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A review on the systems approach for solving the complexity of the environmental problematique of cities in Africa

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Abstract

This article is woven to satisfy interlinked objectives of assessing the determinants for successful greening of the city and comparing and contrasting cities in their greening. A cross-sectional review of literature on the role of planning in city greening, the determinant factors for success and limits to this success has been done coupled by case analyses of five cities in the region. To better the situation and future of the African city space, it is imperative to examine the effect of this lack of interactive data and stakeholders' input into urban greening efforts. Unless such a preliminary analysis is done and a model for addressing this, developed, Africa will miss what the industrial city of the eighteenth century missed which eventually led to misery and suffering as cities developed in an unsustainable manner.
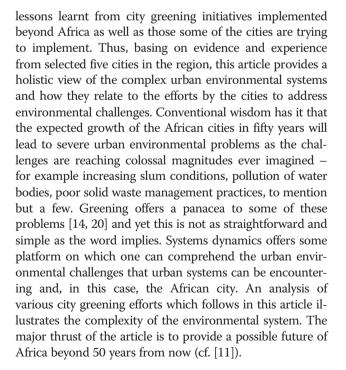
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Introduction

Unfortunately, when most cities in the Global North are embracing greening of cities as the way to go, Africa seems to be taking a piecemeal and generally a wait-and-see approach to the whole debate and practice (MO [11, 16]). Some cities (like Kigali in Rwanda) have done very well while many seem lost in endeavours to serve as successful green cities by the obsession to deal with the brown agenda issues. Nevertheless, there are also limits to the endeavours. Absent in the assessment of the situation on the ground and possible scenarios for an African city systems analysis, at theoretical, policy and action research level. Most urban centres in Africa have disintegrated into nothing but places of misery and hopelessness and, with climate change impacts, the situation can get worse by each day. There are unaccounted prospects that are available in endeavours to green the African cities. This article identifies the complexity of environmental issues that cities of Africa face and are likely to face beyond 2050 [11]. It draws some

lessons learnt from city greening initiatives implemented beyond Africa as well as those some of the cities are trying to implement. Thus, basing on evidence and experience from selected five cities in the region, this article provides a holistic view of the complex urban environmental systems and how they relate to the efforts by the cities to address environmental challenges. Conventional wisdom has it that the expected growth of the African cities in fifty years will lead to severe urban environmental problems as the challenges are reaching colossal magnitudes ever imagined – for example increasing slum conditions, pollution of water bodies, poor solid waste management practices, to mention but a few. Greening offers a panacea to some of these problems [14, 20] and yet this is not as straightforward and simple as the word implies. Systems dynamics offers some platform on which one can comprehend the urban environmental challenges that urban systems can be encountering and, in this case, the African city. An analysis of various city greening efforts which follows in this article illustrates the complexity of the environmental system. The major thrust of the article is to provide a possible future of Africa beyond 50 years from now (cf. [11]).

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Framing the concepts

Accurate projections for Africa in 50 years' time are very difficult because of dynamic social and economic conditions [1]. The African Development Bank estimates suggest that Africa's GDP could increase representing a major leap forward in standard of living and the resultant economic and population growth will be associated with rapid rural to urban migration and urbanisation. The rates of urbanisation in Africa will advance quickly with the proportion of urban dwellers likely to reach 65 % by 2060 [1] with most of these urban dwellers being youth below 25 years [11]. This implies larger cities characterised by a young population which is the most productive group hence most likely to strain the urban environments. Overall, cities are human artefacts, developed and modified over time according to perceived needs and values [18, 19]. They play major role concentrating human activities to confined geographical spaces. Cities are not only providers of better employment, shelter and services but also as centres of culture, learning and technological development, and industrial centres for the processing of agricultural produce and manufacturing, and places to generate income [2]. In Africa, the rapid expansion and commercial development, along with population pressure in the region's urban space, has ushered in deterioration to the urban environment as growth is unmatched with supply of the much needed services [12]. In most parts of the region, cities have become synonymous with decomposition of the urban fabric. Despite this negative set-in, the concept of greening seems to offer some of the much needed solutions to Africa.

Urban greening refers to an integrated method in the development and management of vegetation in cities, towns, urban and peri-urban areas. It has the components of urban forestry, urban agriculture or permaculture and agro-forestry [13]. Greening cities is not only about increasing the vegetation cover, rather it involves all those environmentally friendly initiatives that help to maintain the natural environment in a state of equilibrium while enhancing human well-being. The main objective is to reduce energy consumption, promote conservation and preservation of natural ecosystems in urban areas, reducing environmental degradation and harm while developing infrastructure that helps to sustain the environment. For this article greening cities will thus include efforts undertaken by various stakeholders in cities with the objective of conserving green spaces and establishing infrastructure that co-exists with the natural environment. In simple terms green cities are characterised by green buildings, green transportation, zero waste, clean air, green economy as well as access to nature. Copenhagen is one city that has made great strides in the greening pursuit. For the city 90 % of building waste is reused (zero litter), 36 % of commuters and 50 % of the citizens cycle to work or to school (green

transport), 96 % of the residents live within 15 min walk from a recreational area (access to nature), 24 % was cut in carbon emission between 2005 and 2012 (clean air) [7]. Efforts to green Copenhagen city have not only been the responsibility of the local authorities, rather the successful story has been narrated because the city has managed to place public-private partnerships at the centre of its greening approach.

The green agenda in cities is about ensuring the natural ecosystems of land, water and air are part of the city and its management with the aim of improving the sustainability of ecosystems [14]. Yet, to achieve this, systems' dynamics seems to be a promising tool. Traditionally a "silo approach" has been considered wherein urban development issues have been considered as independent components that are detached from other systems. For example, the transport issues are considered in isolation from the waste management and energy sector yet there is a relationship between all these. Systems dynamics becomes a panacea to solve the complex environmental problems in such a context because the approach views reality from a holistic point of view where the complex web of interrelated components that influence each other and also themselves are treated as causal closed chains or loops. Systems dynamic is a concept that considers the behaviour of a system together with the understanding of the system in terms of the underlying flows that relate to other systems. This way, system dynamics modelling can be a tool for understanding system behaviour over extended periods since no one system can be treated in isolation due to the way systems interlock just like the links of a chain. System dynamics, in short, highlights that, if one wants to fix an issue he is obliged to first understand the whole system. This understanding is made possible because the identification of integrating flows in all systems helps in understanding the interactions that will ultimately contribute to the formulation of policies that affect the whole urban setting. Although the literature on system dynamics modelling is very rich with applications in many fields [8, 15], not many papers on developing system dynamics models were published so far. As urban environment models in system dynamics are extremely complex if an area is subdivided in many dynamic and interacting areas, managing complexity of the environmental network interactions is essential [16]. Environmental problems can be understood through system dynamics simulation. Systems approach to quantification of environmental problems allows better understanding of factors contributing to environmental degradation and more systematic assessment of various measures to solve the problem. No doubt, the urban environmental challenge facing African cities right now is the increasing stress on the environment and little time and resources to rectify the emerging problems [12]. With the heavily populated urban centres, natural bioremediation becomes increasingly

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fractious. Investment to limit the environmental footprint of the urban processes is required. Unfortunately most African governments are focussing on so many pressing and urgent challenges (health, unemployment and inequality). This is a daunting task in improving urban environments given the opportunity cost.

African cities and the green agenda: a review

As things stand, the expansion of African cities will be difficult to manage even with the best urban governance. Urban poverty is the most critical issue facing African cities at the moment. It is also often understated statistically and thus not likely to be addressed in its full dimensions [2]. One of the major consequences of the rapid urbanisation process has been the burgeoning supply of job seekers in both the modern (formal) and traditional (informal) sectors of the urban economy [17]. In most African countries, the supply of workers far outstrips the demand and the result is awfully high rates of unemployment and underemployment in African cities. Urban areas have become pools of squalid, sordid and morbid eyesores for majority of the people who live in absolute poverty. South Africa and Malawi for example use national-level poverty lines which indicate that poverty is lower within cities due to the overall level of amenities. National poverty lines are often defined as household consumption under $1 or $2 a day and yet these thresholds do not take into account a wide range of costs and hazards that urban residents face. For example, while rural residents can typically collect fuels, building materials, some foods, water, and a host of other basic needs from their surroundings, urban residents must pay to access all these.

In most African cities the poor are marginalised and are left with little option but to operate in the administrative or illegal margins in what has been referred to by UN Habitat as 'self-help' urbanisation. Too often African cities suffer from unplanned sprawl [6]. The region has the highest proportion of city dwellers in informal settlements and living in dire poverty in the world. The magnitude and severity of slum and informal settlements are significant indicators for the troubled African urban environment. The living standards in slum areas are agonisingly below the acceptable level. Overall, the water, soil and air qualities are greatly depreciated. Unlike other already developed and developing countries in the Asia region, in Africa, city growth has been through consistent underinvestment in agriculture leading to low productivity gains and low standards of living in rural areas forcing rural–urban migration hence city growth not credited to economic growth and prosperity. Most urban municipalities lack the financial autonomy and capacity to bankroll any initiatives they deem fit for implementation in their jurisdictions. This is also in light of the fact highlighted by [2] that unlike all other regions of the world,

urbanisation in Africa has not contributed, through economies of scale and value-adding production chains, to overall growth in GDP. Finance and lack thereof has played a part in the limited success of the green agenda in African cities. Little research hence has been done and some of the mitigatory measures taken are those which are 'readily available'. This is more pronounced because of inappropriate, unrealistic planning and building regulations, impractical planning theory and imported notions of urban aesthetics which do not reflect the needs of public authorities and the population, as well as current institutional capacities. Many local governments lack the capacity to fulfil their mandate in terms of human resources. This dire lack of skills and qualified personnel coupled with limited manpower can be attributed to Addis Ababa's and Harare's failed urban forestation in which the exotic trees which were planted without any professional advice are facing several problems detrimental to their survival (cf. [4, 9]). The lack of municipality's capacity means that even when better policies are designed, they are difficult to implement at the scale necessary.

Politics of the day is perhaps the most critical of the above issues in understanding the state of African cities especially looking at urban environmental greening which has not been prioritised by politicians. According to the Economist Intelligence Unit [6] one reason why environmental issues are often not prioritised by political elites is that, by definition, sustainability is a long-term issue, requiring investment now for a longer-term benefit in a resource constrained environment. With people struggling to meet basic needs of food, shelter, and water, those sorts of immediate priorities trump longer-term ones. In cases where politicians have been saved from this dilemma for example through external aid, the African governments have shown commitment to greening programmes for example Egypt's Clean Technology Fund (CTF) investment plan. On the whole, the state of African cities is defined by its rapid urbanisation and corollary outcomes. A systems approach in city greening efforts helps in holistically handling a multiplicity of factors that can determine the success or failure of efforts like city greening. A number of greening initiatives have been done by some Africa cities.

Case of five cities in Africa

In this section we assess the greening efforts of the cities of Harare, Johannesburg, Nairobi, Addis Ababa and Cairo. These are megacities in Africa whose settings and contexts may proffer comparable evidence of contrasts and comparison.

Harare

Harare is the capital city of Zimbabwe with an estimated population of 2.8 million in its metropolitan area [9]. Water, waste and sanitation standards are generally dropping in

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Harare. The low consumption of electricity and water is probably due to their erratic supply. The city's water source is located downstream of the populated area which makes it prone to water pollution. In recent years especially after the economic meltdown (from 1997 to 2008), there has been an increase in the problem of solid waste disposal where most open spaces in the urban area are now dump sites. The local authorities could not provide this facility which they did in the past and had to outsource three companies to carry out the waste removal [9]. Just like in Copenhagen, the communities have engaged in waste management in their respect areas due to awareness efforts made by the local authorities. The government through Environmental Management Agency (EMA) has also made a stance on plastic bags which were once for free and are now being sold to minimize their littering the environment. Environmental bodies like EMA have also come up with a 'follow your waste' strategy requiring local companies that produce goods and services which generate litter to follow up and make efforts to clean the waste generated by their products. The private sector (ABC bank, Goldtech electronics, First Pack among others) have also come in and provided bins to be placed in public places. Volunteer cleaners have also helped address this issue through a number of clean up campaigns in many of Zimbabwe's urban centres.

Efforts to green the city through tree planting, maintaining open spaces and other natural ecosystems have been conspicuous with Harare with efforts being spearheaded by the local authorities and the private sector as well. The government of Zimbabwe has emphasised on the plantation of trees through a national tree planting day held the first week of every December and several organisations (NGOs, local authorities as well as individuals) participate in this annual event. Attempts have been made by Harare City Council since the 1970s to plant more trees in the central areas of the city and to boulevard the main highways out of town. A number of roads leading into the central business district of Harare are tree lined with Jacarandas and Australian bottlebrush trees with the north eastern part of the city centre having the densest concentration of trees. In 2010 Harare embarked on a programme to re-green the city. This was after a realisation on the part of the local authorities that the bulk of the city greenline was ageing and required urgent replacing. Trees were planted on parking bays along street pavements. The government both at central and local level have promoted the conservation of green spaces through statutory plans. An example is the Kopje Market Square Local Priority Plan No. 17 that emphasis the need to preserve the Harare Kopje in its natural state with all the trees and vegetation being undisturbed. Urban greening has not only been a responsibility of the local authorities in Harare but some initiatives have

been taken by some property owners who have developed a culture of planting trees on their sites. Moreover, some NGOs such as COSMO have spearheaded the conservation of wetlands in te city of noteworthy Monavale vlei and Marlborough vlei, though there have been some conflicts with some locals who would rather have the wetlands converted into residential areas. The Sunday Mail notes that there is increasing greening culture by individuals in Harare which shows the increase in awareness towards green cities.

Greening efforts have also been observed in infrastructure development in Harare, which is mostly done by the private sector. Since most of the energy is consumed in built environment, efforts have been made to construct buildings that minimise environmental degradation. Eastgate Centre in Harare constructed by Old Mutual is a green building that mimics an anthill that makes use of natural ventilation and lighting thus reducing carbon emission and overall cutting costs of air conditioning and lighting. The building also has overhangs where vegetation is grown. The other building is one housing Ernst and Young offices (Angwa city) which incorporated rooftop gardening. Street and traffic lights are increasingly being replaced with solar powered lights in Harare which is an indication of a city that is transforming and adopting green initiatives through use of environmentally friendly solar energy.

Green tourism, despite all the statistics and research to support it, is still being carried out at lower levels in Zimbabwe and also there is still yet to be a documented framework on green hospitality by the Zimbabwe Tourism Authority (ZTA) [21]. In addition, because of human disturbances, rivers like Manyame which used to have perennial flow have changed since now most of the water is now sewage as evidenced by the proliferation of water hyacinth. There have been efforts by the African Development Bank (AfDB) and a recent US$144 million loan from China to improve water inflows into businesses and homes. There have also been efforts to refurbish the cities major sewage treatment plants, Prince Edward and Morton Jeffrey waterworks where US$78 million has been secured for the project.

A lot has also been done in the transport sector in efforts to green the city of Harare. In Harare, commuter omnibuses (popularly referred to as kombis) have been blamed for traffic congestion and the city in an attempt to address this problem created a holding bay a kilometre from the city which is to hold the kombis currently driving into the city centre. This will be complemented by a mass transit system which will bring forth shuttle buses ferrying people into the city centre. They have also changed roads which used to be two way (R Mugabe, Chinhoyi street, Innez terrace and Leopold Takawira) into one ways to increase traffic flow. Also in a move to increase smooth flow of traffic

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they have installed 'intelligent' robots (King George and Baines avenue) which adjust time with differing traffic flows to ensure smooth traffic movement. With the aid of Old mutual a private company, the city of Harare has also constructed Harare drive as a ring road to limit traffic passing through the already congested city centre. Shopping centre like Westgate, Gleneagles and Avondale and office parks (Arundel Business Park, Mt Pleasant Business Park) have also been put in place to limit the pressure on the central business district. From the colonial days, industrial clustering has been used to improve the impact of green manufacturing practices in industry by enabling reduced energy and water consumption levels, solid waste and wastewater minimisation strategies and enabling increased participation in corporate social responsibility activities. For instance, the plan for industrial clustering was implemented in Old Ardbennie Industrial area in Waterfalls.

Johannesburg

Johannesburg is South Africa's most populous city, with around 3.9 million people. It is located in the Gauteng Province, which has a total population of over 10 million. Water, waste and sanitation standards are generally better than in many of the other cities in Africa. Though it has high consumption of electricity and water, it makes up on consumption with consistently strong environmental policies and good governance with strong local structures in place. In an attempt of greening the electricity sector, the city of Johannesburg is keen to promote solar power as a way to reduce carbon emissions and cut electricity costs. The authorities with funding from the Danish Development Agency have spent US\$1.2 million installing solar water heaters in 700 low cost homes in Cosmo City, a housing development. To add on this, the Johannesburg Road Agency has been installing solar power signals at key city intersections since 2009. In addition to saving energy, the signals are not susceptible to power failures, which cause congestion and higher fuel consumption from queuing drivers. The City of Johannesburg is currently implementing a 'Climate Proofing of Urban Communities' Project in 700 Cosmo City low income houses. Climate proofing involves promoting development that reduces the risks of climate change. The project started in July 2008. It involves the installation of Solar Water Heater (SWH) units, as well as the installation of insulated Isoboard ceilings and distribution of Compact fluorescent lamps (CFL) to 700 low-income households in Cosmo City. The project is funded by the Danish International Development Agency (DANIDA) under the auspices of the embassy as part of a R15-million climate change miniprogramme for Johannesburg.

The large population in Johannesburg culminates into large quantities of waste being produced in the city which calls for a consideration of the waste management in the city. Currently, plans are underway to convert landfill gas from several sites into electricity to power city homes. The conversion of landfill gas has the ability to minimise the negative effects of decomposing solid waste that often cause green house gas emission. Furthermore, the parks department has the mandate to maintain and refurbish green spaces and promote environmental projects, such as tree planting, bird watching, litter collection and river cleaning. A number of parks have been developed from wasteland alongside some townships with a view to create a greener environment for residents.

In an attempt to tackle greenhouse gases and increase the air quality, the city has implemented a high-speed train line, the Gautrain, which links downtown Johannesburg to Pretoria and the Rea Vaya bus rapid transit system connecting the densely populated township of Soweto with downtown Johannesburg. The long-term plan is for the Rea Vaya to cover more than 300 km and become a transport option for 80 % of the city's residents. Officials say it is the single biggest initiative to tackle greenhouse gases in the city claiming that a switch 15 % of Johannesburg's car users to Rea Vaya buses, which run on low-sulphur diesel, instead of using their private vehicles, the city would cut its CO_2 emissions by 1.6 million tonnes by 2020 [6].

One other biggest urban environmental challenge for the city's water department is the looming threat of acid mine drainage. The national Department of Water Affairs has plans to install a US\$25 million pump to divert acid mine water from the city's water sources. In its Growth and Development Strategy the city highlights plans and the need to harvest rain water. In 2008 the water department committed US\$139 million in its capital budget to improving water infrastructure and sewer networks. Work is still ongoing and also the city promotes proper sanitation at water events such as the annual Water Festival held in April. In 2003 the city launched its Air Quality Management Plan having been updated forms part of the 2040 Growth Development Strategy launched in 2011. The proposal is for the additions of five air quality monitoring stations to the existing six. Officials are also in the process of establishing an air pollution control bylaw that will set acceptable industry and commercial emission levels.

Addis Ababa

Addis Ababa has an administrative area covering 500 km^2 with an estimated population of 2.7 million which is expected to grow by over 60 % [18] and is one of the densest cities in Africa. Addis Ababa was founded by the Ethiopian Emperor Menelik II in 1886, unlike most African cities, it has no colonial heritage. Though eucalyptus forests on the Entoto Mountains surrounding the city are protected and provide a watershed, there is limited public green space at 37 square metres per person in the city [4]. The city's master plan calls for reforestation of bordering

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mountains, the revitalisation of existing city parks and the creation of new ones. The most significant new green space will be a pedestrian linear park winding some 5 km through the city centre [6].

Electricity consumption per capita is among the lowest in Africa at 1.8 gigajoules and CO_2 emissions per capita from electricity consumption are 16 kg per capita which is also relatively low. Close to 90 % of Addis Ababa's electricity is produced from renewable energy sources, the bulk of which is hydropower. There is however need to increase the use of solar energy which is abundant in the city.

According to official figures, an estimated 18 % of the city population lives in informal settlements but however, depending on definitions of informal settlements, other sources put the figure higher [6]. In Addis there is the integration of the poor unlike most African cities. The city's most important initiatives are an attempt by the Ethiopian Institute of Architecture, Building Construction and City Development (EiABC) to develop green building codes. The city has received support from Swiss Federal Institute for Technology and the EiABC has been able to contract local private developers to design cheap and green building materials with particular emphasis on substituting Chinese-imported steel and glass with local stone, wood and adobe (a mix of sand, clay and straw) to cut building costs by up to a third, and raise environmental and aesthetic standards.

The city's public transport system relies heavily on Anbessa, the state-owned bus companycomplemented by private minibuses. Addis benefits from a relatively cohesive culture, with income disparity lower than in many other African cities. This means that the city's office workers are more likely to travel to work on public transport than in other African cities. For example, some 40 % of commuters use the Anbessa buses. By 2020, with population growth, Anbessa estimates it will be serving 6 million customers in and around Addis Ababa. In addition, Addis Ababa does have a relatively sophisticated traffic management system, but has yet to introduce any car-pooling lanes, no-car days or other congestion-reduction initiatives and has been failing to encourage citizens to take greener forms of transport. The Ethiopian government acknowledges the problem and has plans to gradually replace automobiles in the city with electric-powered cars, using tax incentives. Completion of the Chinese-backed Gotera Interchange on the city's planned ring road has eased congestion and additional plans are ongoing to build a light rail line, estimated to transport 20,000 passengers a day [4].

The government has intentions to limit the use of plastic in local packaging and increase composting, in an effort to reduce the amount of waste destined for landfills which will be complimented by the city opening new landfill sites in the Doro, Dertu- Mojo, Bole and YekaAbado districts distributed across the city. Recycling remains limited but is likely to increase with the establishment of central recycling depots for metal and plastic. There is limited citywide waste collection. Instead city neighbourhoods ("kebeles") are responsible for collecting rubbish in partnership with private companies, but collection costs remain high. As for policy Addis Ababa does not encourage proper waste management by citizens and fails to impose measures such as bans on littering and making waste dumping illegal [4]. On the other hand, Addis Ababa fares fairly well in the collection and disposal of special waste as it has facilities to deal with chemical and pharmaceutical waste.

Nairobi

Nairobi has an estimated population of 3.1 million people which is expected to double to 7 million by 2020 [6]. Most of the city's energy is from renewable hydro power though insufficient generation and transmission infrastructure results in the frequent use of diesel-fuelled generators. Nairobi has seen increased utilisation of renewable energy resources with the construction of a wind power plant located in the Ngong Hills 22 km outside Nairobi which was completed in 2010 with six turbines producing up to 5 MW of power. A second phase of the project is expected to bring the total capacity to 11 MW. Green economy is another facet of greening cities and this has been at the fore of the greening initiatives in Nairobi where green jobs have been created. An example is the Climate Change Innovation Centre funded by the World Bank and the Danish government that aims to make Nairobi a centre of green technology while creating 4,600 jobs within five years. Moreover, Nairobi is the world headquarters of UN's environmental and urban planning programmes. The UN campus in Gigiri was overhauled in 2011 with energy neutral offices for 1,200 employees. This includes 6,000 square metres of solar panels. The solar panels that cover the entire roof is a key feature of green buildings that help to limit energy use in buildings.

Growth in Nairobi is haphazard; the management of waste, sewage and water are urgent challenges. In an attempt to save forests, the Kenya Wildlife service in partnership with private companies is managing the Green Line Project which is an initiative to plant forest along 30 km of the perimeter of Nairobi National Park in the south of the city with the hope of creating a visible boundary between the park and surrounding new developments, and to discourage lobbying by land developers to cut slices off the park. The tree planting is also part of a wider initiative led by Nobel Prize winner Wangari Mathai to plant new trees throughout Nairobi to improve water catchment and biodiversity [6].

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The three rivers that meet in Nairobi Ngong, Mathare and Nairobi Rivers are clogged with waste and during rains the rivers are thick with human excrement washed out of informal settlements. The Nairobi River Basin initiative, run by the Kenya Ministry of Environment, aims to recover the rivers, providing clear flow through the city, and increasing land and recreational value along the river bank. Planners hope to have reclaimed city centre sections of the river before 2020. Some progress has been made clearing the Nairobi River around the municipal dump at Dandora in the east of the city. Nairobi is incorporating new technology to help track environmental conditions with a new government online data portal that allows Kenyans to identify spending on water and energy, and to keep track of the state of the hydropower dams that are the source of most of the city's energy.

In the transport sector, a ring road planned in the 1970's is being constructed and an eight-lane superhighway linking Nairobi to the neighbouring town of Thika which also includes underpasses and footpaths. There is still more that has to be done in the transport sector especially when one considers the ill-developed non-motorised transport infrastructure in Nairobi that makes it very difficult for pedestrians and cyclists to move in the city.

Cairo

Greater Cairo has a population estimated at 20 million people. It comprises the governorates of Cairo, Giza and Qalyubia. An estimated 7.1 million inhabitants occupy the 370 km^2 area within Cairo Governorate with an estimated 19,100 people per square kilometre. It is estimated that almost all households in Cairo have access to electricity, but the city fares less well in curbing electricity consumption. On average, Cairo consumes 8.0 gigajoules of electricity per capita but despite this high electricity consumption, CO2 emissions from electricity are an estimated 477 kg per capita [6]. The Supreme Council of Energy in 2007 ratified a plan to use renewable energy for 20 % of the nation's needs by 2020. This plan relies mainly on the use of solar and wind energy, with 12 % coming from wind mills and wind farms and 8 % from hydro-power. Prior to this development, from 1991 to 2005, in an effort to encourage the use of wind energy, a joint project between the Egyptian New and Renewable Energy Authority (NREA) and Denmark's Risø National Laboratory created a Wind Atlas for Egypt pinpointing the prime locations for wind farms and wind mills to be used for the establishment of these wind farms. Egypt announced a US$350 million Clean Technology Fund (CTF) investment plan in April 2011 that involves a combination of renewable energy production, clean transport and solid waste management projects [6]. In addition, the government has plans construct three pilot waste-to-energy plants in partnership with a private company [5]. The Al-Darrasa site, located outside the boundary of historic Old Cairo, was used as a place for dumping debris and rubble from the city for centuries but in 2005 inauguration of the Al-Azhar Park, a 30-ha development in Al-Darrasa changed this poor waste management and has contributed to improving the city's air quality.

The government has made great strides in waste management as is evident from the government's successful transferring of 15 million cubic metres of accumulated municipal waste from the residential areas of greater Cairo to controlled dumping sites, according to the Egyptian Environmental Affairs Agency. Furthermore, the private sector has contributed to the efforts made by the Egyptian government in managing waste in Cairo. For example, the initiatives by a German government agency, GIZ, which is carrying out a project to improve waste management in poor areas of Khanka and Khossos in Greater Cairo, have made a difference in improving the city's landscape. Another waste management initiative with a grant of US$5.3 million from The Bill and Melinda Gates Foundation is a project for an analysis of the current system for waste collection, segregation and recycling, and the development of a new solid waste management strategy that stresses the role of the informal sector in waste management. Waste remains a challenge in Cairo where approximately 60 % of solid waste is managed by formal and informal waste collections, disposal or recycling with the rest being dumped on the streets or at illegal dumpsites.

A major programme is under way to improve traffic congestion and reduce polluting emissions from public transport vehicles. The work funded by the World Bank and the multi-donor Clean Technology Fund is being carried out through two schemes – the Egypt Urban Transport Infrastructure Development Project and the Carbon Finance Vehicle Scrapping and Recycling Programme. The government has also spent US$1.2 billion to improve air quality in Greater Cairo between 2006 and 2010 which shows the government's commitment to ensure clean air in Cairo. The several projects involved in the programme, included moving polluting industries out of populated areas, increasing waste collections in informal areas (and thereby reducing waste burning in informal settlements), tree planting and improving Greater Cairo's network of air monitoring stations [6]. The government has introduced fines for the burning of rice husks, which contributes to air pollution in the autumn after the harvest and have provided an alternative of several hundred special compressors to farmers for disposing of the husks. Although waste management has remained an issue in Cairo some efforts have been made by the informal sector as well to manage solid waste that is collected and reused with the aim of attaining a zero-litter city.

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The urban transport project includes the provision of 1,100 new fuel-efficient buses to replace the old fleet, the construction of six bus rapid transit corridors and improvements to the traffic management system. To compliment this, the government intends to promote the use of the river for commercial transport as an alternative to using roads and thereby reducing traffic congestion. Plans include funding a management system to help coordinate river transport, and a committee has been established at the national level to improve safety for river travel. The government has also launched a pilot scheme in an area of Greater Cairo to encourage residents to ride bicycles, the installation of bicycle racks and the sale of bicycles at discounted prices. The promotion of non-motorised transport is a key component that characterise green cities in the developed world as is the case in Copenhagen where 36 % of commuters and 55 % of the city's population cycle to work or school/college. There are efforts by the government to limit vehicle emissions by converting government cars from petrol to compressed natural gas complemented by the introduction of unleaded petrol and creating a national programme for vehicle testing and rehabilitating old taxis which have high fuel consumption rates.

The national government has taken action against water pollution mainly targeted on the Nile River by adopting 12 programmes for the protection of the river. The measures include preventing the flow of industrial effluents and sanitary drainage into the Nile, managing waste from Nile river vessels; treatment of agricultural waste; solid waste management; periodic monitoring of water cleanliness; and developing a water quality database [6]. Five plants have been established to receive waste from river cruisers and safely dispose of the waste in the sanitary drainage networks. Greening the city is also made possible when residents have access to nature hence the action by the government to combat the pollution of Nile River helps to ensure the river flows in its natural state thus increasing the natural ecosystems in the city.

Discussion and policy options

Cities in Africa are vulnerable to systemic shocks which are strong impacts affecting substantial parts or all of an urban system (nationally or internationally), rather than having just isolated (e.g., sector-based or merely local) impacts. These shocks have the potential to threaten the sustainability and survival of the urban system as a whole. The rate and extent of technological advancements and globalization have substantially increased their likelihood, geographic scope and potential magnitudes for example the global economic recession of 2008/09, while others have longer gestation periods, like climate change, the effects of which may be no less severe and will be much longer lasting. System dynamics can be used to solve these systematic shocks in African cities and avoid after effects which in the African context often leads to more challenges and problems.

A synthesis of the case studies provided in this discourse shows the greening efforts yet by the cities and there are many determinant factors to trend. To a great extent, South African cities have successful embraced city greening. This can be attributed to the aspect of good governance after building on from the political resources accumulated after the end the apartheid government in 1994. These political resources lead to strong environmental policies which include strategies, codes and plans to monitor and improve the urban environment which have also been a factor in the success of greening in South Africa's cities. One of the cities with the lowest green ratio, Addis Ababa has no colonial heritage and still maturing governance. Funding is an important factor determining the success or failure of city greening efforts. In a number of cities some well-known successful projects, have effectively received funding from some from external aid by donor agencies and a few from government funding. Financing has been important for the successful greening of cities. For example, Johannesburg received US$5.3 million from The Bill and Melinda Gates Foundation and US$1.2 million from Danish Development Agency; Cairo received US$350 million Clean Technology Fund (CTF) and US$5.3 million from The Bill and Melinda Gates Foundation [6].

For an initiative to be successful in Africa like elsewhere, there is first need to understand the society in which it is to be implemented and incorporate it. Good practices can be taken from Egypt where informal sector is working on facilitating the formalising process [5]. This has made it easier for policies to be implemented especially the brown agenda policies. Addis Ababa has also incorporated the poor along with the rich in dealing with greening issues and this can be credited for the success the greening agenda in the housing sector. The poor make up the majority of populations of the cities, and the quality of the urban economy and environment are shaped by people with middle to low incomes. Given the numbers and needs of the lower income population, it is imperative that they play a central role in planning and implementing urban greening as shown by the initiatives of Addis Ababa Ethiopian and Institute of Architecture, Building Construction and City Development (EiABC) of developing green building codes. Attitudes towards the environment and socio-demographic factors such as age, education determine the success of city greening. These determinants are mainly through the interaction of the households and the environments (i.e. household behaviour and water use, waste generation and recycling and willingness to pay for "environmental" goods). Strengthening people and open space interaction has been a practice

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that has made the greening a success story in cities of South Africa. To achieve this there are capacity building and empowerment programmes and environmental theme days (Water Week, Wetlands Day, Arbor Week, and Environment Week) [3]. It is critical that a part of any urban greening investment goes toward building local institutional capacity.

Government participation and support is important for the success of city greening initiatives. In Africa, government is largely the financing organ to major projects and programmes. Although national governments are not usually involved in the specifics of urban greening programs, they can greatly facilitate country-wide goal attainment by setting policy objectives and standards, and by providing institutional and network support to regional and local governments that do not have the funds to develop such resources on their own [10]. By also integrating urban greening into national environmental plans and performing evaluations, the central government can monitor progress made in urban greening throughout the country. Required often, is a robust legal framework. Normally, laws and regulations have to be enacted at various levels of government, and designed that they complement each other rather than have overlaps and gaps. Regarding laws and regulations, the more developed cities in South Africa have tend to be more active, while in the generality of most sub-Saharan Africa this has not be the case. South African cities have city departments, often under the direction of a city council, to directly oversee and implement policies at the urban level [6].

Review
Missing in existing literature on African cities is a critical review of the systems approach in solvingthe issues of these all-important locales. Offered in this short paper, is a review of aspects of complexity andsystems approach in the definition of environmental parameters of development in African cities.

Conclusion
Urban environmental challenges in Africa are increasingly becoming the centre of focus of African governments and philanthropist. Conventional greening approaches, by themselves, will prove ineffective in addressing these challenges and will, in fact, just treat the symptoms. If cities are to be sustainable in the next fifty years, there is need for a change in the greening approach. Given the much localised characteristics of countries, cities and settlements, it is worth stressing that in the design of any intervention, a strongly situational approach is essential. Urban environments in African cities should be prepared for the expected substantial growth. For urban authorities to fully deal with the urban environmental challenges, environmental impact assessment procedures should be followed

and improved cross-sectoral linkages and joint enforcement of environmental laws and standards should occur. Though this sounds complex, the use of system dynamics in trying to understand all the factors that come into play and how they affect each other will go a long way in ensuring policies fully address issues raised during assessments. Because of the dynamism of African cities, systems dynamics can help solve the African urban environmental problems through system stability. The urban challenges in Africa can be attributed to ignoring (long run) feedback which has led to unintended consequences. System dynamics will help solve this by conceptualising a more stable system whose long run effects can be assessed.

Authors' contribution
IC initiated the study idea and made the draft. SD enhanced the literature review. AM reworked the manuscript and enhanced the discussion. All the authors proofread the manuscript and improved the paperin terms of argumentation and re-conceptualisation.

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References
1. African Development Bank (2011) Africa in 50 years' Time-The Road Towards Inclusive Growth. African Development Bank Group, Tunis
2. Commins S (2011) Urban Fragility and Security in Africa. Africa Security Brief No. 12. Africa Center for Strategic Studies, Washington
3. Conca K (2004) Environmental governance after Johannesburg: from stalled legalization to environmental human rights? J Int Law Int Relat 1(1–2):121–138
4. Dubbale DA, Tsutsumi J, Bendewald MJ (2010) Urban environmental challenges in developing cities: the case of Ethiopian capital Addis Ababa. World Acad Sci Eng Technol 42:397–402
5. Duquennois, A. N., and Newman, P., 2009. Linking the Green and Brown Agendas: A Case Study on Cairo, Egypt,Global Report on Human Settlements 2009: http://www.unhabitat.org/grhs/2009, [Accessed 5 November 2013]
6. Economist Intelligence Unit (2011) African Green City Index: Assessing the Environmental Performance of Africa's Major Cities. Siemens AG, Munich, Germany
7. European Union (2014). Copenhagen - European Green Capital 2014. URL: http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2012/07/ENV-13-004_Copenhagen_EN_final_webres.pdf. (Accessed 14 January 2015)
8. Forrester JW (2009) Some Basic Concepts in System Dynamics. Sloan School of Management Massachusetts Institute of Technology, Massachusetts
9. Herald, 2010, October 14. The Herald. Retrieved from Let's join hands to green Harare: http://www.herald.co.zw/lets-join-hands-to-green-harare, [Accessed 7 November 2013].
10. Inter-American Development Bank. (1997) Good Practices for Urban Greening. Inter-American Development Bank, Washington, D.C
11. Ibrahim Foundation MO (2013) Africa Ahead: The Next 50 Years. 2013 Ibrahim Forum Facts and Figures (pp. 3–112). MO Ibrahim foundation, Addis Ababa
12. Mpofu TP (2013) Environmental challenges of urbanization: a case study for open green space management. Res J Agric Environ Manag 2(4):105–110
13. OECD., 2013. OECD Studies on Environmental Policy and Household Behaviour. Greening Household Behaviour: Overview from the 2011 Survey: http://dx.doi.org/10.1787/9789264181373-en, [Accessed 7 November 2013].
14. Pickett ST, McGrath B, Cadenasso M, Felson AJ (2014) Ecological resilience and resilient cities. Build Res Inf 42(2):143–157

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15. Silvaa J, Kernaghanb S, Luquec A (2012) A systems approach to meeting the challenges of urban climate change. Int J Urban Sustain Dev 2012:1–12
16. The Cities Alliance (2007) Liveable Cities: The Benefits of Urban Environmental Planning. The Cities Alliance, Washington
17. Todaro MP (1997) Urbanization, Unemployment, and Migration in Africa: Theory and Policy. In: Todaro MP (ed) Economic Development (p. Chapter 8). Longman, New York and London
18. UN-HABITAT (2010) The State of African Cities 2010 Governance, Inequality and Urban Land Markets. UN-HABITAT, Nairobi
19. UN-HABITAT (2012) State of the world's Cities 2012/2013 Prosperity of Cities. UN-HABITAT, Nairobi
20. Young E (2013) Looking Beyond the Obvious: Globalization and new Opportunities for Growth. Ernst and Young, London
21. Zengeni N, Zengeni DM, Muzambi S (2013) Hoteliers' perceptions of the impacts of green tourism on hotel operating costs in Zimbabwe: the case of selected Harare hotels. Aust J Bus Manag Res 2(11):64–73