUENCES

Economic consequences

Untangling the economic costs of environmental degradation in urban areas is complex, as they usually go hand in hand with poorly-maintained buildings and infrastructure, poorly-organized street-trading and transport activities and high levels of crime. Neglect of city environments also means that they lack the enhancements one sees in developed cities, such as roadside verges, trees and gardens. While the environmental quality of cities may be treated as a low priority by financially-strapped local governments, it has an important bearing on urban, and hence national, economies. Greener and cleaner cities are likely to have healthier and more productive citizens, as well as being more attractive to property developers and buyers, international business and tourism.

Deterioration of environmental quality arising from urbanization is adversely affecting health, income, productivity, and the quality of life in African economies and cities. Global welfare losses resulting from exposure to household and ambient air pollution were estimated amount to some US$5.11 trillion in 2013, with welfare losses in Sub-Saharan Africa equivalent to 3.8% (2.41%-5.54%) of the regional gross domestic product (GDP; Figure 17; World Bank 2016). Urban residents, in particular poor households, are exposed on a regular basis to elevated concentrations of fine particle air pollution, with potentially serious long-term implications for health and well-being. The total foregone labor output totalled more than US$16 billion in 2013 in Sub-Saharan Africa, or 0.8% of GDP (World Bank 2016). The overall economic loss resulting from lack of access to safe water and basic sanitation is estimated at US$28.4 billion a year, or around 5% of GDP in Sub-Saharan Africa (UN 2009). The healthcare cost and loss in labor productivity from mortality and morbidity due to contaminated water is estimated to cost the Ugandan economy between US$22-35 million every year.

Property values are affected by environmental degradation. Research undertaken in the relatively developed city of Durban, which has a well-developed network of green open space, shows that the premiums paid for proximity to good quality natural and man-made open space areas are significant (see Box 4). These premiums don't exist where open space areas are lacking and house prices are discounted when surrounding natural environments are degraded. Turnover in property markets is thus significantly affected by environmental quality, and this in turn, has implications for the property and financial sectors.

Urban tourism opportunities are being squandered. Although Africa is known for its nature-based and largely rural cultural tourism opportunities, a high proportion of tourism activity, which includes business tourism, is in cities. In South Africa, where cities have a relatively high level of well-kept natural open space areas, even a large proportion of leisure tourism is associated with urban areas (Turpie et al., in review). In Cape Town, total tourism expenditure including business tourism and visiting friends and relatives (VFR) is about US$720 million, and based on visitor data collected locally and photographic data, nature-based attractions account for an estimated US$127 million of this (Turpie unpublished data). In Durban, where total tourism expenditure is about US$520 million, non-agricultural urban open space areas in

Box 4:

Impacts of green open space areas on property prices

(Source: Turpie et al., 2017a)

Durban, South Africa, is a garden city located in a lush subtropical coastal environment. It is well endowed with both natural and man-made green open space areas that make up the Durban Metropolitan Open Space System (D'MOSS).

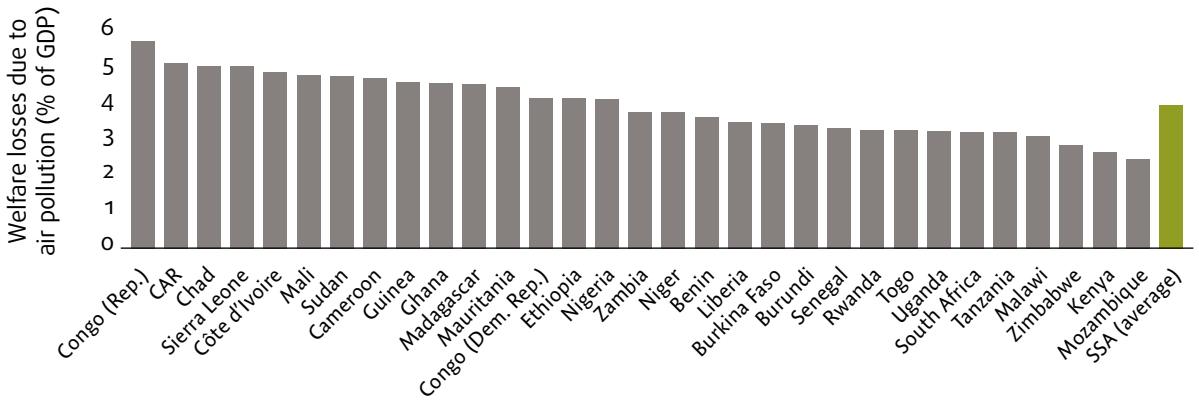
A statistical analysis of house sales data showed that prices paid for properties in Durban are strongly linked to environmental factors. Natural open space areas in a good condition attracted significant and positive price premiums while those in a degraded condition led to discounted prices. Degraded open space patches are not only unattractive but are also often associated with crime. Man-made green open space, such as golf courses and park areas both had a significant positive effect on house prices.

The total premium associated with natural open space in a good condition was 2% of overall property value, which amount to **US$339 million** with an average value of US$8,377 per ha of natural space. This is only part of the asset value of these areas, which also provide other ecosystem services. The highest values are within the main urban core (US$108,000 per ha) and along the coastline where high quality natural coastal forests are still intact (e.g. Umhlanga – US$262,000 per ha). The values are also higher in and around the suburbs of Hillcrest and Kloof (about US$77,000 per ha), both being affluent areas, much like the coastal suburbs of Umhlanga and the city centre, whereas they are lower in the lower-income inland suburbs such as Cato Ridge (US$2,900 per ha) and Pinetown (US$32,600 per ha).

The total premium associated with public parks was approximately 6.4% of overall property value, amounting to a total of **US$1.06 billion** with an average value of US$1.13 million per hectare. Park are most valuable in and around the city centre as well as in other densely populated areas such as Chatsworth (5,500 people per km2) and Phoenix (6,400 people per km2), where residents may value public open space more than residents living more affluent suburbs with private gardens. The high value of parks compared to natural spaces is due to their greater accessibility, perceived safety (being more busy and open rather than forested or bushy) and more multifunctional uses especially for families with children.

Figure 17:

Welfare losses due to air pollution in selected Sub-Saharan African (SSA) countries in 2013, as a percentage of GDP equivalent
(Source: World Bank, 2016)

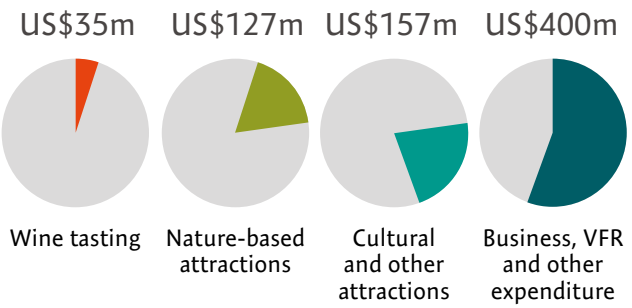


Durban also coincidentally generate an estimated US$127 million per annum in expenditure (see Box 5). Thus in two relatively well-managed African cities, urban open space areas contribute 18-43% of tourism revenues. These figures represent an important contribution to national exports, particularly in the case of Cape Town.
Nature-based tourism is also important in other coastal and non-coastal African cities. For example, beach-based tourism is one of the main attractions in Dar es Salaam, which is evident from the large number of hotels and conference venues along the city's coastline. This is also true of lakeside cities such as Kampala and its satellite town of Entebbe. However, Kampala now faces limitations in the possibilities for development of a waterfront area that could generate significant revenue for the city. The management of effluents and storm water quality is therefore also crucial to the economic development of cities.

The full potential of many African cities is undoubtedly limited by their environmental condition as well as other negative factors such as traffic congestion. Green cities are far more likely to be able to develop a strong tourism sector within their economies (Runfola & Hughes 2014), and may also be more attractive for business and staging of events. There are also important feedback loops to consider. While maintaining green spaces, trees and gardens and clean river systems and beaches in cities can bring important economic benefits, the revenues derived from tourism can also help to finance their green features and environmental management. In Durban, the tourism value generated from green open space is higher than the value of developing these areas (Turpie et al., 2017b).

Figure 18:

Breakdown of tourism expenditure in Cape Town



A lack of environmental management in African cities has also ***increased the economic impacts of extreme weather events***. As cities grow, the magnitude of flood flows arising from any given rainfall event also grows. This means that the natural floodplain areas in low-lying parts of the city also increase. Tolerance of people settling in these floodplains, and lack of recognition of the increasing floodplain area or need to increase the capacity of conveyance infrastructure has led to growing numbers of people at risk. It is no surprise therefore, that the numbers of flood-related disasters have increased exponentially. This is in line with the exponential, uncontrolled growth of cities and probably not entirely to be blamed on climate change, which further exacerbates this problem.

In Dar es Salaam, the expected annual losses from damage to structures in the Msimbazi floodplain alone amount to an estimated US$47.3 million per year. This does not include the loss of productivity as a result of disrupted work by directly-affected households and businesses. Nor does it include the impacts of traffic frequently being brought to a standstill after relatively normal rains. This cost has not been calculated but is likely to be very significant.

The excessive hardening of catchments without maintaining natural areas has meant that the flood attenuation capacity

Box 5:

The importance of environment for urban tourism

(Source: Turpie et al., 2017a)

The city of Durban is a leading tourism destination in South Africa. The year-round warm weather conditions encourage leisure tourists to enjoy the many outdoor tourist attractions, but the beach and marine environment is known to be the core leisure tourism experience on offer.

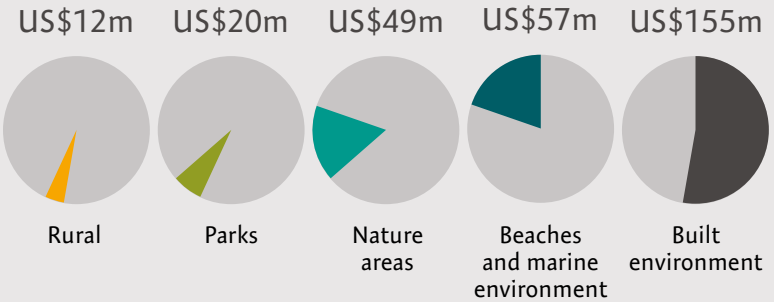
This was the main attraction for 50% of international tourists and 83% of domestic tourists to KwaZulu-Natal (SAT 2014). Nature-based activities such as walking, trail-running and bird watching are also important in certain areas, such as on estuaries and wetlands and in the 27 nature reserves and botanical gardens which feature scenic river gorges, indigenous coastal forest and grassland and an abundance of bird life.

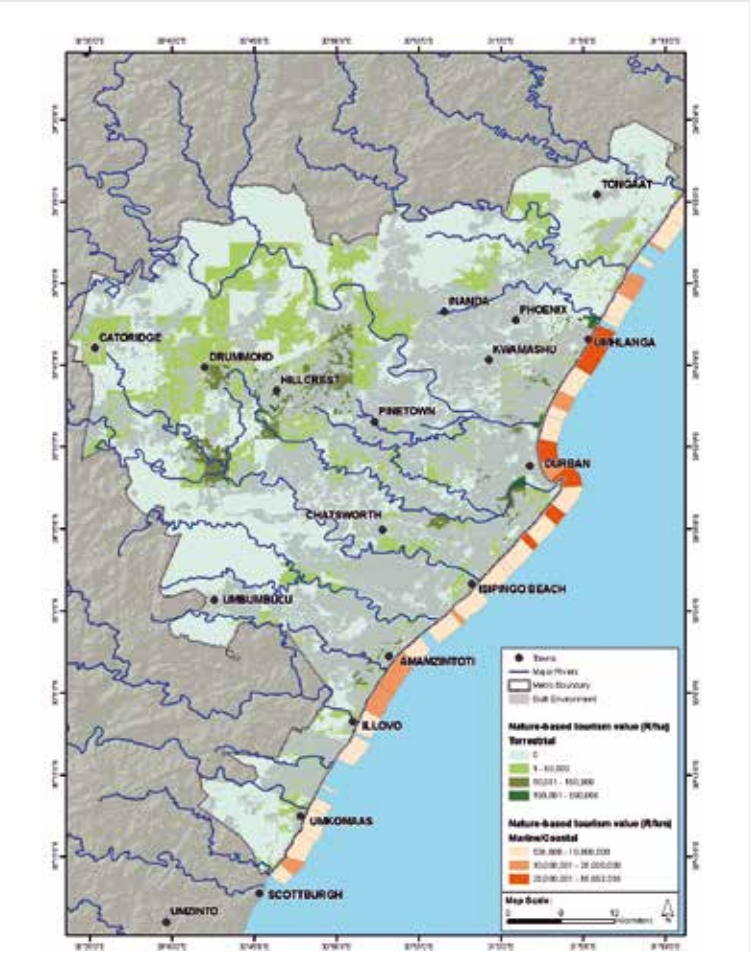
In 2012, some 15.5 million people visited the city, resulting in a total expenditure of about US$438 million and a total GDP contribution of US$750 million. Of the latter, leisure tourists were estimated to contribute some US$294,000 in expenditure and US$428 million of the GDP contribution.

Determining the tourism value of particular areas such as parks or nature reserves usually involves labor-intensive surveys and studies at the scale of a whole city are rare. However, the recent emergence of various social media tools, specifically involving uploading of geotagged photographs, provides an opportunity to assess the spatial behavior of tourists in relation to green space areas. Using data on over 10,000 photographs uploaded to Panoramio.com, which hosts outdoor images of landscapes, natural features and architecture, Turpie et al. (2017a) mapped the value of leisure tourism in Durban. The spatial patterns and photo content analysis suggests that open space areas within the municipal area account for almost half of the tourism attractions in Durban, with coastal attractions, nature areas, parks and rural farmland accounting for 20%, 17%, 7% and 4% of leisure tourism value, respectively.

The tourism value associated with the coast is very high, with the most popular coastal areas contributing up to US$5.1 million per kilometer to GDP. Man-made open space such as parks and golf courses contribute US$18,000 per hectare. The combined tourism value of natural and man-made open space is approximately US$180 million.

Tourism expenditure by type of attraction





of these areas has been lost, raising the cost of the stormwater conveyance infrastructure such as culverts, pipes and drains required to minimize flood risk. In Durban, the flood attenuation service provided by its remaining natural systems translates to a 0.7%-3.5% capital cost saving in stormwater infrastructure, which amounts to about US$26 million in net present value terms (equivalent to US$2.3 million per year; Turpie et al., 2017a).

Fiscal consequences

Local authorities in African cities are confronted with a widening gap between the availability of financial resources and municipal spending needs. Rapid urbanization in the context of low levels of household wealth has generated large informal settlements that need to be provided with basic services. The funds to provide these and other services are obtained from the central fiscus as well as from own-source finance, which is mainly from property taxes and service charges.

Property taxes form a substantial proportion of city income in most cities, and are directly related to the value of property. In Durban, which still maintains substantial areas of green open space, property owners pay a premium for being close to natural and semi-natural open space areas that are in a good condition. This additional property value translates to additional tax revenues amounting to about US$27 million per year which is at least 5% of total property tax income to the municipality. This amount does not include similar benefits that could be attributed to the city's well-maintained beaches. More importantly, it does not include the premium that people are prepared to pay to live in Durban rather than other cities, that could be ascribed to the overall environmental qualities of this attractive city. While it is difficult to determine exactly what income a city might have forfeited, it is clear that environmental degradation can have a significant impact on city revenues, both from property taxes and more broadly. This is an important consideration for achieving self-sufficiency and improving the resilience of cities, especially since own source-revenues are likely to become more important over time as cities expand and revenue systems strengthen.

Environmental degradation in urban areas also has a bearing on the cost of provision of services by national institutions. In Kampala, the city has always channelled its storm water and treated sewage into the Nakivubo wetland on the edge of Lake Victoria's Murchison Bay. The capacity for the wetland to assimilate these wastes has long since been overwhelmed, with the result that the bay has become hypertrophic, harboring frequent algal blooms. This preventable outcome has increased the National Water and Sewerage Corporation's

The first health challenge is the lack of development and inadequate services, including safe drinking water and acceptable sanitation.

(NWSC) costs of supplying water to Kampala city. The city's water treatment works, located just 3 km south of the Nakivubo wetland, has been upgraded twice in order to cope with the deteriorating water quality, including improvements to the facilities and extending the intake pipe deeper into the lake. In spite of this, the cost of water treatment is still over US$1 million per year more than it would be if the water quality were restored (Turpie et al., 2016a). However, the sunk costs of the upgrades and the planning of the next facility at some distance from the city to obtain cleaner water are probably far more significant. At an estimated US$53 million, the cost required to undo this damage and restore the wetland may now be prohibitive.

Social consequences

Environmental quality has a bearing on health and well-being, livelihoods, and household food security through opportunities for agriculture and resource harvesting as well as recreation. The main ways in which nature or green open space contribute to health and well-being in urban environments include improved air quality, enhanced physical activity, greater social cohesion, relaxation and stress reduction (WHO 2016). Rapid and unplanned urban expansion in Africa has caused severe environmental degradation, which has resulted in significant health burdens, rising health costs, and increased incidences in illness and premature deaths. These impacts affect the poorest households as they are more exposed to air and water pollution, lack adequate services and are unable to protect themselves.

Most urban residents in Africa face numerous health challenges. The first challenge relates to the lack of development and inadequate services, including safe drinking water and acceptable sanitation, affecting poverty levels, malnutrition, and the spread of infectious and parasitic diseases such dysentery, diarrhoea, and cholera (Moore et al., 2003, Boadi et al., 2005). These problems are exacerbated by flooding. The second challenge relates to health conditions arising from newly modernizing societies and changes in lifestyle, such as cancers, obesity, cardiovascular disease, diabetes and chronic respiratory diseases caused by unhealthy diets, physical inactivity, air pollution and exposure to toxins and wastes (WHO 2016). Poorly planned urban environments tend to discourage physical activity and promote unhealthy food consumption. Overcrowding, high volume traffic, poor air quality and lack of safe public open space/recreational areas contribute to overall low activity levels in African cities. The third challenge relates to emerging diseases such as mental health and psychiatric disorders associated with poor living conditions, overcrowding and socio-cultural changes (Boadi et al., 2005).

In many African cities subsistence agriculture is widespread and often situated within floodplains and wetland areas where the water is severely contaminated with pathogens that carry a risk to human health. Residents farming in the Nakivubo Wetland in Kampala, for example, are exposed to large loads of parasitic nematodes and faecal bacteria which, when coupled with flooding, cause frequent outbreaks of water-borne diseases such as cholera, which resulted in outbreaks in the city in 1997, 1999, 2004, 2006, and 2008. In Dar es Salaam households use polluted water from the Msimbazi River to water their vegetable gardens and wash produce, causing the spread of diarrheal disease. The rate of diarrhea among children under three years in the informal settlements in Nairobi, Kenya is estimated to be about 8%, which is more than eight times the rate of the city as a whole (African Population and Health Research Centre 2014). In 1994, 61,960 cases of cholera were recorded, resulting in 4,389 deaths in Angola, the Democratic Republic of Congo, Malawi, Mozambique and Tanzania (WHO as cited by Boadi et al., 2005). In that same year, 171,000 cases of dysentery were recorded, with at least 600 deaths reported in Malawi, Mozambique and Zimbabwe. In addition, asthma, chronic pulmonary disease, lead and beryllium poisoning are all associated with increasing air pollution in African cities (Moore et al., 2003).

In other regions, urban green open space areas have been shown to have a positive impact on health and well-being. In Spain, Triguero-Mas et al. (2015) found that an increased exposure to green space was linked to both improved physical and mental health, independent of socioeconomic status or gender. Evidence suggests that living closer to urban green space, such as parks, and having higher levels of neighbourhood greenery is associated with lower levels of mental illness, depression, anxiety and stress (White et al., 2013, Beyer et al., 2014). In Canada green open space in cities has been associated with a reduction in mortality, in particular, mortality from respiratory disease (Villeneuve et al., 2012), and in Spain greenness of neighbourhoods was associated with lower mortality risk during heat waves (Xu et al., 2013). In the United Kingdom an association between small amounts of green open space and elevated risk of circulatory disease was found (Mitchell & Popham 2008) and in Lithuania, higher usage of green open space reduced cardiovascular disease and walking in parks had a greater effect on reducing heart rate and blood pressure than walking in busy urban streets (Tamosiunas et al., 2014, Grazuleviciene et al., 2015).

The condition of green open space areas is also important. Degraded open space areas are often linked to crime, which has massive ramifications for the economy and human welfare. In Cape Town, small neighborhood parks are still abundant, but many are not well maintained and harbor vagrants and criminals. These parks are effectively not available for use, and people avoid using them. To address this problem, the City of Cape Town is changing from many small parks to fewer, large multi-use "smart" parks, which will not only contain a variety of amenities, but will also be the location of small businesses such as restaurants. The idea is to encourage a high level of use in a well maintained environment, which would deter criminals and allow people to come out and enjoy their public open space areas.

F

CHANGING THE TRAJECTORY: GREEN URBAN DEVELOPMENT IN AFRICA

Crystallizing the challenge

The research presented above indicates that most African cities are on a trajectory of environmental degradation that has become self-reinforcing though negative feedbacks. This is the path C1 described earlier in Figure 2. This situation is not sustainable: cities urgently need to change their trajectory by slowing and ultimately reversing environmental decline.
An investment in environmental assets and quality would yield positive economic, social and fiscal returns and rejuvenated cities would be able to make a positive and vitally-needed contribution to national development.

As things stand, much of the already-built urban space in African cities may be too far deteriorated for immediate revitalisation to be feasible. However, Africa's cities are set to increase dramatically in extent in the coming years, and this is where the opportunity lies. If this growth can be guided appropriately, these newly-developed areas will not only be more liveable and productive themselves, but will ultimately be able to pay for some of the costs of restoring already-degraded urban areas later. In sum, the key initial priority is to set African cities on a greener development path; secondly, attention can turn to reversing some of the damage that has already been done.

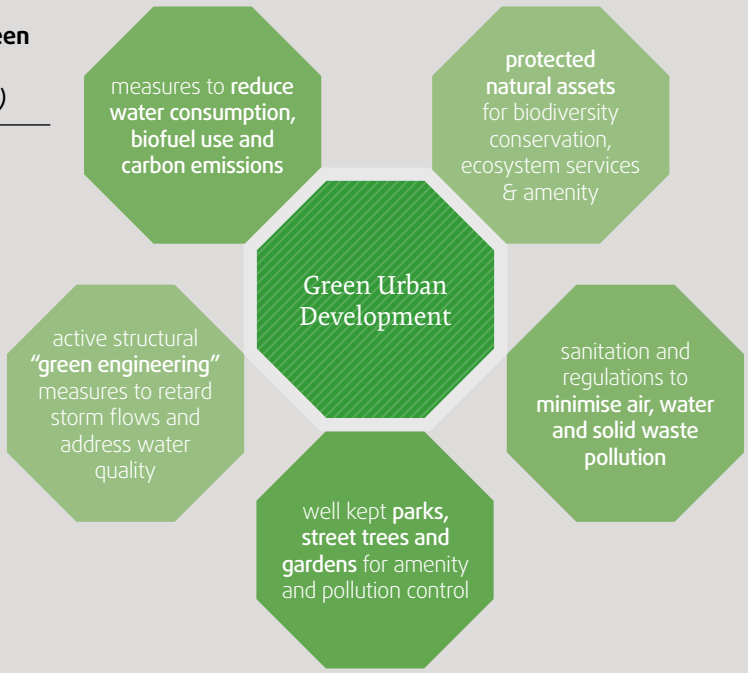
While restoration is typically more costly than avoiding degradation in the first place – one reason why a course-adjustment for future African city growth is so important – there are cases in which investments in the restoration of natural capital will be worthwhile, lowering operating costs and supporting local economic development. Massive environmental rejuvenation of cities has happened in other parts of the world, such as Singapore, Vancouver, San Francisco, Bogotá, and Curitiba. Cities elsewhere have also started to invest in the ecological infrastructure at and beyond their urban limits. For example, New York has secured its source of drinking water by purchasing and restoring the Catskill watershed for US$2 billion. A comparable pre-treatment plant would have cost US$7 billion. In northern coastal regions of Vietnam, where more than 70% of the population is threatened by natural hazards, local communities have planted and protected mangroves. An estimated US$7.3 million a year in sea dike maintenance was saved because of an investment of US$1.1 million on restoration of natural mangrove forests. The project areas suffered significantly less damage than neighboring provinces during typhoon Wukong in 2000. Such restoration programs are also possible in Africa, but will be significantly more challenging, given the under-resourced nature of the cities.

While African cities will have the potential benefit of learning from other country experiences, a green development path will still pose particularly acute challenges for the donor community. Much of the damage that has been done is irreversible or prohibitively costly to fix. Swift action needs to be taken to avoid further such losses and wasted opportunities. Given the rapidity with which degradation takes place under conditions of uncontrolled urbanization, it is imperative that cities prioritize taking firm steps to ensure a green approach to city growth before embarking on a comprehensive plan towards the remedial actions required to address existing environmental problems.

The elements and benefits of green urban development

From the preceding discussions, it is clear what cities should not do (Box 6). Based on this it is possible to formulate the types of actions that will be required to embark on a green urban development path. The environmental challenges described above can be alleviated through a comprehensive green urban development strategy which tackles problems in multiple and mutually-reinforcing ways. Green urban development is an approach that aims to minimize the

Figure 19:
The main elements of a green urban development policy
(Source: Turpie et al., 2017b)



F

Box 6:

What cities should not do

Research undertaken for this report indicates that there are important things that cities should avoid doing if they are to attempt a shift to a positive environmental trajectory. These essentially fall into three broad areas – waste and stormwater, city structure and the use of natural resources – and are also strongly linked to service delivery.

In dealing with **waste and stormwater**, cities should avoid excessive reliance on either natural systems or traditional conveyance infrastructure:

- Passive engineering structures for the conveyance of floodwater become inefficient in the face of urban growth and are damaging to the environment, as they involve the modification of river channels and disconnection of rivers from their floodplains, as well as the alteration of flow dynamics into receiving aquatic ecosystems such as estuaries;
- Using rivers and estuaries as a conduit for treated sewage should be avoided, as the combination of higher flows and pollution alters the health and value of these systems. This impacts on recreational users, people who grow vegetables using polluted water, as well as those who consume this produce. Rather pipe the effluents far out to sea, or preferably recycle the effluents to supply water;
- Natural ecosystems in urban areas cannot realistically be expected to take the place of engineering infrastructure. The capacity of natural wetlands is limited and this will result in their degradation and loss of biodiversity and values. Rather use technology or constructed wetlands that will be more efficient for the purpose;
- Using river systems, wetlands or other open space areas as a short-term solution for the dumping of waste (by citizens or waste services) leads to increased flooding problems, pollution of amenity areas and destruction of animal life.

In **managing urban growth and city structure**, cities should avoid indiscriminate loss of natural and semi-natural open space areas:

- These areas will be increasingly valuable to the city as it grows, and a strategically-determined amount of open space should be allowed to remain in each part of the city;
- Natural areas, parks, gardens and trees within cities provide aesthetic and recreational value, and can have a significantly positive impact on air quality and temperatures;
- Preventing settlements in areas set aside as green open space, especially along rivers and in floodplains will be far less costly than the potential costs of disaster management services, damages to the households themselves, and the inevitable costs of resettlement.

Cities should not neglect looking after their **natural resources**:

- The indiscriminate sourcing of raw materials such as building sand, poles and timber from ecosystems in and around the city can compromise a number of increasingly-valuable services that are delivered by those ecosystems;
- Leakages and inadequate pricing or payment collection can lead to wastage and increase the costs of water supply;
- Allowing the introduction of alien species e.g. via ships and other transportation might impact local resource stocks, habitats and biodiversity.

It is also important that cities do not neglect their poorest citizens. To do so leads to some of the biggest and costliest environmental problems in urban areas. Poor populations' continued reliance on charcoal for energy, disposing of their sewage waste into rivers and wetlands, along with quantities of solid waste that are not managed or disposed of effectively, is bad for their wellbeing and deleterious to the health of cities.

impacts of urbanization on the environment and enhance environmental values. The approach is advocated to increase, rather than limit, the development potential of cities. It is also vital for global welfare.

The main general elements of green urban development are outlined in Figure 19. Suitably adapted, these can address the environmental problems that have arisen in African cities as a result of rapid urbanization and policies that have prioritized growth with little regard for the environment. In a nutshell, green urban development involves tackling the core problems of pollution and waste, the consumption of natural resources and eradication of ecosystems, and the diminution of biodiversity in the context of urban growth. In addition to a range of policy interventions, this involves investing in natural capital as well as use of green structural engineering and conventional grey infrastructure. "Green" is synonymous with "environmentally friendly," and does not just refer to vegetated areas. It should also be emphasized that natural, green and conventional grey infrastructure are complementary and likely to achieve the best results when applied in combination. Grey and green infrastructure can play a critical role in the protection of natural infrastructure, while the latter can reduce the costs of grey infrastructure.

The elements of green urban development include:

- Tackling the problems of air, water and solid waste pollution through the provision of solid and liquid waste management services and enforcement of appropriate regulations to control effluents and emissions from a wide variety of sources. This is not only a necessity from a social and human health perspective, but is also a prerequisite to the success of all other green urban development interventions;
- Replacing natural with built surfaces in a more environmentally friendly manner. This entails implementation of sustainable stormwater management systems that include neutralising the impacts of hardened surfaces on stormwater flows using attenuation measures such as detention ponds, infiltration trenches, porous paving and green roofs (Box 7).
- Tackling water and energy consumption. The former is primarily to ensure the sustainable supply of water from surrounding surface and groundwater source areas as well as the impacts of water use within cities (see Box 8). Dealing with this problem also helps with the problem of waste water management, particularly if waste-water recycling is used as part of the solution. Tackling energy consumption has multiple advantages. It addresses the necessity of reducing carbon emissions to reduce the risks of climate change both globally and locally. Given the high reliance by urban households on wood fuel in Africa, it would also address local air pollution, as well as deforestation in the areas beyond cities, which occurs at great cost to biodiversity and society, and which also exacerbates environmental problems such as flooding.
- Investing in greening measures. These include creating and maintaining recreational green open space areas such as parks, and investing in the planting of trees and gardens along city streets. These will not only provide aesthetic enhancement but will contribute to the reduction of air pollution (Beckett et al., 1998, Jim & Chen 2008) and mitigate against urban heat island effects (Akbari et al., 2001, EPA 2014).
- Securing the protection, restoration or rehabilitation of selected natural areas in order to maintain biodiversity and valuable ecosystem services. Natural systems within cities contribute to livelihoods through the provisioning of natural resources, contribute to human health and wellbeing, property value and tourism through the provision of aesthetic and recreational amenity value, and contribute ecosystem services such as flood control, sediment retention, air and water quality amelioration, carbon storage, pollination of crops and provision of nursery areas for marine fisheries. As cities grow the remaining natural areas within them become increasingly important as refugia for biodiversity. All of these functions are lost however, if they are excessively degraded and fragmented. Thus cities need to plan and manage a system of natural open space areas.

Planning also needs to consider the potential effects of city growth on valuable aquatic and terrestrial ecosystems and put pre-emptive mechanisms in place to avoid their degradation and loss, or to avoid insurmountable costs in trying.

Kampala provides a very clear illustration of the costs a city incurs if it does not develop its structure with due sensitivity to the natural environment and the services ecosystems provide. As urban areas grow, the natural areas that they retain are likely to increase in value as the demand for their services increases, and as they take on new uses such as recreation and tourism. These areas will also become increasingly important as refugia for biodiversity. Economic development plans should recognize the economic and social values of natural systems, particularly in sectors such as tourism, include these assets as part of their core strategies, and allocate resources accordingly. In the case of Durban, it has been shown that the inclusion of substantial green open space areas was key to having a cost-effective strategy for maintaining high levels of environmental quality and ecosystem services (Box 9), while in Dar es Salaam natural systems provide one of few options available to solve the problems of flooding in the city centre (Box 11).

Actualizing green urban development in Africa: an agenda for action

Green urban development will need to be implemented through a combination of local and national government action, and with strategic input from development partners, investors and other stakeholders. The actions required comprise a combination of indirect and direct interventions that will serve synergistically to develop vibrant, resilient cities that are greener in appearance, greener in terms of

F

Box 7:

Sustainable urban stormwater management systems

(Source: Turpie et al., 2017b)

Because urbanisation leads to the hardening of surfaces, the importation of water to supply urban inhabitants and the production of wastewater and sewage, managing the quantity and quality of surface water flows is one of the most important challenges of city planners and engineers. While conventional measures have involved "end-of-pipe" interventions to convey these problems away, these measures have often not been able to keep ahead of the problems, and have also contributed to the pollution and degradation of aquatic systems within and downstream of urban areas. Great strides have been made in the design of more sustainable engineering mechanisms to deal with urban stormwater problems. These active structural and non-structural measures address flooding, water quality problems, or both, and complement the traditional, passive structural measures used to channel storm flows away from flood prone areas (see figure).

Types of measures to address urban stormwater problems

Passive structural measures for conveyance
- Drains, swales
- Modify river channel – widen/deepen/levees
- Hydraulic bypass

Active structural measures ("Green engineering")

Source controls
- Permeable pavement
- Infiltration trenches
- Sub-surface soakaways
- Green roofs
- Rainwater harvesting

Local controls
- Vegetated swales
- Filter strips
- Sand filters
- Bio-retention areas

Regional controls
- Detention basins
- Treatment wetlands

Non-structural measures
- Policies, laws and enforcement (sanitation, effluents, litter)
- Solid waste management, river cleaning programmes
- Riparian buffers
- Catchment conservation areas

Active structural measures aim to modify the hydrograph (i.e. reduce flood peak and volume) and address water quality by retarding water movement, by increasing infiltration or storage in the catchment area. These can be referred to as "green" (sustainable/environmentally-friendly) engineering measures.

Non-structural measures do not involve physical construction but use knowledge, practice or agreements to reduce risks and impacts through behavioral changes, in particular through policies, public awareness raising, training and education. These include flood warning systems, land use regulations such as development setbacks which identify where development can and cannot occur, or to what elevation structures should locate their lowest habitable floor to; regulations that require flood proofing and retrofitting of buildings may increase the strength against flood actions; elevation of buildings may avoid completely the inundation. Flood insurance and relocations also belong to this typology of measures.

These approaches are increasingly being applied in development planning in South Africa, and their inclusion (in any form) has recently become mandatory for new developments in the City of Cape Town and in Durban with the aim that the potential impacts of new developments on stormwater are effectively "neutralized".

their local, regional and global environmental impacts, and in which natural systems provide meaningful refugia for biodiversity and are used to advantage in supplying valuable ecosystem services and tourism assets.

Some actions are urgent as prerequisites for other actions, others can be implemented more gradually. Each city will find its own priorities and optimal programme of action, but the following is a suggested set of interventions in a rough order that will enhance their mutual reinforcement.

Address the "Brown Agenda"

To a significant extent, "Green Urban Development" in Africa equates to "Basic Urban Development" in Africa. For example, as demonstrated by the Nakivubo study in Kampala (see Box 2), extending basic sanitation services throughout African informal settlements is likely to have as many beneficial impacts on the natural environment – including water quality and the wetland ecosystems that are symbiotically related to it – than any other measures that could be considered. At its most fundamental, this it involves the supply of decent latrines to all unserved areas, but it is also important to provide adequate drainage diversions, sludge removal services, sewerage systems and treatment facilities to minimise health and environmental impacts. As cities get these problems under control, so these systems can be further refined with the use of engineered treatment wetlands and other measures to polish effluents and further reduce their environmental impacts.

Equally, the collection and removal of solid waste, and the effective implementation of anti-dumping regulations, would lower pollution levels and have extensive positive impacts on a variety of natural assets and ecosystems throughout African cities. And widened access to electrical power, particularly from renewable sources, would lower rates of fuel wood and charcoal consumption, thus slowing the degradation of forests and improving the quality of city atmospheres. The first priority, then, must be to extend basic services in African cities to un- and underserved populations in an equitable manner which does not encourage overconsumption, and which places as much emphasis on dealing with the waste that urban populations and activities create as it does with providing the goods and services that they consume. As everywhere, the first step in the "greening" of African cities is to deal effectively with the "brown agenda" that cities inevitably create.

Manage natural resource use

Managing the delivery and consumption of natural resources such as water is another area in which more effective and efficient delivery will simultaneously benefit the natural environment. Water supply and use affects cities – and city budgets - directly, especially in water-stressed areas. Cities need to develop comprehensive policies that address the impacts of water consumption on the environment while also ensuring the supply of potable water to their growing numbers of households. These policies should include maintenance of infrastructure to limit leakage, and consideration of measures, such as stepped water pricing, to recover costs and limit overconsumption by wealthier households, ensuring the provision of water at high standards to reduce demand for or avoid the necessity of buying bottled water and the polluting knock-on effects of this, and investing in recycling of waste water. The latter option, while currently out of reach for most African cities, will become a necessity for many in time.

Control traffic and vehicle emissions

The majority of African cities need to address growing congestion problems that have led to increased emissions through increased vehicle numbers, travel time and the increased proportion of high-emitting vehicles such as motorbikes. Improved planning for greater urban spatial efficiency and management of urban traffic flows are required to mitigate these emissions. Short-term solutions include better enforcement of emission standards and improving traffic management; medium-term solutions may include the provision of bus lanes and bicycle lanes and investing in other public transport solutions such as bus rapid transit systems, where these are financially sensible.

Box 8:

Links between cities, water consumption and aquatic ecosystems

Cities can have serious impacts on aquatic ecosystems within and around them as a result of their aggregate water demands. These include the damming and extraction of water from catchment areas which reduces freshwater flows in river systems and impacts biodiversity and ecosystem services. It also includes the impacts of importing water into a concentrated area and releasing it as treated sewage into rivers and estuaries, also changing their functioning, biodiversity and economic value. In order to reduce these impacts, cities need to reduce their per-capita water demands, minimize wastage due to leakage, and invest in lower-impact solutions such as recycling of waste water. As options for increasing water supply from catchment areas become more limited, so these more environmentally sustainable options will become more affordable. Apart from the obvious health benefits, the provision of good quality water will also reduce plastic pollution brought about by the need to purchase bottled water.

F

Box 9:

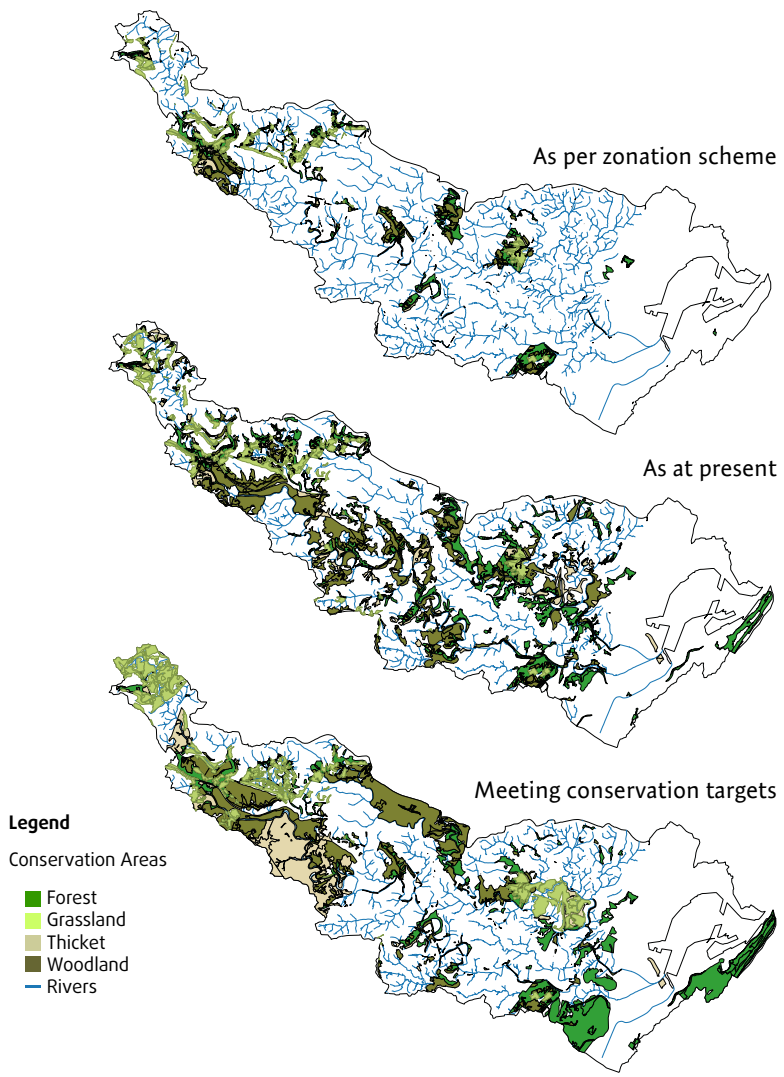
Evaluating the potential returns to investing in Green Urban Development in Durban

(Source: Turpie et al., 2017b)

A scenario-based approach was used to explore the potential costs and benefits of undertaking a green urban development approach to address flooding, water quality and biodiversity loss in Durban, and to explore the potential trade-offs between engineered interventions and the conservation of natural open space areas. Flows and water quality in the central Umhlatuzana - Umbilo catchment were modelled under a series of hypothetical back-casted scenarios in which the development of the area had involved different combinations and extents of GUD measures including better sanitation, stormwater management (including infiltration trenches, subsurface soakaways, permeable paving, green roofs, detention basins, and treatment wetlands) and conservation measures (protection of natural open space areas and riparian buffers). The scenarios were evaluated in terms of their implications for aquatic ecosystem health as well as the infrastructure costs and the losses in property value, tourism and fishery values that would have been avoided under these alternative scenarios.

There was relatively little backlog in sanitation, but addressing this issue and engaging in waste water recycling made a significant difference in water quality in the catchment. With or without this improvement, green engineering interventions were found to have a significant effect. The measures that were specifically designed for stormwater management – source controls (infiltration trenches, soakaways, permeable paving and green roofs) and detention basins – reduced flood peaks by about 10%, and 35%, respectively, and also contributed to improved water quality. Under improved sanitation conditions, treatment wetlands were very effective at improving water quality in the catchment. However, the large-scale application of some of the low-impact stormwater management measures is still extremely costly, even when accounting for economies of scale. Of all the source control measures that could be feasibly implemented, only detention basins could be justified in terms of their cost savings. It is feasible that the rest will become more affordable in time, as necessity will continue to drive this kind of innovation, and bringing these requirements into law in Durban will also drive this process.

The study also analysed the impacts of a planning scheme which allows greater retention of natural green open spaces in the city to meet conservation targets. This strategy had a significant impact on flooding, by virtue of the fact that the hardened area was reduced. It also had a moderate impact on water quality. The net benefits of this strategy far outweighed any other. Smart planning with green open space areas coupled with the other interventions creates the greenest city, in terms of meeting water quality and biodiversity conservation goals, and is an economically justifiable strategy in terms of overall costs and benefits.



Beyond these general – or indirect – measures, however, elements of a more targeted policy agenda can also be developed and used in appropriate combination in African cities. Key measures include:

Control specific sources of pollution through prohibitions and incentives

Multiple options exist to control and disincentivize the generation of particularly problematic types of waste, ranging from the banning of plastic packaging to the imposition of levies and charges for wastewater discharge and recycling incentives. Already, a number of African countries and cities have instituted such systems (see Box 10), but these systems are largely in their infancy in Africa and much greater scope exists for utilizing them than has been exercised thus far. National and local governments need to cooperate to develop legislation to produce regulations and instruments which can make a significant contribution to greater control of solid and liquid waste at source. And, where regulations already exist, poor monitoring and enforcement – widespread in African cities – need to be strengthened. Cities need to invest in manpower and laboratories for long-term monitoring, increasing the transparency and availability of data and information, and better enforcement of their regulations.

Protect and restore the natural environment within and around cities

Cities need to make space for biodiversity as well as capitalise on the capacity of natural systems to supply ecosystem services and contribute to their tourism economies. Cities therefore need to embark on a strategic conservation planning exercise to: develop an understanding of the natural resources, species and ecological process within the planning area, understanding the nature and value of the ecosystem services they provide; and use established methods to devise an efficient strategy for protection. This planning should go hand in hand with spatial development and economic planning, to determine which areas are to be left undeveloped to improve overall functionality and to enhance the tourism assets of the city. These areas also need to be monitored and managed. In addition, measures need be taken to ensure the ecological integrity of the river, estuarine and coastal ecosystems within and downstream of urban areas. This includes protection from sewage effluents and industrial pollution, and control of potentially damaging activities such as sand mining, agriculture and fishing. The efficacy of existing regulations and enforcement efforts need to be assessed, and appropriate regulations, enforcement measures and incentives put in place. Investments in sanitation, stormwater flow attenuation measures, pollution control measures, riparian green belts, and water management will play an important role in maintaining healthy and safe aquatic ecosystems. Instruments – such as user fees and payment for ecosystem services (Box 9) – which provide incentives for communities in and around cities to manage the natural environment in a manner which enhances environmental quality should be explored as means of supporting this objective.

Combine engineering, spatial planning, environmental management and other interventions to produce greener outcomes for particular urban development interventions

One of the challenges of achieving green urban development is to shift the focus from reliance on conventional grey infrastructure and "end of pipe" measures, and find the right balance between ecological and green or grey engineered infrastructure to tackle problems closer to source and maintain healthier, more vibrant and more resilient cities. For example, in Dar es Salaam, where active structural measures for stormwater retention are difficult to implement, the restoration of forest areas and rehabilitation of river systems may be a more viable way of alleviating flooding problems in the Msimbazi floodplain while also generating other benefits from reversing environmental degradation (Box 11).

Invest in a greening programme

African cities need to invest in creating or upgrading public parks and the greening of streets by planting trees and gardens. These uplift citizens and make cities more attractive for doing business. Furthermore the investments should be substantial so as to be sustainable and yield the desired returns. They will involve the creation of tree nurseries so that large trees can be planted that are more likely to survive, and they will require the installation of water supply systems. Innovative mechanisms may need to be designed for their development and maintenance, such as involving the private sector to fund their upkeep in return for advertising rights. Cities can also consider measures such as doing away with large numbers of badly-maintained community parks and investing in fewer, larger and safer multi-use parks, as well as green corridors, e.g. along rivers, that allow increased access and promote outdoor exercise, as well as contributing to ecological integrity.

> "Combine engineering, spatial planning, environmental management and other interventions to produce greener outcomes for particular urban development interventions.

Box 10:

Measures for managing environmental externalities in urban areas

(Source: Black & Rowcroft 2016)

There are a number of policy and other instruments that public agencies within African cities may consider for mitigating the negative environmental externalities deriving from urbanization.

Plastic bag levies
The plastic bag levy has been successfully implemented in several African nations. In Botswana overall plastic bag use dropped by 50% in just 18 months. In South Africa, while there has been an overall decline in the number of plastic bags used, the effectiveness of the levy has also declined over time. This can be attributed to consumers becoming accustomed to the levy and it no longer acting as a strong disincentive.

The plastic bag levy has been successfully implemented in several African nations. In Botswana overall plastic bag use dropped by 50% in just 18 months.

Pollution charges
Pollution charges include disposal fees, effluent permit fees and emission fees. There are few examples of such schemes in African cities, other than the Wastewater Discharge Charge Scheme (WDCS) in South Africa, which is still in its pilot phase. There are two charges associated with the WDCS: a Waste Discharge Levy which provides a disincentive or deterrent to the discharge of waste, and a Waste Mitigation Charge which covers the costs of measures to mitigate waste discharge related impacts.

Tax exemptions on alternative fuels
The setting of zero Value Added Tax (VAT) on Liquid Petroleum Gas (LPG) has been adopted in a number of African countries including Uganda, Senegal, and Botswana. In Senegal, a LPG Program was initiated in 1974 when wood fuel consumption accounted for 90% of energy use. The removal of import duties on gas canisters and cookers, as well as subsidies on LPG, has resulted in a decline in wood fuel dependence and annual savings of approximately 70,000 tons of wood fuel and 90,000 tons of charcoal.

Deposit-refund schemes
In South Africa, a tire recycling scheme was implemented in 2012 in response to the high numbers of illegally disposed scrap tires. Manufacturers and tire importers are charged a levy plus VAT on every kilogram of new rubber tire and the cost of waste tire collection is passed on to consumers. The revenue generated by the levy is used to subsidize the recycling of the tires and acts as an incentive for consumers to return tires to a location for suitable disposal. By mid-2014, more than 17,000 tons of used tires had been collected and diverted from landfill and the waste tire recycling rate had increased from 4% to 19% by the end of 2014.

Environmental funds
In Tanzania, the Eastern Arc Mountains Conservation Endowment Fund is a trust fund established in 2001 as a joint initiative between the Government of Tanzania, the World Bank, and the Global Environmental Facility. The fund aims to provide reliable, long-term financing for community development, biodiversity conservation and applied research projects. Among others, the Government of Norway has committed US$5.9 million over a five-year period from 2011.

Payment for ecosystem services (PES)
The Equitable Payments for Watershed Services (EPWS) in the Uluguru Mountains, Tanzania was initiated in 2006. Unsustainable farming practices and land use change upstream of Dar es Salaam reduce water quality in the catchment and have an impact of water treatment costs in the city. The PES scheme involves two major industrial water consumers paying upstream villages to adopt more water-friendly agricultural practices. As a result of the scheme, sediment levels in the catchment have fallen and the productivity of participating farmers' has increased over threefold.

Box 11:

Investing in ecosystem rehabilitation to ameliorate flooding in Dar es Salaam

(Source: Turpie et al., 2016b)

The potential feasibility of investing in green urban development (GUD) interventions to alleviate flooding problems in the Msimbazi catchment in Dar es Salaam was investigated by analysing a range of stormwater management scenarios.

Sustainable urban drainage (green engineering) measures such as infiltration trenches, porous paving and green roofs were found to be largely infeasible due to the nature of the soils and built environment. A feasible set of GUD interventions to reduce the magnitude of floods was identified: restoration of forests in the upper catchment, rehabilitation and enhancement of riparian and floodplain areas in the middle catchment, river cleaning in the middle catchment and floodplain rehabilitation in the lower catchment. River and floodplain rehabilitation involved the restoration of vegetated riparian areas plus the creation of recreational and agricultural spaces on either side of rivers that could double up as flood storage. The above interventions were considered along with storage basins (feasible in the lower catchment only), and the removal of people from the area at risk.

Available data only supported basic hydrological modelling, but relatively good data for the risk area allowed for a reasonable estimation of the expected annual losses from flooding. The impacts of the interventions were estimated on the basis of their potential storage capacity during a high rainfall event. Changes in the expected annual losses under different combinations of the above interventions were estimated based on the expected effects of the interventions on the flood hydrograph as well as the change in structures at risk. All scenarios led to decreases in the damage costs of flooding, with average annual cost savings from US$10 million to US$26 million, or 21% to 54% of present expected annual losses. The GUD interventions were designed to have a significant cumulative effect on the flood hydrograph. This led to an estimated 19.6% reduction in the number of buildings at risk and a 39% decrease in expected annual losses. When GUD strategies were combined with the floodplain setback zone, this resulted in both reduction of the flood intensity (due to reduction in the hydrograph) and reduction of the exposure (due to relocation of buildings from a setback zone within the flood prone area).

Absolute benefits increase as more measures are combined, but so do costs. All measures would be expensive because of the fact that people have settled illegally in the forest reserve, riparian reserve and floodplain areas, with the full combination amounting to US$138.5 million. Taken alone, catchment rehabilitation measures (US$84 million) would provide higher net benefit than moving people from the flood prone areas (US$62 million), and would also yield the highest rates of return. The addition of a storage basin (+US$40 million) added least value, but this was largely because opportunities for the location of such an intervention were too low down in the catchment to be particularly effective. The results suggested that investment should be secured for the implementation of a combination of rehabilitation measures in the Msimbazi catchment that are specifically designed to attenuate flows and improve drainage, including formal solid waste management and community-based river cleaning programs, reforestation, river and floodplain rehabilitation.

Reduce exposure →

Expected annual losses under different flood mitigation strategies	No interventions in flood prone areas	People and structures removed from 60m buffer zone in flood prone areas
No interventions in catchment	**Baseline** US$47.30 million	**Scenario 1** US$37.24 million (-21%)
Catchment rehabilitation	**Scenario 2** US$28.87 million (-39%)	**Scenario 3** US$23.16 million (-51%)
Catchment rehabilitation + storage	**Scenario 4** US$27.78 million (-41%)	**Scenario 5** US$21.64 million (-54%)

Reduce flood risk ↓

G

UNLOCKING THE BARRIERS TO GREEN URBAN DEVELOPMENT

Strengthen institutions to manage green urban development

Cities need to strengthen the institutions on which effective green urban planning and management rest by addressing structural limitations, accountability and capacity constraints. This includes finding better ways to integrate the protection and management of natural assets that pertain to a range of city and/or government departments.

It is also important to recognize that the widespread planning failures evident in African cities are, in essence, a symptom of institutional weakness. In a "greening" context, green urban planning fails to emerge because African urban management institutions lack the capacity to generate such plans, and, whether or not they are environmentally sensitive, the plans that are produced are seldom implemented or enforced.

While the strengthening of government institutions is key, it is also perhaps one of the most challenging issues to address. Waiting for good institutions to emerge should not be allowed to delay the transition from a downward spiral to green urban development, as there is great urgency in transitioning to sustainable, resilient cities. Nevertheless, immense effort and innovation is needed to push this agenda: where cities are unable to manage natural assets effectively due, for example, to jurisdictional constraints, consideration should be given to allocating these responsibilities to national or regional institutions that have the incentives and capacity to do so.

Targeted finance

Finally, the green urban development agenda needs to be better financially resourced. In the context of the limited fiscal devolution characteristic of cities in many African countries, there is a very substantial agenda here. This is not particular to environmental management concerns, but in the long term it will be a necessary condition of putting African cities on a more environmentally sustainable trajectory. For example, measures involving the extension or upgrading of waste management services will require increased revenues from new and existing users, including reductions in explicit or implicit subsidies in rate setting and increased public expenditure that has to be financed in some other way by local governments. Other measures related to land use and pollution control will require public expenditures for monitoring and enforcement, as well as private compliance costs.

More immediately, given the limited local revenue capacities and authorities of most African cities, consideration needs to be given to targeted environmental programmes supported by conditional grants funded by national governments and/or development partners. Where feasible, the development of innovative financing instruments where the costs of environmental interventions and infrastructure are ultimately recovered from those who benefit most, those interventions (such as Payments for Ecosystem Services (PES) schemes, or the funding of green public space by developers who recover their costs from the sale of residences adjacent to that space), should be explored.

REFERENCES

Action Aid. 2006. Climate change, urban flooding and the rights of the urban poor in Africa. Key findings from six African cities. A report by Action Aid International.

Africa Growth Initiative (AGI). 2017. Foresight Africa: Top priorities for the continent in 2017. Brookings, Washington.

African Population and Health Research Center (APHRC). 2014. Population and Health Dynamics in Nairobi's Informal Settlements: Report of the Nairobi Cross-sectional Slums Survey (NCSS) 2012. Nairobi: APHRC.

Ahrends, A., Burgess, N. D., Milledge, S. A. H., Bulling, M. T., Fisher, B., Smart, J. C. R., Clarke, G. P., Boniface, E. M. & Lewis, S. L. 2010. Predictable waves of sequential forest degradation and biodiversity loss spreading from an African city. Proceedings of the National Academy of Sciences 107(33): 14556-14561.

Allan, D. G. 2012. The waterbirds of Durban Bay – current and historical population trends. Durban Natural Science Museum Novitates 35.

Amaeze, N. H., Egonmwan, R. I., Jolaoso, A. F. & Otitoloju, A. A. 2012. Coastal environmental pollution and fish species diversity in Lagos lagoon, Nigeria. International Journal of Environmental Protection 2: 8–16.

African Ministers' Council on Water (AMCOW) 2012. A Snapshot of Drinking Water and Sanitation in Africa – 2012 Update. In collaboration with the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.

Akbari, H., Pomerantz, M. and Taha, H. 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Solar Energy 70(3): 295-310.

Beckett, K.P., Freer-Smith, P.H. and Taylor, G. 1998. Urban woodlands: their role in reducing the effects of particulate pollution. Environmental Pollution 99(3):347-360.

Behrens, R., McCormick, D and Mfinanga, D., Paratransit in African Cities, 2016.

Beyer, K. M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F. J. & Malecki, K. M. 2014. Exposure to neighbourhood green space and mental health: evidence from the survey of the health of Wisconsin. International Journal of Environmental Research & Public Health 11: 3453-72.

Boadi, K., Kuitunen, M., Raheem, K. & Hanninen, K. 2005. Urbanisation without development: environmental and health implications in African cities. Environment, Development and Sustainability 7: 465–500.

Boon, R., Cockburn, J., Douwes, E., Govender, N., Ground, L., Mclean, C., Roberts, D., Rouget, M. & Slotow, R. 2016. Managing a threatened savanna ecosystem (KwaZulu-Natal Sandstone Sourveld) in an urban biodiversity hotspot: Durban, South Africa. Bothalia 46(2): a2112. http://dx.doi.org/10.4102/abc.v46i2.2112

Brown, C. & Magoba, R. 2009. Rivers and wetlands of Cape Town: caring for our rich aquatic heritage. Water Research Commission, South Africa.

Congedo, L. & Munafò, M. 2013. Assessment of Land Cover Change Using Remote Sensing: Objectives, Methods and Results. Rome: Sapienza University. Available at: http://www.planning4adaptation.eu/

De Risi, R., Jalayer, F., De Paola, F., Iervolino, I., Giugni, M., Topa, M.E., Mbuya, E., Kyessi, A., Manfredi, G. & Gasparini, P. 2013. Flood Risk Assessment for Informal Settlements. Natural Hazards 69(1): 1003-1032.

De Wit, M., van Zyl, H., Crookes, D., Blignaut, J., Jayiya, T., Goiset, V. & Mahumani, B. 2011. Investing in Natural Assets – A Business Case for the Environment in the City of Cape Town. Unpublished report to the City of Cape Town.

Dubbale, D. A., Tsutsumi, J. & Bendewald, M. J. 2010. Urban Environmental Challenges in Developing Cities: The Case of Ethiopian Capital Addis Ababa. International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering 4(6): 164-169.

Economist Intelligence Unit. 2011. African Green City Index, Assessing the environmental performance of Africa's major cities. Siemens, Munich, Germany.

Ellison, J. & Zouh, I. 2012. Vulnerability to Climate Change of Mangroves: Assessment from Cameroon, Central Africa. Biology (Basel) 1(3): 617–638.

Environmental Planning and Climate Protection Department (EPCPD) 2015. State of Biodiversity Report 2014/2015. Compiled by the Environmental Planning and Climate Protection Department for the eThekwini Municipality.

Environmental Protection Agency (EPA). 2008. Reducing Urban Heat Islands: Compendium of Strategies Trees and Vegetation.

Environmental Resources Management (ERM) & Marine and Estuarine Research (MER), 2011. Bay of Natal Estuarine Management Plan Situation Assessment. eThekwini, South Africa: Kwazulu-Natal Department of Agriculture, Environmental Affairs & Rural Development.

Ezzati M. 2010. Indoor Air Pollution and African Death Rates. pp. 196-198 in Parry I.W.H. and F. Day (Eds.), Issues of the Day: 100 Commentaries on Climate, Energy, the Environment, Transportation, and Public Health Policy. Resources for the Future, Washington, D.C.

Fanan, U., Dlama, K. I. & Oluseyi, I. O. 2011. Urban expansion and vegetal cover loss in and around Nigeria's Federal capital city. Journal of Ecology and the Natural Environment 3(1): 1-10.

Forbes, A. T. & Demetriades, N.T. 2008. Estuaries of Durban. EThekwini Municipality Environmental Management Department: Durban.

Fuwape, J.A. & Onyekwelu, C. 2010. Urban Forest Development in West Africa: Benefits and Challenges. Journal of Biodiversity and Ecological Sciences 1(1): 77-94.

Gebre, G. & Van Rooijen, D. 2009. Urban water pollution and irrigated vegetable farming in Addis Ababa. Water, sanitation and hygiene: sustainable development and multi-sectoral approaches. 34th WEDC International Conference, Addis Ababa, Ethiopia, 2009.

Giljum, S., Hinterberger, F., Bruckner, M., Burger, E., Fruhmann, J., Lutter, S., Pirgmaier, E., Polzin, C., Waxwender, H., Kernegger, L. & Warhurst, M. 2009. Overconsumption? Our use of the world´s natural resources. Sustainable Europe Research Institute (SERI) and Austria and GLOBAL 2000 (Friends of the Earth Austria).

Grazuleviciene, R., Vencloviene, J., Kubilius, R., Grizas, V., Dedele, A., Grazulevicius, T., Ceponiene, I., Tamuleviciute-Prasciene, E., Nieuwenhuijsen, M. J., Jones, M. & Gidlow, C. 2015b. The Effect of Park and Urban Environments on Coronary Artery Disease Patients: A Randomized Trial. BioMed Research International 9.

Hill, A. & Linder, C. 2010. Modelling informal urban growth under rapid urbanisation. Prepared for the TU Dortmund University. June 2010

Hoornweg, D. & P. Bhada-Tata. 2012. What a Waste: A Global Review of Solid Waste Management. World Bank, Washington, D.C.

IPCC, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Isunju, J.B., Orach, C.G, & Kemp, J. 2016. Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda. Environment and Urbanization. 28(1):275-293.

Jalayer, F., De Risi, R., Kyessi, A., Mbuya, E., & Yonas, N. 2015. Vulnerability of Built Environment to Flooding in African Cities. Book chapter in Urban Vulnerability and Climate Change in Africa, Future City 4, S. Pauleit et al., (eds.). (pp. 77-106). Springer International Publishing, Switzerland.

Jim, C.Y. & Chen, W.Y. 2008. Assessing the ecosystem service of air pollution removal by urban trees in Guangzhou (China). Journal of Environmental Management 88: 665-676.

KCCA (Kampala Capital City Authority). 2014. KCCA Strategic Plan 2014/15-2018-2019: Laying the Foundation for Kampala City Transportation KCCA, Kampala, Uganda

Lall, S.V., Henderson, J.V. & Venables, A.J. 2017. Africa's Cities: Opening Doors to the World. World Bank, Washington, D.C.

Mclean, C.T., Ground, L.E., Boon, R.G.C., Roberts, D.C., Govender, N. & McInnes, A. 2016. Durban's systematic conservation assessment, EThekwini Municipality, Environmental Planning and Climate Protection Department, Durban, South Africa.

Mensah, C. A. 2014a. Urban Green Spaces in Africa: Nature and Challenges. International Journal of Ecosystem 4(1): 1-11.

Mensah, C. A. 2014b. Destruction of urban green spaces: A problem beyond urbanization in Kumasi city (Ghana). American Journal of Environmental Protection 3(1): 1-9.

Mitchell, R. & Popham, F. 2008. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet 372: 1655-1560.

Mitoni, Y. 2010. Saltwater Intrusion in the Quaternary Aquifer of the Dar es Salaam Region, Tanzania. SWIM21-21st SaltWater Intrusion Meeting. June 21-26, 2010. Azores, Portugal.

Moore, M., Gould, P. & Kearyc, B. S. 2003. Global urbanisation and impact on health. International Journal of Hygiene and Environmental Health 206: 269 – 278.

Mwegoha, W.J.S & Kihampa, C. 2010. Heavy metal contamination in agricultural soils and water in Dar es Salaam city. African Journal of Environmental Science and Technology 4(11): 763-769.

Neumann, B., Vafeidis, A. T., Zimmermann, J., Nicholls, R.J. 2015. Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. PLoS ONE 10(3): e0118571. doi:10.1371/journal.pone.0118571.

Nhapi I., Siebel, M.A. & Gijzen, H.J. 2004. The Impact of Urbanisation on the Water Quality of Lake Chivero, Zimbabwe. Water and Environment Journal 18(1): 44-49.

Niang, S., Sarr, B., Pfeifer, H.-R, Girardet, G.A., Gaye, M.L, Ndiaye, M.L., Daouk, S. & Sow, M. 2007. Impact de la décharge de Mbeubeuss sur les ressources en eau et les sols. Laboratoire de Traitement des eaux Usées. IFAN-UCAD. Rapport final. Dakar-Sénégal.

National Water and Sewage Corporation (NWSC) 2014. Lake Victoria WATSAN Project Package 5a: Development of an Appropriate Sanitation Concept, Review of Water Supply Aspects in Informal Settlements & Feasibility Study. Draft feasibility study report. Government of Uganda.

Rebelo, A.G., Holmes, P.M., Dorse, C. & Wood, J., 2011. Impacts of urbanization in a biodiversity hotspot: Conservation challenges in Metropolitan Cape Town. South African Journal of Botany 77: 20–35.

Richardson, D. M. & van Wilgen, B. W. 2004. Invasive alien plants in South Africa: how well do we understand the ecological impacts? Working for Water, South African Journal of Science 100: 45-52.

Roy, R. 2016. The Cost of Air Pollution in Africa. Organization for Economic Co-operation and Development. OECD, Paris.

RSA 2012. Report on the Status of sanitation services in South Africa. Department of Water and Sanitation, Department of Human Settlements. 40pp.

Runfola, D. & Hughes, S. 2014. What Makes Green Cities Unique? Examining the Economic and Political Characteristics of the Grey-to-Green Continuum. Land 3: 131-147

South African Tourism (SAT) 2014. 2014 Statistics of our Tourism Sector, KwaZulu-Natal.

Satterthwaite, D. 2008. Climate change and urbanization: effects and implications for urban governance. United Nations expert group meeting on population distribution, urbanization, internal migration and development. New York, 21 – 23 January 2008.

Sawyer, L. 2013. Mapping 50 Years of Urban Growth in Lagos. Smart Cities Dive. http://www.smartcitiesdive.com/ex/sustainablecitiescollective/mapping-50-years-urban-growth-lagos/206201/

Schwela, D. 2012. Review of Urban Air Quality in Sub-Saharan Africa Region-Air Quality profile of SSA countries. World Bank.

Secretariat of the Convention on Biological Diversity (SCBD) 2012. Cities and Biodiversity Outlook - Action and Policy. Montreal.

Sedano, F., Silva, J. A., Machoco, R., Meque, C. H., Sitoe, A., Ribeiro, N., Anderson, K., Ombe, Z. A., Baule, S. H. & Tucker, C. J. 2016. The impact of charcoal production on forest degradation: a case study in Tete, Mozambique. Environmental Research Letters 11. doi:10.1088/1748-9326/11/9/094020.

Seto, K. C., Güneralp, B. & Hutyra, L. R. 2012. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences 109(40): 16083-16088.

Seto, K.C., Fragkias, M., Guneralp, B. & Reilly, M.K., 2011. A meta-analysis of global urban land expansion. PLoS One 6(8) e23777. http://dx.doi.org/10.1371/journal. pone.0023777

Shikur, E. T. 2011. Challenges and problems of urban forest development in Addis Ababa, Ethiopia. Trees, people and the built environment. Proceedings of the urban trees research conference, Birmingham, UK, 13-14 April 2011.

Small, C. & Nicholls, R. J. 2003. A global analysis of human settlement in coastal zones. Journal of Coastal Research 19: 584–599.

Tamosiunas, A., Grazuleviciene, R., Luksiene, D., Dedele, A., Reklaitiene, R., Baceviciene, M., Vencloviene, J., Bernotiene, G., Radisauskas, R., Malinauskiene, V., Milinaviciene, E., Bobak, M., Peasey, A. & Nieuwenhuijsen, M. J. 2014. Accessibility and use of urban green spaces, and cardiovascular health: findings from a Kaunas cohort study. Environmental Health 13: 20.

TEEB, 2010. The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington.

Tol, R.S.J. 2012. On the Uncertainty About the Total Economic Impact of Climate Change. Environmental Resource Economics 53: 97–116.

Triguero-mas, M., Dadvand, P., Cirach, M., Martínez, D., Medina, A., Mompart, A., Basagañ, X., Gražulevičienė, R. & Nieuwenhuijsen, M. J. 2015. Natural outdoor environments and mental and physical health: relationships and mechanisms. Environment International 77: 35-41.

Timilsina, G. R., & Dulal, H. B. (2011). Urban road transportation externalities: costs and choice of policy instruments. The World Bank Research Observer, 26(1), 162-191 Schwela, D. (2012). Review of Urban Air Quality in Sub-Saharan Africa Region-Air Quality profile of SSA countries. World Bank.

Turpie, J.K., Day, L., Gelo Kutela, D., Letley, G. & Forsythe, K. 2016a. A preliminary investigation of the potential costs and benefits of rehabilitation of the Nakivubo wetland, Kampala. World Bank Report.

Turpie, J.K., Kroeger, T., De Risi, R., de Paola, F., Letley, G., Forsythe, K. & Day, L. 2016b. Return on investment in Green Urban Development: amelioration of flood risk in the Msimbazi River catchment, Dar es Salaam, Tanzania. World Bank Report.

Turpie, J.K., Letley, G., Chrystal, R. & Corbello, S. 2017a. The value of Durban's natural capital and its role in Green Urban Development. Part 1: A spatial valuation of the natural and semi-natural open space areas in eThekwini Municipality. World Bank Report.

Turpie, J.K., Letley, G., Chrystal, R. & Day, L. 2017b. The value of Durban's natural capital and its role in Green Urban Development. Part 2: Evaluating the potential returns to investing in Green Urban Development in Durban. World Bank Report.

Turpie, J.K., Forsythe, K.J., Letley, G., Knowles, A. & Blignaut, J. In review. Mapping and valuation of South Africa's ecosystem services at a national scale using locally-relevant data: a matter of perspective.

United Nations 2009 World Water Development Report 3. Earthscan.

United Nations Economic Commission for Africa (UN ECA) 2017. Economic Report on Africa 2017: Urbanization and Industrialization for Africa's Transformation. United Nations Addis Ababa, Ethiopia

UN-Habitat. 2008. State of African Cities 2008: A Framework for Addressing Urban Challenges in Africa. United Nations Human Settlement Program. Nairobi, Kenya.

United Nations Environment Program (UNEP). 2011. Water Issues in the Democratic Republic of the Congo: Challenges and Opportunities. Technical Report. UNEP, Nairobi, Kenya.

United Nations Environment Program (UNEP) and National Environmental Management Council (NEMC). 2014. Dar es Salaam Rivers Rehabilitation and Management Programme (DRMP). Project Design Document. March, 2014.

van Ham, C., Genovesi, P. & Scalera, R. 2013. Invasive alien species: the urban dimension, Case studies on strengthening local action in Europe. Brussels, Belgium: IUCN European Union Representative Office. 103pp.

Vermeiren, K., Van Rompaey, A., Loopmans, M., Serwajja, E. & Mukwaya, P. 2012. Urban growth of Kampala, Uganda: Pattern analysis and scenario development. Landscape and Urban Planning 106: 199-206.

Villeneuve, P. J., Jerrett, M., G., Su, J., Burnett, R. T., Chen, H., Wheeler, A. J. & Goldberg, M.S. 2012. A cohort study relating urban green space with mortality in Ontario, Canada. Environmental Research 115: 51-58.

Watkiss, P., Downing, T., Dyszynski, J., Pye, S. et al., 2011. The Economics of Climate Change in the United Republic of Tanzania. Report to Development Partners Group and the UK Department for International Development. Published January 2011.

White, M. P., Alcock, I., Wheeler, B. W. & Depledge, M. H. 2013. Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. Psychology Science 24: 920-928.

World Bank. 2012. Inclusive Green Growth – The Path to Sustainable Development.

World Bank. 2013. Harnessing Urbanization to End Poverty and Boost Prosperity in Africa: An Action Agenda for Transformation. World Bank, Washington, D.C.

World Bank 2015a. Promoting Green Urban Development in African cities Dar es Salaam, Tanzania. Urban Environmental Profile. Washington.

World Bank 2015b. Promoting Green Urban Development in African cities Kampala, Uganda. Urban Environmental Profile. Washington.

World Bank 2015c. Ethiopia Urbanization Review. Washington.

World Bank 2016. The Cost of Air Pollution: Strengthening the Economic Case for Action. The World Bank and Institute for Health Metrics and Evaluation University of Washington, Seattle.

World Health Organization (WHO). 2015. "Urban Population Growth." Available at http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

World Health Organization (WHO) 2016. Global Urban Ambient Air Pollution Database. Available at www.who.int/phe/health_topics/outdoorair/databases/cities/en/

WWF. 2016. Living Planet Report 2016. Risk and resilience in a new era. WWW International, Gland, Switzerland.

Xu, Y., Dadvand, P., Barrera-Gómez, J., Sartini, C., Marí-dell'olmo, M., Borrell, C., Medinaramón, M., Sunyer, J. & Basagaña, X. 2013. Differences on the effect of heat waves on mortality by sociodemographic and urban landscape characteristics. Journal of Epidemiology and Community Health 67: 519-525.

Zari, M. P. Ecosystem Services Analysis in Response to Biodiversity Loss Caused by the Built Environment. Surveys and Perspectives Integrating Environment and Society (SAPIENS) 7(1). http://sapiens.revues.org/1684.

Zulu, L.C. & Richardson, R.B. 2013. Charcoal, livelihoods, and poverty reduction: Evidence from sub-Saharan Africa. Energy for Sustainable Development 17: 127–37

Greening Africa's Cities

Enhancing the relationship between urbanization, environmental assets and ecosystem services

WORLD BANK GROUP

Korea Green Growth Trust Fund

The Nature Conservancy