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Hallmark of a Resilient City: Adoption of Green Infrastructure in African Cities

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Abstract

Dynamic urbanization of African cities has created development trajectories that face systemic challenges in the provision of sustainable and ecologically resilient urban environments. The specific challenges include extensive unregulated growth with informal settlements reflecting poor service levels and high poverty indices, inadequacy in provision of basic services in health, water, housing, transport and communication infrastructure, high reliance on biomass fuels, exposure to environmental stress and implausible climate change coping and mitigation mechanisms among others. Review of extensive literature and synthesis of existing bodies of knowledge on the ecological and management perspectives of urban environments revealed many gaps and understanding of urban transformation processes. The purpose of this review was to contextualize credible pathways for optimization of both ecosystem goods and services from green urban landscapes (Green infrastructure) and non-green infrastructure to ensure sustainable and ecologically resilient urban environments. Attempts were made to rationalize and validate through discussions the benefits of managed urban ecosystems for African cities. On the basis of the evidence from the literature, it is concluded that urban development trajectories that do not embrace multifaceted approaches that deliberately retain and maintain green infrastructure in the urban environment may not be cost-effective. It is recommended that systematic integration of urban forestry concepts in urban planning that involves communities, local and national governments, business entrepreneurs and public and private research institutions provides tenable frameworks for addressing current and future challenges of urbanization in Africa.

Keywords

Resilient Cities, Green Infrastructure, African Urbanization, Ecosystem Goods and Services, Environmental Externalities, Sustainable Urban

1. Introduction

A casual inspection and coherent synthesis of literature on the urbanization trajectories of African cities and development pathways particularly in the context of opportunities and multi-faceted challenges of dynamic transition to urbanization reveals the following salient features:

1). Extensive unregulated urban growth associated with informal settlements with poor service levels (Anderson et al., 2013, Pieterse, 2006, 2010), urban population in Kenya was 27.51% of the total population in 2019 (1960-2019 World Bank Data).

2). High reliance on biomass fuels (Boardi et al., 2005, Anderson et al., 2013, Cilliers et al., 2013); case of Lilongwe city in Malawi, Maputo (Mozampique), peri-urban ecosystems significantly overutilized, Charcoal supplied from Gaza and Inhambane 200 - 500 km from the capital city of Mozampique.

3). Substantially lower per capita incomes (GDP per capita in Kenya was 1816.5 USD in 2019, 1122.1 USD for Tanzania in 2019, and Uganda 776.8 USD in 2019).

4). Exposure of cities to environmental stresses associated with poor climate change coping and mitigation mechanisms.

5). Urban development trajectories that face systemic multiscale challenges impeding the ability to offer exclusively sustainable ecological habitats, Rowcroft & Black (2017) International Institute for Sustainable Development, http://prairieclimatecentre.ca/, https://openknowledge.worldbank.org/.

The factors that explain the dynamic transition path to urbanization of African cities are not completely clear. However, Findlay & Anne (1987), Drakakis-Smith (1993), Kessides (2006) and Alexandra & Chiotha (2019) have pointed out that the rapid urbanization of African cities is attributed to a shift in the balance between rural and urban economies. The differential growth rate of rural and urban economies due to colonial policies and development strategies that created African cities as important hubs of commerce, industrial activities, government and private sector activities as well as national and local government administrative centres, has continued to provide the natural attraction of cities as the rational settling place for the population. Growth of employment opportunities in the non-agricultural sector particularly in the private sector has often remained higher in the cities compared to that in the traditional agricultural sector causing drifting of rural migrants to cities. The rural migrant's contribution to urban population growth in Kenya is 64% whereas that of Tanzania and Tunisia is 85% and 77% respectively. The other factors that will continue to be responsible for rapid urban growth in the future include high fertility rates that have remained unchanged at 6.3 to 6.6 in the last 25 years, and a very high pro-

portion of children and youth in the age bracket of 15 years and younger in the general population (Findlay & Anne, 1987).

The East African cities with a strong European colonial influence show the presence of large urban green spaces that acted as a corridor developed as golf courses, parks and cricket fields. These cordons *sanitaires* are typically exemplified by Nairobi City, the capital of Kenya, Mombasa and to some extent smaller cities of Nakuru, Eldoret and Kisumu. The spatial geographical spaces created to separate the colonized from the colonizers were inherited by the African elites and bureaucrats after independence and serve as a strong reminder of the genesis of the social and economic problems of contemporary African cities.

In the context of the dynamic transition path to urbanization of African cities the current trend witnessed in the influx of rural populations to urban areas in Africa is unlikely to be arrested in the near future. This means that the differential economic growth rates between the rural areas and urban enclaves will continue to be accentuated. This is expected to spur the growth of informal settlements in the urban areas, widen gender disparity in ownership of urban environment resource assets, increase risks and vulnerability to climate change induced hazards and dwindle the capacity to adapt and mitigate the adverse impacts of climate change. The rapid urbanization expansion of African cities and the transformative processes of ecosystem dynamics of urban environments and the nature and integrity of life support benefits of urban ecosystems are not well understood. There is no coherent synthesis of information arising from a theoretical and conceptual contextualization of the application of ecosystem concepts in the search for credible pathways for optimization of ecosystem goods and services for urban environments in Africa. The purpose of this article is to provide a contextualization of bodies of knowledge of what we know about the management challenges of African cities with a view to putting on the spotlight what we do not know for further research in the search for credible pathways for optimization of ecosystem goods and services from green and non-green urban ecosystems. A deliberate attempt is made to elucidate the benefits of managed urban ecosystems for Africa.

2. Methodology

Content analysis techniques and systematic literature coherence and incoherence approaches were used. The subjects and concepts considered included; green infrastructure for cities, sustainable urban transitions, environmental assets and ecosystem services, African urbanization trajectories, environmental and health implications of African cities, peri-urban and urban resource concepts and conceptual frameworks for multifunctionality in green infrastructure planning for urban areas, typology of urban vulnerability under rapid urbanization among others. Theoretical concepts such as sustainability, resilience and ecosystem goods and services that have gained significance in ecological litera-

ture as well as typological conceptual frameworks were carefully examined within the context of provision of environmental services in urban environments in developed European and American cities with extrapolated relevance for the African cities.

3. Results and Discussion

3.1. African Traditional Urban Trajectories

Africa is the fastest urbanizing continent in the world. Demographic forecasts indicate that the greatest demographic pressure will occur in the East African cities of Nairobi, Dar es Salaam and Mombasa whose urban population is expected to grow between 2.5% and 4% in the period 2020-2050. The current urban populations of Nairobi, Dar es Salaam and Mombasa are of the order of 4.7, 4.3 and 3.5 million respectively. Dar es Salaam which is the second fastest growing city in the world is projected to have an urban population of 13.4 million by 2035 (Teye, 2018).

The East African cities of Nairobi, Mombasa, Kisumu, Kampala and Dar es Salaam attracted a special class of Indian business communities and industrialists as well as African political elites and administrators who have continued to predominate and control city economic activities often causing resentment to the majority of the poor marginalized communities "excluded" from city mainstream economic activities. Table 1 and Table 2 illustrate some of the salient trajectories of African urbanization.

The evidence from Table 1 and Table 2 shows that whereas the rate of urbanization is expected to decline from 1.9% in the 1990-1995 to 1.2% in the 2020-2025, the cities in the more developed economies of Eastern Africa such as Nairobi, Dar es Salaam and Mombasa are projected to have the highest urban expansion rates of the order of 3.7% in the next half decade, a rate six times greater than that projected for the industrialized countries. It is for this reason, that I will attempt to consider the challenges of increasing demographic pressure on urban ecological infrastructure as well as local and national governance frameworks for regulation and provision of ecosystem goods and services and maintenance, sustainability and resilience of African cities.

3.2. Perspectives of Management Challenges and Opportunities of African Cities

While recognizing the similarities in the challenges and opportunities of the dynamic transition to urbanization of African cities it is important to recognize that individual cities reflect unique challenges, implying the need to understand the specific processes that have characterized the physical and ecological transformation of the city environment and the consequent need to evolve relevant and contextualized pathways for addressing such challenges (Anderson et al., 2013; Guneralp et al., 2017; Okoh, 2017; Smit, 2016). The similarities of the challenges and opportunities presented by rapid urbanization also provide

Table 1. Percentage of African population residing in urban areas by region 1990-2025.

REGION	1990	1995	2000	2005	2010	2015	2020	2025
AFRICA	33.9	37.3	40.7	44.0	47.4	50.7	53.9	57.1
EASTERN AFRICA	21.8	25.4	29.0	32.5	36.0	39.6	43.2	46.8
MIDDLE AFRICA	37.8	41.6	45.6	49.5	53.4	57.0	60.4	63.6
WESTERN AFRICA	44.6	47.9	51.2	54.5	57.7	60.7	63.6	66.3
SOUTHERN AFRICA	54.9	58.2	61.3	64.2	66.8	69.3	71.6	73.8
WESTERN AFRICA	32.5	36.1	29.8	43.6	47.3	51.0	54.6	58.0

Source: United Nations (1990), World Urbanization Prospects (New York: United Nations, 1991) pp. 106-109.

Table 2. Average annual growth rate of urban population in Africa by region 1990-2025.

REGION	*1990-95*	*1995-2000*	*2000-05*	*2005-10*	*2010-15*	*2015-20*	*2020-25*
AFRICA	4.94	4.72	4.48	4.21	3,85	3.43	3.05
EASTERN AFRICA	6.41	5.94	5.44	5.12	4.72	4.24	3.74
MIDDLE AFRICA	5.07	4.98	4.83	4.56	4.21	3.75	3.24
NORTHERN AFRICA	3.92	3.66	3.40	3.08	2.71	2.36	2.18
SOUTHERN AFRICA	3.49	3.29	3.04	2.79	2.53	2.26	1.97
WESTERN AFRICA	5.32	5.12	4.90	4.59	4.12	3.62	3.16

Source: United Nations (1990), World Urbanization Prospects (New York: United Nations, 1991) pp. 154-155.

avenues for testing and adopting alternative development pathways not akin to those of the Global North cities. The lessons learned from the industrial European and western cities although exhibiting different urbanization trajectories, nevertheless provide a back drop against which to evaluate the plausibility of tested conceptual theories and models as well as innovations for addressing developmental problems of urban expansion in different African city environments.

In order to manage the multiscale and systemic challenges of dynamic African cities such as spiraling poverty indices of city dwellers in the informal settlements, high degree of reliance on natural resources such as biofuels, susceptibility of informal settlements to risks of natural disasters, undeveloped human capital and large populations essentially marginalized and excluded from mainstream city commerce and a multitude of economic activities that charac-

terize city life; it is necessary to account for their complexity (Guneralp et al., 2017; Adelekan et al., 2015; SANBI, 2014; Parnell & Walawege, 2014). The socio-economic and ecological challenges of urban transformation and ensuing developmental challenges have also been attributed to weak governance structures associated with national and local institutions as well the lack of human capacity to implement relevant policies. There is a diversity of actors with responsibility on urban governance issues. Key urban responsibilities such as city planning, city waste management services, revenue collection, development of city infrastructure as well as regulation of informal city settlements are fragmented amongst many actors (Kessides, 2006; Pieterse, 2013; Grimm et al., 2008). The complex mix of competing and often conflicting interests are exemplified by Nairobi, the capital city of Kenya where unequal distribution of power among a diversity of actors with key responsibilities hampers timely and rational approaches to complex urban issues. These actors include government and political parties, private sector, non-governmental business organizations, civil society, development banks, international donor agencies, traditional leaders and multilateral agencies.

There is no doubt that focused research efforts are necessary to better understand the process of the socio-economic and ecological transformation of African cities in the context of their unique development challenges (United Nations Human Settlement Program, 2014; Murray & Myers, 2017; UNDP & The GovLab, 2020). Indeed, the unique experiences of the African cities as well as their colonial legacies are critical in understanding the dynamic transition to urbanization in the 21st century. This requires exploration of the plausibility of resilience approaches frequently associated with integration of green infrastructure with the physical infrastructure in creating resilient and sustainable cities. The concept of "urban resilience" is an applied normative concept with a paradigmatic link to environmental change and catastrophes. It has found a "niche" in urban development and city planning. The main criticism of this concept as seen by authors such as Pieterse and Parnell (2014) is that the concept of resilience is inherently conservative since the underlying change in system disturbance is towards restoration of the system to its initial condition rather than transformation implying that resilience privileges restoration of urban system relations and social structures rather than their transformation. In this context it is argued that there is a danger of perpetuating social injustices and entrenching cycles of poverty where social-economic relations and unequal power relations, competing and conflicting interests play out. It is in recognition of this idea, that the concept of green infrastructure (GI) and its multiple benefits need to be explored for urban spaces in African cities. The application of the GI concept is based on the "principle that nature and natural processes are deliberately integrated at spatial planning and urban development levels in order to maintain and enhance the delivery of ecosystem services and therefore of ecological, sociological and psychological benefits to human societies" (Hansen & Pauleit, 2014).

Although a high proportion of African urban green areas have frequently remained intact and provide a variety of goods and services to city residents, the planning, retention and maintenance of green infrastructure are frequently haphazard. There is lack of recognition of the vital functions of GI on microclimatic regulation, moderating effects on the urban island effect, the role of urban vegetation in mitigating the impacts of global climate change by acting as carbon sinks, improvement of the quality of air and performing a myriad of other ecosystem functions that have direct beneficial human health impacts as well as critical environmental, social and economic services. The psychosocial value of recreational amenities of urban spaces as well as spiritual, aesthetic and medical benefits have not been measured and documented (Albert & Van Haaren, 2017; Austin, 2014). Studies in western cities have shown that the monetary value of ecosystem services accruing from urban green areas may range from 3,212 USD to 17,772 USD per hectare per year (Elmqvist et al., 2015). These estimates on the economic value of ecosystem services provide a rational basis for investments in protection and maintenance of urban ecological infrastructure.

A casual inspection of spatial planning frameworks and policy constructs that guide development of urban infrastructure of African cities indicate lack of recognition of the causal link between ecological infrastructure and developmental solutions of rapidly expanding urban areas (Pieterse, 2013; Austin, 2014; Davies et al., 2006; Du Toit et al., 2018; Sterzel et al., 2020). City planners have often conceptualized the increasing urban sprawl and associated poverty of the inhabitants of informal settlements coupled with problems of economic growth, gender inequality and social injustice as social issues. This conceptualization has negated the gains from formal planning and regulation of urban open spaces often infiltrated by informal settlements. Again, this explains the systematic marginalization of environmental goods and services considered as externalities arising from colonial legacies associated with the role of urban spaces as corridors separating the rich from the poor (Findlay & Anne, 1987; McGregor et al., 2010). Market inefficiencies resulting in undervaluing the benefits of environmental quality afforded by green urban spaces as carbon sinks (negative externalities), provide opportunities for the citizenry to initiate engagements to provide solutions to issues of externality without government intervention. For example, in an urban location where a production firm emits pollutants that trigger health related risks such as upper respiratory diseases in children and increase the health cost burden, parents of the sick children may consider entering into pollution regulation arrangements in which the parents compensate the firm on the basis of costs incurred on medical health in exchange of reduced levels of pollution. The concept of polluter compensation principle allows the parents to save money while the production firm is compensated for the increased costs associated with emission reductions. In a pollution regulatory system where the parents have the right to ensure an environmental quality that guarantees clean air, then the pollution production firm will be obligated to

compensate the parents for allowing higher levels of pollutant emission. However, in order to correct for negative externalities, taxation principles based on the concept of internalizing externality, to ensure that the value of tax is equivalent to the external environmental damage caused or forfeiture of ecosystem goods and services are crucial in formulating sound tax policies.

Permit markets regulating allowable environmental pollution levels are useful instruments for maintaining desirable levels of environmental quality. The total number of permits allocated to an industry is pegged on the amount of pollution allowed. Emissions trading allow industries that reach their allowable limits of pollution to purchase permits from other firms with higher pollution limits. In spite of the challenges of control of multi-sources of carbon emissions and problems of creating mutually agreeable systems for controlling local, regional and global levels of pollution and potential applications of permit marketing to issues of global warming and climate change, the development of carbon markets as well as econometric methodologies are key to providing efficient and cost-effective solutions. Application of econometric methodologies in the regulation of environmental quality through appropriate taxation regimes, carbon trading and policy frameworks have not been put on the spotlight for the African cities.

The existing inequalities in livelihood support systems of different class structures of African urban inhabitants often embracing the high, medium and low economic classes has significant implications on climate change induced hazards, vulnerabilities and impacts. The majority of the populations in the low economic strata living in informal settlements, least cushioned from these hazards also have no access to basic services, most of them with homes in flood prone areas. Climate change impacts are likely to amplify these social-economic inequalities in limited climate change coping strategies particularly in the poor population groups in the informal settlements. These climate change impacts on the urban poor will significantly erode livelihood assets and negatively affect food security and nutrition. Appropriation and access to as well as use of green infrastructure amongst the urban citizenry has the potential to promote equity, ownership and a sense of belonging. This also enables them to mobilize assets and be active and productive in the management of their living space in conformity to their needs and desires.

3.3. Benefits of Managed Urban Ecosystems for Africa

There is overwhelming evidence that green infrastructure has the potential to mitigate the adverse impacts of climate change such as floods, landscape erosion, environmental pollution and ecosystem degradation (Pauleit et al., 2017; Albert & Van Haaren, 2017; Lopes, 2019; Hansen & Pauleit, 2014; Wright, 2011; Sandström, 2002). Green infrastructure, therefore, remains a plausible pathway for realization of cost-efficient and sustainable livelihood security systems through provision of ecosystem goods and services.

Ordinarily, African cities are faced with the dual challenges of lack of adequate conventional physical infrastructure and loss of ecosystem infrastructure due to fragmentation, excessive consumption and displacement by new urban land use developments. There is, therefore, a strong justification for considerations of green infrastructure development in urban spatial planning of urban ecosystem landscapes in the context of land management as well as climate induced disaster risk management. GI provides a functionalistic approach that emphasizes provision of ecosystem goods and services with socio-economic and ecological benefits. Deliberate considerations of the efficacy of green streets, green urban community gardens, green parks, green play grounds and even green roofs as a climate mitigation strategy may pay dividends in terms of increasing the ecosystem health of urban landscapes. This may be variously achieved by realization of positive hydrologic impacts such as increased rainfall infiltration and deep percolation, reduced surface runoff and soil erosion, reductions of floods in the high informal settlements and increased urban ecosystem diversity. Enhanced health of urban ecosystems provides a credible pathway for improvement of human health through enhanced food security as well as income generation and social cohesion (Tyrvainen, 2001; Roy et al., 2012; Kaoma & Shackleton, 2015).

In the context of the integration of the concept of green infrastructure in the spatial planning of urban landscapes, it may be necessary to resolve the intricacies of the divergencies and priorities of urban land owners who include individual, private, public and institutional stakeholders in relation to urban land development. Often, conflicts in terms of priorities in urban development in regard to the different stakeholders may arise. GI raises issues of rights and access to property ownership, arguably linked to dispensation of environmental justice. For example, city planning frameworks and invocation of the relevant by laws by state urban planning agencies have frequently raised issues of customary landownership often creating socio-political tensions. This is true of our East African cities of Nairobi, Nakuru and Dar es Salaam. It is imperative that urban land owners be involved in the planning and implementation of provision of GI environmental services.

Although urban agriculture has been recognized as an integral component of GI in Kenya, there is no policy framework guiding urban agricultural land zoning. A comprehensive policy framework allowing appropriation of urban space, community rights for access and disposal of public space and the leverage to shape the urban space using local pools of knowledge, creativity and innovativeness in accordance to the whims of urban dwellers for the fulfillment of a dignified life appears the way to go for African cities. Afterall, the idea of GI is not new in Africa. Green spaces have been embedded in governance of cities and implemented in planning of post-colonial era African cities with positive aesthetic landscape functions as well as socioeconomic functions. Typical examples are reflected by Dodoma, the national capital city of Tanzania (Roy et al., 2018).

4. Conclusion

Specific case studies are required for African cities to better understand the connections and interactions of the human interface with the urban physical and natural landscape. There is justification from what is known to further interrogate the extent to which GI concepts rooted in the European, Asian and western cultures can be realistically transferred to the heterogenous urban development processes in Africa.

Ecosystem approaches that embrace concepts of ecosystem goods and services such as the role of urban biodiversity in city resilience and sustainability as well as ecosystem infrastructure provide functionalistic tools for analysis of environmental services and benefits to society.

There is need to explore opportunities for harmonizing short term and long-term urban planning strategies in addressing urban challenges such as democratization of community access and mobilization of GI assets to contribute to climate change mitigation and adaptation benefits in the context of cities operating within limited budgets. GI infrastructure blends well with a resilient city defined as one in which individuals, communities, institutions and businesses have the capacity to function and are able to survive, adapt and grow in response to any kind of sudden short or long disruption that they may experience.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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