Advances in 21st Century Human Settlements

Gora Mboup
Banji Oyelaran-Oyeyinka *Editors*

Smart Economy in Smart African Cities

Sustainable, Inclusive, Resilient and Prosperous

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Advances in 21st Century Human Settlements

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Editors

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Foreword I

Africa is moving fast towards being an urbanized continent. It has the highest urban growth rate in the world (3.3% per year between 2000 and 2015) and an urbanization level of 40% in 2018. Today, half a billion people of Africa's population are living in urban areas. When we conclude implementation of the New Urban Agenda in 2036, the majority of Africa's population (52%) will already be living in towns and cities. Africa's rapid urbanization has also been accompanied by a spectacular growth of the number of large cities. Today, the continent has about 55 cities with a population of one million or more and four megacities. The development of large cities and towns provides opportunities for economies of scale and agglomeration, but this will also call for large investments in infrastructures to respond to the increased demand, for instance, for water, sanitation, solid waste management, energy, transport, streets and public spaces. Efficient institutions and laws will also be required for the effective management of social demands and equity in areas such as education and health as well as the protection of people against violence and insecurity.

African urbanization is occurring at a time when information and communication technologies (ICTs) are making the production and the distribution of goods and services more efficient and as well easing the connection between settlements.

This publication, *Smart Economy in Smart African Cities*, comes at an opportune time to integrate ICTs into a robust set of sustainable, inclusive, resilient and prosperous city concepts, including planning, land tenure, housing, infrastructure development, economic development, environmental sustainability, social development, vulnerability to disasters and resilience, as well as peace and security. The growth in ICTs has resulted in an array of commercial practices, including e-commerce, e-banking, e-governance and, finally, the emergence of digitally served towns and cities that will foster economic development without damaging the environment. There will be less consumption of land for private proprieties and few cars than before on the roads, making streets friendly and healthy for walking and cycling. In the long term, this will reduce carbon dioxide emissions, promote the creation of low carbon settlements, reduce land degradation and promote biodiversity among others.

Recognizing the crucial role ICT can play in sustainable development, African Heads of States went further and created a holistic programme called “Smart Africa” in 2013. The programme aims to foster Africa’s development through ICT by 2025. African governments have also put in place policies to transform the urban landscape of cities into sustainable urban development paths, as recently expressed in the New Urban Agenda (NUA), adopted in 2016, as well as Sustainable Development Goal (SDG) Goal 11, adopted in 2015 by the United Nations Member States. The NUA particularly encourages governments to commit themselves to adopting a smart city approach that makes use of opportunities from digitalization, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery (NUA, paragraph 66).

Today, while recognizing that ICTs have reached many corners of the African continent much faster than previous technological innovations and that cities are becoming digitally served, the question is how to turn a digitally served city to a smart city. This book considers the use of ICT as a mean to make cities smart, but ICT alone cannot make a city smart. Other analogue ingredients must be considered in the development of smart cities. ICTs can be seen as substitution and catalyst factors to analogue operations, but numerous urban factors are crucial in making smart cities. Those factors include the city foundation (urban planning, land tenure and basic infrastructures), institutions and laws, infrastructure development, social development, social inclusion, environmental sustainability, disaster prevention and resilience, peace and security. This is where this book is innovative—by taking us back to core components of sustainable, inclusive, resilient and prosperous cities. Following the exigency of the city of the twenty-first century that calls for sustainability, inclusion, resilience and prosperity, this book puts forward ideas to re-conceptualize the future of African cities in the context of an information-driven global and local development.

Maximizing digital dividends requires better integration of ICTs with the other factors of smart cities. Some tasks have aspects that cannot be automated by technologies and that require human judgment, intuition and discretion. However, African cities that are able to swiftly adjust to evolving digital services will reap the greatest digital dividends by transforming their digitalization to smartness. This book develops a conceptual framework of "Smart Economy in Smart Cities" that can assist African policy makers, researchers and other stakeholders in developing urban policies for smart, sustainable, inclusive, resilient and prosperous cities.

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Foreword II

African Smart Cities, Onward!

Africa stands on the cusp of higher levels of sustainable development and renewed realization of the significance of its historical civilization and rich culture. Its cities, as centres of culture, economy and polity, are undergoing extraordinary changes. The fast pace of urban growth in Africa not only poses unprecedented challenges but also provides multiple avenues to harness the opportunities thrown up by the ongoing spread and ever-expanding use of information and communication technologies (ICTs). Africa now has a unique chance to leapfrog into a new blend of urbanism that can meaningfully combine its historical and rich urban culture to its modern economy facilitated by evolving smart technologies.

Smart Economy in Smart African Cities presents and discusses the current thinking and developments in Africa's smart urban economies. Edited by two highly accomplished professionals, Gora Mboup and Banji Oyelaran-Oyeyinka, this volume aims to contribute to the expanding knowledge on the emerging field of smart economy in smart cities.[1] Its fifteen chapters, purposefully written by a multidisciplinary team of authors, cover a wide range of interrelated topics such as climate change, biodiversity, solid waste management, energy, population, air quality, disaster risk management, resilience, peace and security, social and economic development, urban planning and governance. These chapters provide latest insight into the various dimensions of smart cities, and related supporting principles and conditions that may shape and influence the development of smart urban economies in Africa.

This pioneering book on African smart cities offers a few important perspectives in relation to what is hailed a *science*[2]*—policy—practice continuum*. This continuum is vital because these three perspectives need to be integrated with each other if real progress has to be made on smart cities within the larger context of sustainable development.[3] This would be possible when both forward and backward linkages along the science—policy—practice continuum are realized. Scientists and knowledge institutions need to join forces with policy makers to translate scientific knowledge and innovations into effective policies, to support evidence-based policy making and to ensure that policy-related lessons could feed back into scientific and policy research. Cooperation between policy makers and practitioners is significant because, on one hand, putting policies into practice is a *sine qua non* if the smart city agenda should move forward, whether state or non-state actors implement policies; on the other hand, policy makers ought to take into account feedback from state and non-state actors who are involved in putting policies into practice. Collaboration between practitioners, and scientists and knowledge institutions is essential to generate new knowledge based on lessons learnt from (un)successful policy, programme and project implementation and provide evidence-based feedback to scientists and knowledge institutions as well as policy makers.

From the perspective of *science and knowledge institutions*, this collection of scholarly papers provides cutting-edge knowledge on smart cities in Africa and smart urban economies therein. It underlines the fact that large and small cities have flourished in Africa since its ancient past to modern times. It discusses emerging principles related to smart cities and presents the prospect of examining the former and identifying and developing new principles. In doing so, this volume opens up new avenues for conducting inventive research on "smart sustainable cities" across the African continent,[4] within the larger context of "smart city system". The thought-provoking discussions in the book provide opportunities for cross-fertilization of ideas across African countries on how multifarious smart urban

[1] See Vinod Kumar and Dahiya (2017).

[2] This includes various scientists and academics (from diverse disciplines including social and sustainability sciences) hailing from universities, research institutions and think tanks.

[3] For instance, Future Earth, a research initiative on global environmental change and global sustainability, has emphasized the importance of the science—policy—practice continuum (see http://www.futureearth.org).

[4] See Estevez et al. (2016).

economies can be built and strengthened on the basis of local socio-cultural, environmental, economic, technological and processual advantages.

From a *policy maker's perspective*, this volume presents the latest trends and trajectories with regard to smart cities and how smart urban economies have been progressively adopted in African countries. It discusses the up-and-coming public policy issues in the urban arena and gives examples of relevant innovations that could inform policy making. From these wide-ranging essays, national policy makers can appreciate the value of developing smart urban economies, whilst urban policy makers can draw fresh ideas on how to support the functioning of such economies in Africa. The book gives an exposition on the various dimensions of smart cities and (re)emphasizes the importance of working above and beyond administrative silos—a real possibility that is put forth by smart cities with enabling ICTs. It hints at the possibility of cross-border learning on smart economy in smart cities and developing relevant research and development frameworks and programmes that could support a forward-looking process of policy making in the region. Further, for a policy maker, it is critical to understand the larger context of "smart city system" that includes smart people, smart economy, smart mobility, smart environment, smart living and smart governance.[5]

From a *development practitioner's perspective*, this book brings a rich compilation of smart city-related know-how and experience in Africa. It points toward the necessary conditions that need to be met if the practice of developing smart economy in smart African cities should be taken forward. Such necessary conditions include not only ICTs and relevant hard infrastructure but also inclusive governance and innovative regulatory mechanisms. The practice of developing and improving smart urban economies will also require focusing on and expanding the role of "smart people" in Africa's incipient smart city systems. In many ways, the book suggests the need to learn lessons on how the practice of developing and improving smart cities and their economies can be taken forward. In this process, development practitioners—whether they work at national, sub-national or local level—will help themselves by looking beyond African shores to other developing and developed regions.

There are two more perspectives that merit a mention here.

From the *perspective of students (of all ages) and youth interested in smart cities*, whether they hail from urban and regional planning, geography, development studies, art and architecture, built environment, culture and heritage, tourism, ecology and environment, climate change, disaster risk management, energy, waster and sanitation, transport, engineering, science and technology, governance, public management, business administration, public policy, future and foresight studies, innovation studies or other disciplines, this edited volume presents a wealth of multidisciplinary knowledge. The various essays indicate a number of new and fertile areas on which to conduct original research to advance knowledge on smart economy in smart cities, with particular reference to Africa. Using smart technologies and devices itself lends the distinct possibility of combining qualitative

[5] See Vinod Kumar and Dahiya (2017).

and quantitative research methods, harnessing new knowledge and creating innovative solutions for building smart cities. Aspiring researchers, especially young women, may be encouraged to explore this promising topic, which not only has impact on sustainable development, but also provides opportunities to close the gender gap in science and technology.

For a *general reader*, this book brings the latest on-goings vis-à-vis the development of smart urban economies in smart African cities. It sets out the context and background to, and lays out the conditions for the evolution of smart cities in the region. Rich in latest knowledge and relevant case studies, this book provides the reader with a comprehensive overview of smart cities in Africa, indicating the shape and form of things to come in the future.

In sum, this book offers the possibility and potential ways forward for the development and evolution of African cities into those characterized by smart urban economies, as the world transitions into the third decade of the twenty-first century.

African smart cities, onward!

Bangkok, Thailand

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Chapter 1
Relevance of Smart Economy in Smart Cities in Africa

Gora Mboup and Banji Oyelaran-Oyeyinka

Abstract This chapter articulates the relevance of smart Economy in Smart Cities in the African context marked by rapid urbanization. A smart city is conceptualized as a sustainable, inclusive, resilient and prosperous city that promotes a people-centric approach based on three core components—*Smart City Foundation*, *Information and Communications Technology (ICT)* and *Smart Institutions and Laws*. These three core components are the pillars of the seven dimensions of a smart city: *Infrastructure Development*, *Environmental Sustainability, Social Development, Social Inclusion, Disasters Prevention and Resilience, and Peace and Security*. Infrastructure Development includes transport, industrial energy, education and health infrastructures, etc. Environment Sustainability is comprised of elements of energy, transport, building and pollution. Social Inclusion includes aspects of participation in decision making as well as according all city residents equal opportunities for growth and prosperity. Social Development encompasses elements of education, health, public space and social capital. Disaster Prevention and Resilience incorporates elements of mitigation and adaptation to various disasters such as flooding, droughts, storms and earthquakes. Peace and security covers all forms of violence and conflicts, including domestic violence, violence in public places, crime, armed conflicts, terrorism, etc. An insecure city limits opportunities for investment and economic growth and cannot be a smart city.

Keywords Africa · ICT · Smart city · Economy · City foundation · Institutions Laws · Infrastructure · Environment · Social development · Social inclusion Disasters · Resilience · Peace · Security

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1.1 Introduction

Africa is evolving towards a highly urbanized continent with the highest urban growth rates in the world (3.3% per year between 2000 and 2015). When the New Urban Agenda was adopted in Quito (Ecuador) in 2016,[1] along with the adoption of Sustainable Development Goals (SDGs) the previous year, four out of ten of African population lived in cities and towns (41.2%), and by 2035, Africa will be predominantly urban. With an area of about 30.2 million square kilometres and a population of 1.29 billion in 2018, Africa is the world's second largest continent as well as the world's second most populous continent after Asia. In 2018 more than half a billion of African people live in urban areas (548 million). Rapid urbanization in Africa has also been marked by a significant increase of number in cities and urban agglomerations.

African urbanization is attended by both opportunities and challenges in equal measures. When a city reaches a population size of one million, it offers economies of scale and agglomeration, but it also becomes more complex for its planning, design and management compared to secondary and small cities. African cities are generally characterized by insufficient infrastructures, poor urban planning, and weak urban institutions and laws; they do not produce prosperity as observed in other regions. However, African urbanization is occurring at a time when ICTs are making production and distribution of goods and services more efficient and as well easing the connection between settlements. The Smart City framework presented here provides a unique opportunity for African cities that are struggling with unplanned settlements to integrate ICTs and to shift their urban trajectory onto more efficient paths. It is recognized that when ICTs are well integrated in city foundations, institutions and laws they make a city smart. However, applying Smart City concepts to African cities has been long hampered by weak institutions and laws, and widespread and irregular land tenure that hold back various factors of the smart city framework. Many settlements in African cities lack key components of smart basic infrastructure namely, sewerage system, rainwater drainage facilities, while basic waste management sites and networks of water and energy are missing. Beside the specific context of African cities, the relevance of Smart Economy in Smart African Cities lies on the fact that many city concepts developed along urbanization have been barely implemented in African cities. Though, the smartness concept has come along various concepts characterizing cities such as ecological cities, healthy cities, liveable cities, etc., it is important to recognize that none of these concepts have been popularized in the African context except a few. Additionally, there is the need to develop a smart city concept that integrates the notion of ecological security that points to safeguarding the environment, by developing healthy cities that focus on improving health and promoting liveable cities through planning, design and management of cities. This requires a holistic approach of smartness where ICT leverages the concept of ecological, liveable and healthy cities.[2]

[1] United Nations (2017).

[2] Mboup et al. (2017).

This chapter articulates the relevance of smart Economy in Smart Cities in the African context marked by rapid urbanization. A smart city is conceptualized as a sustainable, inclusive, resilient and prosperous city that promotes a people-centric approach based on three core components—Smart City Foundation, Information and Communication Technology (ICT) and Smart Institutions and Laws. These three core components are the pillars of the seven dimensions of a smart city: Economic Development, Infrastructure Development, Environmental Sustainability, Social Development, Social Inclusion, Disasters Prevention and Resilience, and Peace and Security.

- *Economic Development* includes *City product, Employment,* etc.
- *Infrastructure Development* includes transport, industrial energy, education, health infrastructures, etc.
- *Environment Sustainability* is comprised of elements of energy, transport, building and pollution.
- *Social Inclusion* includes aspects of participation in decision making as well as according all city residents equal opportunities for growth and prosperity.
- *Social Development* encompasses elements of education, health, public space and social capital.
- *Disaster Prevention and Resilience* incorporates elements of mitigation and adaptation to various disasters such as flooding, droughts, storms and earthquakes.
- *Peace and security* covers all forms of violence and conflicts, including domestic violence, violence in public places, crime, armed conflicts, terrorism, etc. An insecure city limits opportunities for investment and economic growth and cannot be a smart city.

From the beginning of the 21st century a digital citizenship, particularly the "Millennials" generation, started to emerge in Africa as it occurred globally. "Digital citizenship is the ability to participate in society online… It represents the capacity, belonging and potential for political and economic engagement in society in the information age".[3] Over the past 15 years, African countries have taken various steps to create an environment favourable for the development and use of ICT at all levels. They create legal institutional frameworks to support regulatory mechanisms in the development and use of ICT. They also introduced ICT platforms such as E-Governance, E-Education, E-infrastructure and support education and training on ICT.[4] However, maximizing the digital dividends requires a better integration of ICTs with the other factors of smart cities such as: city foundation, economic development, infrastructure development, environment sustainability, social development, disaster prevention, resilience, peace and security.[5] ICT can be seen as substitution and catalyst factors, but the other factors (or the analogue part) of the operation are crucial in making smart economy.[6] For each of these factors, this chapter will review its contribution in making African cities sustainable, inclusive, resilient and

[3]Mossberger et al. (2008).

[4]Mboup (2017d).

[5]Mboup et al. (2017).

[6]See also the World Bank (2016a).

prosperous, and how the use of ICT will contribute to better outcomes and processes capable to create smart economy in smart cities in the African region.

This chapter presents, in its first section, African cities as places of opportunities and challenges. This section assesses the association between urbanization and economic growth in Africa, and presents the level of human development in African cities using the three components of economy, education and health. Using the conceptual framework of smart economy in smart African cities, this chapter presents in different sections the relevance of smart economy in smart African cities, particularly how ICT can enable smart economy, smart institutions and laws, smart city foundation (smart urban planning, smart land tenure and smart basic infrastructures), smart infrastructure development, smart social development and social inclusion (smart health, smart education, smart African cultural heritage and smart social capital), smart environmental sustainability, smart disaster prevention and resilience, and smart peace and security.

1.2 Cities—Places of Opportunities and Challenges

Urbanization is generally associated with numerous, positive societal outcomes, such as technological innovation, diffusion of ideas, economies of scale, economies of agglomeration, enhanced democratic accountability, women's empowerment, and so on. All these factors together make cities places of opportunity where people tend to concentrate.[7] Africa is urbanizing with the highest urban growth rates in the world (3.3% per year between 2000 and 2015). When the New Urban Agenda was adopted in Quito (Ecuador) in 2016, along with the adoption of Sustainable Development Goals (SDGs) the previous year, four out of ten of African population lived in cities and towns (41.2%). By 2035, Africa will be predominantly urban with Western Africa and Eastern joining in 2020 and 2050 respectively Southern Africa and Northern Africa where the majority of the population has already been living in urban areas for the last 25 years and 11 years, respectively. With an area of about 30.2 million square kilometres and a population of 1.29 billion in 2018, Africa is the world's second largest continent as well as the world's second most populous continent after Asia. In 2018 more than half a billion of African people live in urban areas (548 million). This urban population is projected to grow to one billion in 2040.[8]

Rapid urbanization in Africa has also been marked by a significant increase of the number of cities and urban agglomerations. When a city reaches one million, it offers economies of scale and agglomeration, but it also become more complex for its planning, design and management compared to secondary and small cities. For instance, cities of one million require an efficient public transport in order to run

[7] UN-HABITAT (2010).

[8] UN population Division, Department of Economic and Social Affairs, 2018. World Urbanization Prospects: The 2018 Revision. New York (USA).

efficiently; it must be planned in advance with consideration of land use and density. With only three cities (Cairo, Alexandria and Johannesburg) with a population of 1 million or more in 1950, in 2014 Africa counted 54 cities with a population of 1 million or more. It also counted 133 cities with a population of between 300,000 and 1 million. This makes a total of 187 cities of 300,000 or more. A total of 244 million people live in these cities, representing 52% of the total urban population of Africa, which is 472 million in 2015. Megacities have also emerged in Africa with four cities—Cairo, Lagos, Kinshasa and Johannesburg—having 10 million inhabitants or more. By 2030, Dar-es-Salam and Luanda will also join the group of megacities, and a significant number of African cities will have a population of more than 5 million.[9]

1.2.1 Urbanization and Economic Growth in Africa

Cities are potentially engines of prosperity due to their capacity to produce economies of scale, and agglomeration economies. As well, urban settings foster technological innovation and promote diffusion of ideas due to the proximity of economic actors. High densities of cities reduce transaction costs and make public spending on infrastructure and services economically viable. Urban agglomerations with adequate urban planning and management coupled with good governance will produce wealth and sustain economic and social development.[10] African cities yet occupy a pivotal place in the trade sector both nationally and internationally. Their autonomous ports (for coastal cities), international airports, international trade centres, touristic sites and commercial centres are assets for economic growth. Their contribution ranges from 50 to 70% of the national Gross Domestic Product (GDP).[11] Up to nine out of ten national civil servants, and from 50 to 90% employees in national's trade, transport, banking and industrial enterprises are in cities.

Though African cities are contributing significantly to national economies, the association between urbanization and GDP around the world shows that African cities perform far less than their counterparts in other regions; the relationship between urbanization and development had been uneven across the region. There is a group of African countries where urbanization and development are closely linked, while in others urbanization has not led to economic growth. The most immediate explanation is that rapid urbanization in Africa is propelled largely from the influx of migrants from rural areas who are poor and unskilled; their inflow outpaces job creation in the formal economy. Consequently, urbanization in Africa has been one of despair, slum formation and poverty. In addition to that the "quality" of urban areas in Africa

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[9]Calculated by the author from the United Nations, Department of Economic and Social Affairs, Population Division (2015). World Urbanization Prospects: The 2014 Revision, (ST/ESA/SER.A/366).

[10]United Nations, Department of Economic and Social Affairs, Population Division (2015). World Urbanization Prospects: The 2014 Revision, (ST/ESA/SER.A/366). UN-Habitat, 2012. State of World's Cities 2012/2013: Urban Prosperity. Earthscan, London (United Kingdom).

[11]UN-Habitat (2012).

should be carefully assessed. For example, there are areas classified as urban which in reality either do not display known characteristics of an urban setting, or lack many urban setting features. Expectedly, there are huge disparities in the quality of urbanization. For instance, while empirical analysis show that Western and Central African countries are more urbanized than their Eastern counterparts this does not manifest in specific quantifiable urban advantages. For instance analysis of regional demographic transition shows that rural areas in Kenya have lower mortality rates and higher levels of education than urban areas in Niger.[12] Furthermore It is a paradox that Lagos, Kinshasa and to a less extent Johannesburg and Cairo, the only megacities in the continent, have not been able to fully transform their huge population in terms of economies of scale and agglomeration economies as New York and London did more than 50 years ago. While Johannesburg, the practice of Apartheid for centuries excluded large numbers of black from the urbanization dividends, in Lagos and Kinshasa the situation lies on other factors such as poor governance and administration and weak basic infrastructures, as it is observed in most African cities. There is also insufficient investment in most African cities as noted in the *State of African Cities 2018—The geography of African investment.*[13] However, African cities can boost their economies by positioning themselves as desirable destinations for foreign investment in the age globalization. They need to seize a more prominent position in the world economy, by enhancing their accessibility, connectivity, markets and urban attractiveness.[14]

1.2.2 Using Economy, Education and Health to Build Human Development in African Cities and at the National Level

African cities are still engines of African economies as illustrated in Fig. 1.1 with the HDI in cities much higher than national HDI, except in Liberia, Guinea and Madagascar. In General, cities have better economy outcomes as well as better health and education status. They occupy a pivotal place in the trade sector both nationally and internationally. However, these advantages may also be linked to political choices that concentrate various economic infrastructures in cities such as: ports, international airports, international trade and commercial centres, etc. They also have concentration of civil servants, private sectors such as banking and industrial enterprises. All this makes them contribute more than half of national economies. However, there were not able to pay back and boost the rural economies. Now the question is how to turn the linkages between urban and rural in the way that rural can reap the benefit of urban economies of scale and agglomeration. This is where, ICT as a connector

[12] Mboup (1999).

[13] UN-Habitat et al. (2018).

[14] See Fay and Opal (2000). Also see: Jedwab and Vollrath (2015).

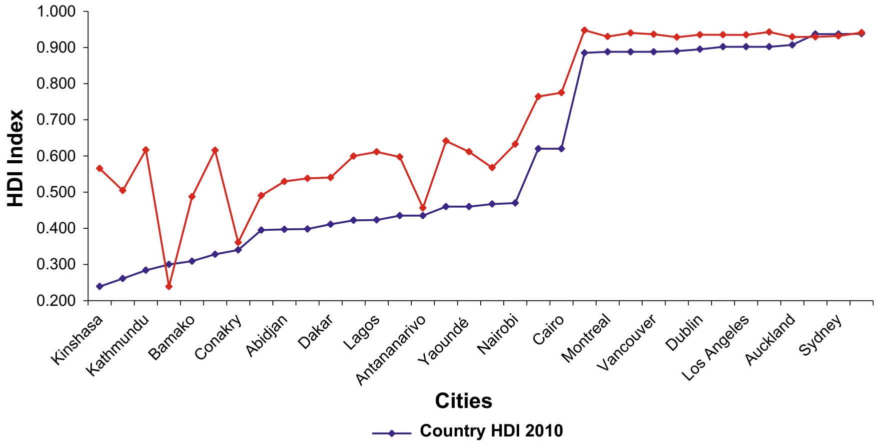

Fig. 1.1 City HDI and country HDI, 2014. *Source* Mboup (2017c)

may play a crucial role in the inter-cooperation between rural and urban making circulation of goods and services cheaper and faster.

For cities to realize their potential, they need to be driven through an efficient administrative and within an efficient governance environment. The existence of a large city with high density is a necessary but not a sufficient condition for economies of scale and agglomeration. In many African countries those ingredients required for urban growth are lacking leading to various negative externalities; rather these externalities encourage widespread diseconomies. Youth un-employment is high in most African countries while young people from impoverished urban areas find employment in the informal sector with no social security coverage, paid and parental leave, retirement, and unemployment benefits. The high rate of unemployment of young people in African cities is reason for concern; the lack of decent, sustainable jobs promotes a sense of displacement in the general youth population and often leads to crime, under-development, and a cycle of poverty. Frustrations accompanying long-term unemployment among groups of urban young men may feed political and ideological unrest and provoke violence.[15]

Though high densities can be a good indicator for economic growth, in African cities they produce congestion, pollution and other factors that need to be mitigated with efficient institutions and infrastructures. The poor performance of African cities is not a result of rapid urbanization, but of lack of adequate urban planning, formal land tenure and provision of basic infrastructure; these are the key components of sustainable city foundation. These are important catalysts for economic growth underpinned by economies of scale and agglomeration, technology innovation and

[15] http://www.africaneconomicoutlook.org/en/theme/youth_employment/. Promoting Youth Employment in Africa. Accessed on 21 October 2015.

diffusion of ideas as it happens everywhere cities are engine of economic development.[16]

The pathways of growth for cities driven by economic development are diverse: economic reforms that facilitate access to capital markets and foreign investment; political changes that make possible greater local fiscal autonomy and permit import and export licenses; government and corporate strategies that increase investments in strategic economic sectors; and national or local initiatives that position cities in global, regional or local spaces of economic flows. The growth of cities through local initiatives reflects a rising trend toward greater urban entrepreneurship and more intense city competition.

The convergence of city-level and private sector initiatives with central government economic and political decisions could bring significant benefits within a positive governance context.

1.3 Relevance of Smart Economy in Smart Cities in the African Context

African urbanization is occurring at a time when ICT is making production and distribution of goods and services more efficient as well easing the connection between settlements. The Smart City framework provides a unique opportunity for African cities that are struggling with unplanned settlements to integrate ICTs and to shift their urban trajectory onto more efficient paths. It is recognized that when ICTs are well integrated in city foundations, institutions and laws they make a city smart. However, the African context is unique because key pillars of city foundation are not in place even at the most basic level contrary to conditions in developed countries where cities are relatively well planned, institutions and laws enforced. African cities are characterised by proliferation of slums marked by lack of basic infrastructure and formal land tenure.

Though cities are hosts to more educational infrastructures than villages and provide young people with opportunities to continue their education and access gainful employment in the formal sector, most African cities generate and intensify the kind of social exclusion that denies the benefits of the "urban advantage" to many marginalized groups. African cities are dramatically vulnerable to disasters because many of them are unplanned and built in disaster prone areas. For instance, the risk of catastrophic losses due to flooding is becoming significant in most African cities as presented in Chap. 10 of this book.[17]

Beside the specific context of African cities, the relevance of Smart Economy in Smart African Cities lies on the fact that many city concepts developed along urbanization have been barely implemented in African cities. Though, the smartness

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[16]World Bank (2009).

[17]For more details refer to Chap. 10 of this book "Smart Disaster Prevention and Resilience in Africa".

concept has come along various concepts characterizing cities such as ecological cities, healthy cities, liveable cities, etc., it is important to recognize that none of these concepts have been popularized in the African context except a few. Additionally, there is the need to develop a smart city concept that integrates the notion of ecological security that points to safeguarding the environment, by developing healthy cities that focus on improving health and promoting liveable cities through planning, design and management of cities. This requires a holistic approach of smartness where ICT leverages the concept of ecological, liveable and healthy cities. The concept of smart cities developed and used here borrows from these concepts with the integration of ICT for efficiency.[18]

In the African context, the concept of "smart" embraces various dimensions including economic that is making urban governance of cities more efficient. Economically, it reduces costs of transactions and eases economies of scale and agglomeration. In the environmental and infrastructure spheres, it eases the development of low carbon cities and reduces the demand for infrastructures such as transport and making the existing means efficient respectively. It also allows a better management of water, sanitation, and solid waste and energy. It makes more efficient the planning of cities, makes land administration and governance efficient, prevents settlements in disaster prone areas, and promotes social development and inclusion, peace and security. However, the integration of these urban dimensions requires adequate human capital as well as faithful enforcement of institutional, laws and accountability at all levels: individual, community and the highest level of government.

While we deploy ICT as a means to make city smart, ICT alone cannot make cities smart; other analogue ingredients must be considered. Also, 'Smart' is not an end in itself.[19] It is the way ICT is integrated in the fabric of city development that will determine successful measure of city smartness. For instance, we expect that with an extensive use of ICT to access services, there will be few cars than before on the road making streets friendlier and healthier for walking and cycling. Streets can be planned and designed as public spaces to serve communities for social interactions as well as mobility. Hence, while promoting infrastructure development, enhancing environmental sustainability, it is possible to support high and inclusive socio-economic development, equity and social inclusion. In the long term, this new approach not only reduces emissions of CO_2, promote the creation of low-carbon cities, reduce land degradation and promote biodiversity, but it also equally fosters human interaction.

[18]Mboup et al. (2017).

[19]Vinod and Dahiya (2017).

1.4 Smart Economy in Smart African Cities: A Conceptual Framework

The importance of ICT is fully anchored in the SDGs. Goal 9 of the SDGs states: "*Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*", member states have committed themselves to "*significantly increase access to information and communications technology (ICT) and strive to provide universal and affordable access to the Internet in Least Developed Countries by 2020*".[20] Most public institutions to varying degrees are now supported by the ICT systems. Since the 1990s the ICT revolution has triggered and sustained the rapid diffusion of e-government systems to automate core administrative tasks, improve the delivery of public services, and promote transparency and accountability. By 2014, all 193 member-states of the United Nations had national websites: 101 enabled citizens to create personal online accounts, 73 to file income taxes online, and 60 to register a business. In all, 190 countries had automated government financial management, 179 had automated customs, and 159 had automated tax systems. Over 148 countries had digital identification schemes, although only 20 had multipurpose digital identification for such services as voting, finance, health care, transportation, and social security.[21] All this will impact various dimensions of urban mobility.

For the African cities covered in this study, a smart city is viewed as sustainable, inclusive, resilient and prosperous. It promotes a people-centric approach based on three core components—*Smart City Foundation, Information and Communications Technology (ICT) and Smart Institutions and Laws.* These three core components are the pillars of the seven dimensions of a smart city: *Economic Development*, *Infrastructure Development*, *Environmental Sustainability, Social Development, Social Inclusion, Disasters Exposure, Resilience, and Peace and Security*. The collective of these components and dimensions enable a Smart Economy (Fig. 1.2).

Infrastructure Development includes transport, ICT, industrial energy, education, health infrastructures and so on. *Environment Sustainability* comprises elements of energy, transport, building and pollution. *Social Inclusion* includes aspects of participation in decision making as well as according all city residents equal opportunities for growth and prosperity. *Social Development* encompasses elements of education, health, public space, social inclusion and social capital. *Disaster Exposure* incorporates elements of mitigation and adaptation to various disasters such as flooding, droughts, storms and earthquakes. *City Resilience* is composed of elements of city foundation, environment, social capital, and social development. *Peace and security* deals with all forms of violence and conflicts, including domestic violence, violence in public places, crime, armed conflicts, terrorism, etc. An insecure city limits opportunities for investment and economic growth and cannot be a smart city.

[20]United Nations (2015).

[21]United Nations (2015).

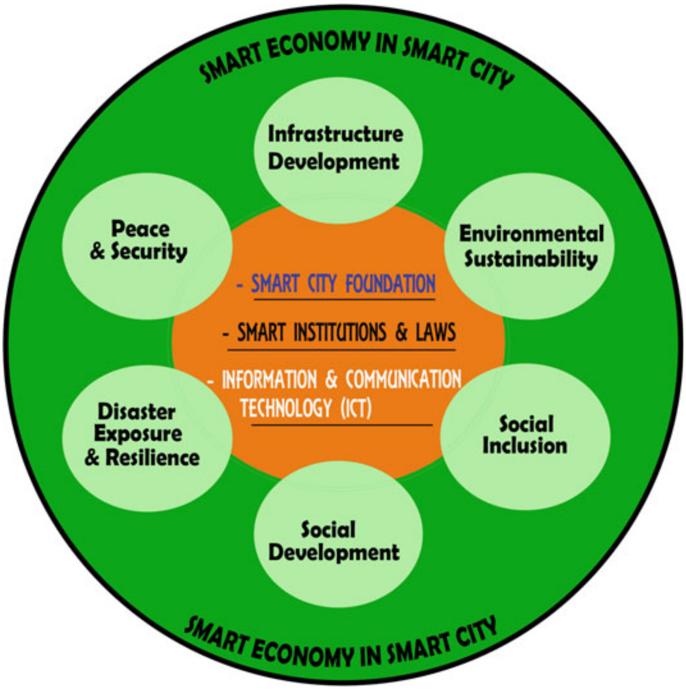

Fig. 1.2 Smart economy in smart African cities conceptual framework. *Source* Mboup et al. (2017)

1.5 ICTs Revolution in Africa: Levels, Trends and Perspectives

Currently, it is recognized that ICTs have been deployed in Africa much as with other developing countries following the rapid pace of technological innovations. In many African countries, it took more than 50 years after its invention, to have electricity but computer-based technologies have diffused far more rapidly and reached most African countries, less than 20 years after its invention. Mobile phones and the internet took only a few years. More households in African countries own a mobile phone than have access to electricity or improved sanitation. Greater internet access has led to an explosion in the production and consumption of information in the continent. Though internet is spreading in the continent, its efficient development and use are still lagging behind compared to the more dynamic emerging countries. Depending on investment and policies, access to internet at the household level should continue to grow in Africa, particularly in urban centres. For instances in Dakar, the use of internet increased from less than 1% in 2005 to 13% in 2011 and 24% in 2014. The coverage of an internet connection has drastically increased since 2005 where the percentage of people living in a household with an internet connection was less than 5%. Six years later, the same percentage was multiplied by six with 24% of people living in a household with internet in 2011. The trend is irreversible with an absolute increase of 13 points in 3 years; in 2014, more than a third (37%) of people lived in a household with an internet connection. With similar trends, this percentage of household with internet connection will reach 62% in 2030 and 75% in 2035.[22] What is happening in Dakar is observed in most African cities, particularly in capital and large cities.

1.6 ICT in the Making of Smart Cities

1.6.1 ICT in the Making of Smart Economy

From the beginning of the 21st century a digital citizenship, particularly the "Millenials" generation, started to emerge in Africa. "Digital citizenship is the ability to participate in society online… It represents the capacity, belonging and potential for political and economic engagement in society in the information age".[23] Over the past 15 years, African countries have taken various steps to create an environment favourable for the development and use of ICT at all levels. They create legal institutional frameworks to support regulatory mechanisms in the development and use of ICT. They also introduced ICT platforms such as E-Governance, E-Education, E-infrastructure and support education and training on ICT. There is increased use in Adoption of broadband internet in African cities though its coverage remains low.

ICT promotes economic productivity through substitution as well as catalytic factors. ICT, through both substitution and catalytic factors, promotes efficiency. It makes routine, transaction-intensive tasks significantly faster and cheaper. It also is environmentally suitable.[24] It increases productivity, reduces transaction costs and eases distribution of services and goods. It automates various activities and reduces labour for the production and distribution of several services and goods. For instance in the publishing sector, since books can be accessed online the production of hard copies have been considerably reduced. With the availability of automated-self checkout counters, the number of cashiers has considerably reduced in many supermarkets. As a catalytic factor, ICT makes more productive existing factors than in their analogue process. Several production and distribution companies are using real-time inventory and supply chain management systems. Taxes are filled online and approved instantly; this is expected to reduce significantly the tax processing time.[25]

ICT promotes innovation and efficiency through substitution and catalytic factors. E-commerce platforms are common in progressively digitized societies.

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[22]Mboup (2017d).

[23]Mossberger et al. (2008).

[24]World Bank (2016b).

[25]World Bank (2016b).

Digital transactions systems are expanding trade and economic outcomes with minimum costs. ICT eases greater organization and collaboration among economic agents in a common, open platform of searching, matching, and sharing information. Such a platform empowers people with real-time opportunities and increases operation efficiency of firms.[26] It increases the availability of variety of goods and services. It promotes competition and foster economies of scale and agglomeration. Increased accessibility to information provides customs with possibilities to compare prices and make rational decisions based on their purchasing power. It also eases benchmarking where firms will tailor their products and processes to best practices.[27] According to people's perceptions in 12 African countries digital technologies have made them better off: 65% of people believe that their family is better off because they have mobile phones, whereas only 20% disagree and 14.5% are undecided.[28]

In the communication sector, landlines have been drastically replaced by smart mobile phones, and instant messaging apps are significantly substituting telecoms services. Analogue traditional newspapers are becoming "obsolete" for advertising with the emergence of multiple search engines coupled with the social media revolution. Mobile money is also substituting to traditional banking systems. ICT has also led to a full automation of services such as in the airline industry and has digitally transformed others such as taxi and hospitality services as well as health and education. With the revolution of E-commerce the share of the brick-and mortar firms have substantially reduced.[29]

Thorough increased efficiency and innovation, ICT increases economies of scale and agglomeration, and promote diffusion of knowledge, even at the smaller human settlements. Small human settlements as small firms are benefiting from ICT in making their goods and services beyond their territories. Virtual offices, virtual networks, teleconferences are increasing inclusive public participation. Digital firms can start and scale up quickly with relatively little staffing or capital investment. Startup and scale up costs as well as investment risks have been considerably reduced with the emergence of the leasing of computing and data storage services, as cloud computing.[30]

ICTs finally harness the benefits of agglomeration economies in easing circulation of goods and services and encouraging polycentric urban development and allowing synergies between centres and sub-centres. They intensify urban nodes and corridors to maximize the benefits of concentration. ICT also increases economic productivity and competitiveness through increased smart mobility that reduces traffic congestion and commuting costs. It reduces the use of motorized means of transport and promotes walking and cycling. Efficient urban mobility, in turn, increases labour productivity by reducing commuting times, and increasing worker productivity. It will improve the overall health of city residents, thereby reducing the health and economic costs

[26] World Bank (2016b).

[27] World Bank (2016c).

[28] World Bank (2016d).

[29] World Bank (2016d).

[30] World Bank (2016d).

of workers who are absent due to illness. Another important benefit is on consumer expenditure, as less is spent on cars and fuel. It can also lead to a drop in the share of the household budget devoted to motorized means of transport, such as cars, which are expensive in many African cities.[31]

Better Planning, Management and Monitoring through of ICTs. ICT increases teamwork, communication, planning and coordination in all sectors. Monitoring the performance of workers is fundamental for efficient management and evaluation for results.[32] Digital monitoring combined with institutional reforms and infrastructure improvement increase workers' productivity. "Better information helps companies make better use of existing capacity, optimizes inventory and supply chain management, cuts downtime of capital equipment, and reduces risk".[33] Real-time data also allows better planning and management of service facilities as it was observed in African countries such as Ghana, Kenya, Tanzania, and Zambia where health workers use mobile phones to report counterfeit drugs and stock-outs.[34] When aggregated in a central geo-referenced database, this information helps managers and technicians to anticipate and timely address drug and equipment shortages.[35] Mobile phone has also been used in the educational system to record teacher attendance and transmit data to a central database that generates weekly reports. Combined with incentive pay for teachers tied to attendance, this attendance recording has reduced teacher absenteeism from 27 to 11%.[36]

ICT promotes inclusion of vulnerable and disadvantaged groups. ICT provides tangible economic benefits to people who have skills to leverage technology as well as to those who are lagging behind for various reasons. For the latter ICT provides them with more opportunities to access to jobs and other services, particularly in countries where the governments and the private sector tailor digital services to the vulnerable and disadvantaged groups who often face barriers in finding jobs or productive inputs.[37] ICT finally promotes inclusion of vulnerable and disadvantaged groups particularly persons with disabilities, women, young people, and those living in remote areas and slum settlements. Outsourcing, for instance, brings internet-based jobs to those groups. It can particularly promote the participation of women in the productive economy in a continent where the majority of women work at home. The most important benefit may be in better integrating marginalized or disadvantaged groups into society.[38]

Leveraging ICT in the informal sector. Considering the importance of informal sector in African urban economies, it is important to explore the way ICT can make the sector more productive. Though there are several country success stories in Africa,

[31] Mboup (2017a).

[32] World Bank (2016d).

[33] World Bank (2016d).

[34] World Bank (2016d).

[35] World Bank (2016d).

[36] World Bank (2016d).

[37] World Bank (2016d).

[38] World Bank (2016d).

the effect of technology on economic productivity, expansion of opportunity city wide, particularly to the informal sector remain limited.[39] With the informal sector constituting more 50–80% in many African cities, the battle of smart economy will be won or lost in the informal sector. Though mobile phone is making a difference in the informal sector, more needs to be done in digitizing the labour division in the sector and helping informal activities to be more efficient and rudimentary activities to be innovated. This will particularly require digitally vocational education in the sector.

The digital dividends are real, and the rapid adoption of digital technologies in the African economy will have huge benefits directly as well as indirectly. However, ICT alone will produce little in the smart economy; maximizing the digital dividends requires better integration of ICTs with the other factors of smart cities such as: city foundation, infrastructure development, environment sustainability, social development, disaster prevention, resilience, peace and security. Human judgment, intuition, and discretion are fundamental in the context where all tasks cannot be automated by technologies. Institutions and laws, efficient governance, management and administration are central for an efficient development, use and integration of technologies to analogue systems. However, without improvement on accountability at all levels, ICT alone cannot change the outcome of the economic productivity equation. African Countries that are able to swiftly embrace the emerging digital economy will reap the greatest digital dividends, while those that remain with the analogue economic system are likely to be left behind.[40]

1.6.2 ICT for Smart Institutions and Laws

ICTs can ease the enforcement of institutions and laws with efficient governance and administration systems and services

The institutions and laws that govern human settlements are one fundamental driver of a sustainable, inclusive, resilient and prosperous city. The way the city is planned, land distributed and basic infrastructure laid down is governed and administered within functioning institutions and laws. With functioning institutions and laws, for instance, land and housing assets can contribute to the planning, management and provision of services in settlements. However, in absence of functioning institutions and laws providing legal propriety rights, most of these assets remain dead investments sheltering only people.[41] The smartness of African cities has been long time hampered by weak institutions and laws holding back various factors of the smart city framework, making informality the norms in many sectors starting with the city foundation surrounded by informal settlements with irregular land tenure.

[39] World Bank (2016d).

[40] World Bank (2016d).

[41] Mboup (2017d), also see De Soto (2000).

Lack of transparency and good governance that promote corruption hamper development in many sectors such as infrastructure development, social development, and disaster prevention leave the majority vulnerable to exploitation.

As African governments increasingly adopt digital technologies, there is an expected rise in efficiency and productivity through automation and data-driven management. However, without the human commitment to enforce institutions and laws, ICT alone cannot make a city smart. ICT is a means not an end in the city smartness process. There is urgent need to transform African institutions and laws to serve the people. This will start with people participation, accountability, good governance and transparency. Good governance, accountability and participation are “bedrocks” for the overall development of African countries. Better tools for communicating with citizens and providing information also allow greater participation of citizens in public programme planning, management and monitoring.[42] ICT provides opportunities for citizens to participate in several administrative processes including policy development, budget planning and programme implementation. Citizens can also monitor local as well as national programmes and connect online and organize for collective action and put pressure when government performance falls short of their expectations.[43] For instance, mobile phones enable citizens to report instances of violence and voter intimidation, improving electoral participation as it is observed in some African countries such as Mozambique, where electoral voters use SMS messages to report electoral irregularities; voter turnout was increased by five percentage points. In Kenya, electoral violence was reported and geo-referenced using crowd-sourced applications, Ushahidi and Uchaguzi. With the existence of multiplying the sources of information, the risk of media capture and make censorship have become difficult and challenging for public authorities.[44] Governments are constrained to be more responsive to the demand of their citizens.

Public participation must, however, start with the recognition of people identity rights. Lack of identity is an impediment for poor people to exercise their basic democratic and human rights. Where civil registration systems are weak or non-existent, many of the poor are simply not counted. Digital identification can help overcome barriers to participation. Digital identity (ID) schemes or specific systems for elections or to manage post conflict transfers are progressively adopted in many African countries. This is expected to generate numerous benefits, including increasing the efficiency of the public sector. Automate tax and customs administration as well as budget preparation, execution, and accounting are also adopted in most African public administrations. With online portals (including e-filing, one-stop computerized service centres) Tax compliance costs have significantly been reduced, and service efficiency increase.[45] ICT can also make institutions and laws enforced in all sectors

[42] UNDP and Panos Institute West Africa (PIWA) (2009).

[43] World Bank (2016d).

[44] World Bank (2016d). See also Aker et al. (2013).

[45] World Bank (2016d). See also Yilmaz and Coolidge (2013).

Fig. 1.3 Smart city foundation. *Source* Mboup, G. et al. (2017)

as illustrated in the land tenure system. Different activities can be concentrated and made accessible with the help of internet portals supporting participation.[46]

1.6.3 ICT for Smart City Foundation

Despite their potential to be sustainable, inclusive, resilient and prosperous, African cities lack of a smart city foundation. A smart city foundation is composed of three elements: Urban planning and design, land policies and basic infrastructure (Fig. 1.3). African cities are not adequately planned with sufficient land allocated to streets and public spaces, and they lack smart basic infrastructure and smart institutions and laws.[47] Many settlements in the city lack a sewerage system and rainwater drainage facilities, and adequate waste management sites are missing, which are key components of smart basic infrastructure along with connection to water and energy. Flooding during rainy seasons as well as uncollected garbage is frequent phenomena in many parts of African cities, but particularly in the poor settlements. Frequent energy shortages also affect the African cities' economy. These challenges are associated with poor land administration and governance, characterized by lack of transparency and corruption.

Lack of smart city foundation is part of the reason why digital dividends are not being reaped in most African cities. ICTs alone cannot build smart cities, but in appropriate settings they can boost growth, expand opportunities and improve service delivery. The analogue settings such as urban planning, provision of basic infrastruc-

[46]Klessmann (2010).

[47]Mboup (2015b).

tures and land tenure are key for smart cities. For ICT to be transformational there is a minimum requirement associated to the city foundation as well as to institutions and laws that establish the management and the administration of cities. For a city foundation to be smart, it must be inclusive at the onset of the urban planning and promote mixed neighbourhoods where social clustering is discouraged. Having all the poor living together creates slums and fuels instability and insecurity. Inclusive urban planning eases access to basic services (water, sanitation, housing, education and health) and to decent employment for all. A key element of smart urban planning is a smart street network that reduces travel time and encourages walking and social interactions. Smart urban planning enhances infrastructure development, environmental sustainability, economic and social development; makes cities resilient and prepared to overcome natural disasters; and promotes mixed neighbourhoods where services are walking distances from people's residences.[48] ICT plays a crucial role in promoting a smart city foundation, by enabling inclusiveness in planning, policy and infrastructure provision processes such as through public participation; as well as creating enormous non-physically limiting opportunities to all city residents.

1.6.3.1 ICT for Smart Urban Planning: From Conventional Planning to Inclusive E-Planning

Numerous societal problems are explored and addressed in urban and regional planning agencies, including urban growth, unemployment and economic revitalization, transportation, environmental degradation and protection, neighbourhood decline and redevelopment, conservation of land and natural resources, provision of open space, parks and recreational facilities, etc. At the moment, urban planning in African cities has serious flaws and the most notable consequence of this failure is slums. Slums are the clearer evidence of the failures of urban planning in African cities.[49]

In order to cope with urban planning in African cities, it is crucial that we understand the mechanisms that contribute to these failures as well as the situation as far as informal activities and land tenure are concerned. One of the reasons for this is the lack of communication and information exchange between urban stakeholders. It is rare that African city planners take into account input from citizens though they are obligated to at least inform and engage them in various planning issues included land use, provision of services and housing.[50] Citizen participation in planning aims to enhance the outcomes of policy and project decisions in a community.[51] As noted by Madanipour (2001), cities are integrated environments with various attractive places and space for different cultures. Planning them requires knowledge based on a "soft" understanding of places and the more detailed incorporation of hard, physical

[48]Mboup et al. (2017).

[49]Repetti and Bolay (2010).

[50]Conroy and Gordon (2004).

[51]Conroy and Evans-Cowley (2010).

facts.[52] Lack of active citizen participation in the planning process has indeed hampered the implementation of numerous planning procedures, rules and regulations and made challenged the sustainable urban development in many African countries as it is observed elsewhere.[53] Despite the existence of comprehensive urban legislative, rules and regulations, the urbanization of most African countries have been marked par proliferation of informal settlements. Indeed, a cumbersome regulatory approval process constrains the implementation of several urban policies and plans.

New urban planning instruments are becoming available with the generalization of ICTs. Digital technologies make it possible to adopt innovative e-planning approaches, strengthen communication between urban stakeholders, and make communication available at various stages of the planning process. Real-time information creates a transparent, and open platform where local governments engage their citizens to gain support for key urban policies and programmes, identify unforeseen concerns, and anticipate on potential conflicts.[54]

Cities are dynamic living organisms that are constantly evolving, particularly in the digital era. ICT has begun to turn some places into real-time cities. This rapidly changing society makes the assessment and anticipation of future needs of city dwellers in terms of services, including transport, water, energy, employment, education and health, even more problematic. Addressing the multiple issues and needs in the planning process, it is important to integrate the physical structure of the city and the intangible economic, social and environmental factors.[55] Planning procedures make use of models that show historic and present situations and communicate planned situations. Urban planners and designers have employed wide range of techniques in order to plan, model and simulate the outcome of urban planning and development processes. The main thrust of computing applications in urban planning is their contribution to sound decision-making and planning practices. During the last couple of decades many new computing tools and technologies, including geospatial technologies, are designed to enhance planners' capability in dealing with complex urban environments and planning for prosperous and healthy communities. The introduction of ICTs allows planners and planning departments to carry out new actions or to implement conventional practices through new tools, such as GIS, virtual reality technologies, e-participation devices, including public participation, GIS applications, among other tools, with the aim of improving conventional decision-making processes. The shift from conventional urban planning to e-planning will allow efficient planning and urban management services with lower costs within

[52] Madanipur (2017), Madanipur (2001).

[53] Brody et al. (2004), Laurian (2004). Cited by Conroy and Evans-Cowley (2010).

[54] Conroy and Berke (2004), Conroy and Gordon (2004), Wild and Marshall (1999). Cited by Conroy and Evans-Cowley (2010).

[55] Chen et al. (2010).

time, and a more collaborative and participative, transparent and accountable planning decision-making process.[56,57]

However, ICTs will not by itself resolve these challenges; applications needs to be accompanied by other human capabilities to meet the key conditions of tackling the challenges of urban planning in developing cities. ICT will not turn unplanned to planned cities, but it can ease the re-structuration of unplanned through digital mapping. This will happen only if there is democratic political will that encourages public participation. Socio-cultural and political contexts condition and shape e-planning and its comparative advantages.[58,59]

1.6.3.2 ICT for Smart Land Tenure

Providing security of tenure depends on a range of policies related to institutions and laws that protect people against unlawful eviction and ensure equitable distribution to basic services to all communities. Transparent and accountable processes of land regulation are key for secure land tenure. However, in most African cities, land tenure is neither well governed nor well administered. Poor land governance is surrounded by poor land administration characterized by a poor determination, recording and dissemination of information about tenure. Most African cities still fail to provide inclusive land administration services that reach all stakeholders in equal terms, plus they tend to be slow in adapting alternative new approaches and technologies to enhance the land tenure administration and governance. In addition to being exposed to eviction, without legal proof of ownership, households cannot enjoy the economic and financial opportunity associated with investment and saving using their property as collateral. At the community level, the municipality cannot also legally collect various taxes that can be used to improve basic infrastructures. Promotion of secure land tenure in African cities will boost investment in property development, increase municipal tax collection and in turn promote economic growth.[60]

Land administration systems in African cities are, indeed, heavily influenced by their long history of lack of proper recording that make cumbersome the adoption of new approaches, thinking and innovation in land administration.[61] ICT can help to promote principles of good land administration and governance. ICT revolution is opening new frontiers in land tenure reform, but land tenure experts and stakeholders must grasp this unique opportunity for the regularization of land that go hand and

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[56] Silva (2010), (http://www.igi-global.com/viewtitlesample.aspx?id=43177&ptid=41793&t=the+e-planning+paradigm+%E2%80%93+theory%2c+methods+and+tools%3a+an+overview), downloaded, 9 April 2017. The Use of Social Media for Urban Planning: Virtual Urban Landscapes Created Using Twitter Data.

[57] Yigitcanlar (2013).

[58] Horelli and Wallin (2010).

[59] Staffans et al. (2010).

[60] Mboup (2017b).

[61] Törhönen et al. (2013).

hand with e-planning. Data revolution along the generalization of ICT, by enabling easy access to transparent, open platform on urban development issues and policies to all stakeholders, enhances promptness and accuracy of decision-making and facilitates effective and efficient management.[62] Apart from being a prerequisite for a functioning market economy, environmental action and secure livelihoods, land administration systems create invaluable base data for all spatially based innovation. Connecting land registration to personal mobile phones, enable citizens to locate land and property, record a geographic boundary of their properties using geographical coordinates, and edit and submit a landowner's profile. Putting land administration records, cadastres and land registries in a transparent and open digital platform will break down silos between land authorities and other stakeholders. This will particularly of value in remote areas, urban slum areas and other vulnerable groups that are often not served by conventional land administration systems that prevail in African cities. Kenya is an example with an extensive experience in the use of digital technologies to include slum areas such as Kibera in the planning and land administration. The new ISO standard on the Land Administration Domain Model (LADM, ISO 19152) makes available a generic solution to countries starting with little background.[63]

1.6.3.3 ICT for Smart Basic Infrastructure

In a smart city foundation, basic infrastructures such as piped water services, sewerage facilities electricity sources and solid management are considered along the city planning. They are part of the city planning prior to settlements of households. In a smart city foundation, use of improved water from piped water services, sewerage facilities, solid waste management, energy for lightning is quasi universal. However, most African cities, as illustrated in the monitoring of the MDGs and the Habitat Agenda, are lagging behind the provision of these amenities despite progress made in the last decade. African cities have not been able to cope with rapid population in the provision of basic infrastructure. In addition, climate change is becoming a real and global threat; without smart management, hundreds of millions of African people will face severe water and energy shortages, ultimately leading to hunger and disease outbreaks. Increased occurrence of droughts and flooding have threatened road to sustainable development in the continent. Water scarcity, pollution, flooding, and other forms of water stress pose extreme threats to the African community. Growing pressures on freshwater resources are rising along with increasing populations, growing needs for agriculture and industrial purposes, as well as increases in energy consumption. Over-exploitation of water resources is another cause of water scarcity, as African countries will push for economic development. Water leakage is also a high concern. This is a clear indication that there is need for smarter infrastructure as well as for investment to replace ageing infrastructure.

[62] Aikins (2013).

[63] Törhönen et al. (2013).

In time of scarce supply of clean, fresh water, effective planning, monitoring and management through ICT are fundamental for efficient production and usage of water resources. For instance, advanced metering technologies allow for real-time communication of consumption patterns. Innovative demand forecasting technologies also allow the alignment people needs and production capacity of water sources.[64] Water-use efficiency is recognized as central for the achievement of the SDGs Goal 6 "Ensure availability and sustainable management of water and sanitation for all". The specific target for that is the SDGs 6.4, which is "by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity".[65] The achievement of this target calls for the use of ICTs to enhance water sustainability, efficiency and accessibility. As outlined in the Waterwise 2017 Flash report "ICT and water efficiency is a key policy issue with potential for new research area that includes decision supporting system for the measurement of water quality and quantity including the recycling and water reuse processes. Though sustainable water management policies have been high on the agenda of most governments, the potential of ICT to improve water management has not been exploited fully… Harnessing the capabilities of ICT within the water sector is a smart means to manage and protect water resources in Africa. Good governance is, however, required to ensure that these technologies are properly managed to protect water resources, and to ensure sustainable development and the equitable distribution of water-derived benefits".[66]

The Water and Sanitation Program (WSP) of the World Bank study shows the potential of ICTs for the improvement of water and sanitation services in Africa.[67] Use of ICT can contribute to efficient management of water, such as: use of Water Point Mapper to establish inventories of assets, mapping of infrastructure, enumeration of users, assessment of the quality and conditions of services, and timely, reliable monitoring of services with minimum cost. Timely, reliable monitoring provides opportunities to learn from practices (good or bad) and adjust courses of programmes and projects. For instance, the Community-Led Total Sanitation (CLTS) Mapper is a simple monitoring that allows the production of geo-referenced indicators including latrine coverage, open defecation free status and water contamination.[68] For instance in the city Lilongwe of Malawi, sanitation data collection through mobile phones along with web-based sanitation monitoring systems enabled real time sanitation information that could guide timely responses.[69]

ICT-based Solid Waste (SW) exchange can also address challenges related to sanitary landfills for solid waste disposal. It can increase the efficiency of use of resources through reduction, reuse, and recycling. Other applications include monitoring ille-

[64] http://ec.europa.eu/information_society/activities/sustainable_growth/water/index_en.htm.

[65] United Nations (2015).

[66] European Commission (2017).

[67] Ndaw (2015).

[68] http://www.communityledtotalsanitation.org/, Accessed 9 April 2017.

[69] World Bank (2015a).

gal dumping using Global Positioning Systems (GPS) and promoting recycling of resources. Nowadays, the selection of appropriate landfill sites as well as the design of a planning system for autonomous landfill compaction is accurately made through the use of ICT technologies. GIS-based analysis also allows reliable estimations of Solid Waste generation and optimum allocation of commercially available containers. Collection, transport and disposal systems are rationally and efficiently designed using ICT technologies. Triangulated irregular network (TIN) for waste estimation, allocation to containers and removal frequency, available container size, type and placement possibilities can be used during this GIS-based analysis. Firms discharging industrial waste, firms recycling industrial waste, and firms using industrial waste can be all connected through ICT-based waste exchange tools to better promote recycling of industrial waste. ICTs can finally make a valuable contribution to Integrated Sustainable Solid Waste Management.[70]

Monitoring and management of energy consumption can also be efficient through the use of ICTs. Complex measures and figures on different levels can be managed and aggregated in a comparable way in order to enable efficient monitoring and the adoption of a long-term approach. There are emerging solutions in computing that are in themselves energy efficient, such as thin clients, grid computing and virtualization technologies. Electricity at the household level can be tracked and monitored using smart meters. This can lead to efficient domestic energy use along with the creation of incentives for behavioural change. This will address energy saving potential in the energy end-use sectors that are not covered by the Emissions. This is a paradigm shift to "change the behavioural patterns of producers and consumers of goods and services to use less energy while increasing outcomes of quality of life as it is already noted in innovative cities".[71]

1.6.4 ICT for Infrastructure Development

Infrastructure Development complements the basic infrastructure services under smart city foundation and extends to actual investment and advancement of services such as transport, ICT, industrial energy, education, health, etc. Enormous efficiency gains of the use of ICT emerge in several sectors including transport. ICT impact the transport sector in many ways among them we can enumerate two: (a) the digitalization of the transport sector as it happens in all sectors and; (b) substitution (partial or full) of mobility to perform or access services.[72] The opportunities for ICT to support the overall urban challenges and opportunities are enormous, and African cities can integrate and use ICT solutions to facilitate the greater provision-

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[70]http://newsletter.epfl.ch/mir/index.php?module=Newspaper&func=viewarticle&np_id=106&np_eid=24&catid=0.

[71]http://www.government.se/contentassets/f496d0e0cc864e8fa57b22ea247a829e/report-ict-and-energy-efficiency-in-sweden.

[72]World Bank (2016a).

ing of urban services. Newly cheap ICT can unlock possibilities for greater transport efficiency. Cities may be able to use real-time data to design and implement policies that increase transit accessibility, decrease travel time, substitute for expensive road construction, and abate congestion and pollution.[73] The widening use of smartphones, high urbanization rates, and the rapid evolution of technologies are driving the expansion of real time passenger information (RTPI) systems for urban transport services. RTPI provides accurate information on actual departure and arrival times and service disruptions, enabling passengers to plan more-efficient trips.[74] National and local authorities can also build awareness on "Intelligent Transportation" with the integration of ICT to address transport challenges. The ICT revolution with the rapid development and use of Internet, digital mobile communication, and "big data" analysis enable to create a less costly and more powerful "intelligent transport systems" (ITS).[75] The ITS have a greater potential to more efficiently manage transportation assets, improve road safety, reduce traffic congestion and travel time. This will boost productivity and reduce greenhouse gas (GHG) emissions.

Substitution Digital businesses support a sustainable transport in reducing the demand for both motorized and non-motorized means of mobility. Digital businesses include mobile money, price comparator websites, and online media. At the higher scale, we are moving to the era of digital goods traded exclusively online, as for e-books, online search, and streaming music and videos—making transport, storage, and distribution obsolete for these transactions. Nowadays, increased newly created businesses operate model entirely on the web but offer traditional services that require traditional means of transport, and existing businesses are operating part their activities through the web.[76] ICT finally offers a form of substitution for physical mobility. It can be expected that work-related movements can be mitigated through telecommuting with the use of ICT to perform work at a location away from the traditional office location and environment. Commuting is thus substituted and it is implied that it took place remotely instead. There are obviously various degrees of telecommuting ranging from a partial substitution where a worker may spend one day per week performing work at another location, to a complete substitution where the work is performed elsewhere, such as in an offshore call centre.[77] This depends on the type of the job, the World Bank Digital Dividend publication provided some initial indications on the type of job that can fully telecommuted and those that cannot.[78] In 12 countries surveyed in Africa, 73% say mobile phones help save on travel time and costs, with only 10% saying otherwise.[79]

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[73] Krambeck (2015) and Haddad et al. (2014).

[74] Pulido and Canales (2015).

[75] http://www.worldbank.org/en/topic/transport/brief/connections-note-26. By Winnie Wang, Raman Krishnan, and Adam Diehl.

[76] Rodrigue et al. (2013).

[77] Rodrigue et al. (2013).

[78] World Bank (2016d).

[79] World Bank (2016d).

1.6.5 Creation of Smart Digitally Served Towns and Villages Through ICT

Through ICT, towns and villages have also access to innovations, can participate in democratic debates, and make their voices heard. Today, voices are not just originating from the cities but also from the villages. Finally, the emergence of these digitally served towns and villages will foster economic development without damaging the environment; there will be less consumption of land for private proprieties, and few cars than before in the road making streets friendly and healthy for walking and cycling. In a long term, this will reduce emissions of CO_2, promote the creation of low carbon settlements, reduce land degradation and promote biodiversity. These digitally connected settlements will provide economic advantages at a larger scale while safeguarding the environment. They will be sustainable, inclusive, resilient and prosperous, what cities of today aim to be. This will mark the end of big cities and the rise of digitally served towns and villages: *the digital urbanization*.

In Africa, we are moving to the era of digital towns and villages that are connected via internet for their commercial, financial, administrative, and social activities. Digital settlements will be the future of development in Africa; they are the trajectory of our urban planet. There are many examples of digitally served villages around the region already for which ICT advances have dubbed the spatial obstacles irrelevant and opened up remote areas to the region and world with great local and regional benefits. For example, as noted in the publication of the World Bank Development Report 2016 "Digital Dividends", in Uganda, wider mobile phone coverage is contributing to increased sale of perishable crops such as bananas from farmers in remote areas.[80] In Rwanda, off-grid energy is supplied to villagers by combining solar energy technology with mobile phone–based loan payments.[81]

1.6.6 ICT for Smart Social Development and Smart Social Inclusion

Social Development encompasses elements of education, health, public space, social inclusion, social capital and cultural heritage. **Social Inclusion** includes aspects of participation in decision making as well as according all city residents equal opportunities for growth and prosperity. Averages may hide the invisible; the situation on the ground shows different pictures with persistent social inequalities across settlements that influence and shape the education system. Though cities are hosts to more educational infrastructures than villages and provide young people with opportunities to continue their education and access gainful employment in the formal sector, they can also generate and intensify the kind of social exclusion that denies the ben-

[80] Muto and Yamano (2009).

[81] World Bank (2016d). See also http://www.plugintheworld.com/mobisol/.

efits of the “urban advantage” to youth and other marginalized groups, particularly in conditions of unprecedented urban growth, increasing poverty and inequality, or inadequate policies.[82] In the same city, some youth are able to succeed and prosper while others drop out of school, fail to find productive employment and sink into poverty.

1.6.6.1 ICT for Smart Heath

The level of urbanization is generally associated with numerous, positive societal outcomes, such as technological innovation, various forms of creativity, economic progress, higher standards of living, enhanced democratic accountability, and women’s empowerment. In the dreams of all those who move to urban areas, cities foster the healthy development of children and young people, providing easier access to education, health care and employment than is available in rural areas.[83] The Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Surveys held in many African countries show a constant progress in access to health services in Africa during the past 25 years. In the 1990s, access to health services was very limited and infant and child mortality rates were consequently high. With a steady improvement in health coverage, enhanced with the Millennium Development Goals (MDGs) 4, 5 and 6, the improvement was accelerated during the 15 years of the MDGs despite the incidence and prevalence of HIV and AIDS in some parts of Africa.[84,85]

Despite the urban advantage, urbanization has also come with challenges that can be enormous such as finding a decent job and accessing basic services—adequate shelter, safe water, adequate sanitation, food, education and health services. In many African cities, living conditions in slum communities are worse than in rural areas. The poor are typically driven to the least developed areas of a city, often places that are poorly integrated to the urban fabric, where dilapidated environments lead to worse health outcomes and greater risks of premature deaths than in improved and well-maintained urban areas. Beside health inequalities, modern environmental diseases appear to impede decline in morbidity and mortality rates. These modern environmental diseases are associated to changes in urban life with the increased motorized means that has enormous negative impacts on people’s lives. Modern environmental health hazards include water pollution, urban air pollution from automobiles, radiation hazards, land degradation, climate change, and emerging and re-emerging infectious diseases.[86,87,88]

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[82] UN-Habitat (2010).
[83] UN-Habitat (2010).
[84] UNICEF and WHO (2015).
[85] Mboup (2017c).
[86] Mboup (2017c) and UN-Habitat (2010).
[87] Smith (1995).
[88] Staton and Harding (2001).

ICT Revolution and Smart Health Services

ICTs can play a critical role in improving health care for individuals and communities. By providing new and more efficient ways of accessing, communicating, and storing information, ICTs can help to bridge the information divides that have emerged in the health sector in Africa, particularly between health professionals and the communities they serve and between the producers of health research and the practitioners who need it. Through the development of databases and other applications, ICTs also provide the capacity to improve health system efficiencies and prevent medical errors.

Universal Health Care calls for transformative actions with increased integration of ICTs in the health sector: transforming the analogue health sector to an ehealth sector[89] as underscored in the WHO Report for the World Summit on the Information Society in Tunis (2005): "Today, ICT is fundamental for health systems to meet obligations to deliver care, pursue research, educate students, treat patients and monitor public health". The smartness of health care will depend on how well ICTs are integrated in health services and systems for efficiency of care delivery. Transformational change in care delivery will result from emerging, ubiquitous, participatory preventive and personalized smart models of care. Various possibilities in care delivery are associated with the use of mobile devices and the internet to address health care challenges. Introducing ehealth support self-management as well as "participatory healthcare".[90]

As underscored by the World Health Organization (2016), eHealth plays a vital role in promoting universal health coverage in a variety of ways including: (a) provision of services to remote populations and underserved communities through telehealth or mHealth; (b) training of the health workforce through the use of eLearning, and making education more widely accessible especially for those who are isolated; (c) efficiency of diagnosis and treatment by providing accurate and timely patient information through electronic health records and; (d) improvement of heath services' cost-efficiency. Further, WHO noted that "eHealth is the cost-effective and secure use of ICT in support of health and health-related fields, including healthcare services, health surveillance, health literature, and health education, knowledge and research."[91]

The extensive use of ICT in healthcare is a basic condition for the development, implementation and further generation of innovative health care technologies. As noted Rudowski (2005), ehealth has advantages at various levels.[92] "With the use of MEDLINE search training and the hospital's Internet connection, a physician in

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[89]At 58th session in May 2005, the World Health Assembly (WHA) adopted a resolution WHA 58.25 establishing eHealth strategy for WHO promoting the use ICTs in the health sector and services for all (citizens, patients, healthcare professionals, healthcare providers, as well as policy makers).

[90]http://www.oecd.org/sti/ieconomy/ict-and-the-health-sector.htm. ICTs and the Health Sector: Towards Smarter Health and Wellness Models. OECD, 2013.

[91].WHO (2016).

[92]Rudowski (2005).

a remote rural hospital is able to diagnose and successfully treat the patient for a tropical disease. Using the electronic health record, the hospital's prescription trends can also be analysed to assess whether prescriptions whether or not are done according international guidelines. In a situation where these guidelines are not respected, hospital's administration can intervene to reinforce the adherence to these guidelines. There numerous ICT technologies that can be used to improve the health care systems including CT-scans, other medical images by e-mail to help in diagnosing and treating a variety of health issues". ICT also allow better planning, monitoring and management of health services and systems. For instance, an ehealth pilot programme focusing on chronic heart diseases has been launched to test a multi-lingual electronic health record. The relevant data will be self-recorded by the citizens with chronic diseases.[93]

Challenges Associated with the Integration of ICT in the Health Sector

Though in most developed countries, the ICT is widely available in health systems, in many African cities, its penetration is still limited. Social capacity, knowledge and acceptance to use of eHealth technologies among citizens and medical professionals need to be strengthened throughout the African region. The use of ICT to support health care faces many barriers such as the need for a trained workforce skilled in using eHealth solutions, the need for proper governance, funding, infrastructure, technical support, and sustainability. In the 21st century the delivery of health care and improvements of health systems must consider the contribution of ICT as an essential component, not an add-on. eHealth is now an integral part of delivering improvements in health. However, the process of embedding eHealth everywhere still has a long way to go, both in terms of coverage and functionality from its foundations; legal frameworks; telehealth; the electronic health records; the use of elearning in health sciences; the mhealth; to social media and big data.

The ICT revolution is also associated with the generation of a wealth of data (big data) from multiple sources accessible to various stakeholders and citizens, notably in the health sector. However, transforming this wealth of data to meaningful health information is also another challenge. Key challenges of using big data also lie on the management and analysis of data, particularly patient data that require confidentiality and to be stored securely and accurately. The European Space Agency (ESA) identifies a list of key regulatory issues associated of the use of eHealth in Sub-Saharan Africa: (a) access to data; (b) security and access to clinical information systems by patients and care providers; (c) privacy and confidentiality; (d) informed consent for data use; (e) data ownership; (f) access rights to patient data; (g) integrity of data and; (h) patient safety.[94] Statistics from WHO's Global Observatory for

[93]WHO (2016).

[94]WHO (2016). ESA supported the publication of four linked studies whose objective it was to explore the challenges and opportunities of a satellite-enhanced e-health and telemedicine infrastructure for sub-Saharan Africa.

ehealth, also show that the African region is lagging behind in introducing many components of health[95] despite various opportunities that ICT platforms offer.

1.6.6.2 ICT for Smart Education

Education has been for a long time obtained in a classroom with a teacher and students. Today, the ICT has transformed the learning environment and methods and calls for a paradigm shift in assessing level of education and knowledge in Africa as it is happening in many regions. Knowledge transfer is becoming possible outside the classroom. ICT offers a unique, historical opportunity for most African countries where the educational resources in terms of school facilities and human resources have been unable to meet the growing demand in education from sustained increased of children and young population to be enrolled in primary, secondary and higher education levels. Despite efforts for free primary education and lower secondary education in some countries, with the shortage of classrooms and teachers, disadvantaged children and young people have been left behind without education or just with some education in the continent. Despite the huge investments of African governments for these past years on educational infrastructures with the opening of more schools in remote areas and the decentralization of secondary schools and colleges, African countries still face shortage in infrastructures as well as in human resources. Exponential growth of private schools have been also noticed making school more accessible, but these are affordable in most cases to only rich families; those available for poor families are in most cases at a substandard performance in terms of infrastructure as well as in terms of human resources. Bridging the gap in terms of social inequalities as well as in terms of supply-demand will call for a paradigm shift with the integration of the digital approach in learning. Investing in the ICT infrastructures will allow to reach the poor in a lower costs and will also allow to fill the deficit supply to demand in lower cost and in a sustainable manner.

Improving the Quality of Education Through Use of ICT

Digital technologies affect the whole skill formation process by changing both the teaching and the learning processes. It constitutes an effective way of improving the quality of education, particularly in developing countries where the ratio teacher to students is exceptionally high.[96] Digitization of the education system with the provision of ICT infrastructure such as computer and internet connection will allow real time access and use of teaching materials and knowledge in general, making teaching more relevant and effective. Teachers can use online portals to connect with

[95]WHO (2015).

[96]World Bank (2015b).

each other and to share lesson plans and best practices, while students can use ICT to access online libraries and to master new technologies.[97]

Several actors, such as families, school and training systems and other social and religious institutions, also play a key role on children education in building these skills in early age and throughout the life cycle. In the future, all these diverse institutions and groups will use digital technologies in the building of foundational skills. While there are concerns about the impact of digital technologies on cognitive capacities and socialization, especially among young children, increased development and use of these technologies are irreversible. At home, children are exposed to a series of mobile phones and other digital gadgets where their literacy and numeracy initiation starts.[98] In addition to that, online educational games introduced to young children prior to starting school can enhance foundational skills.[99] Access to the internet, laptops, tablets, mobile phones, digital whiteboards, and video-based instruction are increasingly common in primary and secondary education. Most countries have also introduced programs like One Laptop per Child (OLPC).

Bridging the Education Divide with the Digitalization of the Education Systems and Methods

Many African in general have been unable to satisfy the educational demand, particularly at secondary and higher levels. In this regard, ICT revolution can play a significant role. For instance, the Massive Open Online Courses (MOOCs) is a recent development in distance learning, characterized by three key aspects: open enrolment, online assessment, and an interactive forum. They are at a large scale and mostly free, except fees for certification. Platforms such as Coursera.org, Udacity.com, and edX.org host these online courses, and are also used to assess participants' performances.[100] Coding classes through free specialized online platforms such as Codecademy are also available. Two factors have contributed to the rapid rise of online courses such as MOOCs.[101] Firstly, digital technology has come of age, with widespread use of laptops, tablets and smartphones with growing broadband penetration in many countries. Secondly, the 'digital native' generation has now reached university age and is totally at ease with the all-pervasive use of digital social networks for personal communication.[102] The digital revolution is one new and disruptive way for universities to 'go global' beyond their single campuses to reach a global audi-

[97] World Bank (2015c).

[98] Mboup (2017c).

[99] Flannery et al. (2013). ScratchJr, is an application aimed at teaching algorithm thinking and coding principles to kids at young age (5–7 years) using a simple drag and drop interface.

[100] Ho et al. (2015).

[101] Escher et al. (2014).

[102] Mboup (2017c). The number of world-class universities committed to this digital innovation is steadily growing, as is the number of students—one MOOCs provider, Coursera, has seen the number of students almost double from 7 million in April 2014 to 12 million in 2015.

ence. Cloud computing and supercomputing as well as the handling of big data, have already transformed research.

ICT is indeed considered in national policies on research and innovation based on the vision of most African countries of becoming a middle-income country by 2035. This vision considers higher education and research as a catalyst to socio-economic development and thus a priority for reform. Making ICT infrastructure economically, socially and environmentally sustainable for learning and knowledge sharing is the key in driving the African cities towards smartness.

1.6.6.3 ICT for Smart African Cultural Heritage

Cultural heritage may be considered as tangible (artefacts, the written word and documentation) or intangible (oral tradition, stories, performance, etc.) as advocated and demonstrated UNESCO. Cultural heritage is a driver and enabler of economic, social and environmental factors, and of sustainable development in general. It plays a key role in the making of cities smart, but it is often overlooked in the analysis of urban life. Heritage and culture are core of the city foundation and must be considered in the main elements of cities such as the planning, the land tenure, the provision of basic infrastructure through institutions and laws. Indigenous traditions, native religions, ethnic identification also constitute the heritage and cultural identity of settlements being a city, a town or a village. La question is, in the process of urbanization with land expansion or proliferation of slum, how an African city will be able to sustain itself in terms of heritage and culture? In this process, how an African city will also be able to foster cultural diversity and creativity and stimulate innovation? Land rights are especially important for Indigenous people, for whom lands, territories, and other resources may also hold significant spiritual or cultural values and have implications for their right to development.[103]

The historical place of the urban setting that has shaped various social, economic and political transformations in Africa had been overlooked in various studies of African human settlements in the pre-colonial area. Although African societies have been predominantly rural for most of their history, urban settlements have existed for centuries and have been an important feature of Africa's history. Archaeological works have shown different forms of urban centres and towns in Africa during the pre-colonial period with an African face made of combination of villages and urban centres.[104]

Africa has, indeed, a long and rich history of urbanization dating back thousands of years. Cities in ancient Egypt, the Western Sudan, Nigeria, Ethiopia, the East African City States, and Southern Africa appeared long before the arrival of Euro-

[103] Mboup (2015a).

[104] Bill Freund, University of KwaZulu-Natal, The African City—A History. Cambridge University Press 978-0-521-52792-7; see also See also Catherine Coquery-Vidrovitch, African urban history for the 1991 African Studies Review and; Alan Mabin and Sue Parnell, two distinguished urban scholars in South Africa.

peans to Africa's coasts.[105] In time and space, African cities expressed a social and cultural evolution resulting from the interrelationship between urban people and their environment, structured along given political and social factors, and ecological, technological, and ideological constraints.[106] Walled cities have also been common in the pre-colonial era as means for protection from neighbouring communities. Walled cities or settlements were found in ten African countries: three in Algeria (including Algiers), three in Egypt (including Cairo), one in Ethiopia (Harar), 15 in Libya (including Tripoli and Benghazi.), three in Mali (Djenne, Gao and Timbuktu), 28 in Morocco (including Casablanca, Marrakech, Meknes and Rabat), one in Niger (Zinder), three in Nigeria (Benin City, Kano and Keffi), four in Tunisia (Kairouan, Sfax, Sousse,Tunis), and one in Zimbabwe (Great Zimbabwe).[107]

In terms of housing, architecture and organization, Blier (2012)[108] noted three historic patterns of urban settlements in the pre-colonial Africa: (a) The *Monumental urbanism*, especially prominent in north, eastern and southern Africa (from Egypt and Eritrea to Zimbabwe), was characterized by substantial permanent structures in stone; (b) The *Satellite urbanism,* found especially in West Africa (from Mali to northern and southern areas of Nigeria), was characterized, on one hand, by its earthen structures and, on another hand, by the collaboration between interlinked community clusters that together create an urban settlement structure and; (c) *Migratory or peripatetic urban settlements*, found mostly in central Africa, were characterized by the nomadic identity of their population. In the latter, following the death of a ruler or a sequence of traumatic events, interlinked cities were often re-established on a new site. However, European colonialism dramatically impacted city planning and design in Africa with two particular negative impacts: (a) one associated to the destruction of the African patrimony of indigenously designed and developed urban places and spaces, with culturally-rooted built environments eroding; (b) the other is that the pressures are commodifying the place-identity of historic urban spaces and places, detaching them from their local, spatial, and temporal continuity, whilst still representing them as preserved authentic artefacts for global cultural consumption.

ICT technologies can be used for the preservation of African culture and heritage. Like education and health, heritage is personal, though influenced by the collective through commonalities in personal experiences.[109] ICT can enhance the way cultural expressions are created, produced, disseminated and accessed and play an increasingly pertinent role in the safeguarding and transmission of cultural heritage. It can also respond to major global challenges through the exercise of freedom of expression and the promotion cultural diversity.[110] However, this will require a pre-

[105]Edited by Salm and Falola (2005).

[106]Coquery-Vidrovitch (2005).

[107]https://en.wikipedia.org/wiki/List_of_cities_with_defensive_walls.

[108]Blier Suzanne Preston (2012).

[109]https://ercim-news.ercim.eu/en86/special/introduction-to-the-special-theme-ict-for-cultural-heritage.

[110]http://www.unesco.org/new/en/media-services/single-view/news/culture_and_ict_as_drivers_of_sustainable_development/.

cise development of metadata, metadata; the semantics of shape; digital provenance; and long-term preservation. The more challenging is the integration of knowledge across multiple sources and their metadata. Knowledge of "possible pasts" including facts, events, material, social and psychological influences and motivations are fundamental for any historical research. This will require to use and reconcile of multiple sources in different forms with some of them require content-based analysis to understand the artefact's "meaning". This is where the ICT is invaluable to debunk the black box of this big data of culture and heritage.

1.6.6.4 Social Media: Connecting People to People and Enhancing Social Capital

Through social media, people, within families and communities, engage on various social issues ranging from family matters to community and political issues. In most African cities, every household has at least a mobile phone, and some are connected to internet from mobile providers easing the use of Facebook, WhatsApp, Viber, Messenger, and other communication apps. However, the role social media can play in enhancing social capital varies across social groups will depend on variations in access and use of the ICT platform. There are large variations on how people use social media and how they share information. It is now common in many African countries that family arrange meetings through the ICT platform, exchange on social issues, collect funds to build their community, spread news for social functions such as marriage, funeral, and religious ceremonies. People also use the ICT platform to raise concerns about the organization of their communities including connections to basic services such as water, electricity, solid management, flooding, etc. Social media also play a political role in spreading democratic ideals as it is witnessed with the Arab Spring or social demand such as the Wall Street movement. However, social media can also spread false information or correct misinformation as it recently happens with various hot topics such as matters related to sexual orientation and others.[111]

1.6.7 ICT for Smart Environmental Sustainability

The use of ICTs along with the planning of compact cities with socially mixed neighbourhood and mixed land used (residential and commercial activities together) will reduce the emission of CO_2 through various channels such as: (1) reduce the demand for total motorized transport; (2) promote the use of "low-emission" transport modes such as walking, cycling, and public transport and; (3) use the most efficient fuel-vehicle technology system possible for all trips. ICT will also decongest large unplanned African cities with the creation of smart secondary urban centres without

[111]World Bank (2016). The Digital Dividend, Box 08: The four digital enablers: Social Banking, Social Media, Digital Identity, Data Revolution, pp. 27–28.

increasing the use of motorized means of mobility. ICT will also enable digital urbanization with green walkable, liveable, healthy spaces. Digital urbanization will foster economic development without damaging the environment; there will be less consumption of land for private proprieties, and few cars than before in the road making streets friendly and healthy for walking and cycling. In a long term, this will reduce emissions of CO_2, promote the creation of low carbon settlements, reduce land degradation and promote biodiversity. Digitally connected settlements will provide economic advantages at a larger scale while safeguarding the environment. These settlements will be sustainable, inclusive, resilient and prosperous, what cities of today aim to be.

As developed in Chap. 9 of this book, with the growing availability and application of Information and Communication Technology (ICT) for conservation, cities are now more than ever well-placed to integrate biodiversity priorities in urban planning processes. From the use of computers for spatial mapping and analysis of biodiversity data, to camera traps for monitoring wildlife movement in the city-scape, and mobile phones for advancing citizen science, the opportunity for application of ICT in development of smart and sustainable cities is quite promising. ICT application can foster efficient collection and appropriate use of biodiversity information to inform decision-making and actions on sustainable use and conservation of biodiversity.[112]

ICT has been also instrumental for the development of tools for the monitoring of air quality. As developed in Chap. 10 of this book, air quality monitoring stations are equipped with ambient air analyzers, which allow continuous measurements of pollutants including: Nitrogen Oxides (NOx); Ozone (O_3); Particulate matter 10 μm in diameter (PM_{10}); Particulate matter 2.5 μm in diameter ($PM_{2.5}$); Benzene, Toluene, Xylene (BTX); Carbon monoxide (CO); Sulfur dioxide (SO_2).

1.6.8 ICT for Smart Disaster Prevention and Resilience

African cities are dramatically vulnerable to disasters. This hampers their social and economic development. To manage, and mitigate disasters, “It is critically important that the Resilience of Nations and Communities to Disasters be translated into concrete actions at all levels and that achievements are followed up through the International Strategy for Disaster Reduction, in order to reduce disaster risks and vulnerabilities”.[113] However, instead of managing underlying risk drivers for disaster risk reduction, many African cities focus on managing disasters. However, as recommended in the Sendai Framework for Disaster Risk Reduction of the Third UN World Conference on Disaster Risk Reduction held in March 2015, disaster risk management needs to be about managing the risk inherent in social and eco-

[112] Maezawa et al. (2014).

[113] As noted in the Hyogo Declaration and Hyogo Framework for Action (HFA) 2005–2015.

nomic activity, rather than simply mainstreaming disaster risk management to protect against external threats like natural hazards.[114]

For instance, the risk of catastrophic losses due to flooding is becoming significant as a result of deforestation and the increasing proximity of large populations to coastal areas, river basins and lakeshores.[115] Floods are the most common natural disaster and the leading cause of natural disaster fatalities in African cities and in the world generally.[116] In African cities, the vulnerability to flooding is particularly related to the fact many poor households have been forced to settle in flood prone areas due to inaccessibility to planned land in most African cities. Due to poor land administration and governance, there is no compliance with standards of occupancy of the space leading a high building density and irregularity of the urban fabric. In addition to the fact that settlements are flood prone areas, the climate change made the situation worse, particularly in coastal cities where it contributes to the increase of sea levels. The impacts of floods on people and communities are enormous ranging from economic, social and health issues to environmental aspects. By Affecting social development with inaccessible of most services, the economic development is also severely affected with significant decline of productivity of the active population. The impact of flooding related disasters remains a significant challenge to sustainable development of the many African cities.

African cities must undertake a transformative move to a green, smart city where fighting floods and their consequences is no longer in the city agenda, but in history books. Better management, mitigation and deployment of early warnings can save more lives in future. For instance, a flooding observatory that aims to collecting and

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[114]The Sendai Framework's seven global targets are (a) Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015; (b) Substantially reduce the number of affected people globally by 2030, aiming to lower average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015; (c) Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030; (d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030; (e) Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020; (f) Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of this Framework by 2030; and (g) Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people by 2030. See https://www.unisdr.org/we/coordinate/sendai-framework.

[115]UNISDR 2015: "The reporting gaps underline the need for UNISDR and partners to continue working with governments to establish robust and well-maintained national disaster loss databases to improve record-keeping and accountability. Universally acceptable loss indicators are currently under development to measure progress in reducing disaster losses as set out in the Sendai Framework for Disaster Risk Reduction 2015–2030".

[116]The term hazard refers to a severe or extreme event such as a flood, storm, cold spell or heatwave etc. which occurs naturally anywhere in the world. Hazards only become disasters when human lives are lost and livelihoods damaged or destroyed. Rises in the global population increase the risk of disasters because more people live in harm's way. (Reference: Centre for Research on the Epidemiology od Disasters (CRED) and UNISDR The Human Cost of weather related disasters (1995–2015).

analysing events prior, during and after flooding will assist in the development of informed policies.[117] This observatory can be supported by different types of data collection and analysis software tools in the field of disasters (post-disaster conditions as well as long-term measure to mitigate the risk of the disasters). For instance, characteristics and effects of different types of disasters, particularly the ones not visible from global or national scales can be captured using the DesInventar software. This information can be used for planning, risk mitigation and disaster recovery purposes as well as to simulate disasters and their impact, particularly on the possible loss of human lives, impact on the economy and damage to infrastructure, etc.[118] From DesInventar, the programme for Monitoring, Mapping and Analysis of Disaster Incidents in South Africa (MANDISA)[119] as a core activity for the Disaster Mitigation for Sustainable Livelihoods Programme of the University of Cape Town. MANDISA allow the collection and analysis of hazards in South Africa, including large urban 'non-drainage' floods, wildfires and extreme wind events, as well as highly frequent 'small' and 'medium' fires. Development conditions that predispose to disaster as well as socio-economic and environmental risk factors that affect disaster impact were also collected and analysis where possible.

1.6.9 ICT for Smart Peace and Security

The impact of ICT on Peace, Security & Governance in Africa Peace Building in the information age

Lack of peace and security in Africa hampers social and economic development of the continent. Crime and insecurity create social instability and have serious implications on social and economic development. As analysed in Chap. 13 of this book by Opiyo, in African cities, Crime and insecurty manifest in multiple forms such as organized crimes, cybercrimes, terrorist threats; drug trafficking, money laundering, homicides, rape, defilement, robberies and crimes involving officers.[120] "Crime ranks as one of the major inhibitors to investment on the Africa continent and those countries with higher rates of violent crime tend to make less progress in reducing poverty and expanding development. These concerns bring out clearly the need to articulate security matters in cities in helping them achieve competitiveness, which is more critical for most African cities whose citizens are keen in making sustainable progress by improving the livability conditions and attraction of investors. African

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[117]"Centre for Research on the Epidemiology od Disasters (CRED) and UNISDR The Human Cost of weather related disasters (1995–2015). "The World Conference on Disaster Reduction, held in Kobe, in Japan's Hyogo Prefecture, from 18 to 22 January, 2005".

[118]United Nations (2009).

[119]Disaster Mitigation for Sustainable Livelihoods Programme, University of Cape Town, South Africa, www.egs.uct.ac.za/dimp. In UN-Habitat, 2007. Enhancing Urban Safety and Security, Global Report on Human Settlements (GRHS) 2007. Published by Earthscan, UK and US.

[120]Opiyo (2018).

has been facing challenges of insecurity attributed to key components of the smart economy in smart city conceptual framework such as: (a)urban planning which has exacerbated social divide leaving the poor in unplanned settlements; (b) basic infrastructure which has contributed to dilapidated environment of hopelessness of broken windows principle of crime and (c) poor institutional governance which has slowed functions and capacities of institutions to spearhead smart development".[121]

Despite all these fundamental challenges in the security sector, the opportunities of attaining smart development in African cities is emerging given the modern technologies of surveillance and security provision for example the rapid expansion and accessibility of mobile communications technology in Africa which is creating new opportunities for combating crime and strengthening police accountability. Twitter, SMS, and event-mapping technologies are being used to connect communities with police and security forces as never before. In 12 countries surveyed in Africa, two-thirds believe that having a mobile phone makes them feel more safe and secure.[122] Mobile phones play an important role in detection and prevention of violence.

Regional organizations are also taking advantage of new communication tools to better protect their citizens. The Inter-Governmental Authority on Development (IGAD) in Eastern Africa has developed a Conflict Early Warning and Response Mechanism (CEWARN) in order to respond to and prevent conflict in their region (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda). In partnership with ICT4Peace, CEWARN has assessed how ICTs could be used in areas that generally have no access to communication technology, and started using high-frequency radios, satellite phones, and other technology to access areas that used to take days to travel to and review.8 Similar initiatives have also been developed by the Economic Community of Western African States (ECOWAS) within their ECOWAS Warning and Response Network.[123]Mapping Urban Space through Closed Circuit Television Cameras (CCTV) also allows the monitoring, management and prevention of crimes in cities. CCTV system can assist to reduce the complexity of both public encounters and urban space so as to make policing easier.

However, it is frequently noted that misuse and abuse of ICT's are exposing populations and communities to environmental insecurity. Blackmailing and identity thefts along with inculcation of forced conflict have emerged along with the ICT revolution. Terrorist organizations also use means of ICT to promote their activities, ideology, propaganda, and justification for their actions and create fear among people, particularly the ones most vulnerable in the community. The manipulation of grievances such as injustice and social exclusion is one the approaches to enrol vulnerable people, particularly children. The United Nations Office of Drugs and Crime (UNODC)[124] has identified three means by which extremist organization acquire

[121]Ndugwa et al. (2017).

[122]World Bank (2016d).

[123]As noted by Opiyo (2018). Op. Cit., Search for Common Ground (SFCG) (Undated). Communication for Peace building: Practices, Trends and Challenges. Supported by United States Institute of Peace (USIP). http://cu-csds.org/wp-content/uploads/2009/10/usip2011vdk.pdf.

[124]UNODC (2012).

funds for their acts of terror: direct solicitation, e-commerce, payment tools along with bogus charitable organization. They also use ICT platforms to train their recruits, plan an attack, communicate and coordinate involvement of multiple parties.[125] For these past five years, acts of terrorist are frequent in many African countries: Al-Shabab in Somalia, Boka Haram in Nigeria, Aqmi in Mali and several other sub-groups. However, ICT can also be used to fight these acts of terrorists as any other ICT-related crimes. For instance, ICT4Peace Foundation[126] promotes cyber security and a peaceful cyberspace through international negotiations with governments, companies and non-state sectors.

Social media can also help communities to appreciate their diversities, share experiences, voice their salient issues, prevent eventual conflicts and solve their problems. ICT can be the refuge for peace and security through participatory governance principles enforced in a harmonized and transparent digital platform. Listening to people needs and grievance, governments can respond to and prevent potential conflicts. With the multiple interdependent and multifaceted problems, the search for solutions requires an digitally integrated platform that promotes citizens' participation. However, autocratic regimes may also have the tendency to use ICT platform for other purposes than citizens' participation, for their own parochial end and propaganda to impede their use by people and organized associations. In many corners of the continent pro-democracy movements are threatened and activists are punished and even killed.[127]

1.7 Conclusion and Structure of the Book

African cities are potentially engines of prosperity due to their capacity to produce economies of scale, and agglomeration economies; their contribution ranges from 50 to 70% of the national Gross Domestic Product (GDP). But, they perform far less than their counterparts in other regions due to multiple challenges such as poor urban planning, insufficient infrastructure, weak land tenure, inefficient institutions and urban laws. However, African urbanization is occurring at a time when ICT is making the production and the distribution of goods and services more efficient and as well easing the connection between settlements. Over the past 15 years, African countries have taken various steps to create an environment favourable for the development and use of ICT at all levels. They create legal institutional frameworks to support regulatory mechanisms in the development and use of ICT and introduce digital platforms such as E-Governance, E-Education, E-infrastructure. However, this chapter has demonstrated that maximizing the digital dividends requires bet-

[125] https://www.linkedin.com/pulse/maintaining-international-peace-security-using-icts-anant-mishra.

[126] ICT4Peace is another policy and action-oriented International Foundation: www.ict4peace.org.

[127] https://milunesco.unaoc.org/mil-articles/the-impact-of-ict-on-peace-security-governance-in-africa/.

ter integration of ICTs with several dimensions of cities such as: city foundation, infrastructure development, environment sustainability, social development, disaster prevention, resilience, peace and security.

Based on the holistic approach of smart economy in smart cities, this publication consists of 15 chapters presented below.

The chapter "Relevance of Smart Economy in Smart cities in Africa" presented here by Gora Mboup and Banji Oyeralan-Oyeyinka articulates the relevance of smart Economy in Smart Cities in the African context marked by rapid urbanization. Following the exigency of the city of the 21st century, the governance and sustainability of cities that guarantee inclusion, resilience and prosperity, call for different types of planning and management tools. This chapter suggests the application of the broad notion of "smart economy" and "smart city" mechanisms in transforming African cities in ways that make them knowledge-based and innovation-driven. There is an emerging consensus on the various conditions that make cities liveable and these include key pillars of ecology/green, social, economic, political and health equities. Realizing a liveable city is underpinned by the deliberate and progressive investment in ICT infrastructures and their correlates such as social media and in general big data. This is the context in which the chapter locates the concept "Smart Economy in Smart African Cities" to unlock the potential of African cities to be sustainable, inclusive, resilient and prosperous.

Chapter 2 presents "African Cities in Time and Space: Past, Emerging Trends and Perspectives" by Gora Mboup. As people have histories, cities do too. This chapter presents the African conception of urban spaces, religious factors as well as colonial ideologies, and conceptions of cities contribute to the transformation of urban spaces in Africa. It presents the historical place of the urban setting that has shaped various social, economic and political transformations in Africa. Although African societies have been predominantly rural for most of their history, urban settlements have existed for centuries and have been an important feature of Africa's history. The dynamic transformation of African urbanization occurred in different paces, times and places. Long before the penetration of Islam in Africa and the European colonialism, Africa displayed various systems of cities and villages required for sustainable growth and social harmony. However, there is noticeable transformation of the African Urban Space consistent with European Colonial conception, particularly in terms of urban planning and provision of basic infrastructure. Independence in African countries marked a significant turning point in African urbanization with massive migration from rural areas seeking jobs, particularly in capital cities. This unsustainable trajectory of migration gave rise to the emergence of multiple faces of slums in the process of African urbanization. Additionally, this chapter presents different forms of the Urban System in Africa characterized by the emergence of large size cities in many African countries.

Chapter 3 by Gora Mboup titled "Africa's Smart City Foundation: Urbanization, Urban Form and Structure, Land Tenure and Basic Infrastructures". This chapter assesses the spatial growth of the city and how populations are spatially distributed. While the population of the city has been well researched and presented in the tradition of the UN Population Division to update the urban levels and trends and city growth in its yearly publication titled: *Urbanization Prospects*, few studies provide sufficient accurate information on spatial growth of cities in different periods. Little was known on the spatial growth of cities until recently with the development and use of GIS technologies. The chapter will also analyse land tenure and the provision of basic infrastructures such as water, sanitation in African cities. It will also introduce the concept and measurement of city foundation.

Chapter 4 presents "Cities in the Context of Climate Change: Opportunities for Local Authorities in Climate Action in Africa" by William Kojo Agyemang-Bonsu, Kusum Lata and Vintura Silva. The achievement of global emission reduction targets under the Paris Agreement could be greatly enhanced with the active engagement of cities. Cities are one of the major contributors to global greenhouse gas emissions while providing habitation to more than half of the world's population. The Convention provides avenues for cities to identify, implement, monitor, report and gain recognition for the actions undertaken. This chapter defines what climate smart cities means, evolution of cities as actors of climate actions, and highlights some of the mechanisms and opportunities available under the Convention for which African cities could avail themselves of, including co-benefits associated with the implementation of these climate actions.

Chapter 5 presents "Biodiversity for Smart Cities" by Mohamed Imam Bakarr. In most African countries, urbanization means expansion of cities and increasing pressure on municipal governments to balance urban development needs with environmental sustainability. For cities located in the continent's biodiversity hotpots, the urban expansion will occur at the expense of biodiversity and fragile ecosystems. Because of the potential for urbanization to drive economic growth and prosperity in Africa, it is essential that cities and municipalities embrace a paradigm of urban development that is smart and sustainable, and as a result contribute toward safeguarding biodiversity. Such a paradigm will embody two key priorities to integrate biodiversity: (a) African cities must tackle threats to biodiversity from urban sprawl, including habitat loss, overexploitation of species, and degradation of ecosystem services; and (b) cities must harness ecosystem services by integrating components of biodiversity as livelihood assets and "green infrastructure" to enhance sustainability and resilience in the city-scape. Drawing on examples from across the continent, this chapter discusses these two priorities as basis for Africa's cities to integrate biodiversity conservation in their planning processes toward smart and sustainable growth.

Chapter 6 presents "Wastes Management in African Cities" by Ibrahima Sow. Wastes are considered as normal and inevitable output of production and consumption processes, but when they are poorly managed, they are potentially harmful to the environment, health and socioeconomic development. Indeed, misconceptions and inappropriate management of solid wastes by traditional methods such as uncontrolled landfill, open burning practices, informal recycling, can possibly lead to health, ecological, economic and social disasters. Waste management is a major obstacle to sustainable development in almost all African cities due to various factors that include: high population growth, rapid urbanization, increasing economic activity, increasing need for consumer goods, bad waste management practices, and more importantly the lack of sustainable waste management strategies both at national and local levels, including lack of adequate policies—legal and regulatory framework, lack of education and information on waste management. The combination of these factors creates significant amounts of waste whose management represents a major challenge for sustainable development of the cities in African countries. Sustainable solutions in waste management will require an integrated approach through a comprehensive urban planning system, use of Information and Communication Technologies (ICT), a strong and innovative financial mechanism, appropriate mechanisms for community participation and private sector involvement. This present chapter focuses mainly on solid waste management in the context of African cities.

Chapter 7 presents Smart Energy for Smart Infrastructure Development by Naledzani Mudau and Paida Mhangara. Energy forms an inevitable part of our day to day life. Access to energy is required to support a number of social and economic activities including transportation, communication and production of goods. Without access to electricity education and health services cannot operate optimally which may impact welfare and human capital development. Access to energy in Africa is lower that the world average with almost 70% of the population without access to electricity. In addition to lack of access, there is no guaranteed supply of electricity for those who have access which threatens economic growth. Access to energy in Africa has increased in recent decades; however, the electrification rate is lower than the population and urban growth. Africa is endowed with natural energy sources that remain untapped. Smart energy technologies provide opportunities to generate, transmit, distribute and use energy in a sustainable manner. This chapter assesses the status of smart energy development in Africa. Smart energy is the solution for Africa to increase access and improve reliability of the energy supply in Africa. Finally, the chapter assesses the status of ICT infrastructure and highlight—using case studies—smart energy systems aimed at energy efficiency and smart grid development.

Chapter 8 presents "Smart Urban Accessibility and Mobility for Smart Economy" by Gora Mboup. Africa's rapid urbanization provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand for urban accessibility. For cities to act as integrated labour markets and match jobs seekers and employers, they need to make employment spatially accessible to all residents. Economies of scale and agglomeration are, indeed, greater in cities where mobility infrastructures are able to respond accessibility needs with higher access to markets and resources than those where people mobility is impeded by deficient mobility infrastructures. Efficient urban mobility systems increase accessibility to markets, employment and investments and therefore provide better access of people to economic and social opportunities. Deficient mobility systems create negative externalities and are source of social inequalities in cities. Efficient mobility systems make mobility means accessible and affordable to all people, while deficient mobility systems exclude the urban poor from many urban advantages and opportunities. The mobility of people and freight reflects the level of accessibility of urban residents to the multiple economic opportunities that cities offer. Demand for accessibility and mobility depends first on how the cities are designed in terms of urban form and structure. Urban form and structure depend on how the cities are planned in terms of: mixed land use, compactness, densities and street planning and design among other factors. The first three elements were addressed in Chap. 3 showing that African cities are particularly dense, and most of them are monocentric with services far away from the residence. Some are still compact while others have lost their compactness during the urbanization process. While these three elements will be recalled here, the first section of this chapter is dedicated to streets as the basic element of the form of a city. Street planning and design determines in large the connectivity degree of cities. The second dimension of urban accessibility relates to the means of mobility: motorized means, walking or cycling. This second dimension had been for long time the main focus of urban mobility studies, particularly the motorized means of movement. The emergence of ICTs has impacted in significant ways on mobility demand.

Chapter 9 addresses the "Air Quality in African Cities" by Aminata Mbow Diokhane. Air pollution in Africa has become a public health concern during the last decade. According to a recent World Health Organization report, 9 cities out of 10 in low- and middle income countries with more than 100,000 inhabitants do not meet WHO air quality guidelines. About 600,000 deaths every year across the continent are associated with air pollution (UN Environment, 2016). Air pollution occurs when a high quantity of harmful gases and particulates released into the air. These pollutants are mainly emitted by transport, especially with diesel cars, open burning of agricultural/municipal waste industrial activities, etc. Air pollution can also have natural sources such as dust from Sahara desert that affect many African countries. This chapter presents general analysis of air pollution in Africa and an in-depth assessment of air pollution in Dakar.

Chapter 10 presents "Smart Disaster Prevention and Resilience in Africa" by Femi Olokesusi and Femi Ola Aiyegbajeje. Disaster is a sudden accident or a natural catastrophe that causes great damage or loss of life. Disaster risk management is a very crucial ingredient for the social and infrastructural development which involves taking prevention and control measures and building resilience of cities and its citizens. Metropolitan cities are confronted with an array of disaster challenges such as flooding, ocean surge and building collapse. Disaster management is often on the concurrent list of most African countries, so, both the national and sub-national governments are involved. This chapter therefore examines the nature of disaster in selected African cities while focusing on the extent to which Lagos metropolis has adopted smart strategies and initiatives especially information and communication technology to address the issues of disaster prevention and resilience. It concludes that greater adoption of ICT, public education and awareness and engagement constitute imperatives for more effective disaster resilience and prevention in Lagos and other African cities.

Chapter 11 by Romanius Opiyo focuses on Smart Peace and Security in Africa. The importance of Information and Communication Technology (ICTs) in the study of conflict formation and escalation has been widely recognized and researched. There is widespread agreement that ICTs has the potential to equally contribute to peace building and security. This chapter explores the nature of conflicts in African cities and the wider urban areas with the aim of building a framework for understanding the ways of linking digital platform with attainment of peace and security in African cities. The chapter reviews extant literature focusing on the major areas of practical and theoretical relevance initiatives that address smart peace and security globally and in Africa.

Chapter 12 presents "Smart and Open Urban Governance in Africa" by Merlin Chatwin and Godwin Arku. The rapid development of digital technology provides local governments globally a way to enhance the collective ability of governance stakeholders to increase the prosperity and liveability of cities. There is no 'right-way' forward for cities, and local governance must adapt to the institutional, social, economic, and political context. Technology, in and of itself, will just be another smokescreen that gets in the way of true development unless it is seen as a means to an end, and not an end itself. A focus on technological infrastructure and harnessing big data that needs to be analysed distracts from hearing the expertise and experience of the public. This chapter starts with the premise that smart governance is predicated on openness and collaboration amongst all stakeholders, including members of the public who are typically marginalized. 'Smart' cities in Africa, those that achieve economic growth through policy reform, will be the ones that create an environment where the voices of stakeholders are heard, and governments harness their wisdom and lived experience through the use of contextually relevant technology.

Chapter 13 presents "Smart Social Development Key for Smart African Cities" by Priscilla Idele and Gora Mboup. This chapter focuses on one of the dimensions of smart cities, the Social Development which is composed of elements of health and education. Healthy workers are more productive, bringing greater income to families and higher levels of economic growth for nations, and then enhance smart economy. The first section of this chapter is on health considering that healthy population is critical to realizing any social and economic development. The second section of this chapter is on Education, which is critical to meeting the challenges of smart city, as it connects people to new approaches, solutions and technologies that enable them to identify, clarify and tackle local and global problems. When education and Health are combined, they contribute significantly to human development. In both dimensions, African cities have made significant progress during these past twenty years.

Chapter 14 presents "Smart Urban Economy in Africa" by Banji Oyelaran-Oyeyinka and Gora Mboup. Despite the disproportionate economic contribution of urban areas and their high level of productivity, urbanization is often ignored in development policy or not duly integrated in development strategies and plans. This neglect is especially prevalent in Africa where urbanization has been associated with growing urban poverty and unemployment. This has led numerous policy makers in Africa to formulate policies to halt rapid urbanization. However, studies have shown that the level of urbanization and GDP per capita is actually positive. Countries with higher GDP growth experienced faster urbanization, and rapid urbanization came hand-in hand with higher growth in industries and services. This is primarily because urbanization and structural transformation are two processes going hand in hand and mutually reinforcing each other. Urbanization is a powerful force for transformation as it enables agglomeration that facilitates industrial productions and economies of scale. This chapter aims at investigating the urban opportunities in traditional pattern of growth with the urbanization process in Africa. It then highlights the flip side of rapid urbanization and how national economies might miss out to gain from the urban advantage. It also examines the phenomenon of 'consumption cities' and absence of industrialization in urban centres. Finally, the chapter provides recommendation to seize the urban advantage in Africa in order to achieve liveable Smart Cities that undergo inclusive sustainable economic growth and development.

Chapter 15 "Information and Communication Technologies in Africa: Levels, Trends and Perspectives" by Beda Franck presents a hierarchy of ICTs as they correlate with emerging urban trends in Africa. Since the beginning of the millennium, African governments have adopted legislative and regulatory components of new technologies to create a legal environment favourable to their development. The first step was the establishment by Law or Codes of Telecommunications and as well, the different national level varieties Regulatory Agencies for Telecommunications and Posts responsible for providing the telecommunications sector with an effective and transparent legal frameworks, and promoting fair competition to the benefit of users of telecommunications networks and services. Another key step in the process of ICT development in Africa was the creation of State Information Technology Agencies which have the mandate to stimulate public action in the treatment and dissemination of information in accordance with international legal and technical standards for quality, availability, safety and performance. These prototypical agencies launched a process that led to the adoption of appropriate laws and regulations, followed by several laws on: orientation law on information society; electronic transactions; Cybercrime; the protection of personal data; Establishment of a voluntary contribution on public procurement of goods and digital services; Establishment of a royalty on access or use of public telecommunications network—RUTEL and; Cryptology with the creation of a National Commission of Cryptology; the Central Technical Services of Numbers and Security of Information Systems—STCC; Privacy Protection Commission (CDP) as an Independent Administrative Authority (IAA) established for the protection of personal data. In West Africa, there is Adoption of a telecommunication code implementing most of the directives adopted by the Economic and Monetary Union of West Africa (UEMOA) and additional acts that the Treaty of the Economic Community of African States (ECOWAS) to create a legal environment conducive to the emergence of a regional market.

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Chapter 2
African Cities in Time and Space: Past, Emerging Trends and Perspectives

Gora Mboup

Abstract This chapter presents the historical place of the urban setting that has shaped various social, economic and political transformations in Africa. It presents several examples of African cities that existed in the pre-colonial period. It also shows how the African urban space remarkably changes during the colonial period both quantitatively and qualitatively. Some pre-colonial African cities were overtaken by colonial cities along with a significant change in terms of urban planning and provision of basic infrastructure. After independence of African countries, urbanization has accelerated with the apparition of large cities, but with the influence of the colonial urban planning. Today over half a billion of African population live in urban areas. This African urban population is projected to reach 1 billion in 2040 and 1.5 billion in 2050.

Keywords Africa · History · Urban spaces · Religions · Cultures · Cities Urbanization · Colonization · Migration · Rural · Urban systems · Mega cities

2.1 Introduction

As people have histories, cities do too. The historical urban setting that has shaped various social, economic and political transformations in Africa had been overlooked in various studies of African human settlements in the pre-colonial area. However, several archaeological and anthropologic studies demonstrate that cities emerged in Africa long before the European colonialism.[1] As noted by Coquery-Vidrovitch et al. (1993 and 2009), "*Cities have existed in sub-Saharan Africa since antiquity. But only now are historians and archaeologists rediscovering their rich heritage: the ancient ruins of Great Zimbabwe and Congo, the harbor cities at the Indian Ocean,*

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[1] Coquery-Vidrovitch (2005), Blier (2012), zu Selhausen (2016), Bill Freund, Steven J. Salm and Toyin Falola (2005), Mabogunje (1962), Afolabi Ojo (1966), Hull (1976) and Balandier (1968).

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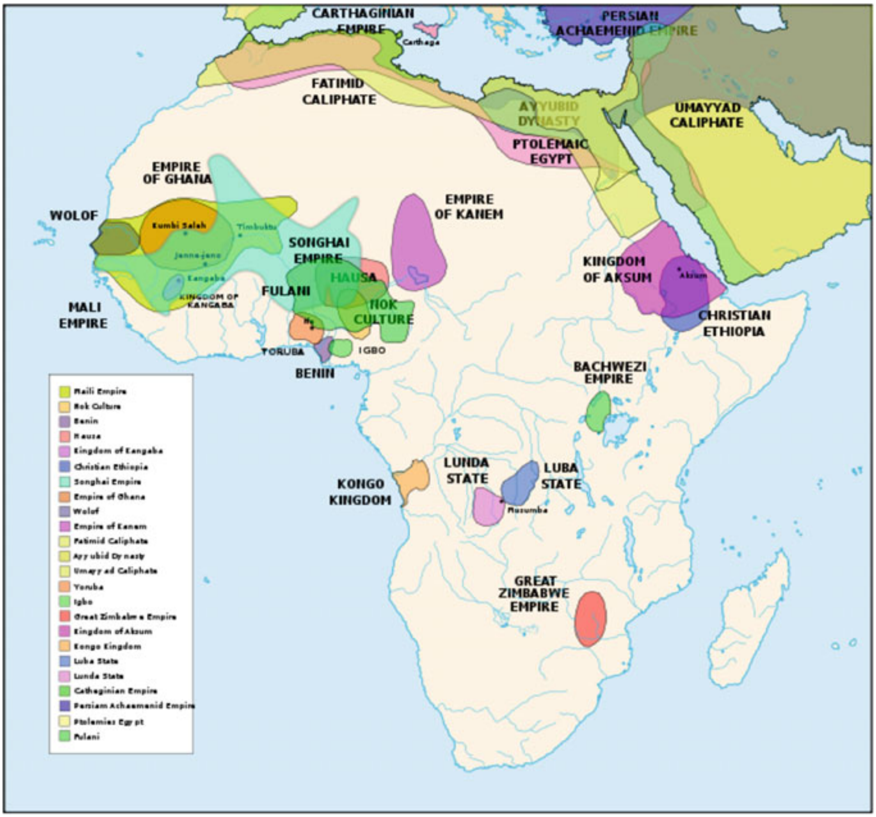

Fig. 2.1 Geographical location of pre-colonial African cities. *Source* https://images.search.yahoo.com/yhs/search?p=Map+of+African+pre-colonial+cities&fr=yhs-iba-1&hspart=iba&hsimp=yhs1&imgurl=http%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fe%2Fe7%2FAfrican-civilizations-map-precolonial.svg#id=0&iurl=http%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fe%2Fe7%2FAfrican-civilizations-map-pre-colonial.svg&action=click

the capitals of the Bantu Kingdoms, the Atlantic cities from the 16th to the 18th centuries, and the urban revolutions in the 19th century".[2] Though African societies were predominantly rural during the pre-colonial era, pre-colonial African urban settlements exhibited economic, comparative opportunities, as well as political and social advantages long before the arrival of European colonisers as also noted by zu Selhausen (2016) (Fig. 2.1).[3]

However, there has been noticeable transformation of the African urban space consistent with the European colonial conception of cities, particularly in terms of

[2]Coquery-Vidrovitch and Baker (2009, 1993).

[3]zu Selhausen (2016).

urban planning.[4] Independence of African countries (during mostly the 1960s) also marked a significant turning point in African urbanization with massive migration from rural areas seeking jobs, particularly to capital cities. This has shaped the African urbanization in terms both of population numbers and urban systems. In 2018, half a billion of African people lived in urban areas. This urban population is projected to grow to one billion in 2040.[5] Africa's rapid urbanization provides opportunities for economies of scale and agglomeration, but it will also come with challenges that call for large investments in infrastructures to respond to the increased demand for water, sanitation, solid management, energy and mobility. These challenges are largely determined by the way cities grow and form the urban space.

The dynamic transformation of African urbanization has occurred in different paces, times and places. Along the African urbanization, cities form and grow in many different parts of the continent for various different reasons, such as rural-to-urban migration, economic opportunities, politics, natural disasters, social conflicts, etc.[6] In a given country, these factors associate to determine the size and national distribution of cities. In Africa, as it is observed elsewhere, natural population increase (decrease in mortality and increase in fertility) and massive migration rural to urban, particularly during the post-independence period (starting at 1960 for most African French colonies) have also contributed to rapid urbanization.

Considering that cities had existed in Africa long before the European colonisation, this chapter presents, in its Sect. 2.2, different forms of African cities during the pre-colonial period in terms of geographical locations, urban form and structure, city size, land use and population and density, architecture, culture and heritage. Section 2.3 presents the transformation of the African urban space along the colonial era and post independence. Section 2.4 presents the Africa's urban transition since the end of the 20th century and the beginning of the 21st century. The Sect. 2.5 present the urbanization and the emergence of large size cities in the African region while the Sect. 2.6 National analyses national urban systems in Africa.

2.2 African Cities in the Pre-colonial Period

2.2.1 History of Pre-colonial African Cities

People have histories; cities do too

Urbanization in Africa is a complex process, with diverse relationships that form around class, ethnicity, race, occupation, and religion across pre-colonial, colonial, and contemporary urban spaces. Cities existed in Africa long before the European

[4]Mboup (2013).

[5]UN population Division, Department of Economic and Social Affairs (2018).

[6]United Nations, Department of Economic and Social Affairs, Population Division (2015).

colonialism.[7] The dynamic transformation of African urbanization occurred in different paces, times and places. African urbanization was indeed a dynamic and long-term process, expressing as much continuities as changes. As noted by Coquery-Vidrovitch (2005):

> Most of the time, these changes were not sudden, but resulted from long and often imperceptible adjusting processes, the accumulation of which resulted in revolutions of mind and society: urban spaces came to embody urban minds. These cultural trends were all the more decisive because they diffused from city centres to the whole of African societies. In short, cities, which in the nineteenth and twentieth centuries became the major locations for labour markets and political struggles, were definitely decisive places for cultural and social change.[8]

Archaeological works have shown different forms of urban centres and towns in Africa during the pre-colonial period.[9] Long before the penetration of Islam in Africa and the European colonialism, various forms of cities and towns existed in the African continent in respect to urban planning, provision of basic services, economic exchanges and social interactions. These forms of cities emerged from Western to Eastern, Northern to Southern and central Africa. In every corner of Africa, there were some forms of existence of towns and cities based on social, economic and political opportunities. As noted by Salm and Falola (2004), the African urbanization is historically rich and dated back thousands of years in ancient Egypt, the Western Sudan, Nigeria, Ethiopia, the East African City States, and Southern Africa, long before the arrival of European colonisers.[10]

Historical facts are always determinant for a better understanding of levels and trends of events. As noted by Coquery-Vidrovitch (2005),[11] cities existed in Africa in ancient archaeological times and during the age of medieval Islam. Selected sites for early urban centres exhibited economic, comparative opportunities, such as on soils, water sources, minerals, and trade potential, as well as political and social advantages. The early African urban development was indeed associated with agriculture and the Neolithic revolution. This led to high population densities that propelled economies of scale and agglomerations and new forms of specialization as well as political and administrative organizations.[12]

As further noted by Coquery-Vidrovitch (2005) "*In time and space African cities expressed a social and cultural evolution resulting from the interrelationship between urban people and their environment, structured along given political and social factors, and ecological, technological, and ideological constraints*".[13] For instance, in West Africa, several urban centres such as Jenne-Jeno (Djene) in Mali existed

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[7] Freund (2007); Coquery-Vidrovitch (1991).

[8] Coquery-Vidrovitch (2005).

[9] See Footnote 7.

[10] Salm and Falola (2004).

[11] See Footnote 1.

[12] Blier (2012); see also Anderson and Rathbone (2000); Freund (2007); Falola and Salm (2004); Adekola (2009).

[13] See Footnote 1.

long before the arrival of European settlers.[14] Jenne-Jeno in the 3rd century BCE benefited from numerous comparative advantages, such as productive rice-farming conditions and good pasturage. Its geographical position adjacent to Niger River was equally central to its development with the migration of populations during the Sahara aridity that began around 1000 BCE. Jenne-Jeno, finally made of a group of urban settlements along the inner Niger River floodplain of Mali, was "seen as a composite or clustered city marked by the aggregation of semi-specialized settlements with coordinated activities".[15] This is the first characteristic of what is called today city region where a central city is linked to several cities around it with specific activities associated to each urban centre. In the same region of Mali, the trans-Saharan trading town of Timbuktu also emerged in the 15th century as an intellectual, spiritual and Islamic capital in Africa and beyond.[16]

The city-state of Ife (Ile-Ife) of Nigeria was also strategically located near the headwaters of the Oni River, which flows into the Atlantic, and at the juncture of forest and savannah; it sits on high ground that is surrounded by wetlands, hills, and a fertile savannah plain.[17] Through cooperation in trade and others services, settlements in the hills might also form together a single urban centre.[18,19] The larger Ife area also functioned as a natural elephant-trapping area where local groups could block escape routes from the Ife valley wetlands.[20] Through the Niger–Benue River confluence, Ife was also able to access to distant trade centres.

On the East African coast, as noted by zu Selhausen (2016),[21] we also have the Arab trading hubs of Mombasa and Zanzibar that functioned as centres around which societies were organized; they served as focal points of trade, political authority, military garrison, religious and cultural ceremonies, or as refuge and collective shelter in troubled times. Swahili coastal sites, such as Kilwa and Mombasa, also benefited from the Indian Ocean trade in gold, ivory, and other goods. The earliest known cities of Africa emerged around the Nile Valley—the most famous being Alexandria in Egypt. Also the kingdoms of highland Ethiopia organised themselves around towns two thousand years ago. Later, in the 11th century the kingdom of Great Zimbabwe in southern Africa also constructed a complex walled city.[22] Urbanization in East

[14] Jenne-Jeno is a UNESCO World Heritage Site located in the Niger River Valley in the country of Mali. Literally translated to "ancient Djenné", it is the original site of Djenné, Mali and considered to be among the oldest urbanized centers and the best known archaeology site in sub-Saharan Africa (https://en.wikipedia.org/wiki/Djenn%C3%A9-Djenno). See also Susan Keech McIntosh and Roderick J. McIntoshm Jenne-jeno, an ancient African city.

[15] Blier (2012).

[16] See also Salm and Falola (2005).

[17] See Footnote 15.

[18] See Footnote 15.

[19] See also Mabogunje (1962); Afolabi Ojo (1966); Smith (1969). See also Ogundiran (2003).

[20] See also Fisher (1977).

[21] See Footnote 3.

[22] https://www.aehnetwork.org/wp-content/uploads/2016/01/Meier-zu-Selhausen.Growing-Cities.pdf: Growing Cities: Urbanization in Africa.

Africa drastically increased throughout the nineteenth century with the international growth of the Sultanate of Zanzibar following the “Swahili urbanism”.[23]

In the pre-colonial era, while villages were mainly composed of people from the same ethnic group, usually referred to tribes, African cities were often inhabited by different ethnic groups. They were, indeed, featured not only in terms of their size but also particularly by their degree of heterogeneity as being the place where people from different localities agglomerated for different social, economic and political purposes. This marked the fundamental function of roads and the choice of locations for human settlements. Memphis (near modern Cairo) was one of the most heterogeneous urban settlements with diverse population groups hailing from different places, such as Syria, Phoenicia, Canaan, and Kush (the latter in modern Sudan). Swahili cities were also composed of different ethnic groups, including African indigenous, Arabic, and Persian, along their 1500 km coastal region. Aksum city (400 BCE to CE 619), situated in modern Eritrea, was also an important early urban centre, a compact city inhabited by political and trade elites, with producers at the centre’s outskirts. Between the 11th and the 16th century CE, the Tellem and the Dogon populations also merged in Bandiagara Escarpment of Mali with the creation of densely populated and ethnically diverse centres featuring an integrated culture based on agricultural innovation (irrigated onion farming), technological and ritual specialization (iron working and so on), and various forms of external trade.[24]

2.2.2 Planning of Pre-colonial African Cities and Towns

One key element of urban planning is the street. Pre-colonial African cities and towns were organized along streets and roads with the main purposes of mobility, commerce and social interactions. Streets, as public spaces, linked residential houses, commercial buildings and other structures to fulfil their social, economic and political functions that are crucial to urban life in any time period. The traditional, pre-colonial urban settlement was also one with a central meeting place for transactional activities, such as commerce or governance, surrounded by housing, workshops, and neighbourhood services, with the wealthiest and most influential inhabitants living closest to the centre. Streets radiated from the nucleus of the city, which was usually the seat of political power or place of worship, such as a mosque, a temple or a cathedral, or some other structure(s) of political, commercial or cultural significance, such as a royal palace. They shaped the urban form and structure by separating blocks and linking different places of interest within the city.[25]

[23] See Footnote 8.

[24] See Footnote 15.

[25] Mboup (2013).

Urban form and structure in the pre-colonial area result from organic urban planning and design principles that feature clustered layouts around compound.[26,27] The principles of the layout of pre-colonial African cities favour the circularity in the pattern of dwellings, streets, walls, plazas and settlement patterns. As noted by Amankwah-Ayeh (1996), "circularity in African culture reveals a hierarchy in the urban structure which does not lead to alienation of the masses but maintain a good sense of control of the environment." According to Mabogunje (1962), the rational of the circular nature of Yoruba dwellings, shelter, town form and plaza design was glued on the Yoruba's belief that the form of the world is circular, and, because of the two road axes (oriented N-S and E-W) which intersect at the world centre is divided into halves and quarters.[28] The principles of circularity were also prevalent in Southern Africa as documented by Frescuro (1981) and Hull (1976).[29]

Streets played, indeed, a central role in the planning and designing of Yoruba cities. For instance, by the early 15th century, the city of Ile-Ife was reconfigured around a central plan that was defined by a circumscribing moat-wall, broad avenues leading to a central palace and adjacent market, as well as wards extending radially from the centre.[30] Festivals and political events generally took place in city centres served with large squares. Yoruba cities were generally sited on hills, where palaces are the most prominent architectural feature; Their design based on striking axes and sightlines, along with a grid style radial form as part of defining characteristics of urban forms and structures, was a key component of refined urban planning in pre-colonial Africa. The Kano chronicle dates the first permanent market in Kano to the 15th century. Later that century, the Kano city walls were extended and a centralized palace and a new market were built. In symbolic terms, Hausa urban settings carried varied cosmological significance, based in part on orientation toward the cardinal directions and the positioning of special gates.[31]

In Yoruba cities, planning and architecture are linked to feature the urban form and structure. Centrally placed within most Yoruba towns was the palace of the Oba the head of the city administration and the symbol of its urban status. So important was the palace that its grounds occupied an extensive area of land. Opposite the palace was the most important market of the city.[32]

African Walled Cities in the pre-colonial era

The circularity of pre-colonial African cities was also justified by the fact that there was a necessity to create walled cities. Throughout history, one of the protection strategies against an external enemy was to build a walled city. Walls were usually massive structures, punctuated with guard towers. Some were built on hills, making

[26]Coquery-Vidrovitch (2005); Blier (2012); Hull (1976); Mabogunje (1962).

[27]Amankwah-Ayeh (1996).

[28]See Footnote 27.

[29]Hull (1976).

[30]See Footnote 15.

[31]See Footnote 15.

[32]Mabogunje (1968); Amankwah-Ayeh (1996).

invasions more difficult, while others fronted seas and oceans to protect the towns from invaders in ships or, in some cases, pirates. Wall systems also played a role in the control of merchants and goods for purposes of taxes, tolls and the reduction of smuggling. Today well-preserved walls bring tourist from across the world to wonder around these medieval walled cities.[33] Walled cities have been common in Africa's pre-colonial era as a means of protection from hostile neighbouring communities. In these walled cities, the palace was positioned at the middle of the city. Walled cities or settlements were found in ten African countries: three in Algeria (including Algiers), three in Egypt (including Cairo), one in Ethiopia (Harar), 15 in Libya (including Tripoli and Benghazi.), three in Mali (Djenne, Gao and Timbuktu), 28 in Morocco (including Casablanca, Marrakech, Meknes and Rabat), one in Niger (Zinder), three in Nigeria (Benin City, Kano and Keffi), four in Tunisia (Kairouan, Sfax, Sousse, Tunis), and one in Zimbabwe (Great Zimbabwe).[34]

Box 2.1 The Great Walls of Benin

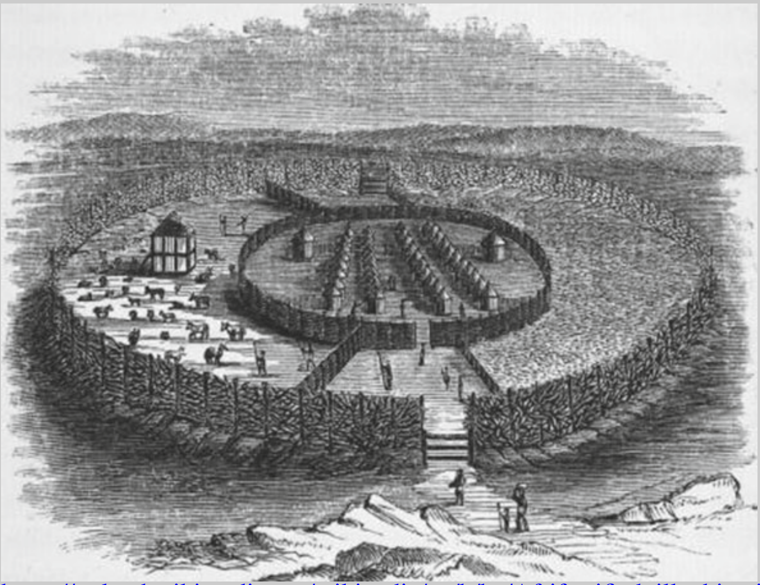
The Walls of Benin were a combination of ramparts and moats, called "Iva" in the local language, used as a defense of the defunct Kingdom of Benin, which is present-day Benin City, the capital of present-day Edo, Nigeria. It was considered the largest man-made structure lengthwise and was hailed as the largest earthwork in the world. It is larger than Sungbo's Eredo in Southwest Nigeria.[35] It enclosed 6500 square kilometres of community lands. Its length was over 16,000 km.[36] It was estimated that earliest construction began in 800 CE and continued into the mid-15th century. Benin City was described as "wealthy and industrious, well governed and richly decorated. This is the story of a lost medieval city you've probably never heard about. Benin City, originally known as Edo, was once the capital of a pre-colonial African empire located in what is now southern Nigeria. The Benin empire was one of the oldest and most highly developed states in west Africa, dating back the 11th century.

[33] http://www.touropia.com/walled-cities-in-the-world/ Last updated on October 24, 2017.

[34] https://en.wikipedia.org/wiki/List_of_cities_with_defensive_walls.

[35] Sungbo's Eredo was built in honour of the Ijebu noblewoman Oloye Bilikisu Sungbo. The total length of the fortifications is more than 160 km.

[36] The Guinness Book Records (1974 edition) described the walls of Benin City and its surrounding kingdom as the world's largest earthworks carried out prior to the mechanical era. According to estimates by the New Scientist's Fred Pearce, Benin City's walls were at one point "four times longer than the Great Wall of China, and consumed a hundred times more material than the Great Pyramid of Cheops". This site was added, along with Sungbo's Eredo, to the UNESCO World Heritage Tentative List of 1 November 1995 in the Cultural category. (Quoted in http://solarey.net/great-walls-benin-west-africa/).



https://upload.wikimedia.org/wikipedia/en/b/bc/Afrifortifiedvillagbige.jpg

The Benin Walls were ravaged by the British in 1897 during what has come to be called the Punitive expedition. Scattered pieces of the structure remain in Edo, with the vast majority of them being used by the locals for building purposes. What remains of the wall itself continues to be torn down for real estate developments.[37] Benin City, the mighty medieval capital, is now lost without trace. With its mathematical layout and earthworks longer than the Great Wall of China, Benin City was one of the best planned cities in the world when London was a place of "thievery and murder".

Source: Sola rey, 2016: http://solarey.net/great-walls-benin-west-africa/.[38]

In terms of housing, architecture and organization, Blier (2012) also noted three historic patterns of urban settlements in the pre-colonial Africa:

(a) *Monumental urbanism*, especially prominent in north, eastern and southern Africa (from Egypt and Eritrea to Zimbabwe), was characterized by substantial permanent structures in stone;
(b) *Satellite urbanism,* found especially in West Africa (from Mali to northern and southern areas of Nigeria), was characterized, on one hand, by its earthen structures and, on another hand, by the collaboration between interlinked community clusters that together create an urban settlement structure and;

[37] http://solarey.net/great-walls-benin-west-africa/.

[38] See also https://www.theguardian.com/cities/2016/mar/18/story-of-cities-5-benin-city-edo-nigeria-mighty-medieval-capital-lost-without-trace; https://en.wikipedia.org/wiki/Walls_of_Benin.

(c) *Migratory or peripatetic urban settlements*, found mostly in central Africa, were characterized by the nomadic identity of their population. In the latter, following the death of a ruler or a sequence of traumatic events, interlinked cities were often re-established on a new site.

Classification from Coquery-Vidrovitch (1993 and 2009) puts forward notions of: (a) mercantile cities that opened Africa to the world, (b) Islamic cities that became centers of scholarship and the trans-Saharan trade, (c) Creole cities that appeared after the first contact with Europeans, and (d) Bantu cities of the hinterland that reacted against them.[39]

The architecture of metropolitan centres in Egypt features an array of monumental building forms serving multiple functions, some dating back to the pre-dynastic and early dynastic periods.[40] They were among the largest and most durable centres in the global urban history. The most fascinating architecture was observed in the ancient cities of Egypt that featured the "monumental urbanism". The Shona capital of Great Zimbabwe, which flourished in the 11th–14th centuries CE, also displayed durable structures made of stone. During the 8th to 19th centuries CE, cities on the East African coast also displaced elaborately decorated, stone-like, coral edifices. The city of Jenno-Jeno displayed durable structures with walls, 3.7 m wide at the base, made with cylindrical brick building forms.[41] In the West African savannah area, the Mande architectural sources were also identified as symbolic organization consistent with utopian idioms, defined by flexible anthropomorphic design referents, which was a feature of other populations.[42] The use of domes was particularly promoted in the Hausa urban architecture. However, decorative features varied from one urban setting to another, with palaces, merchant residences and mosques being particularly ornamental.

Pre-colonial African architecture featured attributes of local building materials providing unique possibilities for urban and housing sustainability as it is sought in today's national and global agendas. Target 11.c, of the Sustainable Development Goal (SDG) 11 aims to support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.[43]

[39] See Footnote 2.

[40] The prehistory of Egypt spans the period from earliest human settlement to the beginning of the Early Dynastic Period (Egypt) around 3100 BC, starting with the first Pharaoh, Narmer for some egyptologists, Hor-Aha for others, (also known as Menes). This Predynastic era is traditionally equivalent to the final part of the Neolithic period beginning c. 6000 BC, and corresponds to the Naqada III period.

[41] See Footnote 15.

[42] On Tellem and Dogon architecture, see also other articles cited by Blier (2012) including: Rita Bolland, Tellem textiles; Archaeological finds from burial caves in Mali's Bandiagara Cliff, Amsterdam: Royal Tropical Institute; Leiden, Rijksmuseum voor Volkenkunde; Bamako: Institut des Sciences Humaines; Bamako: Musée National, 1991; Jean-Christophe Huet, Villages perchés des Dogon du Mali: Habitat, espace et société, Paris: L'Harmattan, 1994.

[43] United Nations (2015).

In the pre-colonial period, for human settlements geographical locations always matter for several reasons and particularly for accessibility and existence of natural resources. During the pre-colonial period, means of mobility were mainly either walking or riding animals, such as horses and camels. Under these circumstances, accessibility was a key factor for the choice and planning of places for human settlements. The proximity to rivers and/or mountains as well as being central axis plans with bilateral siting of key structures was significant determinant for most urban centres. For instance, Hausa cities were located to sites close to the intersections of major trade routes, valued resources, especially iron, and powerful spirit locales.[44] They are economically and politically linked within a system of satellite urban settlements, as noted by d by Blier (2012), with the five-six main Hausa cities furnishing key goods or services within the larger network: (a) textiles from Kano, (b) markets in Katsina and Daura, (c) militias from Gobir, and (d) slaves from Zaria.[45,46]

According to Hull (1976) (cited by Amankwah-Ayeh 1996),[47] The Ibo people of Nigeria achieved an efficient use of space, living in homes that were clustered in plan. Within an area of high population density, hundreds of Ibo villages separated by large open spaces and groves of shady trees that led to 'extended' family meeting places. A central market place was the focus of all the paths that led from the 'extended' family meeting places.

Pre-colonial African urban centres also recognized the benefits of inter-communal cooperation for their economic development as well as political strength long before the arrival of European settlers. The communal need to address complex issues associated to disaster prevention, protection, manufacturing, trade control, hunting was also determinant for inter urban centres cooperation. In the 16th century, African communities were conscious of the need of inter-city cooperation for a drainage system to prevent flooding and other natural disasters. For instance, the setting of the Luba Kingdom (1585–1889) situated in the wet grasslands of the Upemba depression, with the source of the Zaire River to the southeast, was critical to its political development, encouraging shared communal activities and cooperation in the creation of dams and drainage systems to counter seasonal flooding, which might impact various sectors from housing to agriculture and fishing.[48] Economic performance of Luba and other connected urban centres was anchored on agriculture, specialized

[44] See Footnote 15.

[45] Blackpast.org, The Hausa City States. http://www.blackpast.org/gah/hausa-city-states: Accessed on 7 June 2017. See also Shillington (2014); Oliver and Crowder (1981).

[46] Blier 2012. Blier noted that the urban centres of Kongo, Kuba and Luba, as well as those of the Lunda Kingdom (c. 1600–1887)—and of the Cameroon grasslands—take an array of symbolic forms. Other important urban forms associated with these settlements include Ethiopian royal capitals and Buganda dynastic capitals, as well as Zulu war centres, the latter evoking Assyrian and Roman war cities.

[47] Hull (1976) cited by cited by Amankwah-Ayeh (1996).

[48] Reefe (1975) cited by Blier (2012).

metal work, and trade in salt, iron, charcoal and copper (from the Zambian copper belt), as well as cowrie shells and glass beads from the Indian Ocean.[49,50]

In pre-colonial African towns and cities, nature conservation and environmental protection measures were also emphasized in the planning and design of human settlements. For instance, in eighteenth-century Mbanza Kongo this was anchored in the building of large-spaced houses around existing trees to avoid disrupting the ecological balance.[51] The traditional building rules practised in the Bangala towns in present day northern Zaire (Congo) constitute other examples where towns have to be bordered by rectangular patches of banana plants and double rows of palm trees (Vansina, 1973).[52]

2.2.3 City Size, Land Use and Population Density in the Pre-colonial Era

Though population and area figures were seldom estimated during the pre-colonial era, studies have indicated that pre-colonial African cities were sufficiently populated and dense to provide relative economies of scale and agglomeration. In 1661, Riccioli estimated the African population at 100 million inhabitants.[53] However, during the 17th century, a decline of African population was noted and might be associated to climate and other geologic conditions that expose people to high morbidity as it was also observed in many parts of the world.[54] In the 18th century, the slave trade accelerate the decline of African urban population (Figs. 2.2 and 2.3).[55]

Similarly to the scarcity of country data, urban data was very limited. Where data was available, it is noted there are African cities that had more than 100,000 inhabitants during the pre-colonial period, figure similar to the population of New York in early 19th century. For instance, in the 12th–15th centuries, the Ife metropolitan area might have occupied an area of 3000 hectares, with a population of about 130,000 inhabitants, or a population density of 43 persons per hectares, which was sufficient to propel economies of scale and agglomeration as well as diffusion of ideas and technological innovations. More than thousands years BCE, available estimates indicate that some African cities were already of more than 10,000 inhabitants. For

[49]Roberts and Roberts (1996). Mary Nooter and Allen Roberts have discussed the enduring importance of Luba capital cities that, once abandoned by rulers when new centres were founded, became key ritual sites. As revealed from archaeological studies, human occupation in Luba dated from at least the 5th century CE, with urban settlements emerging around the 10th century.

[50]McIntosh (2005); McIntosh and McIntosh (1981).

[51]Balandier, 1968 and Bashilele near Mbanza Kongo (Johnston, 1969) cited by Amankwah-Ayeh (1996).

[52]Vansina, (1973) cited by Amankwah-Ayeh (1996).

[53]Cited Hayashi (2007). See also Willcox (1933).

[54]Durand or McEvedy and Jones (1978) cited Hayashi (2007).

[55]Lovejoy (1982) cited Hayashi (2007).

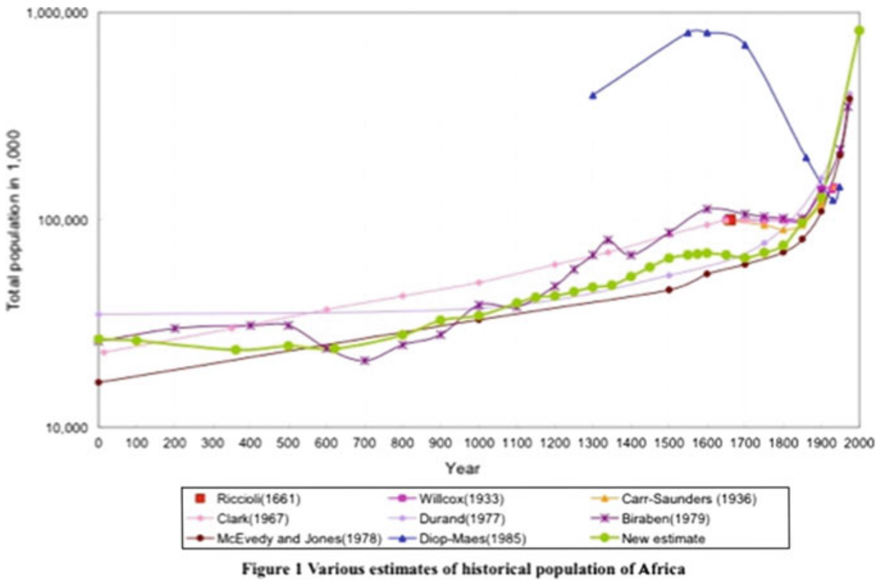


Fig. 2.2 Estimates of African population from several sources. *Source* Hayashi (2007)

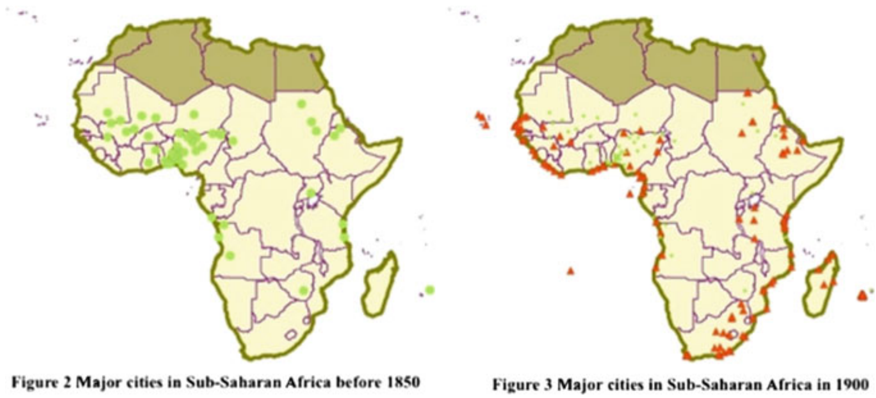


Fig. 2.3 Major cities in sub-Saharan Africa. *Source* Hayashi (2007)

instance, the Shona capital of Great Zimbabwe might have had a population 18,000 inhabitants in an area of about 722 hectares.[56] Memphis, founded around 3100 BCE, as the administrative, religious and trade centre of the lower Egypt, was considered probably the largest world metropolis around 2250 BCE with an estimated population range of 6000 to 30,000 inhabitants.[57] By CE 850 when it functioned as a

[56] See Footnote 15.

[57] See Footnote 15.

single urban complex, Jenno-Jeno occupied an area of 41 hectares.[58] Some studies have linked the size of pre-colonial African cities to the type of government, with cities cites governed by a central authority being of large size. In absence of central authority, cities have the tendency to be of small size; this allow to maintain a feeling of smallness and intimacy keeping strong social, economic, cultural and physical linkages even in areas of high population densities.[59]

However, most of these early urban centres rarely appeared on official national population estimates that mostly included only large urban agglomerations. Without being part of the UNESCO heritage sites, these early African urban centres would be forgotten and/or remain unaccounted for. In fact, during the colonial period, numerous pre-colonial African cities were either destroyed or downgraded in economic importance due to colonisers' politico-economic objectives.

2.2.4 Cities—Engine of Economic and Political Power During the Pre-colonial Era

Based on their economic, social and political functions as well as their connected geographical locations, pre-colonial African cities were engines of economic development well before the contact with Islam and the European colonisers. Compared to rural areas, they allowed social interactions as well as commercial transactions for agricultural goods and other value-added metals. Though their economic transactions may not be comparable to those of today, towns in the pre-colonial period promoted economies of scale and agglomeration compared to rural areas. It is also of importance to note that pre-colonial African cities cooperated beyond the African territory, showing that globalization dated back the ancient era. As noted by Blier (2012), by the end of the first millennium CE, the Igbo area was already trading with southwest Asia and creating works of extraordinary complexity in bronze and elaborate burial forms at Igbo Ukwu sites. Kilwa, an international African port, produced its own currency in the 11th–14th centuries.[60] Strong economic centres were the driver of the prosperity and sustainability of empires. Today, Information and Communication Technologies (ICTs) make it easier to cooperate globally, and African cities must take these opportunities and reach the world with competitive products and services. In addition, ICTs foster social transactions and allow social and cultural heterogeneity. They also promote diffusion of ideas and innovations.

In Yoruba oral traditions, a complementary satellite-style urbanism is supposed to have characterized the city-state of Ife (Ile-Ife) by the end of the first millennium. Obalufon also appears to have had diplomatic and trade treaties with several other Yoruba cities, along with military and tribute agreements with affiliated crown cities

[58] See Footnote 15.

[59] See Footnote 27.

[60] See Footnote 15.

for the provision of certain goods.[61] Other established Yoruba cities were Ibadan and Lagos, which were later formed as military camps. Whatever the origins, Yoruba metropolitan centres grew to enormous scale and featured unique craft specialization (from metal- and glass working to weaving and dyeing), marked population diversity (through trade and war) and major population shifts throughout the year (many inhabitants moving to distant agricultural fields for part of the rainy season).[62] All these cities exhibited different urban forms and structures in terms of streets, housing and architecture; they were shaped in manner, which reflects their economic and political power.

2.2.5 Decentralized Administration and Governance Started with the Pre-colonial African Cities

During the pre-colonial several African urban settlements were based on decentralized administration and governance as it was observed in the Lebou Group in Dakar (Senegal) in the 15th and the 16th centuries (Box 2.2).

Box 2.2 Decentralized administration and governance in the first settlements in Dakar by the Lebou group

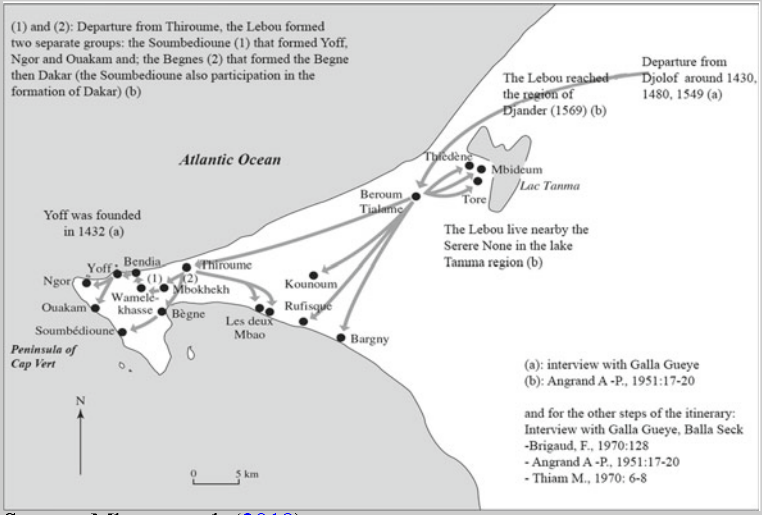
The first settlements in Dakar, particularly in Yoff located to the north of the city and in other areas such as Ouakam, Ngor and Camberene during the 15th and 16th centuries were influenced by the Lebou groups' system of governance that promoted decentralized social, economic and political structures, including integration among various ethnic groups. The Lebou group was, indeed, a symbiosis of various ethnic groups. The Lebou system of governance, which was the opposite of the kingship system practiced in other parts of Senegal, promoted equality among community members, and creation of autonomous villages that constituted the settlements of Yoff. Each village was under the leadership of a "Djaraf", assisted by a "Ndeye ji Rew" for interior and foreign affairs, and a "Saltigue" who was in charge of land, water and local communities. With the influence of Islam, the function of Serigne Ndakarou was introduced in late 18th century to provide justice based on the Quran. Until today, the Lebou community conserves its socio-political structure where the Serigne Ndakarou and other local authorities still play a key role.[63]

[61] Blier (2012). As noted by Blier (2012) "Early Yoruba cities were sometimes discounted by Western theorists because they were assumed to be lineage-based (rather than heterogeneous). In Yoruba urban centres, however, 'lineage' is used to define a wide array of non-kin social relationships as well, among these prisoners of war and strangers who were integrated into lineage like units for socio-political-religious reasons".

[62] See Footnote 15.

[63] Dumez and Kâ (2000).

Settlements of the Lebou group in 15th and 16th centuries in the Peninsula of Cap Vert (Dakar).



Source: Mboup et al. (2018).

2.3 Transformation of the African Urban Space in the Colonial and Post Independence Eras

For centuries, Europeans had colonialized most African countries. Prior to that, the African continent was devastated by slavery. Slavery and colonization considerably impacted the African urban population. Though we do not have a global number of their impact, tentative estimates indicated that more 100 million Africans were deported to America and Europe, and over 100 cities were destroyed or downgraded. Estimates from Carr-Saunders (1936) suggest that the slavery had drastically reduced 650 million Africans in 1500 to 150 million level in 1900.[64] Archaeological works indicated that the city of Ife, with a population of 18,000 inhabitants in the 5th century, would have a population of over 1 million in 1950 if it was not exploited through slavery and colonization. However, according to the UNDESA World Urbanization Prospects of 2015, Ife had a population of only 107,000 in 1950. Colonisation might have affected Ife in various ways particularly weakening its economic and political importance with the choice of Lagos and Ibadan as privileged places for Europeans settlers. In 2015, the population of Ife is only 1 million inhabitants while Lagos was a megacity with 13 million inhabitants and Ibadan a large city with a population

[64] Diop-Maes, 1991.

of 3.1 million. Similar situations had existed in many African countries where pre-colonial cities had declined in population size associated to their loss of economic and political power for other colonial preferred cities.

2.3.1 Emergence of Colonial Cities and Prime Settlements in the Colonial Era

Some African capital cities were a result of the process of transformation of former pre-colonial urban centres to fit the new interest of European colonisers. The history of the city of Dakar in the extreme west of Senegal is also marked by several migrations dating back to the 14th century. The most prominent recorded settlements were however in the 15th and 16th centuries when the Lebou group settled in the area called "Yoff" located to the north of the city and in other areas such as Ouakam, Ngor and Camberene. The second major settlement was recorded later in the 19th century when the French colons started to settle to the extreme south of the city, which later became the center of the city—hosting most administrative and state buildings (*including the State house, the Parliament and the Court house*). Both settlement eras had varying influence on the city form of Dakar, which has resulted into two unique spatial organization patterns—an organic pattern evident in the Yoff area and a grid system evident in the French occupied southern parts.[65] Lagos started around the Island and Mainland areas and served as a major slave trade centre between 1404 and 1889. It was captured by British forces in 1851, annexed as a British colony in 1861 and became the capital (regional administrative centre) of the colony and protectorate of Nigeria in 1914, a status it maintained until 1991 when the country's capital was formally moved to Abuja. Lagos has been administered under a variety of territorial schemes. When it was ceded to the British in 1861, it was administered as a city-state with its own separate administration. In 1866 it was included in the West African Settlements under a Governor-in-Chief resident in Sierra Leone, but retained a separate legislative council and a local administration. Various changes followed, through its status as a separate colony, to its merger with Western Nigeria in 1951. When Lagos state was carved out as one of the then 12 states in the federation, Lagos assumed new role as a regional administrative centre.[66]

Box 2.3 Geographical location matters for human settlement

Usually in the past as in the present, there have been good reasons why towns developed where they currently are. For some of the larger areas of settlement in Africa the location of natural resources (e.g. water, energy sources, copper, gold and diamonds) was important in determining where people settled in the

[65] Mboup et al. (2018).

[66] Olokesusi et al. (2017).

first place at the beginning of the colonial era in the late 19th century. For example, completely new industrial-urban economies emerged as a direct consequence of the discovery of minerals in Southern and Central Africa. Rapidly urban areas started to grow around industrial plants and housed the mining companies' administration and workers. The first mineral discoveries in the late 19th century in regions that attracted migrant labourers were for example Johannesburg, Witwatersrand (gold) and Kimberly (diamonds) in South Africa, Kitwe and Ndola in Northern Rhodesia (now Zambia), and Lubumbashi (copper and cobalt) in the southern Congo (now Democratic Republic of Congo). Those areas grew rapidly into industrial mining, smelting and refining towns creating vast employment opportunities in the factories as well as offering a market for agricultural products for surrounding farmers. South Africa became the largest producer of gold in the world and the majority came from the mining town of Johannesburg, which already by then had a population of 250,000, the largest urban centre in sub Saharan Africa. Mining created an urban-industrial civilization with rapid urbanization process contrary to the more gradual development of towns in non-mining areas.

The construction of the railway by colonial administrations for the extraction of natural resources and cash crops (e.g. cocoa, cotton, coffee, tobacco, sugar, and palm oil) to the coast also played an important role in determining the location of harbour towns for exports. For example, Nairobi was an uninhabited swamp and only started to attract settlement in 1899 when it became the railway depot and headquarters during the construction by the British of the railway line that connected Mombasa on the Indian Ocean coast with Uganda. Another driver behind urbanization in European settler colonies, such as Kenya, Southern Rhodesia (now Zimbabwe), and South Africa concerned the expropriation of fertile land from Africans, which was parcelled out to white settlers. The clearance of African inhabitants from their land by the colonial government marginalized Africans economically. They were forced into reserves or drifted into cities in search of work contributing to the rapid growth of Nairobi in Kenya and Salisbury (now Harare) in Southern Rhodesia for example.

Source: Felix Meier zu Selhausen, Growing Cities. https://www.aehnetwork.org/wp-content/uploads/2016/01/Meier-zu-Selhausen.Growing-Cities.pdf: Growing Cities: Urbanization in Africa.

2.3.2 *Planning of African Cities During the Colonial Period and Beyond*[67]

The European colonisers brought forth a new form of monocentric settlement system. The centre of such colonial cities hosted large administrative and commercial buildings as well as the European residences, while the indigenous people were relocated to areas that lacked most basic services (such as piped water, sewerage systems, education facilities and health centres) as well as administrative and commercial businesses. Being the only places where indigenous groups were allowed to settle, these colonial settlements became densely populated; since they lacked basic services, disease outbreaks became the norm. These areas were neither properly planned nor were there adequate basic service provisions; the indigenous communities as well as migrants were excluded from the comparative urban advantage a city can offer. Today, these areas remain haunted by this early spatial and social segregation.

The urban monocentrism as well as the colonial urban divide has been (thoughtlessly) pursued in most African capital cities after independence without taking into account ground realities. In these cities, residential areas were also designed along economic class lines. This has led to social and economic fragmentations that have disadvantaged lower income groups in accessing basic services, such as public transport, and prevent social interaction and integration. Today, the urban monocentrism is a source of traffic congestion and an obstacle to city smartness.

One element of this colonial-era urban monocentrism is the design of street network. The grid system, which was prevalent in Greek and Roman cities that influenced the planning of most European cities of the 18th and 19th centuries, was also extended to Africa during the colonization period. As illustrated with the street planning of Dakar in Senegal, and Cairo and Alexandria in Egypt, cities in colonial Africa also adopted the grid system, despite resistance from indigenous populations.

Box 2.4 Dual Street Planning of Dakar

Before the arrival of French colonialists in Senegal, the city of Dakar constituted villages organized around mosques in a circular pattern around an open central space, reflecting the influence of Islam on local spatial organization.[68] However, the arrival of French troops in the 19th century changed the face of Dakar with the French colonialists imposing a city plan that reflected the city plan of Paris, with large boulevards and avenues. Reflecting the military-led development of the city, these boulevards were designed perpendicular to a military fort in order to ease colonial troops' access throughout Dakar.[69] However, Dakar has a dual planning system with districts that were exclusively

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[67] Summary from Mboup (2015).

[68] Harris (2008). Chenal (2009). Harris (2011).

[69] Harris (2011).

for Europeans and others that were for the local Africans. Expelled from the centre, the indigenous people were left to their own devices in overcrowded areas where streets were irregular with no adequate sewerage and drainage systems. This marked the beginning of the segregation of distribution of basic services through urban planning in Dakar and other West African cities.[70] Construction with temporary building materials was authorized in the indigenous settlements, but “the inhabitant only obtained a property title when built out of permanent materials”.[71] Rather quickly, in the 1950s, the authorities were overwhelmed by the arrival of new migrants, and many shantytowns appeared on the non-developed urban fringes. It was at that time that a new policy of massive exodus of the “illegals” toward the periphery began.[72]

Map 1: The displacement of the lebu residential quarters from the city centre of colonial dakar by the 1910s. **Source:** *Bigon,2012*
Map 2: Dakar's French Influenced Boulevards. **Source:** *Image © 2013 DigitalGlobe*

Source: Mboup (2013).

This kind of urban divide as illustrated with the city of Dakar was also a hallmark of British colonialism in Africa, when in the early part of the 20th century cities, such as Nairobi and Harare, were planned along racial lines, with the local Africans being relegated to the least serviced parts of the city, while the Europeans laid claim on the planned parts of the city that had better geographical location, and enjoyed superior services and better infrastructure. Like many historical coastal East African

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[70]Harris (2011). The implementation of an orthogonal plan in Dakar was not a new practice, but a typical urban planning approach in other French colonial settlements in Africa and elsewhere in the eighteenth and nineteenth centuries.

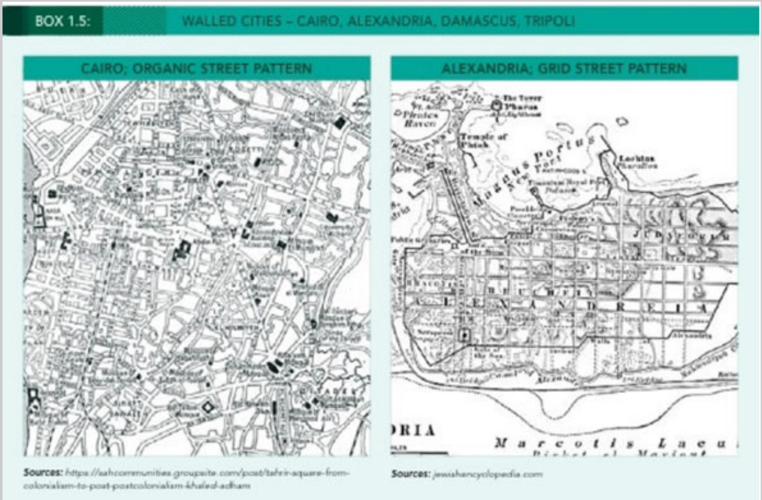
[71]Sinou (1990).

[72]See Footnote 71.

cities, Mogadishu's architecture and street planning reflected what is known as the "Swahili culture" of East Africa that has strong Arab and Persian influences mixed with local African traditions. However, Italians settlers controlled the city in 1920 and expanded it to build a modern city, complete with boulevards, majestic arches and cathedrals. In 1929, the first master plan for Mogadishu was developed to establish it as the political and administrative capital of Italian Somaliland. The city remained the seat of government when Somalia attained independence in 1960.[73]

Box 2.5 Historic city of Cairo

The historic city of Cairo, built between the 7th and 10th century after the Arab conquest, adopted an organic pattern of streets with a large number of dead-end streets.[74] A number of restrictions governed the Cairo's spatial expansion through time. The northern part is less connected although there are two main gates on that wall. On the eastern part, the walled city is completely segregated due to the existing of Al Azhar park and a huge cemetery (in literature it is called the 'dead city'), in addition to Al Mouqatum Hill, which forced the city to expand mainly toward the river Nile. El Muiz Street is the main accessible street inside historic Cairo and it connects the walled city directly through the northern gates and by a number of horizontal routes with the surrounding urban patterns. At the difference of Cairo, during the period 1805–1849, the city of Alexandria gained its current European Grid-iron pattern. The type of urban fabric inside the walled city is an orthogonal pattern at the opposite of Cairo with its organic pattern.



Source: Mboup (2013).

[73]Warah R, Dirios and Osman, 2012, cited by Mboup (2013).

[74]Mohareb and Kronenburgarab (2012).

Independence of African countries, since the 1950s, led to massive rural-to-urban migration as migrant workers sought jobs in capital cities. Suburbs dominated the physical growth of cities in these regions throughout most of the 20th century, a process that has continued into the 21st century. The monocentric form of street design and planning that characterized many cities in the colonial era started to change in the 20th century and accelerated with the independence of countries from the 1950s onwards. Street designs became more irregular following the peripherization of urban growth, which saw poor families moving to the outskirts of cities.

Suburbanization in African cities has been mostly synonymous with slum expansion, except for some pockets of gated suburbs occupied by wealthy families. Urban growth and slum growth often occur simultaneously in African cities, as presented in the State of the World's Cities Report 2006/7.[75] Urban expansion is often the result of poor households moving to the outskirts because they cannot afford to live in the city centre given unaffordable land values and property prices. The suburban areas have street connectivity similar to those of slum areas, with irregular street patterns with multiple unplanned dead-end roads. These dead-ends are not the result of city planning but the result of the addition of plots by land owners who subdivide land in search of profits. In this situation, it is common to find a street ending where a subdivision starts. The result is a high frequency of dead-ends with few interections that do not promote connectivity.

2.4 Africa's Urban Transition

The cities we study today when analysing African urbanization are not the same as the cities in the Pre-Colonial Africa. For instance, in Nigeria the population of the pre-colonial city of Ife had drastically decreased in favour of Lagos and Ibadan where the Europeans settled during the colonial period. Today, Lagos is among the few megacities (with a population on 10 million or more) that count the African continent. Most of the African capital cities such as Nairobi in Kenya, Dakar in Senegal, and Harare in Zimbabwe are colonial cities. In Mali, we barely heard the name of Djene and Timbuktu in urban studies but instead Bamako, the colonial capital. Except the recognition of UNESCO as heritage cities, many African pre-colonial cities are forgotten or unaccounted for in African urban studies. The influence of the colonialism was not only limited to the emergence of colonial cities but also embraced the way cities were planned, designed and managed. Due to lack of consistent trends data during the pre-colonial period, our analysis of the urbanization in Africa will be based on statistics from the UNDESA's World Urbanization Prospects since 1950.

[75] UN-Habitat (2008).

2.4.1 African Urbanization from 1950 to 2015

In 1950, whilst the European and North American regions completed their urban transition with more than half of their population living in cities, Africa had only 14.3% of its population residing in cities according to the 2018 World Urbanization Prospects publication.[76] At that time, the size of most African cities was below 50,000 inhabitants. A quarter century later, when the Habitat I was adopted in 1976, the African urban population rate increased to 20%, almost the double of its level in 1950. Twenty years later, at the Habitat II conference in 1996 in Istanbul (Turkey), the African urban population continued to grow and reached 29%. This is an indication of a progressive urbanization of the African continent. Indeed, for another twenty years, in 2016 when the New Urban Agenda was adopted in Quito (Ecuador), along with the adoption of the SDGs the previous year, four out of ten of African population lived in cites and towns (41.2% in 2015). Africa is, indeed, moving towards an urbanized continent with the highest urban growth rates in the world (3.3% per year between 2000 and 2015). The African urban level is expected to reach 48.4% at the end of the SDGs period in 2030, and the majority of the African populations are expected live in cities and towns at the end of the New Urban Agenda period in 2036 (50.9% in 2035).

With an area of about 30.2 million square kilometres and a population of 1.29 billion in 2018, Africa is the world's third largest continent as well as the world's second most populous continent after Asia. For the first time, around 2010, Africa's total population exceeded one billion (1.05 billion in 2010), of which a population of 409 million lives in urban areas. In 2018 more than half a billion of African people live in urban areas (548 million). This African urban population is projected to grow to 1.12 billion in 2040, and to 1.49 billion in 2050. Today, while ageing is a crucial problem in most developed countries, African population is particularly young and progressively educated: 70% of African people living in urban areas are below 35 years old, and most of them constitute the generation of the "millennial" born and grow along with the development and use of Information and Communication Technologies (ICTs). Educated, young people constitute a comparative advantage as a demographic dividend. With adequate institutions and good governance, this can be translated into economic opportunities.[77]

2.4.2 Urbanization in Africa by Sub-region 1950–2050

While in Southern Africa and Northern Africa the majority of the population has already been living in urban areas for the last 25 years and 11 years, respectively, in Middle Africa, Western Africa and Eastern Africa, where urbanization levels are

[76] UN population Division, Department of Economic and Social Affairs (2018).

[77] http://www.africaneconomicoutlook.org/en/theme/youth_employment/ Accessed on 21 October 2015. Promoting Youth Employment in Africa. Lori (2007).

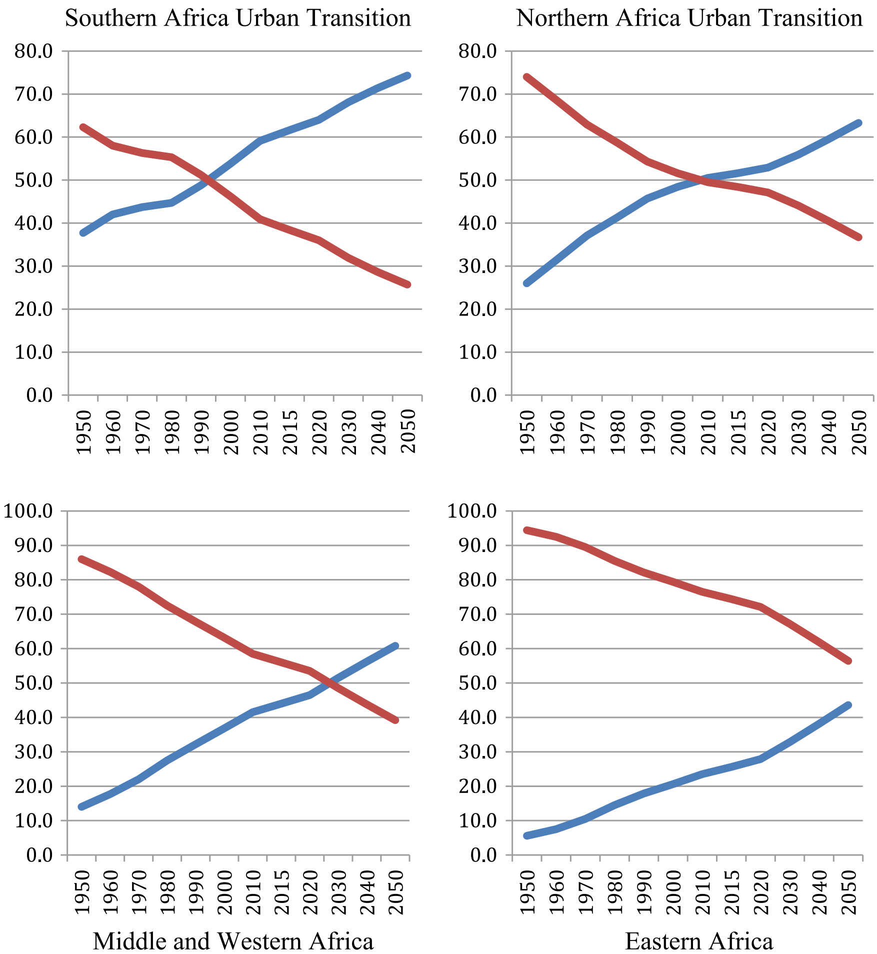


Fig. 2.4 Urbanization in Africa by region 1950–2050

49.5, 46.4 and 28% in 2018, respectively, the majority of the population will live in urban areas in 2020 and 2050, respectively. By the middle of the century, the urban transition will then reach all corners of the African continent (Fig. 2.4).

Southern Africa is the most urbanized region in Africa, but this average reflects particularly the situation of South Africa, which is highly urbanized (66.4% in 2018) and hosts over 80% of the population of the whole region. After South Africa, only Botswana is predominantly urban in the region (69.4% in 2018) followed by Namibia with a moderate rate (50% in 2018); the other two countries, Lesotho and Swaziland, have a low urban rate of 28.2 and 23.8% in 2018 respectively.

Similar situation is observed in Northern Africa where Algeria, Libya, Morocco and Tunisia had achieved their urban transition since 2000, while the level of urbanization in 2018 is 42.7% in Egypt and 34.6% in Sudan. Despite the fact that Egypt hosts the only megacity of the region and the largest African megacity, which is Cairo with its 19 million inhabitants, it is still predominantly rural. The population of the urban agglomeration of Cairo is higher than the population of most African countries in the Western and central regions.

In Middle Africa, except Chad with a low urban rate of 22%, most of the countries are predominantly or moderately urbanized with Gabon having the highest urban rate of 87% followed by Congo, Sao Tome and Principe (65% in both countries) and Cameroon (54%). The remaining countries, Angola, DRC and Equatorial Guinea, have a urban rate slightly higher than 40%. Despite the high level of urbanization of Gabon, Congo, Sao Tome and Principe and Cameroun, the regional average reflects the moderate level of the DRC and Angola with their huge national population.

In Western Africa, only two countries have a low level of urbanization: Niger and Burkina Faso (18 and 30% respectively). The rest of the countries are either predominantly urbanized (Cabo Verde, Gambia, Cote d'Ivoire, Ghana and Mauritania) or moderately urbanized—the club of 40 (Benin, Bissau Guinea, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo). In 2020, Guinea will join this club from its rate of 36% in 2015.

East Africa, with the urban rate of 28% in 2018, has nine of its countries with an urban rate below 30%: Burundi, Comoros, Eritrea, Ethiopia, Kenya, Malawi, Rwanda, South Sudan and Uganda. At the opposite, countries such as Djibouti, Reunion and Seychelles are predominantly urban with a rate of 78, 99.6 and 57% respectively. However, due to their small size their figures did not influence the regional average. Countries with a moderate level of urbanization are: Mauritius, Mayotte, Somalia and Zambia, Mozambique, Madagascar, Tanzania and Zimbabwe. Eastern African countries are in general rural, this dated back to 1950 and before. The post-colonial period has not changed much to this trend though there is progressive urbanization but with low pace.

Overall at the regional level, there is uneven urbanization across countries with the ten more urbanized countries mainly located in Southern and Northern Africa that have completed their urban transition. In contrast, the ten least urbanized countries are located mainly in Eastern Africa and some in Western and Central Africa.

As noted with the level of urbanization in the Southern, Northern, Central and Western Africa influenced by South Africa, Egypt, RDC and Nigeria respectively, regional averages hide diversity of urban patterns and call the need disaggregate regional averages to debunk countries' specificities and realities. When analysing the urbanization in Africa, it is, indeed, important to take into consideration four countries of large population size that have an important share in the Africa urban population: South Africa, Egypt, DRC and Nigeria. Over 122 million people reside in the cities and towns of these four countries, i.e. 49.6% of the population of cities with 300 thousands people or more. These four countries also have the four megacities of the region: Johannesburg, Cairo, Kinshasa and Lagos respectively with a population respective of 9.4 million, 18.8 million, 11.6 million and 13.1 million, together representing 21.7% of the population of cities of 300 thousands or more. It is important to take into consideration the population of these large cities when analysing regional urbanization in Africa. Any change in these countries or cities will affect considerably Africa urban transition.

2.5 Urbanization and Emergence of Large Size Cities in the African Region

The urban planning, the transport planning and the infrastructures depend on the size of each city; they must be taken into consideration in the classification of cities by their size. When a city reaches one million of population size, its planning, design and management becomes complex compared to a small city. For instance, in term of transport, cities of one million requires an efficient public transport in order to run efficiently; it must be planned in advance with consideration of land use and density.

Rapidly increasing urbanization levels from the 20th to the 21st century in Africa have also been accompanied by spectacular growth in city sizes. While most cities analysed here had less than 50,000 inhabitants in 1950, their populations in the 21st centuries began reaching the one million mark. From only three cities (Cairo, Alexandria and Johannesburg) with a population of 1 million or more in 1950, the number of cities with a population of 1 million or more has grown to 54 in 2014. In 2014, four African cities—Cairo, Lagos, Kinshasa and Johannesburg—are megacities with more than 10 million inhabitants. It is projected by 2025, that Cairo and Lagos will have a population of more than 20,000 million (22.4 million and 20.0 respectively), a size of a metacity. By 2030, Dar-es-Salam and Luanda will also join the group of megacities with a population of 10.8 million and 10.4 million respectively. The pace of growth in city sizes is much rapid in Africa than observed in cities of developed regions during the 19th century. For instance, Whereas London required 130 years to grow from 1 million to 8 million inhabitants, it took only 50 and 40 years, for Cairo and Lagos respectively to do so.[78] However, the four African megacities differ in size and growth paths. They rank from 9.2 million in Johannesburg in 2014 to 18.4 million inhabitants in Cairo in 2014, and together they are home to around 53 million people, or about 22% of Africa's urban dwellers in cities with 300,000 inhabitants or more. It is projected by 2025, that Cairo and Lagos will have a population of more than 20,000 million (22.4 million and 20.0 respectively), a size of a metacity as per UN-Habitat's definition presented for the first in the State of the World's Cities 2008/2009.[79] According to the Urbanization Prospects—15 Revision, by 2035, Lagos will be the largest city in Africa surpassing the city of Cairo that has held this place since the 1950. The city of Kinshasa will reach a size of 20 million in 2030 also joining the group of metacities. By 2030, Dar-es-Salam and Luanda will also join the group of megacities with a population of 10.8 million and 10.4 million respectively (Table 2.1 and Figs. 2.5, 2.6).

[78] WHO, UN-HABITAT (2010).

[79] See Footnote 75.

Table 2.1 Selected capital and large cities in 2014 according to their size in 1950

Cities less 50,000	(50,000–100,000)	(100,000–300,000)	(300,000–650,000)	(1–1.5 million)
Cottoned (20) Ouagadougou (33) Bujumbura (19) Yaoundé (32) Bangui (42) Ndjamena (25) Pointe Noire (16) Bouake (31) Libreville (15) Banjul (26) Conakry (31) Bissau (18) Monrovia (35) Lilongwe (4) Nouakchott (3) Windhoek (19) Niamey (24) Abuja (19) Kigali (20) Juba (6) Lusaka (31)	Brazzaville (83) Abidjan (65) Asmara (67) Douala (95) Mombasa (94) Bamako (89) Maputo (92) Freetown (92) Mogadishu (55) Kampala (95) Dar es Salam (84)	Luanda (138) Kinshasa (202) Accra (177) Nairobi (137) Tripoli (106) Antananarivo (177) Dakar (214) Pretoria (275) Port Elizabeth (192) Khartoum (183) Harare (143) Casablanca Rabat (145) Marrakech (209)	Addis Ababa (392), Ibadan (450), Lagos (325), Tunis (472), Cape Town (618), Durban (484) Algiers (516) Casablanca (625)	Cairo, Alexandria Johannesburg

Source Constructed by the author from UNDESA Population Division, 2015. The World Urbanization Prospects: The 2014 Revision

However, it is important to note that while cities such as Lagos, Cairo, Kinshasa and Johannesburg had grown spectacularly since 1950, others had maintained a moderate or low population growth rate. Cities such as Alexandria, Cape Town,[80] Ibadan, Casablanca and Addis Ababa that held similar population or more than Lagos and Johannesburg in 1950, are still far from reaching the size of a megacity. Except the case of Egypt, countries of Northern Africa such as Algeria, Morocco and Tunisia were able to urbanize without the development of large urban agglomerations. These countries were also able to urbanize without concentration of their population in the capital cities. These different patterns call for caution in generalizing the African urbanization; this urbanization has occurred at different times with different paces, each pattern with different underlining factors. For different reasons, demographic, geographic, economic, social and politic, cities had used different trajectories of growth in terms of number, form and structure.

By 2030, there will be an increased number of cities with a size of more than 5 million constituting economic and social opportunities as well as challenges depending on how the urban growth was planned and managed. Development of large urban

[80]The situation of Cape Town can be associated to the practice of Apartheid that limited migration of black people to the city.

Fig. 2.5 Large cities in Africa. *Source* https://www.mapsofworld.com/africa/maps/africa-cities.jpg

agglomerations provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand, for instance, for water, sanitation, solid management, energy, streets and public spaces. It will also require efficient institutions for the management of social demand and equity such as on education and health as well as protection of people against violence and insecurity. Development of large metropolitan region will also come with increased demand on mobility that must be satisfied with an efficient public transit accompanied with increased spaces for pedestrians and cyclists in order to safeguard the environment while creating economic growth. Economies of scale and agglomeration economies are greater in metropolitan areas where transportation infrastructures are able to answer mobility needs with higher access to markets and resources than those where people mobility is impeded by deficient transportation infrastructures. This will also allow large-scale production of goods and services that can be distributed within the metropolitan regions and beyond with time, cost and reliability opportunities.[81] This is the way the economies of scale and agglomeration

[81] See Rodrigue (2013).

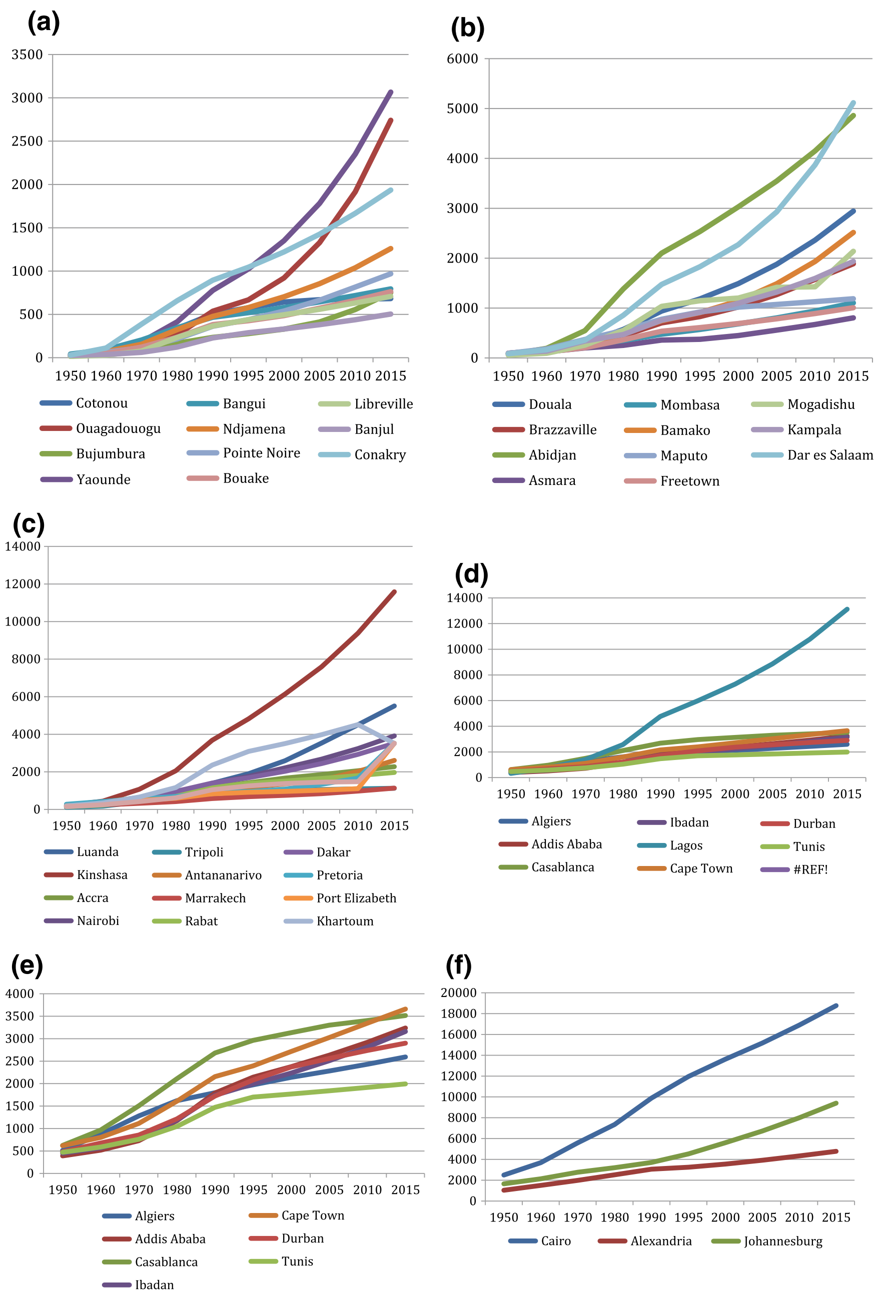


Fig. 2.6 Evolution of City sizes between 1950 and 2015 by population in 1950. **a** Cities with less than 50,000 in 1950, **b** cities with population between 50,000 and 100,000 in 1950, **c** cities with population between 100,000 and 300,000 in 1950, **d** cities with population between 300,000 and 650,000 in 1950, **e** cities with population between 300,000 and 650,000 in 1950 (without Lagos), **f** cities with population of 1 million or plus in 1950

associated with large urban agglomerations and high densities can be materialized. Without efficient mobility, a metropolitan region losses its economic power and remains just clusters of disconnected settlements.

2.6 National Urban Systems in Africa

The urban system of a country is determined by the way cities and towns of different sizes are geographically distributed. In the urbanization process, some countries are able to develop a balanced system of cities with no city does predominantly hold a large share of the urban population while others concentrate their population in one city, particularly in the capital city.[82] Analysis of a national urban system is of importance, particularly for national urban policies and programmes. For instance, urban policies and programmes for a large city that requires an efficient public transport, may not be same for a small size city that is already compact with a mixed-land use. Large size cities are locations with a high level of accumulation and concentration of economic activities but they are also complex spatial structures that require elaborated transport systems. The larger the city, the greater is its complexity and the potential for disruptions, particularly when this complexity is not effectively managed. The most important transport problems are often related to urban areas and take place when transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility.[83]

An urban system is associated with several demographic and urban variables such as country size, population density, and the stage of urban transition, among other factors.[84] An urban system can be characterised by a predominance of one or two large cities to other medium or small cities. Within an urban system, a city is considered as a primate cite when its share on the total urban population is 40% ore more. High primacy shares imply a high concentration of persons in one city, enabling cities to benefit from the positive effects of high density such as economies of scale and agglomeration, diffusion of ideas and innovation. However, the association between city primacy and economic performance is in a non-linear form and depends on other variables. As noted by UNDESA (2015) "While there is evidence to support such a positive relationship between concentration of people and economic efficiency, research has also found that city primacy can create an unbalanced urban hierarchy and bias development processes".[85]

Along the urbanization process associated with natural population growth, migration and reclassification of settlements from rural to urban, an urban system can be

[82]See Footnote 6.

[83]See Footnote 81.

[84]Organisation for Economic Co-operation and Development (OECD) (2012). Short and Pinet-Peralta (2009).

[85]United Nations, Department of Economic and Social Affairs, Population Division (2015). See also Short and Pinet-Peralta (2009), UN-Habitat 2013 and 2008 cited by UNDESA.

affected by several variables such as urban policies and programmes at the national, regional, and local levels.[86] An urban system may also determine the need for specific urban development policies, consistent with the size, growth and function of each city. As noted by UNDESA (2015), 'the interplay of forces towards population agglomeration and distribution makes the empirical relationships between a country's existing urban system and its future development multidimensional non-linear".[87] For instance, a situation where a primate city receives preferential consideration for, for instance, the provision of administrative and commercial services and infrastructures at the detriment of other cities, could be detrimental to an efficient and balanced economic development, and could lead to spatial inequality. Advantages and challenges associated with urban primacy finally vary in pace and time and require specific country assessment.

2.6.1 Primate Cities (City with a Share of 40% or More to the Total Urban Population)

When all cities equally contribute to the total urban growth rate, the city growth (small or high, negative or positive) will not affect its share to the total urban population. The share of a city to the total urban population is a good indicator of a city performance, attractiveness or a simple political preference. For instance, when all the national social and economic investments as well as political decisions are vested in a particular city at the detriment of others, people do not have limited choices for their well-being except moving to that city to access basic needs and enjoy other opportunities. In our analysis, in a given country, a city is considered primate when it accounts for at least 40% of the urban population in a particular year.[88] In addition, the ratio of cities of population of 300,000 or more to the total urban population will be used to assess the representation of small size cities on the total national urban population.

The urban primacy as defined here characterizes the urbanization process in many African countries. Indeed, out of the 45 cities of 300,000 or more analysed here, nearly half (22 cities) are primate cities with a share of 40% or more of the total urban population of their respective countries in 2015. The rest is evenly distributed across cities with a share of between 30 and 40% and cities with a share of below 30% (11 and 12 cities respectively). Most of the primate cities in 2015 are located in Western and Central Africa (18 out of the 22 primate cities). The remaining primate cities are located in Eastern Africa: Asmara of Eretria, Mogadishu of Somalia, and Khartoum of Sudan, a share of 53, 49 and 38% (nearly 40%) respectively of their national urban population; and in North Africa, where only Cairo is a primate city with a share of

[86] Kim and Law (2012).

[87] See Footnote 6.

[88] This definition is from the United Nations, Department of Economic and Social Affairs, Population Division (2015).

51% of the national urban population of Egypt. There are cities that have a very high primacy rate, which is above 50%; in other terms they concentrate more than half of the total urban population of their country. Ten cities, that have a share nearly half of the population of their country, belong to this group: Djibouti, Brazzaville, Bujumbura, Monrovia, Bissau, Luanda, Dakar, Asmara, Cairo and Ouagadougou. However for Djibouti, Bissau and Bujumbura, this is predictable as per the small size of their respective countries.

Cities that are not considered primate by definition but have a moderate share of the total urban population of their country represent 11 out of the 45 cities. They are mainly located in Eastern Africa (Kigali, Lusaka, Nairobi, Lilongwe, Dar-es Salam, Antananarivo and Kampala); two cities are located in Southern Africa (Windhoek and Harare); and the other two cities are in Western Africa (Lomé and Niamey).

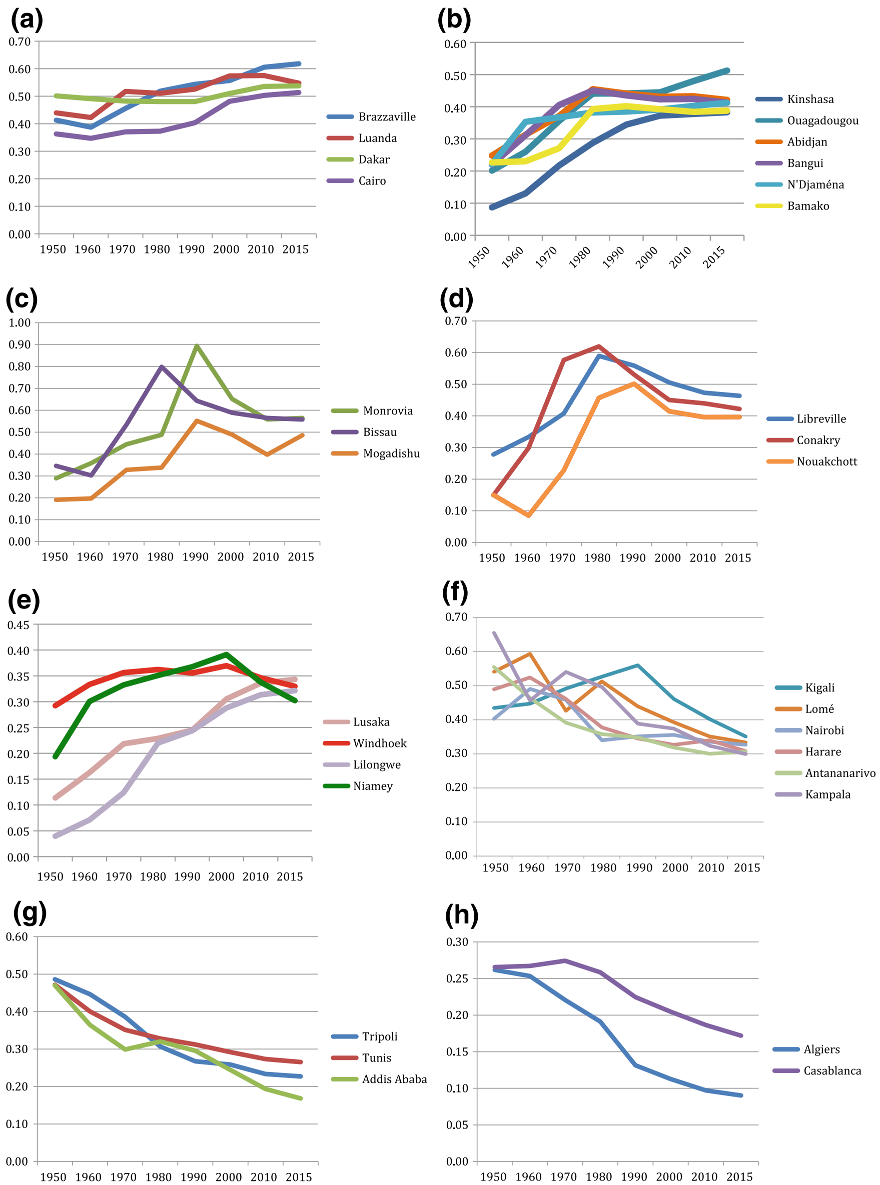
Cities with a low share of the total urban population represent 12 of the 45 cities. Except Cairo, all the largest cities in Northern African countries (Tunis, Tripoli, Casablanca and Algiers) belong to this group, with four in Western and Central African cities (Yaoundé, Accra, Lagos and Cotonou), and four in South-Eastern African cities (Johannesburg, Addis Ababa, Juba and Maputo). The city of Algiers has only a share of 9% of the total urban population of Algeria where there is a net predominance of small size cities.

It is important to assess whether a city had been primate city since 1950, or it had become a primate city during the urbanization process, or it was a primate city but had lost its primacy during the urbanization process. This pattern depends closely on various factors, economic, environmental, politic and administrative. During the period of 1950–2015, four scenarios can be underlined: (1) Primate City in 2015; (2) From low share towards primate city; (3) Initially primate city but lost their status due to continuous decline of their share and; (4) Cities that had never been primate. Each scenario, as presented in subsequent sub-sections, may display some variances, but they share some core characteristics (Fig. 2.7).

Permanently primate City between 1950 and 2015

The permanent primate city status of Dakar, Luanda, Brazzaville is mainly due to the fact that all national economic activities and political and administrative functions are concentrated on them. For instance in Senegal, apart Dakar, there is no other city that reached the 1 million mark of population, and all of them, except Touba, have of population size below 300,000 inhabitants. Today, Dakar occupies a pivotal place in the trade sector both nationally and internationally. The autonomous port of Dakar, the international airport, the international trade centre, its touristic sites and its commercial centres give it a huge comparative advantage compared to other Senegalese cities. Indeed, Dakar contributes nearly 55% of the national Gross Domestic Product (GDP)[89] and has a concentration of nearly half of Senegalese civil servants. Nine out of ten employees in Senegal's trade, transport, banking and industrial enterprises are

[89]Republique du Senegal, Cities Alliance and UN-Habitat (2010).


(a)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Brazzaville
Luanda
Dakar
Cairo
(b)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Kinshasa
Ouagadougou
Abidjan
Bangui
N'Djaména
Bamako
(c)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Monrovia
Bissau
Mogadishu
(d)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Libreville
Conakry
Nouakchott
(e)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Lusaka
Windhoek
Lilongwe
Niamey
(f)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Kigali
Lomé
Nairobi
Harare
Antananarivo
Kampala
(g)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Tripoli
Tunis
Addis Ababa
(h)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1950 1960 1970 1980 1990 2000 2010 2015
Algiers
Casablanca

◀**Fig. 2.7** **a** Permanently primate cities (share equal or higher than 40%): Share of a city population to the national population (1950–2015). **b** From a low share (less than 40%) to a high share (40% or more) to become a primate: Share of a city population to the national population (1950–2015). **c** Increased share to reach the status of primate city: Share of a city population to the national population (1950–2015). **d** Increased share to reach the status of primate city followed by a decline: Share of a city population to the national population (1950–2015). **e** From low share to high share towards primate city: Share of a city population to the national population (1950–2015). **f** Initial primate cities but lost their primacy status: Share of a city population to the national population (1950–2015). **g** Initial primate cities but lost their primacy status: Share of a city population to the national population (1950–2015). **h** Urban system without primate cities: Share of a city population to the national population (1950–2015). *Source* Computed from United Nations, Department of Economic and Social Affairs, Population Division (2015)

in Dakar.[90] Except Dakar, none of the Senegalese cities offer job opportunity with their economic activities mainly based on trades and services in an informal form. This system of cities does not foster economies of scale and agglomeration. Finally Dakar is the only destination for a better future from small towns as well as from rural areas, in a country continuously affected by drought. The population density of Dakar is estimated at 16,500 inhabitants per square km. The situation of Brazzaville is quite different, since there is another city, Pointe Noire, with more than a million people following closely the city of Brazzaville. Together, the two cities constitute more than 90% of the national urban population of Congo. In Egypt, Half of the urban population is located in Cairo (51%), this is the result of sustained increase of the share of Cairo in the national population since 1990 from a level of 40 to 48% in 2000 and 50% in 2010, and 51% in 2015. It is important note that the growth of the city of Cairo was also accompanied with the increase of the number of cities with a population of 300,000 or more; from level of 67% in 1950, these cities represent 78% of the Egyptian population in 2015. At the opposite of Cairo and Brazzaville where there is at least other large cities, the situation of Dakar is alarming since there is no other city than Dakar that foster economies of scale and agglomeration.

From a low share to a high share to become a primate city

It is clear that after the independence of most African countries in the 1960s, many African capital cities grew in an unprecedented way considering their political and administrative functions. Among those capital cities are Kinshasa, Ouagadougou, Abidjan, Bangui, Ndjamena and Bamako. In 1950, only 9% of the total urban population lived in the city of Kinshasa. Between 1950 and 2016, this figure grew in a logistic form until 1990 where it reached 34%, more than the triple of its level in 1950. It grew linearly to reach 38%, a sufficient level to put Kinshasa nearly a primate city in 2016. Today 11 million people live in Kinshasa, the only megacity in Central Africa with high population density of 19,500 km^2, the highest population density in Africa. A similar trend was observed with the city Abidjan who became a primate city in 1980 (45%) from a level of 25% in 1950. Since then, the city of

[90]Republique du Senegal, Cities Alliance and UN-Habitat (2010). The Geography of Transport Systems.

Abidjan remains a primate city with a density of 12,800 people per square km for a population of 4.9 million in 2015. Similar patterns were also observed with the city of Ouagadougou with a share that rose from 19% in 1950 to reach 36% in 1970, and before 1980 it became a primate city with a share of 44% of the national urban population. Today 51% of the Burkina Faso national urban population live in the city of Ouagadougou. The city has a density of 6100 people per square km. The population growth of the city of Ouagadougou, at the opposite of the city of Kinshasa and Abidjan, was accompanied with a rapid land expansion with the spread of low-density settlements.

Increased share to reach the status of primate city, but had accounted years of turbulence related to conflicts and other factors

Since 1950, there is sustained increase of the share of Bissau and Monrovia in their respective national urban population. There had been persistent political instability in Bissau Guinea, and most people fled to the capital city Bissau where 80% of the urban population lived in 1980 from 30% in 1960. However, this drastic increase was just temporary with certain people might have returned to their usual places of residence or somewhere else, or have been refugees in other countries. Today 56% of the Guinea Bissau national urban population of the Bissau Guinea live in Bissau, which remains a primate city. In Monrovia the highest share was observed in 1990 with a level of 90%, a level more than two times higher than its level in 1960. Though there is a steady increase of their share since 1950 but due to conflicts and other factors both cities Bissau and Monrovia accounted some fluctuations prior to 1980 and 1990 respectively. Since then, it had been noted a sharp decline of their respective share pointing out circumstantial variations that can be associated with various events. For instance, eruption of a civil war can lead to the agglomeration of people in a safer area such as the capital city as it can be the case in Liberia and Guinea Bissau. In Liberia Conflicts and political violence began in 1980 with a military coup that lasted ten years. This period was marked by corruption, economic mismanagement, ethnic-based discrimination and general violence orchestrated politically and militarily. Grievances and greed lead to emergence of various rebel factions not only of ideological differences but the desire to control natural resources including gold and diamonds.[91] This political instability marked by civil wars ended in 1997 with a democratic presidential election. Despite democratic environment, the instability persists and spread in Monrovia. It is only beginning 2005 that peace returned to the country. However the post-conflict period still affects the urbanization trends and patterns in Liberia. The effects of the war in Liberia were catastrophic with an estimate of 250,000 people dead and a third of the population flee to neighbouring countries or somewhere else.[92] While in Liberia, the conflict has ended since 2005, Guinea Bissau is still in an unstable political situation. Another country that

[91]Global Security.org, Liberian Conflict. https://www.globalsecurity.org/military/world/war/liberia.htm: Accessed on 9 June 2017.

[92]Peace Insight, https://www.insightonconflict.org/conflicts/liberia/conflict-profile/: Accessed on 9 June 2017.

has experienced conflicts and civil wars is Somalia. In this country, the share of the capital city Mogadishu has increased from a level of 19% in 1950 to a level of 55% in 1990. Since then it has started to decline to reach a level of 40% in 2010; but in 2015 an increase is noted with a level of 49%. This irregular pattern may reflect the situation of civil and political conflicts along with terrorism, which are still on course in Somalia.[93] During conflict, people have the tendency to relocate temporarily to the city, particularly to the capital city. This has been largely documented on the linkages between environmental changes and migration. In absence of peace and security, social and economic sustainability is jeopardized.

Increased share to reach the status of primate city followed by a decline

The cities of Conakry, Libreville and Nouakchott are those primate cities that accounted an increase of share since 1950 followed by a decline since 1980 for the first two countries and since 1990 for the latter. Since 1950, the city of Conakry was marked by continuous increase of its share in the national urban population from 15 to 30% in 1960. This exponential growth made it to reach 58% in 1970, and 62% in 1980. However From 1980, there is a decline of its share with the growth of other cities such as the second largest city in Guinea, NZerekore (343,000 inhabitants). The first population growth of the city of Conakry is associated with the fact that the city became the capital of French Guinea in 1904 and prospered as an export port, particularly after a railway (now closed) to Kankan opened up the interior of the country for the large-scale export of groundnut. In decades after independence, the population of Conakry boomed, from 50,000 inhabitants in 1958 to 600,000 in 1980, to over 1.9 million today.[94] A similar trend is observed with the city of Nouakchott, which was a small village of little importance until 1958, when it was chosen as the capital of the emerging nation of Mauritania. It was first designed and built to accommodate 15,000 people, but droughts and increasing desertification since the 1970s have displaced a vast number of Mauritanians who resettled in Nouakchott. This caused massive urban growth and overcrowding, with the city having an official population of just under a million as of 2013.[95] With a share of 8% in the national urban population in 1960, the city of Nouakchott, due its new statue as capital city of Mauritania grew spectacularly between 1960 and 1980 to have a share of 23% in 1970, which doubled in 1980 (46%). In 1990, half of the national urban population of Mauritania lived in the city of Nouakchott. However, this level became unsustainable with the growth of population living in slum conditions, and the government undertook a slum resettlement programme while some residents opted to migrate in

[93] The Somali Civil War grew out of resistance to the Siad Barre regime during the 1980s. By 1988–90, the Somali Armed Forces began engaging various armed rebel groups. By the time The Siad Barre's regime collapsed in 1991 the Somali society had begun to witness an unprecedented outbreak of inter- and intra- clan conflicts. https://en.wikipedia.org/wiki/Somali_Civil_War: Accessed on 9 June 2017.

[94] See Footnote 65.

[95] Centre for Affordable Housing Finance in Africa (CAHF) (2014).

other areas since 2000[96] as illustrated by the decline of the share of Nouakchott in the national urban population to reach a level of 40%.

2.6.2 From Low Share to High Share Towards Primate City

Increase of share had also been observed in other capital cities though they had not reached a sufficient level of share to be considered primate cities. Those cities are Lusaka, Windhoek, Lilongwe and Niamey. A spectacular increase of share in Lilongwe that represented less than 5% of the total urban population of Malawi in 1950, a percentage that continually rose to reach 32% in 2015. Similar trends were observed in Lusaka with a percentage that rose from 11% in 1950 to 34% in 2015. Niamey and Windhoek present similar scenario though there is an increase of their share from 1950 to 2015. In Windhoek, the increase is modest and became irregular since 1980 when it reached a level of 36% compared to a level 32% in 2015. In Niamey there is steady increase until 2000 with a level of 39% compared to 19% in 1950. But since 1990, it seems decreasing to reach a level of 30% in 2015.

2.6.3 Initial Primate Cities but Lost Their Status Due to Continuous Decline of Their Share

A loss of city primacy may be a pointer that along the urbanization of a country, there is a greater diversification of its urban system, with the result that the preponderance of one city in a country's urban system is eroded by the growth of medium-sized and smaller urban centres. Except Lome and Tunis, all these cities are located in Eastern Africa that has the lowest urbanization rate in Africa. All these cities have a share of between 30 and 40% compared to their status of primate city in 1950. The most spectacular loss of primacy was observed with Kampala that moved from a share of 66% in 1950 to 30% in 2015, followed by Nairobi with a decline of share from 49% in 1960 to 30% in 2015. Primate city in 1950 with a share of 47% of the national urban population, Addis Ababa lost its status progressively to reach a share of 17% in 2015. Ethiopia remained a rural country with only 20% of its population living in urban areas with 83% living in cities of small size towns (of less than 300,000 inhabitants).

The city of Kigali first experienced an increase of its share in the Rwandan urban population until 1990 where its share reached 56% from a level of 43% in 1950. After the genocide of 1994, its share started declining with a level of 46 and 40% in 2000 and 2010 respectively. In 2015 Kigali is no longer a primate city with its shared reaching 35%. With an irregular trend from 1950 and 1990, the city of Lome started

[96] See Footnote 95.

steadily losing its share from 1990 where it was a primate city with a level of 44% to reach a level of 33% in 2015.

Though the city of Tunis was a primate city in 1950, it has lost its supremacy to the development of cities of smaller size. Its share decreased from 47% in 1950 to 27% in 2010, a rate that remains invariant until 2015. Similar decline has been observed among the cities of 300,000 or more from a level of 55 to 36%. Indeed the urbanization of Tunisia is mainly associated with the emergence of small size cities with a population less than 300,000. A similar scenario was observed with the city of Tripoli in Libya that lost its share from 49% in 1950 to 23% in 2015.

2.6.4 Urban System Without Primate Cities

Except Casablanca and Algiers, African capital cities had been primate cities always or sometimes during the period 1950–2015.

In Morocco, the share of Casablanca in the national urban population has been low since 1950 with a level of 27% and has declined since then to reach 17% in 2015. However, in Morocco, there is a development of cities of size of 300,000–1000,000 making the share of cities of 300,000 or more 58% from a level of 71% in 1950. Though Casablanca is not the capital city, it is the commercial hub of Morocco where various financial and economic transactions occur compared to the capital city, Rabat. Casablanca is the most populated city in Morocco with a population of 3.5 million, but there are important cities in the country that together create a balanced urban system: Rabat, 2 million, Marrakech, 1.3 million, Fez 1.2 million and Tanger (nearly 1 million). In the case of Algiers, the scenario is quite different since except Algiers with its population of 2.6 million, there is no other city in Algeria with a population of 1 million or more. Cities of population of between 300,000 and 1,000,000 represent only 10%. Cities of population below 300,000 represent a very important share of 80%. Algeria urban system is quite specific with the predominance of small size cities.

2.7 Conclusion

Although African societies were predominantly rural during the pre-colonial era, urban settlements existed for centuries and were an important feature of Africa's history long before the European colonialism. In every corner of Africa, from Western to Eastern, and Northern to Southern Africa crossing the centre of the continent, there were some forms of existence of towns and cities based on social, economic and political opportunities. Archaeological works have also shown that Africa displayed various systems of cities and villages in a sustainable growth and social harmony manners. African cities were, indeed, featured not only in terms of their size but also particularly by their degree of heterogeneity as being the place where people from different localities agglomerate for different social, economic and political purposes. The presence of natural resources as well as the geographical position was determinant for the choice of sites for human settlements. African towns and cities were also historically organized around their streets and roads with the main purposes of mobility, commerce and social interactions.

In terms of housing, architecture and organization, pre-colonial African cities display historic partners that Blier (2012) classified in three categories: (a) The *Monumental urbanism* characterized by substantial permanent structures in stone; (b) The *Satellite urbanism* characterized, on one hand, by its earthen structures and, on another hand, by the collaboration between interlinked community clusters that together create an urban settlement structure and; (c) *Migratory or peripatetic urban settlements* characterized by the nomadic identity of their population. Throughout history city wall systems were also adopted for purposes of control of merchants and goods, taxes, tolls and the reduction of smuggling. There were more than 50 walled cities distributed across ten African countries. However, most of these early urban centres rarely appear on official national population estimates that mostly include only large urban agglomerations. Without being part of the UNESCO heritage sites, these early African urban centres would be forgotten and uncounted. In fact during colonial period numerous pre-colonial African cities were either destroyed or downgraded. The cities we study today when analysing African urbanization are not the same as the cities in the Pre-Colonial Africa. The slavery and the colonization have impacted considerably the African urban population. Though we do not have a global number of the impact of slavery on the African population, tentative estimations indicated that more 100 million Africans were deported to America and Europe and over 100 cities were destroyed or downgraded.

The settlement of the Europeans brought forth a new form of monocentric system with the centre, hosting large administrative and commercial buildings as well as the European residences, while the indigenous people are relocated to areas that lacked most basic services such as piped water, sewerage systems, education facilities and health centres as well as administrative and commercial businesses. The monocentrism as well as the colonial urban divide had been pursued in most African capital cities after independence. In these cities, residential areas were also designed along economic class lines. This has led to social and economic fragmentation that disadvantaged lower income groups in accessing basic services such as public transport, and prevent social interaction and integration. The monocentrism is, today, a source of traffic congestion and an obstacle to city smartness, characteristics of African cities we are studying today, different from the decentralized organization of cities during the pre-colonial period.

The African population is estimated at 1.3 billion in 2018 in an area of about 30.2 million square kilometres. Africa is the world's third largest continent as well as the world's second most populous continent after Asia. Today, while ageing is a crucial problem in the world, African population is particularly young and progressively educated: 70% of African people living in urban areas are below 35 years old, and most of them constitute the generation of the "millennial" born and grow along with the development and use of Information and Communication Technologies (ICTs).

Educated, young people constitute a comparative advantage as a demographic dividend as well as economic opportunities. Overall at the regional level, there is uneven urbanization across countries with the ten more urbanized countries mainly located in Southern and Northern Africa that have completed their urban transition. In contrast, the ten least urbanized countries are located mainly in Eastern Africa and some in Western and Central Africa. Rapidly increasing urbanization levels from the 20th to the 21st century in Africa have also been accompanied by spectacular growth in city sizes. By 2030, there will be an increased number of cities with a size of more than 5 million. The increased number of large cities in Africa constitutes economic and social opportunities as well as challenges depending on how the urban growth was planned and managed. Development of large urban agglomerations provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand, for instance, for water, sanitation, solid waste management, energy, streets and public spaces. It will also require efficient institutions for the management of social demand and equity such as on education and health as well as protection of people against violence and insecurity. Development of large metropolitan region will also come with increased demand on mobility that must be satisfied with an efficient public transit accompanied with increased spaces for pedestrians and cyclists in order to safeguard the environment while creating economic growth. The other chapters of the book will analyse aspects associated to environment, infrastructure, social development, disaster exposure and resilience as well as peace and security.

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Chapter 3
Africa's Smart City Foundation: Urbanization, Urban Form and Structure, Land Tenure and Basic Infrastructures

Gora Mboup

Abstract Cities grow in population size as well as in land use. This chapter assesses the spatial growth of city and how populations are spatially distributed. It assesses the spatial growth of cities and how populations are spatially distributed in terms of density, compactness and land use (infill, extension, inclusion and leapfrogging). While the population of the city has been well researched and presented in the tradition of the UN Population Division to update the urban levels and trends and city growth in its yearly publication titled: *World Urbanization Prospects*, few studies provide sufficient accurate information on spatial growth of cities in different periods. Little was known on the spatial growth of cities until recently with the development and use of GIS technologies. The chapter will also analyse land tenure and the provision of basic infrastructures such as water, sanitation in African cities. It will also introduce the concept and measurement of a smart city foundation. A smart city is viewed as a sustainable, inclusive, resilient and prosperous city that promotes a people-centric approach based on three core components and seven dimensions. The three core components are *Smart City Foundation*, ICT, and Smart Institutions and Laws, which in turn are the pillars of the other dimensions of a smart city: Infrastructure Development, Environmental Sustainability, Social Development, Social Inclusion, Economic Development, Disasters Exposure, Resilience, Peace and Security. The three components together with the seven dimensions make a Smart Economy. A smart city foundation is composed of three elements: *Urban Planning and Design*, *Land Policies and Basic Infrastructure*. For a city foundation to be smart, it must be inclusive at the onset of the urban planning and promotes mixed neighbourhoods where social clustering is discouraged.

Keywords Smart city · Smart economy · Smart city foundation · Urban planning
Streets · Public spaces · Secure tenure · Basic infrastructure · Flooding
Adaptation · Mitigation · Policies · Programmes

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3.1 Introduction

Cities grow in population size as well as in land use. While Chap. 2 was centred on the measurement of growth of cities in population size, this chapter assesses the spatial growth of cities and how populations are spatially distributed in terms of density, compactness and land use (infill, extension, inclusion and leapfrogging). While the population of the city has been well researched and presented in the tradition of the UN Population Division to update the urban levels and trends and city growth in its yearly publication titled: *World Urbanization Prospects*, few studies provide sufficient accurate information on spatial growth of cities in different periods. Little was known on the spatial growth of cities until recently with the development and use of GIS technologies.

The increased number of large cities in Africa, as illustrated in Chap. 2, constitutes economic and social opportunities as well as challenges depending on how the urban growth was planned and managed. Development of large urban agglomerations provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand, for instance, for water, sanitation, solid waste management, energy, streets and public spaces. A smart city is viewed as a sustainable, inclusive, resilient and prosperous city that promotes a people-centric approach based on three core components and seven dimensions. The three core components are *Smart City Foundation*, *ICT*, and *Smart Institutions and Laws*, which in turn are the pillars of the other dimensions of a smart city: Infrastructure Development, Environmental Sustainability, Social Development, Social Inclusion, Economic Development, Disasters Exposure, Resilience, Peace and Security. The three components together with the seven dimensions make a Smart Economy. A smart city foundation is composed of three elements: *Urban Planning and Design*, *Land Policies and Basic Infrastructure*. For a city foundation to be smart, it must be inclusive at the onset of the urban planning and promotes mixed neighbourhoods where social clustering is discouraged.

This chapter is composed of the following section: (3.2) Urbanization, density, land use and compactness; (3.3) African City Foundation: street connectivity, basic infrastructures and land tenure; (3.4) Urbanization and Proliferation of slums; and (3.5) Use of ICT for an inclusive planning of African cities.

3.2 Urbanization, Density, Land Use and Compactness

This section analyses urban population densities from different sources (Demographia, Atlas of Urban Expansion—The 2016 Edition, Africapolis) using different categories of indicators. First it uses the urban density as it is commonly known: the city population to its total urban extent. It discusses the relevance of urban density with some methodological considerations. Density analysis was followed by the analysis of change in urban form and compactness along the African urbanization. This section also analyses different patterns of urban density within cities. Using the data from the Atlas of Urban Expansion—The 2016 Edition, it has assessed different forms of transformation of the urban extent. In space, growth of city can occur in many ways: infill, extension, inclusion or leapfrog. Using the definition of the Atlas of Urban Expansion—The 2016 Edition,[1] land use along urbanization is categorized as follow "City growth within the same urban extent is known as *city infill* that consists of all built-up pixels added in the new period that occupy urbanized open space within the urban extent of the earlier period. City can also grow beyond its previous urban extent in a contiguous manner. This type of city growth is know as city *extension* that consists of all built-up pixels added in the new period that constitute *contiguous* urban clusters that are *attached* to the urban extent of the earlier period. The growth of city can also occur through *inclusion* that consists of all urban, rural, or suburban built-up pixels that were *outside* the urban extent in the earlier period and are now within the urban extent of the new period. There is appearance of another trajectory of growth where city expand to *over rural open space* that were *not attached* to the urban extent of the earlier period or to new extension clusters. This is known as leapfrog".

3.2.1 Urbanization and Urban Density

3.2.1.1 Relevance and Measurement of Urban Density

Relevance

The population size is an important component of urbanization, but to address various questions in urban economics, environment and infrastructure development, information on the population density is valuable.[2] Population distribution as well as land use is also crucial for transport and infrastructures programmes and policies.[3] From an economic point of view, the higher the density of an urban agglomeration is, the lower are the costs of transactions and provision of infrastructures, and the more prosperous is the economy. With high density, there is also economy of land use. Indeed, although half of the world population leaves in cities and towns, only 0.3% of the world land area is occupied by urban dwellers. A deficient spatial structure fragments labour and consumer markets into smaller less efficient markets; it contributes also to higher transactions costs by unnecessarily increasing distances between people and places. A deficient spatial structure increases the length of the city infrastructure network and therefore increases its capital and operating costs. A deficient spatial structure can reduce a city's productivity. Positive production or residential externalities, as well as negative externalities such as congestion, are function

[1] Angel et al. (2016).

[2] see also Bryan et al. (2007).

[3] Bertaud (2004), Bertaud and Richardson (2004).

of density among others.[4,5] From an environmental point of view, a deficient spatial structure can decrease the quality of life by increasing the time spent on transport, by increasing air pollution, and by contributing to unnecessary expansion of urbanized areas in natural sites.

Measurement

Both population and building densities are important to assess the land, housing, basic services, infrastructure needs as well as other social and economic issues in cities and human settlements. This information is also important for emergency response and environment impact assessment. Density can be calculated either within the urban extent (built up as well as non built areas) or within the urban built up area (excluding the non built up areas), the later being always higher than the former. Both figures are identical only when all the urban extent is built, a situation practically rare indicating that the city is saturated leaving no space for further spatial urbanization.[6] Density can also be disaggregated across municipalities or localities of a city or according to the urban core and the suburbs. Other types of density can be also produced: employment density, age-specific density, sex-specific density etc. This disaggregation will help to better assessment needs for employment, education, health, etc. along future growth of cities.

3.2.1.2 Levels of Population Densities of African Cities

African cities are densely populated

The publication "Demographia-World Urban Areas 14th Annual Edition 2016"[7] provides density statistics for 118 African cities.[8] Key findings from this publication indicate that most of African cities are densely populated: 36% of cities analysed here have a population density of more than 10,000 persons per square km, and 40% a population density of between 5000 and 10,000 persons per square km. In other terms, three out of four African cities have a population density of 5000 persons or more per square km. Data collected in the late 80s and early 90s as published in the Atlas of Urban Expansion—The 2016 Edition also illustrate the fact that African cities are densely populated. Out of the 18 large African cities included in the Atlas of Urban Expansion—The 2016 Edition, four have a population density higher than 20,000 inhabitants per square km (as observed in Kinshasa in 1988, Alexandria and Cairo

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[4]Bryan et al. (2007) (Chatterjee and Carlino 2001; Lucas and Rossi-Hansberg 2002). Cited by Conroy and Evans-Cowley (2010).

[5]Carlino et al. (2007), Ciccone and Hall (1996).

[6]More details on density methodology are presented in Annex.

[7]http://www.demographia.com/db-worldua.pdf: Demographia World Urban Areas 14th Annual Edition: 201804.

[8]Demographia World Urban Areas (Built-up Urban Areas or Urban Agglomerations) is an annually published inventory of population, corresponding land area and population density for urban areas with more than 500,000 people. Unlike metropolitan area lists, Demographia World Urban Areas applies a generally consistent definition to built-up urban areas.

in 1994 and Arusha in 1988), four a density between 10,000 and 15,000 inhabitants per square km (as observed in Lagos, Addis Ababa, Luanda and Algiers), seven have a density of between 5000 and 10,000 persons per square km (as observed in Accra, Kigali, Bamako, Lubumbashi, Marrakech, Ibadan and Khartoum), and only three have a density of below 5000 persons per square (as observed in two South African cities (Johannesburg and Port Elizabeth), and Kampala of Uganda. If we recalculated the population density excluding the urbanized open space, the figures are drastically high, more than 30,000 persons per square in the group with the highest urban extent population density, more than 10,000 persons per square km in 12 out of the 18 cities, between 5000 and 10,000 persons per square km in five cities, and only one city, Johannesburg, had a density below 5000 persons per square km.

3.2.2 African Urbanization and Urbanized Open Space: Urban Extent Density and Built up Area Density

The difference between the urban extent density and the built area density reflects the degree of fragmentation of the urban extent. The highest the difference is, the highest the degree of fragmentation of the urban extent is with a high share of urbanized open space. Data analysed here is from the Atlas of Urban Expansion—The 2016 Edition.[9] The highest difference is observed in the city of Kigali where the urban extent density was 9600 inhabitants per square km in 1987, but when we exclude the urbanized open space in the calculation, the urbanized open space density jumped to 22,000 inhabitants per square km, which is more than the twice the former. The ratio of the built area density to the urban extent density is in fact the inverse of the share of the built up area in the urban extent.[10] The comparison of these two figures across cities can yield to interesting findings. For instance, the urban extent density of Kigali in 1987 is close to the urban extent density of Accra in 1991, but the built up area density of Kigali is nearly twice (1.7 time) the built area density of Accra (22,000 vs. 13,000 per square km). This difference reflect the fact that the city of Kigali is more fragmented with a share of built area of 0.44 in 1987 than the city of Accra with a share of 0.75 in 1991. This indicates that to better assess urban form of a city, it is suitable to have both densities; the former will tell how the population is distributed in the entire urban extent while the latter will tell how this distribution is in the built up area. This also provides indication on the possibility either to infill an urban extent or to extend in association with other economic, social and environmental constraints (Table 3.1).

There are various scenarios of change in land use to be considered. In the situation where the urban extent remains the same, there is constraint of space, the urban extent density can increase in two ways: either in filling it with more built areas or

[9] Angel et al. (2016).

[10] The mathematical formulation of the share of built-up-area in the urban extent and the density ratio is presented in Annex.

Table 3.1 Urban area density and built-up area density (1980–2015)

City name	Country	Urban area density (persons/ha)			Built-up area density (persons/ha)		
		T1	T2	T3	T1	T2	T3
Kinshasa	DRC	289	218	224	536	317	303
Alexandria	Egypt	256	154	143	327	202	191
Cairo	Egypt	234	205	115	324	262	169
Arusha	Tanzania	218	130	117	472	261	241
Lagos	Nigeria	130	125	133	199	191	209
Addis Ababa	Ethiopia	125	125	102	192	194	142
Luanda	Angola	112	116	109	151	157	151
Algiers	Algeria	110	86	69	206	140	111
Accra	Ghana	98	61	51	130	78	72
Kigali	Rwanda	96	64	59	220	107	99
Bamako	Mali	86	85	92	133	124	134
Lubumbashi	DRC	76	78	79	120	112	110
Marrakesh	Morocco	72	71	54	97	94	77
Ibadan	Nigeria	58	61	60	78	78	80
Khartoum	Sudan	54	68	68	97	109	87
Kampala	Uganda	44	54	59	82	92	100
Port Elizabeth	South Africa	36	35	35	59	53	53
Johannesburg	South Africa	22	29	30	41	51	44

Source Angel et al. (2016)

increasing the building within the same built up area or increase the number of person per buildings, or all three together. The Population can also decrease in the situation where due to high saturation, people decide to move to other areas rich or poor depending on the main reason of movement. In American cities, ownership of automobile has created the urban sprawl with low-density settlements. A large number of cities feature very land-consuming suburban sprawling patterns that often extend even to farther peripheries. this is well known as sprawling with low population. But in most African cities, lack of affordability of land and houses is the main reason that pushes the poor to move to outskirts of the city, often with high population density. Indeed, in many African cities, the pattern of density decreasing from the CBD is not always observed, and the density function is irregular. For instance in Nairobi, the biggest slum settlement is near the CBD with the highest population density, while in Dakar, the population density is irregular: high in the settlements of Medina (less than 5 km from the CBD), low in the settlements of Point E (5–10 km from the CBD) and very high in the outskirts of the city (10 km and more from the CBD).

Cities grow in terms of population size as well as in terms of space either through extension, or inclusion of existent settlements or new settlements in opened rural areas or just filling it its urban extent. However, when calculating the population density considering these different scenarios, variations in the urban density must be interpreted with caution. There is often the tendency of studies comparing the density in two period to assert that the urban density is declining while this decline is just associated to the emergence of low density settlements either by extension, inclusion or leapfrogging against the high density filling the previous urban extent produces. In this situation the population density of the current urban extent can be lower than the population density of previous urban extent, but when comparing population density within the previous urban extent, this can increase. This scenario is likely in the case of inclusion of settlements of low population density. Disaggregating urban density will help to better capture these changes in land use and to better assess service needs across city neighbourhoods. This will also help to go beyond the single figure of urban density average, which, as such, suffers all biases associated to averages; it masks disparities across cities, particularly for vulnerable groups that require a particular attention.

Evidence from European and North American cities showed that as cities grow, they exhibit decreased density and diminished compactness. This change in central density has been associated with the change in transportation technology resulting from increased ownership of automobiles over time. In North American cities, ownership of automobile has created the urban sprawl with low-density settlements. Clark (1951) introduced the monocentric density model to express the variation of density from the central business district (CBD).[11] This model dominated urban studies in the second half of the 20th century, particularly in North America and Europe. It is a simple spatial model that relates urban population density to distance from the centre of the city, usually defined as the CBD. Excluding the business and commercial area, the populated density is supposed to decrease when moving away from the centre. However, as time passes the population density decreases in the central areas and increases in the suburbs, thus producing a territorial expansion of the city.[12] The model proposed by Clark (1951) expresses the urban population density as negative function of the distance from the city centre as follow:

$$D = Doe^{-\gamma x},$$

D represents the population density at distance x from the centre of a city; Do is the density at the centre; e is the base of natural logarithms; γ is the distance gradient, or the rate at which density falls from the centre. The monocentric model supposes a city with constant returns Cobb-Douglas production functions for housing, consumers with identical tastes and incomes, and unit price elasticity of demand for housing.[13] Following Clark, several models have been developed relaxing this

[11]Clark (1951, 1958).

[12]Martori and Suriñach (2001).

[13]Bertaud (2004), Bertaud and Richardson (2004).

strict monocentricity, including some that have two centres, some that have a centre and a beltline of employment, others that have multiple nodes or a beltline. Others related urban density to traffic planning,[14] to housing market.[15] Some amenities can be of high quality of infrastructures—schools, health centres, etc. while other can be of poor quality lacking most basic services. The latter foster crime or pollution. Variations in urban land cover, average density, and fragmentation among cities and countries, as well as their rates of change, can be largely explained by variations in city population, household income, buildable land, the cost of agricultural land in the urban periphery, and the cost of urban transport.

However, the monocentric model and other forms of urban density models developed in the context of North America and Europe have major limitations in the context of African cities where sub-urban areas are densely populated by poor families, that cannot afford the expensive costs of living in the city core. In Africa, instead of observing a decline of density from the centre to the outskirts of the city, we witness a combination of changes in density. There are cities where densities increase when moving from the city centre to the outskirts. There are also cities where density decreases first then increases such as the case of Dakar where the lowest density is observed in Fann, Point E which is 5 km from the CBD and the highest in settlements in the outskirts Pikine and Guediawaye which are 10–15 km from the CBD. There are also cities, where density increases then decreases in the outskirts such as Nairobi where the highest density is observed in Kibera which is at 5 km from the CDB and the lowest in the settlements of Muthaiga, Runda and Gigiri which are 5–10 km from the CBD. There is no specific model associated to the variation of densities in Africa, except the fact that high densities are observed in most African suburbs. Lack of specific model of densities in African cities is associated with the lack of functioning master urban plan. Most African households settle first in unplanned settlements either at the outskirts or anywhere in the cities where there is space for settlements and then undertake legal steps for land regularization.

Box 3.1 Illustration of the Density Distribution from the CDB: Dakar Case Study

To verify the model monocentric density distribution in Senegal, since the city of Dakar is not in a circular form due to its peninsular form, we have opted to subdivide Dakar in three main axes: Plateau-Almadies, Plateau-Grand Dakar and Plateau Camberene. In the axe Dakar Plateau-Dakar, considering the high level of business and commercial areas in the CBD, we have opted to start the series from Medina, which is just juxtaposed to the CBD. As noted in the historical formation of Dakar, Medina was formed by early development of Dakar with a high population density. It is a walking-distance to the CBD. Based on this, all densities in the axe is lower than the density of Median,

[14]Tanner (1961), Smeed (1963).

[15]Muth (1969).

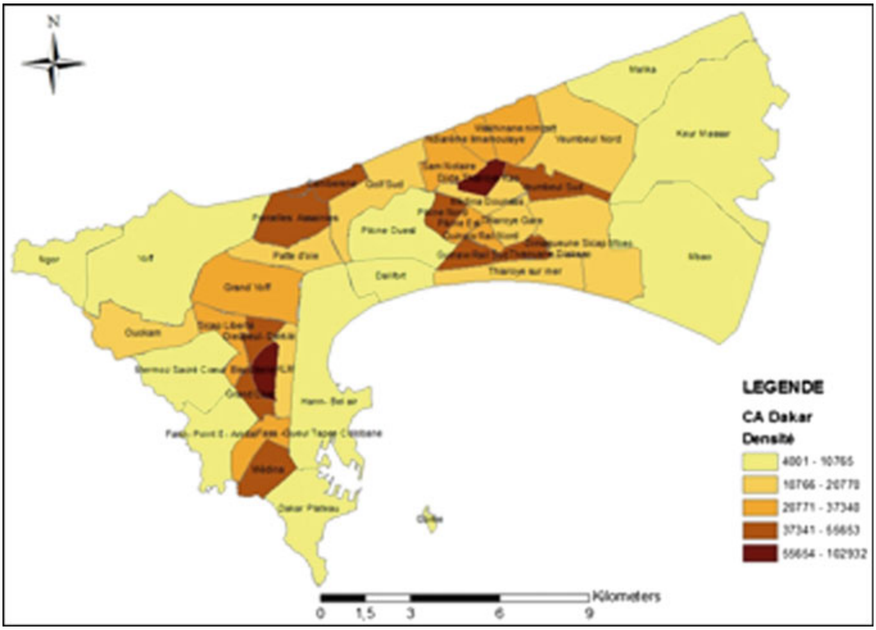


Fig. 3.1 Population density, 2013, Dakar (Senegal). *Source* Mboup et al. (2018)

varying from 43,519 persons per square to less than 7000 persons per square km in the following municipalities except the density of the Municipality of Ouakam which is 27,747 persons per square km. The high level of the density of Ouakam witness the fact the municipality of Ouakam is populated by various social economic groups, kind of middle class while the other municipalities following Medina are mostly populated by high high-income group. Overall, the density distribution from Medina to Yoff follows more or less the density model of Clark. When the municipality of Ouakam is excluded, the density model from Medina to Yoff is $D = 43,519e^{-432x}$. The monocentric and other forms of urban density models have major limitations in other axes from the Dakar CBD (Figs. 3.1 and 3.2).

In the axes of Plateau-Grand Dakar and Plateau-Camberene, instead of observing a decline of density from the centre to the outskirts of the city, we witness a combination of changes in density. Lack of specific model of densities in these axes is due to lack of functioning, disconnected, unplanned settlements. In most of the municipalities in these axes, households settle generally first in unplanned settlements either at the outskirts or anywhere in the cities where there is space to settle. In these axes, poor families that are not able to afford the expensive costs of living of the city core live in densely populated sub-urban areas. While in these two axes, in one hand we found very high densities such

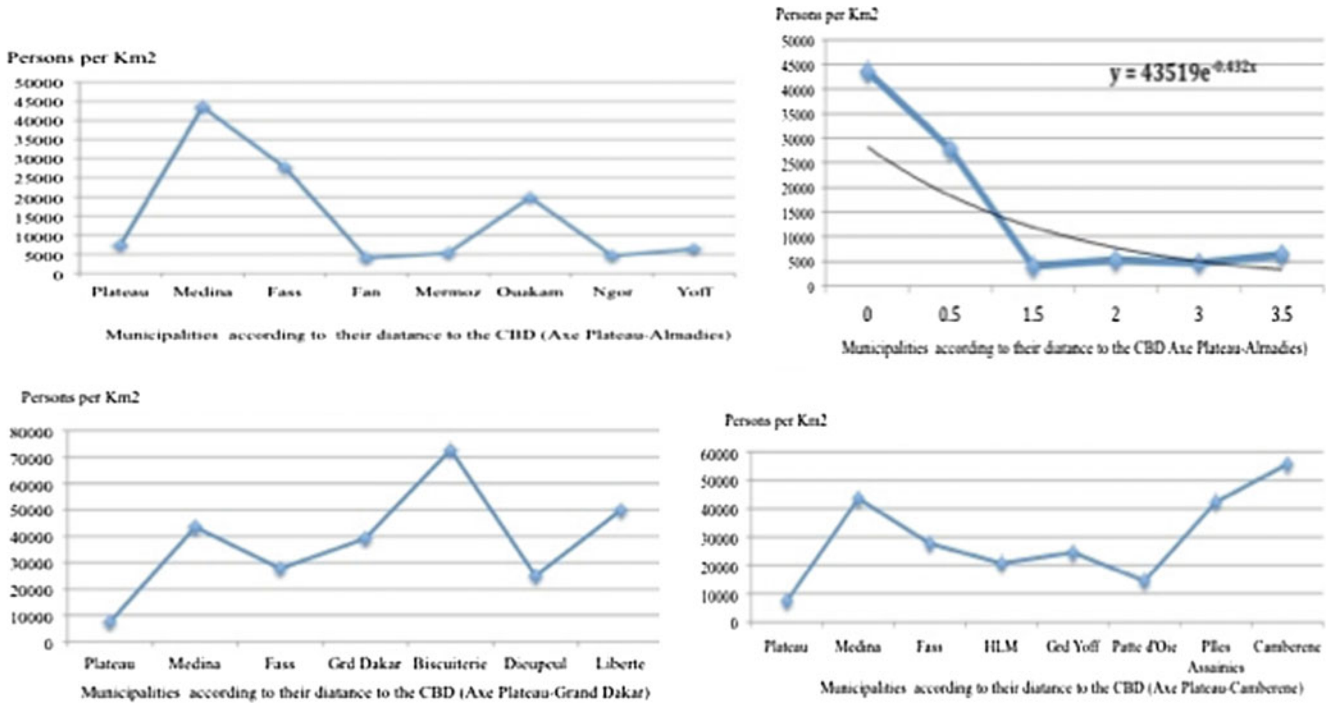


Fig. 3.2 Population density by distance to the city centre. *Source* Mboup et al. (2018)

as in Medina, Grand Dakar, Biscuiterie and Camberene with more than 40,000 inhabitants per square km, on the other hand, the municipalities in the axe Medina-Yoff have densities as low as 10,000 inhabitants per square km. These figures are indicative of a segregated city and point to a need for the national and local authorities to consider a balanced spatial planning of the city of Dakar coupled with provision of basic services in poor neighbourhoods.

The situation is alarming in many municipalities of Pikine where densities exceed 50,000 habitants per km^2. Yeumbeul Sud (51,468 habitants per km^2), Djidah Thiaroye Kao (102,932 habitants per km^2) and Pikine Sud (49,665 habitants per km^2) are among the municipalities with very high population densities in Pikine. In all these very highly populated settlements, few streets are built, and they are lacking other public spaces. This can explain the permanent high prevalence of infant and child diseases in Dakar compared to other cities and the rural areas of Senegal.[16]

The city of Dakar is a typical example of irregular distribution of population density with densities in suburbs drastically greater than the densities in CBDs. These suburbs are not only densely populated but they also lack most basic infrastructures and features the face of slums.

Source: Mboup et al. (2018).

3.2.3 Urbanization and Changes in City Compactness

Cities are in many different shapes that are function of the surface of the built-up area, the shape of the built-up area and the distribution of the population density within the same built-up area.[17] Represented as 3-dimensional object, cities have a centre of gravity, which is the point to which the sum of distance from all other points of the shape is the shortest. As noted in Angel et al. (2010, 2016), a city shape, which decreases the distance between people's residences and the main place of work and consumption will be more favourable to the functioning of labour and consumer markets. For a given built-up area, the shorter the average distance per person to the main place of work or to the main commercial areas, the better would be the performance of the city shape. Compactness measures the extent to which the overall geographic shape of urban extent approximates a circle, the shape that minimizes the average distance from any point within it to its centre or, alternatively, the shape that minimizes the average distance between all points within it. The perfect circle is considered to be the most compact of all two-dimensional shapes in a number of respects (Angel et al. 2010).[18] One of the shape compactness measurements used

[16] Mboup (2011).

[17] Angel et al. (2010).

[18] Angel et al. (2010).

in the Atlas of Urban Expansion—the proximity index—is for measuring the compactness of cities where the main concern is one of maximizing access, either access to jobs in the CBD in monocentric cities or access from all locations to all others in more decentralized cities. The proximity index is the ratio of the average beeline distance of all points in the equal area circle to city hall and the average beeline distance of all points in the urban extent to city hall. It varies between 0 and 1, with higher values corresponding to urban extents that are closer in shape to the circle.[19]

Except Alexandria of Egypt and Beira of Mozambique where the compactness is about 0.40, the compactness of African cities is higher than 0.70, indicating that African cities are quite in a compact form. The highest proximity index is observed with Ibadan, Lubumbashi (0.94 and 0.96). Ibadan is among the few African cities where the population density has not practically changed over time varying from 5800 persons per square km in 1984 to 6000 persons per square km in 2013. Indeed, it is important to note that Ibadan is also among the cities with moderate population density compared to many African cities analysed here. Despite the fact Ibadan is among the less densely population cities among the African cities analysed here, it indeed the highest compactness index; a situation that illustrates the fact that high density and compactness measure two different aspects of the urban form. While the urban density measures the number and the distribution of people in a specific area, the compactness index used here provides the geographical form of that area compared to a circle (Fig. 3.3).

Decline of compactness along the urbanization process: The case of Beria (Mozambique) and Alexandria (Egypt)

Along the urbanization process the compactness of a city may reduce over time due to the fact that the land growth may occur not necessary around the initial form following specific directions influenced by urban planning and geological constraints. The loss of compactness may be associated with the fact the city spatially grows following a specific direction not all directions of the shape, removing the circular form of the geographical of the city. The most important loss of compactness in African cities analysed here is observed in the city of Beira of Mozambique where the proximity index decreased from 0.88 to 0.40 between 1991 and 2013. Beira is followed by the city of Alexandria of Egypt with a proximity index averaging 0.43. Both cities grew spatially following one direction, shaping in a rectangular form. For instance, while between 1991 and 2001, Beira has kept its compactness, between 2001 and 2013 it drastically grew in one direction as illustrated the shape. During this period its population has more than doubled from 143,908 to 382,575 inhabitants. However, it is important to note that most its grow (75%) is associated to inclusion of existing human settlements (urban, suburban or rural areas). This can serve as a justification of the transformation of its shape. In this typical case, comparing urban density is misleading. In fact here, the change of urban density is particularly associated in the spatial reference. In the previous urban extent, the density may increase with the infill of 12% while the population density in the included settlements may be low. This

[19]See Footnote 1.

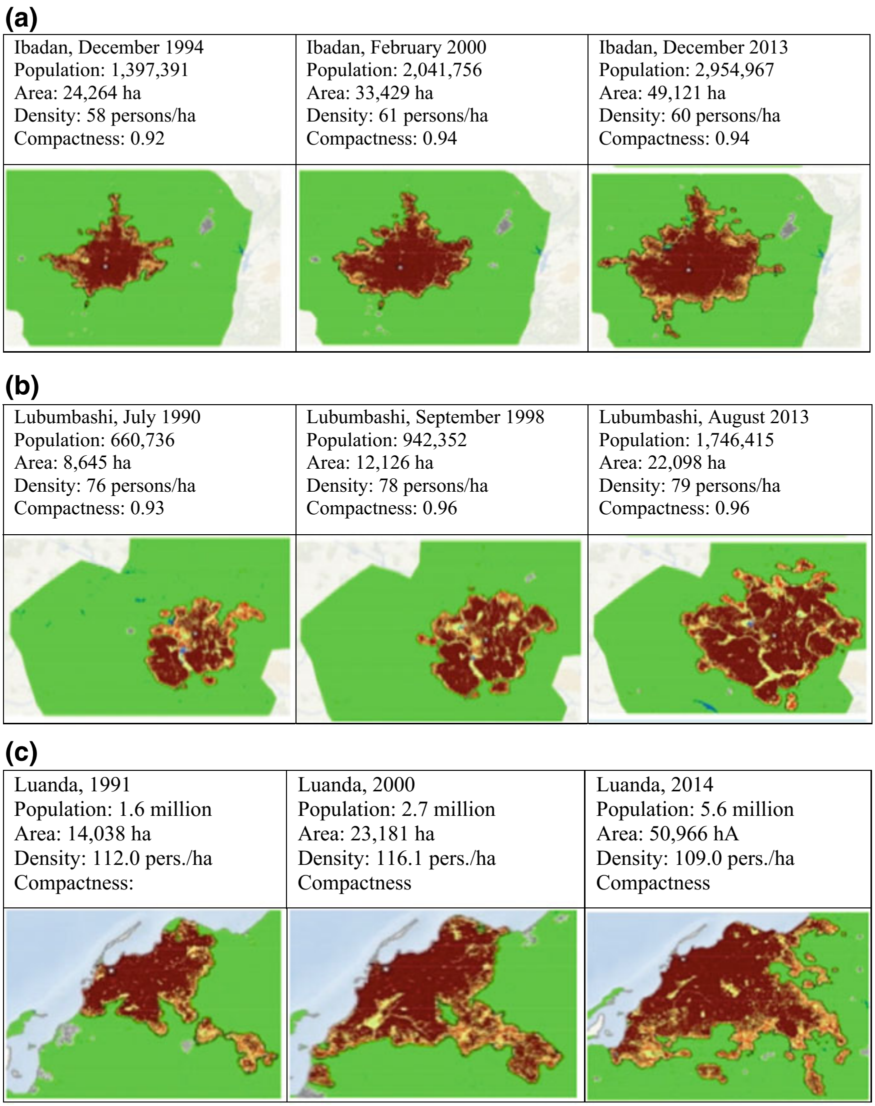
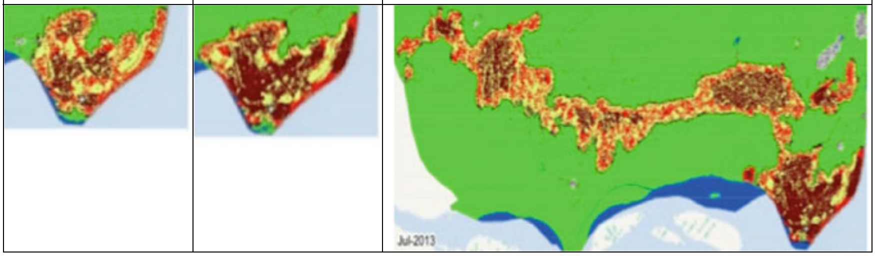


Fig. 3.3 **a** Population, urban area, urban density and compactness index of Ibadan. **b** Population, urban area, urban density and compactness index of Lubumbashi. **c** Population, urban area, urban density and compactness index of Luanda. *Source* Angel et al. (2016)

comfort the position that comparing density overtime to conclude any trend analysis is not appropriate, particularly when the urban extents are completely different. For instance, between 1991 and 2001, the population density of Beria moved from 6000 to 5000 inhabitants per square km, while in 2013, its level is practically half of its level in 1991 (3100 inhabitants per square km). We cannot conclude that the density

(a)

Beira, March 1991	Beira, March 2001	Beira, July 2013
Population: 131,884 Area: 2,207 ha Density: 60 pers./ha Compactness: 0.88	Population: 143,908 Area: 2,631 ha Density: 55 pers./ha Compactness: 0.89	Population: 382,575 Area: 12,153 ha Density: 31 pers./ha Compactness: 0.40



(b)

Alexandria, October 1987	Alexandria, April 1999	Alexandria, July 2013
Population: 2,558,891 Area: 9,993 ha Density: 256 persons/ha Compactness: 0.42	Population: 3,132,780 Area: 20,356 ha Density: 154 persons/ha Compactness: 0.43	Population: 4,345,193 Area: 30,418 ha Density: 143 persons/ha Compactness: 0.44

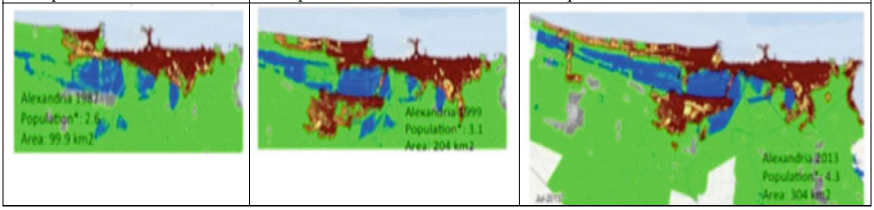


Fig. 3.4 **a** Population, urban area, urban density and compactness index of Beira, **b** population, urban area, urban density and compactness index of Alexandria. *Source* Angel et al. (2016)

of Beira has changed because the Beira of 2013 is different of the Beira of 1991. In other terms, the change is due to change of the spatial definition of Beira (Fig. 3.4).

Alexandria: Population growth, land use, compactness and density (1987–2013)

Considering its geographical position as a coastal city, Alexandria is constrained to be a densely populated city. Since it cannot grow circularly but in length along the river or through inclusion of existing settlements, its compactness is also affected with a level averaging 0.43 during the period 1987–2013. Most part the urban extent is also built with a share of built area of more or less three quarts through out the period 1987–2013. There are few public spaces except the streets with a share of 15% of total land, and the beaches. The population growth of Alexandria indeed took place along the river as an urban extension as well as with the inclusion of existent settlements. Between 1987 and 1999, the population of the city was multiplied by 1.2 while the urban extent was multiplied by 2. This implies more consumption of land compared to the population growth and a decline of urban extent density from 25,600 to 15,400 inhabitants per square km. This land consumption was mainly by urban extension (58%) and inclusion of settlements (25%); only 17% was due to the filling of the existing urban extent. Between 1999 and 2013, the population growth and urban land growth is quite similar leading to similar urban extent density (15,400 and 14,300 inhabitants per square km respectively).

3.2.4 Distribution of the Changes in Urban Land Use (Infill, Extension, Inclusion and Leapfrog)

In space, growth of city can occur in many ways: infill, extension, inclusion or leapfrog as noted in the Atlas of Urban Expansion—The 2016 Edition.[20]

City growth within the same urban extent is known as *city infill* that "consists of all built-up pixels added in the new period that occupy urbanized open space within the urban extent of the earlier period". There are African cities where their population growth is due to densification of the previous urban extent with a share of city infill of 30% of more of land use during along population growth during the same period. Those cities include: Johannesburg (43%), Addis Ababa (32%), Kampala, Ibadan, Lagos and Algiers (each 30%). Johannesburg and Ibadan also have the highest compactness index among the African cities analysed here. Accra and Cairo are, at the opposite, among the cities with a low share of infill (19 and 18% respectively). Both cities have a high level of sprawling through extension (63 and 50% respectively) and inclusion (18 and 32% respectively).

City can also grow beyond its previous urban extent in a contiguous manner. This type of city growth is know as *city extension* that consists of all built-up pixels added in the new period that constitute contiguous urban clusters that are attached to the urban extent of the earlier period. *City extension* is the main contributor to the change of urban extent in most African cities. Among the 18 African cities covered here, the highest value of increase in land use associated to urban extension is observed in Kinshasa, Arusha, Luanda, Accra, Kigali and Marrakech (more than 60%), followed by Khartoum, Ibadan, Lubumbashi, Lagos, Alexandria (between 50 and 60%); the lowest share of the urban extension is observed in Kampala and Bamako (28 and 27% respectively).

The growth of city can also occur through *inclusion* that consists of all urban, rural, or suburban built-up pixels that were *outside* the urban extent in the earlier period and are now within the urban extent of the new period.[21] Inclusion is extremely high for Port Elizabeth with a value of 66% in the last period. The share of inclusion is continuously high in the change of urban extent in Kampala and Algiers (35%). In both cities there was further inclusion in the second period with a share of 28 and 20% respectively. Inclusion is also evident in Cairo and Addis Ababa with a value of 32%

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[20]See Footnote 1.

[21]See Footnote 1.

Bamako, January 1990	Bamako, October 2000	Bamako, November 2013
Population: 352,486 Area: 4,081 Density: 86 Leapfrog:	Population: 1,113,715 Area: 13,138 Density: 85 Leapfrog(1990-2000): 38.6%	Population: 2,358,106 Area: 25,538 Density: 92 Leapfrog (2000-2013): 32.4%

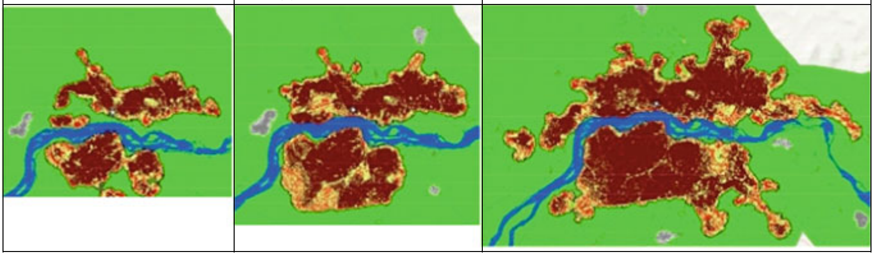


Fig. 3.5 Population, urban area, urban density and leapfrog, Bamako. *Source* Angel et al. (2016)

in the last period and 26% in the first period respectively. The figures for Alexandria, Lagos and Johannesburg are 25, 23 and 24%, and 16, 16 and 14% respectively.

There is also appearance of another form of spatial growth where city expands to *over rural open space* that were *not attached* to the urban extent of the earlier period or to new extension clusters. This is known as leapfrog. In addition to land expansion at the edge of the city, there is increase of leapfrog development with settlements far outside the initial city boundaries. In Bamako the contribution of leapfrog is significant with a share of 39 and 32% respectively in the added area between, followed by Lagos 7 and 14% respectively. Khartoum and Port Elizabeth have the value respective of 9%. In Kinshasa, leapfrog appeared only in the second period with a contribution of 0.7%. However, every time rural land is converted for urban uses, there is an opportunity cost to be considered. There is an environmental cost including land degradation, loss of biodiversity and climate change as well as a huge economic for the farmers who depend on agriculture activities in economic and financial terms (Fig. 3.5).

Box 3.2 Change in Urban Land Use in Kampala (Uganda): Infill, Extension, Inclusion and Leapfrog

The growth of the urban extent of Kampala between 1988 and 2003 is due to infill as well as to extension and inclusion with the shared values of 36, 28 and 35% respectively. The fact that this corresponds to an increase of urban density from 44 persons per ha to 54 persons per ha indicated that the urban extent as well as the inclusion must be also of equivalent density. Similar findings were observed in the second period of between 2003 and 2013 with shared values of 30, 41 and 28% respectively with a continuous increase of the urban density to reach 59 persons per ha. This indicated that the increase of the urban extent in Kampala either through extension or inclusion of existing

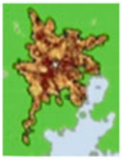
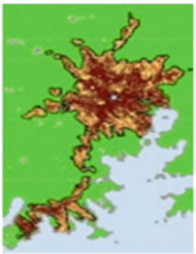
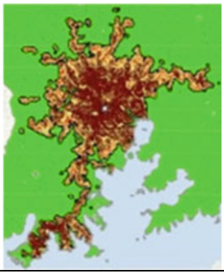
Kampala, 1988 Population: 0.7 million Area: 16,492 ha Density: 44 pers./ha	Kampala, 2003 Population: 1.7 million Area: 30,698 ha Density: 54 pers./ha	Kampala, 2015 Population: 3.0 million Area: 51,321 ha Density: 59 pers./ha
		

Fig. 3.6 Population, urban area, urban density of Kampala

settlements was not done with densely populated settlements. This is a pointer that this increase of urban extent is different from one was observed with most European and American cities where the growth of the urban extent resulted from urban sprawl with low dense settlements. What is observed in Kampala is characteristic of the urban expansion in African cities most created by the movement of poor urban households to the periphery or to other settlements (such as satellite cities) that later are incorporated in the main urban core (Fig. 3.6).

Urban Sprawl in Africa through extension, inclusion and leapfrog—Though African cities are of high density, we should not overlook that fact that sprawling is also happening in some African cities. There are emerging trends in some African countries where cities are expanding in a discontinuous, scattered and low-density form that is not sustainable: A defining feature of these cities is an outward expansion far beyond formal administrative boundaries, largely propelled by land speculation. A large number of cities feature very land-consuming suburban sprawling patterns that often extend even to farther peripheries. The city of Accra is a typical example of urban sprawl, with its population growth marked by continuous consumption of land more than the population growth. The situation of Accra is characteristic of urban growth of many African cities, which, in addition to rapid land expansion, creates slum proliferation. Indeed, most of these people are those that cannot afford the living standard of the city core and are forced to move to settlements that are not planned in advance with connection to basic services. Today with its population of more than 4 million, the city of Accra may face problem of public transport due to low population density preventing economies of scale and agglomeration.

Accra, 1991 Population: 1,307,784 Area: 13,324 ha Density: 98 persons/ha	Accra, 2000 Population: 2,513,026 Area: 41,241 ha Density: 61 persons/ha	Accra, 2014 Population: 4,429,649 Area: 87,212 ha Density: 51 persons/ha

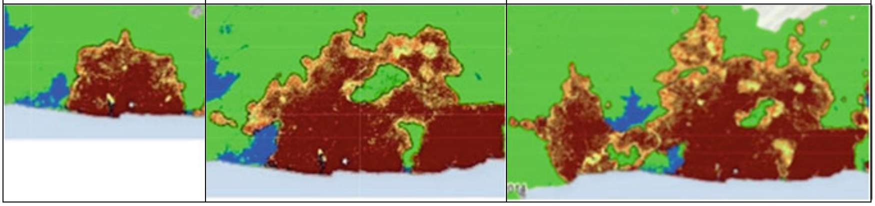


Fig. 3.7 Population, urban area, urban density of Accra. *Source* Angel et al. (2016)

Box 3.3 Urban sprawl of Accra (Ghana)

With a population size of 1.3 million on an area of 133.24 square km in 1991, the city of Accra grows to population 2.5 million on area of 412.41 square km in 2000. This means that while the population has nearly doubled in 9 years (1.9 time), the urban has more than tripled in the same period (3.1). In other terms there is more consumption of land compared to the population growth and therefore a decline of urban extent density from 9800 to 6100 inhabitants per square km). The growth of land consumption during the same period is mainly associated to urban extension with a shared value of 62%. Filling the urban extent represents only 14% with 86% are due to either urban extent (62%), inclusion (13%) and leapfrog (11%). The sprawling character of the city of Accra is established after having reached 1.3 million of population. In 2014, the population of Accra reached a size of 4.4 million on an area of 872.12 square km. This corresponds to an increase of the population of 1.8 and increase of urban area of 2.1 between 2000 and 2014 (Fig. 3.7).

There is further decline of the urban population density to reach 5100 persons per square km. The growth of Accra is a typical case of sprawl with continuous decline of population density from 98 persons per ha in 1991 to 51 persons per ha in 2014, i.e. nearly half its level 23 years ago. Indeed during the same period the total urban area has increased from 10,022 to 87,212 ha, i.e. 8.7 times its level in 1991 while the population 3.4 times its level in 1991 (from 1.3 to 4.4 million inhabitants in 2014). In terms of proportion the consumption of urban land 2.6 times the increase in absolute population. In terms of built up areas, the decline of the population density is further pronounced from 130 to 51 persons per ha between 1991 and 2014. The population density of the built up area in 2014 is nearly the third of its level in 1991. The major change occurred during the period of 1991 and 2000 where the built up area density declined from 130 to 61 persons per ha. During that period, most the added built up areas are either extension with a level 13,830 ha or leapfrog with a level

2353 ha against 3091 of infill areas. During the period of 2000 and 2014, most of the built up occurred in the urban extension with a level 18,718 ha versus a level of infill areas of 5522 ha. During that period there was no leapfrog area.

3.2.5 Urbanization and Land Use Expansion in African Megacities

The urban agglomerations of Cairo, Lagos, Kinshasa and Johannesburg offer the opportunity to assess the change in urban extent along the increase in population size and serve lessons for African cities that are moving to large size population. The situation of large cites such as Cairo with low population density, the situation is dramatic since sparse settlements reduce efforts in enhancing public transport with metro and tramways. For instance, in a period of 20 years, the population density of Cairo has been halved from 233.5 inhabitants per ha in 1992 to 115.4 inhabitants per ha in 2014, making provision of public transport challenging (Fig. 3.8).

Kinshasa and Lagos offer a contrasted situation compared to Cairo. For both cities, the population had remained high during their transition to the league of megacity. In Kinshasa, remains higher than 200 persons per ha (289 persons per ha in 1994, 218 persons per ha in 2000 and 224 persons per ha in 2013). Lagos had also maintained similar levels of population density during its transition to the league of megacity: 130, 125 and 133 persons/ha.

Overall, Kinshasa and Lagos had grown to reach a megacity status without sprawling; they had maintained very high levels of urban extent population density during the period. However, it is important to note that the built up area population density of Kinshasa is drastically high (more 300 persons per ha) and require particularly adequate response in provision of basic infrastructures and services in order to avoid negative externalities such as multiplication of diseases that can offset the economies of scale and agglomerations associated to high population density.

Johannesburg offers another contrasted situation in terms of density levels and trends. In the African context where many cities are of density higher than 10,000 persons per square km, South African cities are particularly of low density. This is particularly true in the case of Johannesburg where the population density is only 3000 persons per square km in 2013, much lower the density observed in Cairo, Kinshasa and Lagos. The case of Johannesburg is common to South African cities as illustrated by the low population density also observed in Cape Town (4700 persons per square km), Durban (3200 persons per square km) and Pretoria (2500 persons per square km), all being cities of 3 million or more. Low level of urban density in South African cities can be associated to the regime of Apartheid regime that

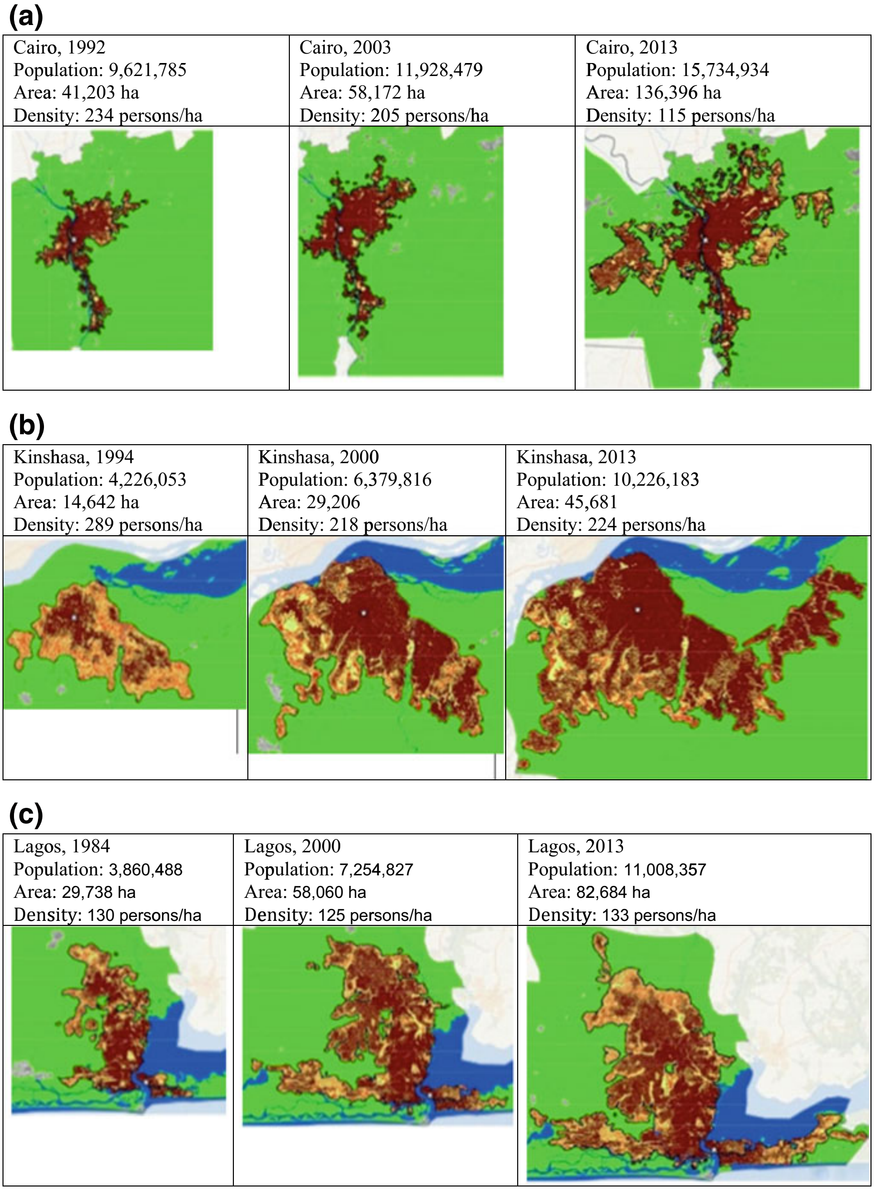


Fig. 3.8 **a** Population, urban area, urban density of Cairo, **b** population, urban area, urban density of Kinshasa, **c** population, urban area, urban density of Lagos, **d** population, urban area, urban density of Johannesburg. *Source* Angel et al. (2016)

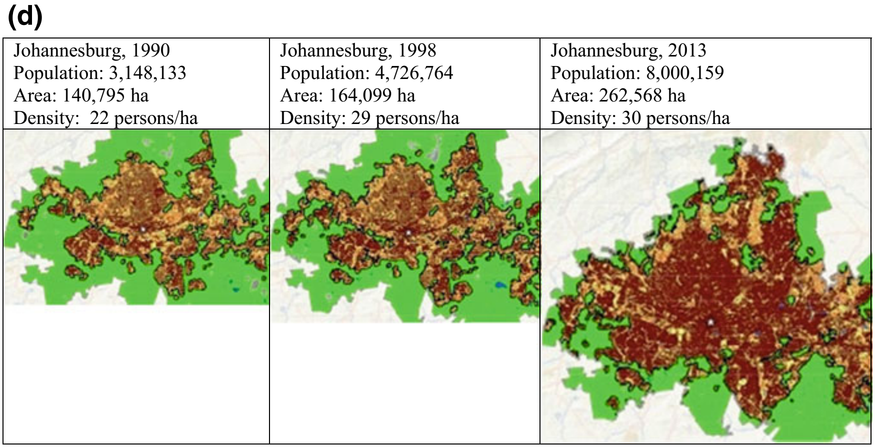


Fig. 3.8 (continued)

lasted until 1990 excluding the back people from many parts of large South African cities. However, after the abolition of the Apartheid in 1990, it seems the situation is improving as shown by the increase in population density of the city of Johannesburg from 22 persons per ha in 1990 to 29 persons per ha in 1998 and 30 persons per ha in 2013.

3.2.6 African Urban Transition and Emergence of Urban Corridors

Another urban development is the emergence of urban corridors, which present a type of spatial organization with specific economic and transportation objectives. In African countries, governments are also encouraging growth, convergence and spatial spread of geographically linked metropolitan areas and other agglomerations. These are emerging in various parts of Africa, turning into spatial units that are territorially and functionally bound by economic, political, socio-cultural, and ecological systems. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation. Another urban development is the emergence of urban corridors, which present a type of spatial organization with specific economic and transportation objectives.

They are polycentric urban clusters surrounded by low-density hinterlands.[22] They are characterized by linear systems of urban spaces linked through transportation networks. In urban corridors, a number of city centres of various sizes are connected along transportation routes in linear development axes that are often linked to a number of cities, encompassing their hinterlands.[23] The experience of urban corridor may connect more small and medium size cities of less than 300,000 to form a digital metropolitan region of a large size. Urban corridors are creating new forms of interdependence among cities, beyond the economic dimension and capture social and political dimensions. Urban corridors are going beyond national boundaries and connect countries. For instance, the greater Ibadan-Lagos-Accra urban corridor, spanning roughly 600 km across four countries, is the engine of West Africa's regional economy.[24] Africa intra-regional cooperation may scale up this type of development. However, Africa must invest in infrastructure development in consideration to the development of urban corridors. More holistic approach of corridor policies is needed to include economic development of areas in the corridor zone of influence and support continental.

However, all these forms of urban growth require planning and management of the space, and efficient mobility means. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation.[25]

It is particularly important to assess the change in urban form among the megacities in order to inform urban policies considering that most African cities are moved towards becoming large. As illustrated in the Chap. 2, by 2035 Dar es Salam and Luanda will be megacities, and many cities of 3 million inhabitants in 2015 will be over 5 million. In these cities, the way the population growth is spatially distributed is important in order to plan for provision of basic infrastructures and transportation that are closely linked to elements of the urban form such as density and compactness. The main impact of urbanization has been the expansion of urban land use, particularly when cities reach the 1 million mark of population size. Such large cities obviously cannot be supported without a vast and complex transport system. The spatial location of activities like residence, work, shopping, production and consumption give some indications on the required travel demand and average distances between activities. With a tendency towards specialized land use functions and thus a spatial segregation between economic activities, interactions are proportionally increasing. However, in most African cities there is lack of adequate provision of transport service, particularly in suburban areas, where land use density (residential and commercial) is not sufficiently high for a profitable public transit system, and the streets are few and narrow to accommodate public transit.

[22]UN-Habitat (2010a).

[23]See Footnote 22.

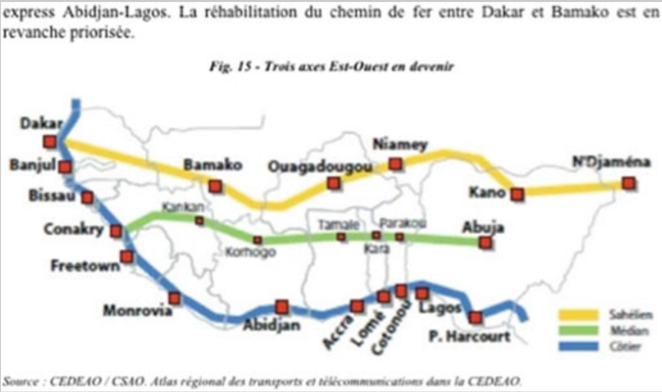
[24]See Footnote 22.

[25]See Rodrigue (2017).

Box 3.4 Emergence of Urban Corridors in Senegal and Neighbouring Countries

In Senegal, the government is encouraging growth, convergence and spatial spread of geographically linked metropolitan areas and other agglomerations. These are emerging trends linking Dakar-Thies-Mbour, turning into spatial units that are territorially and functionally bound by economic, political, socio-cultural, and ecological systems. It expected that the Dakar master include Thies and Mbour. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation. Linking Senegal to Mali, Mauritania, Cape Verde, Guinea, and Guinea Bissau and beyond. This is inline with Africa intra-regional cooperation as outlined in Africa Agenda 2063. However, More holistic approach of corridor policies is needed to include economic development of areas in the corridor zone of influence and support continental cooperation.

Inter-regional urban corridors



Source Republic of Senegal, 2014. Review of Senegalese Urbanization

However, all these forms of urban growth require planning and management of the space, and efficient mobility means. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation.[26]

[26] See Footnote 25.

3.3 African City Foundation: Street Connectivity, Basic Infrastructures and Land Tenure

Using the concept of "Smart Economy in Smart City", this section assesses the foundation of African cities in terms of urban planning, land policies and basic infrastructures. As developed in the Chap. 1, a smart city is viewed as a sustainable, inclusive resilient and prosperous city that promotes a people-centric approach based on three core components and seven dimensions. The three core components are *Smart City Foundation*, *ICT*, *and Smart Institutions and Laws*, which in turn are the pillars of the other dimensions of a smart city: Infrastructure Development, Environmental Sustainability, Social Development, Social Inclusion, Economic Development, Disasters Exposure, Resilience, Peace and Security. The three components together with the seven dimensions make a Smart Economy. A smart city foundation is composed of three elements: *Urban Planning and Design*, *Land Policies and Basic Infrastructures*. For a city foundation to be smart, it must be inclusive at the onset of the urban planning and promotes mixed neighbourhoods where social clustering is discouraged (Fig. 3.9).

Together with smart institutions and laws, the smart city foundation is the key pillar to the other dimensions of a smart city. *Infrastructure Development* includes transport, ICT, industrial energy, school, health, etc. in addition to the basic infrastructure as elements of the city foundation: water facilities, household energy sources, sanitation systems, solid waste and water waste management. *Environment Sustainability* is composed of elements of energy, transport, building and pollution. *Social Inclusion* includes aspects of participation in decision making as well as according all city residents equal opportunities for growth and prosperity. *Social Development* is composed of elements of education, health, public spaces, social inclusion and social capital. *Disaster Exposure* incorporates elements of exposure, mitigation and adaptation to various disasters such as flooding, droughts, storms and earthquakes.

Fig. 3.9 City foundation conceptual framework. *Source* Mboup et al. (2017)

Table 3.2 City foundation and institutions and laws variables

Dimensions	Variables
City foundation	**Spatial planning** Planned settlements, Urban form and structure, Streets, Other Open Public Spaces, etc. **Land tenure** Land: Documentation or perceived eviction Housing: Proportion of urban population living in slums, informal settlements or inadequate housing **Basic infrastructures** Connection to piped water, Connection to sewerage system, Connection to electricity, management of solid waste, etc.
Institutions and laws	Urban Planning Codes, Urban Policies, Urban Plans, Unplanned settlements, Resilient building codes, standards, development permits, land use by-laws and ordinances, and planning regulations, etc.

City Resilience is composed of elements of City Foundation, Environment, Social Capital, and Social Development. *Peace and security* incorporates all forms of violence and conflicts, including domestic violence, violence in public places, crime, armed conflicts, terrorism, policing, etc. An insecure city limits opportunities for investment and economic growth and cannot be a smart city.

The Table 3.2 provides different variables that compose a city foundation. However, due to lack of data, the calculation of the City Foundation Index will be limited to one variable of spatial planning, streets, two elements of basic infrastructure, piped water and sewerage facilities, and one element of land tenure, secure of tenure (documentation and perceived eviction). This constitutes a provisional estimation of a CFI and will be followed with a comprehensive assessment of a CFI in coming publications (Table 3.2).

3.3.1 Urbanization and State of Streets and Public Spaces in African Cities

In recent years streets have been recognized as an integral factor in the achievement of sustainable urban development. Various notions of streets have been proposed, such as "liveable" streets, "complete" streets, "streets for all", "quality" streets; "friendly" streets, and "healthy" streets.[27] In terms of variables, these notions embrace more or less similar concepts that touch on people's wellbeing and that make cities more

[27]Lusher et al. (2008), Finn and McElhanney (2012), Smart Growth America (2010), Svensson (2004), Central London Partnership (2003).

prosperous. The "liveable streets" movement emphasizes streets as the fabric of social and urban life. Safety, security, social interactions are among the key components of liveable streets.[28] Gehl's early work in Copenhagen suggested the need to promote non-motorized means of mobility in order to create liveable streets. Based on Gehl's findings, in 1962, Copenhagen made a shift towards increased use of bicycles as an alternative to cars.[29] During the same period, there was also another advocate of liveable streets in the United States, the writer and urbanist Jane Jacobs (1961).[30]

A sustainable, inclusive and prosperous city expands multimodal transport systems with sidewalks and bicycle paths, ensures eco-efficiency of infrastructural systems, and supports density through integrated infrastructure development, thereby enhancing efficiency and access. In addition to accommodating all kinds of users (pedestrians, cyclists, motorists), sufficient land allocated to streets promotes connections to services that contribute to good health and productivity, such as clean water, sewerage facilities, drainage systems, power supply, and information and communication technologies. Streets that provide space only to motorists are characterized by congestion and high CO_2 emissions.

Urban planning with streets is the starting point for a physical integration of all urban dwellers into the formal and official systems of planning and urban management that govern a city. A street pattern and hierarchy are laid down by an area-based plan that results in a final urban settlement layout connected to the overall city plan. This provides a strong spatial frame to deal with the complexities of regularizing tenure and retrofitting services as part of urban networks, the two key interventions of slum upgrading.[31] A well-connected street network reduces travel time and encourages walking and social interactions. It enhances infrastructure development, environment sustainability, and economic and social development. It makes cities resilient and prepared to overcome natural disasters.

Street concepts and measurements

A variety of measures of street connectivity have been used in various fields, including transport, urban planning, geography, and landscape ecology. There are various indices that have been created to directly or indirectly measure street connectivity in an area. Stephan J. Schmidt and Jan S. Wells (Transit Village Monitoring Research, October 2005) recommend that for a best connectivity measurement, research should be done to construct a composite street connectivity index that includes the usual quantitative measures and other qualitative measures. Although all these indices are relevant to assess connectivity, we have selected only those that are relevant for policies and those for which large sets of data are available. These indices are: land allocated to streets; street density; intersection density; connected node ratio; and

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28 Appleyard and Lintell (1977), Moudon (1986).

29 Beacom (2012), City of Melbourne and Gehl Architects (2004).

30 Jacobs J. is among the pioneers of Livable street are environmental design researchers such as Whyte (1980) and Appleyard (1981), cited by Conroy and Evans-Cowley (2010). Jacobs (1961, 1970), Jacobs et al. (2002), Appleyard et al. (1981), Whyte (1980).

31 Mboup (2013).

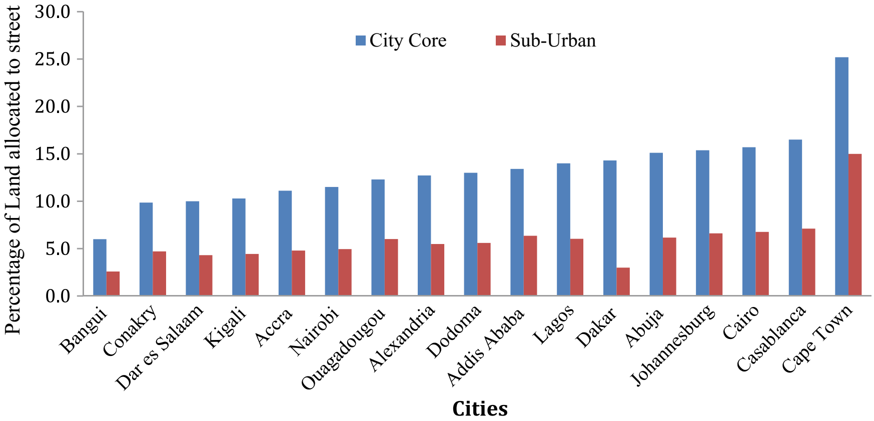

Fig. 3.10 Land allocated to street (LAS) in African cities. *Source* Mboup (2013)

link-to-node ratio. These are likely to be highly, positively correlated to each other, and can be expressed through a composite index. During these past ten years progress has been made in the development of remote sensing and GIS that allows the collection and analysis of crucial information on the layout and planning of cities.[32] For instance, UN-Habitat and partners had worked together to advance on the spatial dimension of slums. The UN-Habitat's publication "Streets as Public Spaces and Drivers of Urban Prosperity" authored by Mboup (2013) used GIS data from over 100 cities to not only analyse the urban form but to also associate it with other variables of slum conditions.[33]

This section assesses the share of streets and other open public spaces in urban land areas in selected cities in the world. It analyses the proportion of land allocated to streets, disaggregated by city core and suburban areas in selected cities (Fig. 3.10).[34]

The state of streets in most African countries is quite different from that observed in cities of developed countries such as New York, Barcelona, Paris, Melbourne both in terms of quantity and quality. While in most cities of developed countries, sufficient land is allocated to street (more than 25%), in most African cities, there are not enough streets (less than 15% of share of land), and those that exist are either not well designed or well maintained. In the cities of the developed countries there is not only relatively sufficient land allocated to streets, but also the streets are paved with sidewalks and are well maintained, and street norms and regulations are enforced. African cities, at the opposite, share common characteristics: inadequate and deteriorating street networks; and poor facilities for non-motorized mobility (walking and cycling). One effect of these problems has been the further marginalization of the most vulnerable segments of society who rely the most on public transport and

[32]See Footnote 31.

[33]See Footnote 31.

[34]See Footnote 31.

Fig. 3.11 Example of overcrowded informal urban settlements. *Source* Mboup (2015)

cannot afford private alternatives. However, these similarities do come with differences as well—in terms of size, geography, cultural setting and administrative structure—which are considered in this analysis (Fig. 3.11).

A large majority of African cities allocate a very small proportion of land to streets: varying from 15 to 6% as observed in Bangui in the Central African Republic. In Bangui as in most cities in Francophone countries, the influence of the city planning of French colonial settlements with wide boulevards oriented towards places of political and economic interest,[35] was limited to a small proportion of the city core, leaving the rest of the city poorly served with streets. The streets are narrow and short and the street network is disconnected with few intersections. Other cities in this group have more land allocated to streets, but the levels are still very low, varying from 10% in Tanzania's major city Dar es Salaam to 14.3% in Senegal's capital Dakar. Three cities in this group, namely, Alexandria, and Dakar, offer better connectivity in the city core with an intersection density greater than 100% (194, 174 and 159%, respectively). Kenya's capital Nairobi, Tanzania's capital Dar es Salaam and Ghana's capital Accra have only 11.5, 10 and 11.1% land allocated to streets, respectively. Intersection density is also relatively low in these cities, at 36, 34 and 38%, respectively. Dodoma (Tanzania), Lagos (Nigeria), and Addis Abba (Ethiopia)[36] have slightly more land

[35]See Harris (2008). According to Harris, the implementation of an orthogonal plan in Dakar was not a new practice, but a typical urban planning approach in other French colonial settlements in Africa and elsewhere in the eighteenth and nineteenth centuries.

[36]See also Baumeister and Knebel (2009).

allocated to streets, varying from between 13 and 14% and an intersection density varying from between 65 and 85%.

Cape Town, as an exception, allocates 25% of its land to streets. In addition to sufficient land allocated to streets, street networks are well connected, with intersection density levels higher than 100 intersections per one square kilometre. In fact, the grid pattern that favours high intersections is predominant in the city cores of these cities, with large avenues and boulevards along the street network.

Regardless of the level of connectivity in the city core, in the suburban areas of African cities, not only are there few streets built (with less than 5% of land allocated to streets), but also those that exist are narrow and disconnected, except for one or two arterial streets passing through neighbourhoods. The city of Dakar offers a typical example: the proportion of land allocated to streets in the suburbs is more than three times lower than its level in the city core (3% vs. 14%).

Poor maintenance of road infrastructures characterizes most streets in African cities. In these cities, the street networks have barely kept pace with urban growth. Infrastructure for non-motorized transport (e.g. pavements or sidewalks for walking and bicycle lanes for cycling) is often lacking, poorly developed, on the decline or does not appear to rank high among city planners' priorities. This has led to high incidences of traffic fatalities involving pedestrians and cyclists.[37] Better urban infrastructure, more and safer bicycle routes throughout the city, more pedestrian-friendly streets, and well-planned transport systems that provide safe options for getting around the city are needed to curb the rise in traffic deaths. The dysfunctional nature of road infrastructure in most African cities poses a major challenge to mobility and is an important source of traffic congestion. Congested streets and poor facilities for pedestrians are the most pervasive transport problems affecting cities in Africa. Evidence shows that traffic congestion is the main form of infrastructure deficiency plaguing cities in these regions, hindering free movement and making travel frustrating and time-consuming, according to local experts.[38]

3.3.2 Urbanization and Land Tenure

One fundamental driver of a sustainable city foundation lies on the institutions and laws that govern human settlements being a city, a town or a village. Policies intervene at the individual as well as settlement level. At the individual level, they intervene in providing or not security of tenure that involves various aspects. At the settlement level, they intervene in the planning of the settlement and provision of basic infrastructure. The way the city is planned and its basic infrastructures are laid down are governed and administrated within clear institutions and laws. Planning of cities is composed of physical aspect such as partitioning the land in terms public uses and private proprieties. These required also laws that define the relation between land

[37] Dahl (2004), WHO (World Health Organization) (2004), Pucher et al. (2007).

[38] UN-Habitat (2011).

and people. While public land is associated to the state, private land is related to people with documentation attached to it. This calls for good governance as well as efficient administration. Urban planning initiatives recognize tenure recognize the importance of the policy dimension that shapes the processes towards secure land tenure.

In most African cities there is a continuum of tenure rights where different sources of land access and use patterns may coexist. This lies to the system of the land governance which concerns the process by which decisions are made regarding access to and use of land, the manner in which those decisions are implemented and the way that conflicting interests in land are reconciled.[39]

Providing security tenure depends on a range of policies related to institutions and laws put in place to protect people against unlawful eviction, to ensure equitable distribution to basic services to all communities, and to put in place transparent and accountable process of land regulation, key for secure land tenure. This also includes the planning of the city.

However, in most African cities, land tenure is neither well governed nor well administrated. Land tenure has been in the centre of global human settlements agendas. At its onset in 2000, the United Nations Millennium Declaration committed world leaders to improving the lives of slum dwellers through security of land tenure. It was understood that giving people security of tenure would contribute to the improvement of their lives. In 2011, during UN-Habitat's 23rd Governing Council, member states reiterated the importance of security of tenure and committed themselves to: "*Promote security of tenure for all segments of society by recognising and respecting a plurality of tenure systems, identifying and adopting, as appropriate to particular situations, intermediate forms of tenure arrangements, adopting alternative forms of land administration and land records alongside conventional land administration systems, and intensifying efforts to achieve secure tenure in post-conflict and post-disaster situations.*"

The legal institutional framework in a give country or city plays a key role on various elements of security of tenure such as acquisition or adjudication which is the process of final and authoritative determination of the existing rights and claims of people to land. Once the land acquired, another element that depends to legal institutional framework is the acquisition of a building permit, which is at the authority of the local governing body on land use and planning for construction or renovation of a property. Another element that lies to the authority is the cadastre system, which is a parcel based and up-to-date land information system containing a record of interests in land (i.e. rights, restrictions and responsibilities). Indeed, security of tenure depends heavily to the land governance that establishes the rules, processes and structures through which decisions are made regarding access to and the use of land, the manner in which those decisions are implemented and the way that conflicting interests in land are managed. In many cities of the developing poor land governance is surrounded by poor land administration or registration characterized

[39]Bazoglu et al. (2011).

by a poor determination, recording and dissemination of information about tenure, value and use of land during the implementation of land management policies.

Indeed, land shall not be seen only as a social asset providing shelter to people, but as also an economic and financial asset providing opportunity for investment and saving. At the shelter dimension, Secure tenure refers to the right of all individuals and groups to effective protection by the state against forced evictions that are, under international law, against "the permanent or temporary removal against their will of individuals, families and/communities from the home and/or the land they occupy, without the provision of, or access to, appropriate forms of legal or other protection". Security of tenure is, indeed, an effective way to safeguard the relationship between people and land. At the economic and financial aspect, various social and economic advantages include access to the financial and economic market as demonstrated in the Hernando De Soto, in his publication (The Mistery of Capital 2000). De Soto argued that granting titles to the poor would liberate the plots they occupy and transform them into capital. This, in turn, could be used as collateral for loans to jumpstart their businesses, or improve their houses, among other gains that increase their quality of life and clean the society of extra-legal relationships and methods. Prominent world leaders advocating De Soto's thesis promoted the idea of land titling further.

3.3.2.1 Land Tenure Indicators Measurements

Recently, the Global Land Initiatives Indicators proposed a set of indicators grouped within five clusters: Tenure security; Legal frameworks; Official recognition of the plurality of tenure systems; Quality and effectiveness of land administration systems; Levels of conflict related to land and; Sustainability in land use.[40]

- **Tenure security**, including both documentation of legally recognized land rights and perceptions of secure protection from dispossession and eviction, as documentation and legal recognition alone do not necessarily lead to real security in practice.
- **Legal frameworks** to ensure women's tenure security specifically, and gender equality in terms of access to land, and rights to hold, inherit and bequeath land and property.
- **Official recognition of the plurality of tenure systems**, with provision for clear definition and security of rights, covering statutory and customary, individual and collective tenure regimes, temporary and permanent forms of tenure based on ownership, state land concessions or licences, rental and leasing arrangements, etc.
- **Quality and effectiveness of land administration systems**, including their accuracy, geographical coverage, efficiency, relevance and accessibility to all social groups irrespective of forms of tenure, and their degree of freedom from corruption, as discussed in the previous section.

[40] Kumar et al. (2017).

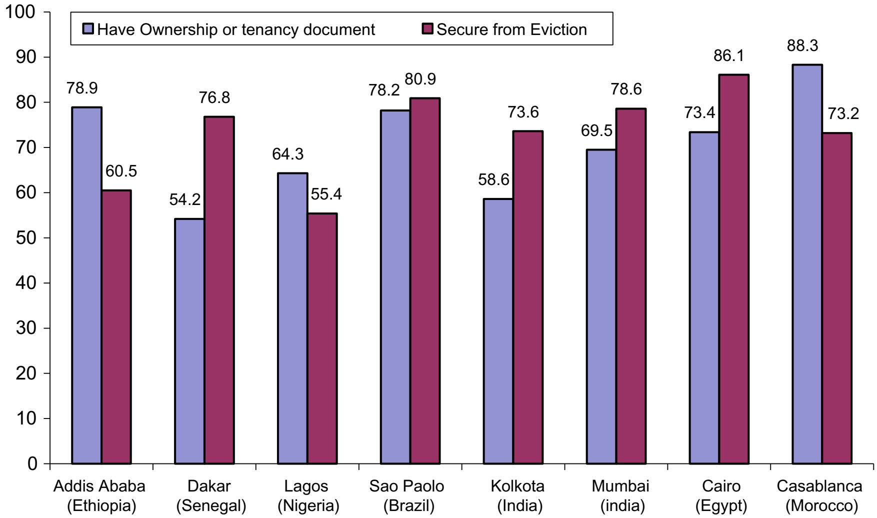

Fig. 3.12 Proportion of households with adequate document for proof of ownership or tenancy, and proportion of households secure from eviction in selected cities (2004–2007). *Source* Mboup (2015)

- **Levels of conflict related to land**, and efficiency and effectiveness of systems for land dispute and conflict resolution.
- **Sustainability in land use** as a critical basis for maintaining ecological systems, environmental services and biodiversity, and successful adaptation to climate change, and as a key objective of land use planning at farm, landscape and territorial levels.

Regarding the first cluster, Security of tenure, UN-Habitat and partners have now made considerable progress in developing a measurement method of security of tenure. The method had been implemented in 25 cities around the world through Urban Inequities Surveys. People or households are considered to have secure tenure when there is *evidence of documentation* that can be used as proof of secure tenure status or when there is either de facto or *perceived protection against forced evictions*. Security of tenure is an incremental process. For owners, documents that are adequate for proof of security of tenure are: land registration certificate, title deed to dwelling, purchase agreement for land, lease agreement for land and certificate of occupation. For tenants, documents that are adequate for proof of security of tenure are: registered or not registered lease agreement and informal agreement (written) (Fig. 3.12).

Possession of ownership or tenancy document varies widely across the eight cities, with the highest proportion reported in Casablanca (88%), and the lowest in Dakar (54%). However, it is interesting to note that in the city of Dakar, despite the low proportion of households with ownership or tenancy document, a large proportion of households feel protected against eviction (77%). An opposite scenario is observed in Addis Ababa where an important proportion of households with ownership or tenancy document feel not protected against eviction. In the city of Addis Ababa, only 61% of households feel protected against eviction compared to 79% that have reported having ownership or tenancy document. In general, despite existence of ownership or tenancy documents, insecurity regarding possible eviction is high, ranging from 45% of inhabitants in Lagos to nearly 20% in Sao Paolo. Measures to reduce the risk and stress associated with lack of documents and fear of eviction are based on recognizing and respecting a plurality of tenure systems, including intermediate forms of tenure arrangements and alternative forms of land administration and land records.

Providing security of tenure depends on a range of policies related to institutions and laws put in place to protect people against unlawful eviction, to ensure equitable distribution to basic services to all communities, and to put in place transparent and accountable processes of land regulation, key for secure land tenure. However, in most African cities, land tenure is neither well governed nor well administered. Poor land governance is surrounded by poor land administration characterized by a poor determination, recording and dissemination of information about tenure. Most African cities still fail to provide inclusive land administration services that reach all stakeholders in equal terms, plus they tend to be slow in adapting alternative new approaches and technologies to enhance the land tenure administration and governance. In addition to being exposed to eviction, without legal proof of ownership, households cannot enjoy the economic and financial opportunity associated with investment and saving using their property as collateral. At the community level, the municipality cannot also legally collect various taxes that can be used to improve basic infrastructures. Promotion of secure land tenure in African cities will boost investment in property development, increase municipal tax collection and in turn promote economic growth.

Box 3.5 Case Study: Dakar Official Classification of Building Based on the Regularity and the Formality of the Land

The Urban Master Plan of Dakar has established criteria to classify houses and building on the following categories: Individual house type villa; Planned housing type real estate company; Regular spontaneous Habitat; Irregular Spontaneous Habitat; Habitat type buildings and; Village dwelling.

Individual house type villa: These are the residential districts (Fann Residence, Point E, Mermoz, Almadies, Corniche West, etc.). The habitat consists of villa of high standing with a maximum of three levels with possibility of swimming pool. The subdivisions have a very good-asphalted road. Most sidewalks are paved.

Planned housing type real estate company: These are housing programs carried out by public or private bodies specialized in real estate development (SN HLM, SICAP, SIPRES, HAMO, COMICO, etc.). This type of habitat has asphalted roads for the main streets.

Regular spontaneous habitat: This type of habitat, realized in self-construction on approved subdivisions, is constituted of so-called popular districts such as Medina, Gueule Tapée, Colobane, Grand Dakar and certain districts of Pikine and Guediawaye. High densities characterized this type of habitat.

Irregular Spontaneous habitat: This type of habitat is manifested by an anarchic and unauthorized occupation of public spaces and land, especially in the urban peripheries. It is made up of poor quality buildings, more or less precarious, sometimes even slum type, most often installed in non-aedificandi areas, where the problems of infrastructure and public facilities are acute. The streets are narrow, sandy and difficult to access for motorized vehicles.

Habitat type buildings: buildings exceeding three floors characterize this type of housing. It is generally located in the city centre and is the administrative district of the Plateau. It has the particularity of being located in buildings with a large proportion of offices, as well as commercial premises (on the ground floor). The road is paved and the sidewalks are all paved.

Village dwelling: These are mainly "traditional villages" in Dakar (Ngor, Yoff, Ouakam, Hann, Cambérène) and Pikine (Keur Massar, Thiaroye sur Mer, Mbao and Keur Mbaye Fall). These villages are characterized by a habitat of summary materials gradually replaced by permanent dwellings. The streets are narrow and sandy for the most part, only the primary road is paved. The shape of the lots is not regular and the houses are grouped around small squares (Pinthes) or around a mosque. The government has also classified settlements based on their coverage in terms of infrastructures. It has classified them as: settlements with infrastructures; settlements with limited infrastructures and; irregular settlements. The 19 municipalities of Dakar were distributed according to their settlements.

Based on the above classification of land use various sources of information on land tenure had been developed according to the purpose of the project that are supposed to inform. Official information indicated that the percentage of population living in regular areas is 60% in Dakar, 35.8% in Pikine, and 30% in Guédiawaye. Another study "Cities of Senegal without slums" revealed that there were 49 spontaneous settlements in the city core of Dakar, covering a total area of 418 ha; 47 large spontaneous settlements in the suburbs of Dakar covering a total area of 1856 ha. In the urban audit conducted in the city of Dakar in 2001,[41] equipped settlements were defined as settlements within a radius of 500 m that have an elementary school and a health centre in addition to be connected to water, electricity and a paved street network. This type

[41] Agence de Developement Municipal (ADM) (2001).

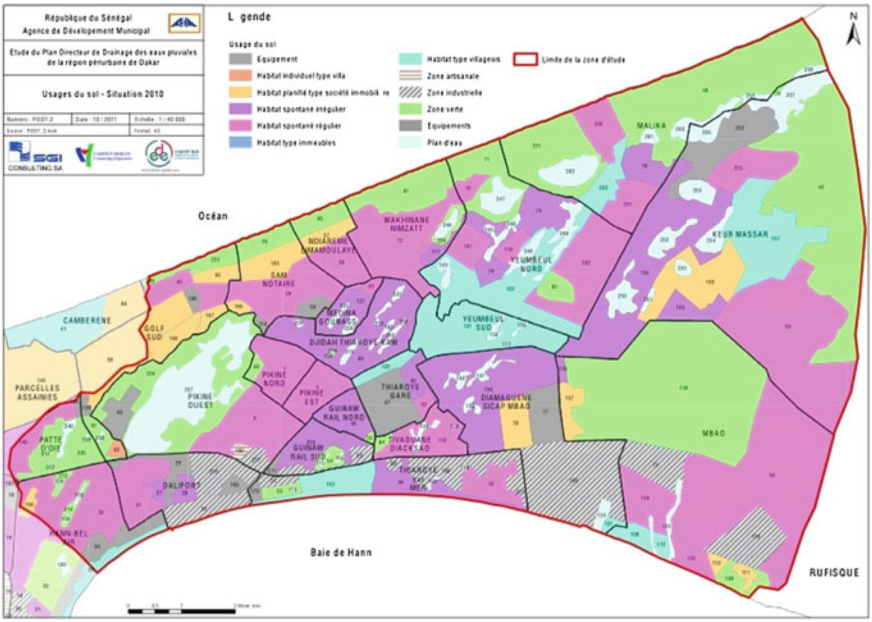

Fig. 3.13 Classification of land use in the peri-urban of Dakar. *Source* Mboup et al. (2018)

of settlements covers an area of 1917.56 ha in 2001, i.e. 57.8% of the total built up area of the core of Dakar. Under equipped settlements, defined as settlements that do not have these infrastructures or are far away from them, cover an area of 1029.96 ha, i.e. 31.1% of the total built area of Dakar. Others are considered irregular planned settlements with traditional structures, which mostly are the first settlements of Dakar, cover an area of 367.15 ha, i.e. 11.1% of the total built up area of the core of Dakar. However, it is important to note that these settlements considered are irregular in terms of planning such as Ngor are also those hosting now wealthy people. The indigenous have sold their land to wealthy people who settled without changing the layout of the neighbourhood. Other irregular settlements are in areas such as Camberene where mainly lively some indigenous people and poor migrants that cannot afford the cost of living in the centre of Dakar. These settlements have an irregular planning and lack most the basic infrastructures. This again supports our assumption that irregularity in Dakar does not necessary means poverty. Irregular settlements can host rich families as well as poor families. As we previously state it, informal land tenure in Dakar does not concern only the poor, but also the rich; it is across social classes. Without access to financial market households are obliged to build based on their capacity. Mortgaged houses are about 5% in Senegal (Fig. 3.13).

3.3.2.2 Use of ICT for a Smart Land Tenure in African Cities

Land administration systems in African cities are heavily influenced by their long history of lack proper recording that make cumbersome the adoption of new approaches, thinking and innovation in land administration.[42] ICT can help to promote principles of good land administration and governance. ICT revolution is opening new frontiers in land tenure reform, but land tenure experts and stakeholders must grasp this unique opportunity for the regularization of land that go hand and hand with e-planning. Data revolution along the generalization of ICT, by enabling easy access to transparent, open platform on urban development issues and policies to all stakeholders, enhances promptness and accuracy of decision-making and facilitates effective and efficient management.[43] Apart from being a prerequisite for a functioning market economy, environmental action and secure livelihoods, land administration systems create invaluable base data for all spatially based innovation. Connecting land registration to personal mobile phones, enable citizens to locate land and property, record a geographic boundary of their properties using geographical coordinates, and edit and submit a landowner's profile. Putting land administration records, cadastres and land registries in a transparent and open digital platform will break down silos between land authorities and other stakeholders. This will particularly of value in remote areas, urban slum areas and other vulnerable groups that are often not served by conventional land administration systems that prevail in African cities. Kenya is an example with an extensive experience in the use of digital technologies to include slum areas such as Kibera in the planning and land administration. The new ISO standard on the Land Administration Domain Model (LADM, ISO 19152) makes available a generic solution to countries starting with little background.[44]

3.3.3 Urbanization and Basic Infrastructures

In a smart city foundation, basic infrastructure such as piped water services, sewerage facilities electricity sources and solid management are considered along the city planning. They are part of the city planning prior to settlements of households. In a smart city foundation, use of improved water from piped water services, sewerage facilities, solid waste management, energy for lightning is quasi universal. However, most African cities, as illustrated in the monitoring of the MDGs and the Habitat Agenda, are lagging behind the provision of these amenities despite progress made in the last decade. African cities have not been able to cope with rapid population in the provision of basic infrastructures. In addition, climate change is becoming a real and global threat; without smart management, hundreds of millions of African people will face severe water and energy shortages, ultimately leading to hunger and

[42] Törhönen et al. (2013).

[43] Aikins (2013).

[44] See Footnote 44.

disease outbreaks. Increased occurrence of droughts and flooding have threatened road to sustainable development in the continent. Water scarcity, pollution, flooding, and other forms of water stress pose extreme threats to the African community. Growing pressures on freshwater resources are rising along with increasing populations, growing needs for agriculture and industrial purposes, as well as increases in energy consumption. Over-exploitation of water resources is another cause of water scarcity, as African countries will push for economic development. Water leakage is also a high concern. This is a clear indication that there is need for smarter infrastructure as well as for investment to replace ageing infrastructure.

3.3.3.1 Connection to Water Services and Sanitation Facilities

In most cities of developed countries, basic infrastructures such as piped water services, sewerage facilities and electricity sources are considered along the city planning. They are part of the city planning prior to settlements of households. In these cities, use of improved water from piped water services, improved sanitation from sewerage facilities, and electric energy for lightning is quasi universal. At the opposite, in most sub Saharan African cities where there are few streets built, provision of basic infrastructures such as piped water services, sewerage facilities and electricity sources, were not factored during the city planning. In these cities, it is not surprising to note low coverage of basic infrastructures. For instance in Bangui of Central African Republic, Ndjamena of Chad, Addis Abba of Ethiopia, Lagos of Nigeria, less than 50% of households are connected to piped water services. The situation is particularly alarming when we consider access to sewerage facilities. In most of these cities, access to sewerage facilities is below 30%, with the lowest observed in Bangui (5%), Addis Ababa (5%), Dar es Salam (10%), Lagos (14%) and Ouagadougou (10%). These cities are followed by Dakar (40%), Abuja (41%) and Accra (45%).

However, the situation is totally different in South African cities and cities in North Africa where a large majority of households have access to sewerage facilities. The 2011 South Africa census shows that in Johannesburg as in most cities of the Gauteng region, more than 80% of households are connected to sewerage facilities. In the Northern African region as observed in many cities of developed countries, the use of sewerage facilities is quasi universal with a level of 99% in Casablanca and 90% in Cairo. In Northern Africa, most residents in cities as well as in rural areas enjoy regular, affordable piped water access. Findings from Northern Africa show that the world's "water crisis" is more of a political and governance crisis than a physical scarcity crisis (Fig. 3.14).[45]

Without connection to a piped water source, many poor urban households have to use water from unimproved sources such as unprotected well and rivers. Lack of access to improved water sources in overcrowded urban areas has negative impact on health as a factor of proliferation of diseases. Waterborne diseases such as diarrhea

[45] UN-Habitat (2006).

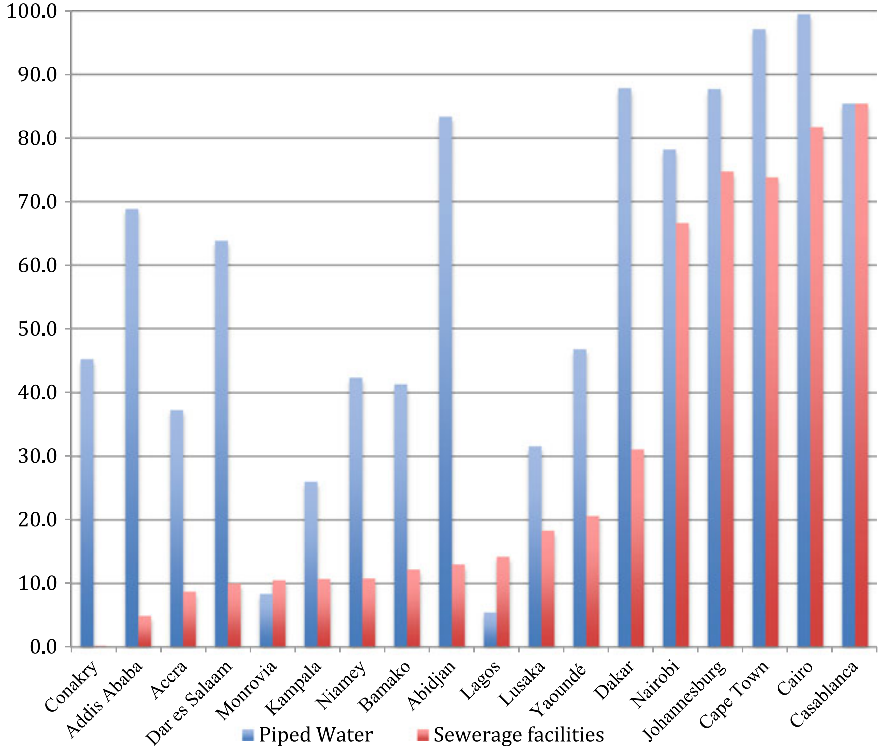

Fig. 3.14 Proportion of population with access to connection to piped water services and sewerage facilities. *Source* Computed by author from Demographic and Health Surveys several for different years (2000–2012)

and respiratory infections are frequent in cities without low coverage of connection to improved water sources and improved sanitation facilities. In capital cities such as Dakar, Abidjan, Maputo and Moroni, it is constantly found that diarrhea and respiratory infections are more frequent than in rural areas. From instance, in Dakar, series of demographic and health surveys conducted in these last twenty years show constantly high levels of diarrhea diseases and respiratory infections than in the rural areas.[46] This can be partly associated to low coverage of sewerage facilities, with its correlate, high frequency of floods during raining seasons.

3.3.3.2 Use of ICT for Smart Basic Infrastructures in African Cities

In time of scarce supply of clean, fresh water, effective planning, monitoring and management through ICT are fundamental for efficient production and usage of water

[46] See Footnote 16.

resources. For instance, advanced metering technologies allow for real-time communication of consumption patterns. Innovative demand forecasting technologies also allow the alignment people needs and production capacity of water sources.[47] Water-use efficiency is recognized as central for the achievement of the SDGs Goal 6 "Ensure availability and sustainable management of water and sanitation for all". The specific target for that is the SDGs 6.4, which is "by 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity".[48] The achievement of this target calls for the use of ICTs to enhance water sustainability, efficiency and accessibility. As outlined in the Waterwise 2017 Flash report "ICT and water efficiency is a key policy issue with potential for new research area that includes decision supporting system for the measurement of water quality and quantity including the recycling and water reuse processes. Though sustainable water management policies have been high on the agenda of most governments, the potential of ICT to improve water management has not been exploited fully… Harnessing the capabilities of ICT within the water sector is a smart means to manage and protect water resources in Africa. Good governance is, however, required to ensure that these technologies are properly managed to protect water resources, and to ensure sustainable development and the equitable distribution of water-derived benefits".[49]

The Water and Sanitation Program (WSP) of the World Bank study highlights the potential of ICTs to unlock and improve water and sanitation services in Africa.[50] In several ways use of ICT contributes to efficient management of water, such as use of Water Point Mapper to establish inventories of assets. ICT technologies allow mapping of infrastructure, enumeration of users, assessment of the quality and conditions of services, and timely, reliable monitoring of services with low cost. Timely, reliable monitoring can provide an opportunity to learn from best/good practices and/or identify and correct challenges. For instance, the Community-Led Total Sanitation (CLTS) Mapper is a simple monitoring that allows the production of geo-referenced indicators including latrine coverage, open defecation free status and water contamination.[51] For instance in the city Lilongwe of Malawi, sanitation data collection through mobile phones along with web-based sanitation monitoring systems enabled real time sanitation information that could guide timely responses.[52]

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[47] http://ec.europa.eu/information_society/activities/sustainable_growth/water/index_en.htm.

[48] United Nations (2015).

[49] European Commission (2017).

[50] Ndaw (2015).

[51] http://www.communityledtotalsanitation.org/.

[52] http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/LilongweBriefing_ICTS_0.pdf, World Bank (2015).

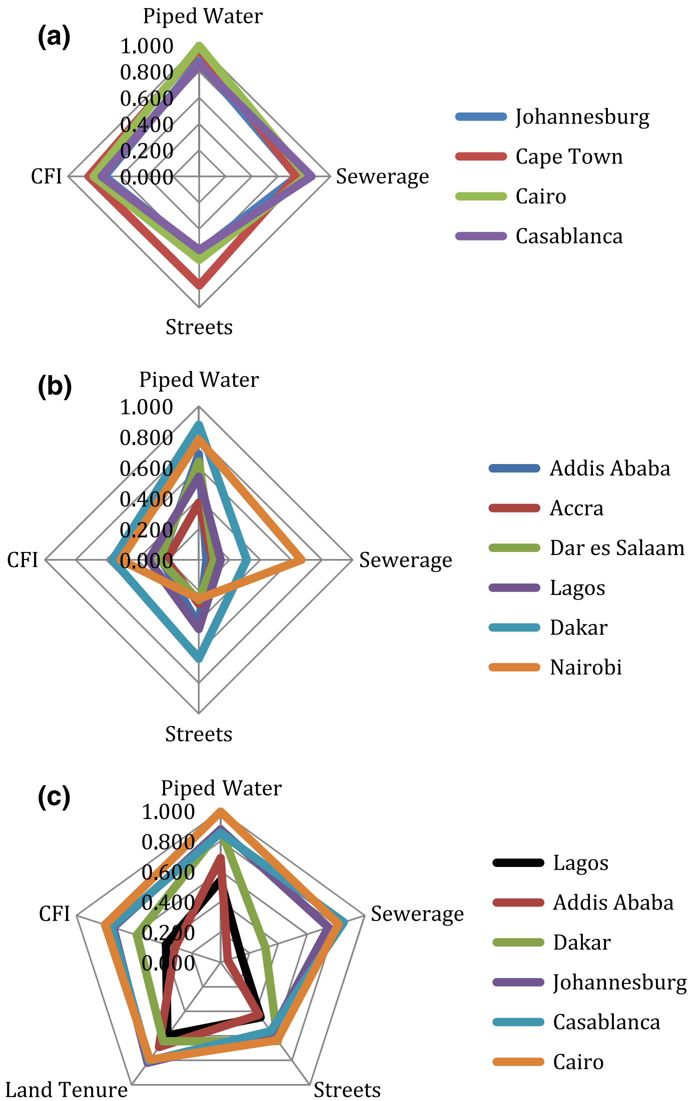

Fig. 3.15 **a** African cities with a partial City Foundation Index (CFI) higher than 0.700: connection to piped water, to sewerage facilities with sufficient street connectivity, **b** African cities with a partial City Foundation Index (CFI) lower than 0.500 (Addis Ababa, Dar es Salam, Lagos and Accra) and between 0.500 and 0.600 (Dakar and Nairobi): connection to piped water, to sewerage facilities with sufficient street connectivity, **c** City Foundation Index (CFI) for selected African cities: connection to piped water, to sewerage facilities, with secure land tenure and sufficient street connectivity. *Source* Computed by the author from Demographic Health Surveys

3.3.4 Measurement of the City Foundation Index

Using three main components of the city foundation (Street connectivity, basic infrastructures and land tenure), we have computed the City Foundation composite index (CFI) that represents the overall city foundation with values varying from 0 to 1. A value closes to 0 means that a city lacks most of the elements of the city foundation elements, and value closes to 1 means that a city enjoys most of the elements of the city foundation. Due to lack of data, particularly on land tenure, we have computed two types of CFI, one with two components—basic infrastructure (piped water and sewerage facilities) and street connectivity (partial CFI), and another with the three components: basic infrastructure (piped water and sewerage facilities), street connectivity and land tenure.

While partial CFIs of Johannesburg in South African cities and Casablanca and Cairo in Northern Africa are estimated at more than 0.700, the CFIs of the other sub Saharan African cities included in this study are below of 0.500. The low level of the CFIs in these African cities is particularly due to low coverage of sewerage facilities. These cities also perform poorly in land governance and administration with a proliferation of informal settlements as illustrated with the full CFI (Fig. 3.15).

Information with the full component of the CFI is available only for few cities: Lagos, Addis Ababa, Dakar, Johannesburg, Casablanca and Cairo. As observed previously, the highest CFI is noted in Northern African cities—Casablanca and Cairo—and South African cities (Johannesburg) with a level higher than 0.740, followed by the city of Dakar (0.580). The lowest level of CFI is observed in Addis Ababa and Lagos (0.316 and 0.379 respectively).

National and local authorities must improve the foundation of their cities with smart planning, smart basic infrastructure and smart land tenure. Smart basic infrastructures, which are particularly of great urgency in African cities, include connection to water, connection to sewerage facilities and connection to energy sources, as well as development of efficient waste management systems. Effecting these changes will enhance the economic value of land, encourage investments, reduce risks from natural hazards, increase resilience and minimize the costs of infrastructure maintenance among various other positive impacts. This calls for use of ICT and GIS in space planning, land tenure governance and administration, and management and monitoring of the provision of basic infrastructures.

3.4 Urbanization and Proliferation of Slums

Africa rapid urbanization is characterized by proliferation of slums with high-density, unplanned settlements as well as emerging planned land expansion with low-density settlements in recent years. The former is composed of the majority of the population that cannot afford the living standard of city cores and are forced to move to unplanned settlements without or limited connection to basic services such as water, sanitation,

Fig. 3.16 Areal view of Nairobi with statistics on land allocated to streets in percentage. *Source* Mboup (2015)

sewerage, energy, streets and public spaces. While the latter, which represents a small proportion, is composed mostly by the upper high-income groups that cannot tolerate the pollution, noise and violence of the city and opted to settle in the outskirts of the city where they can enjoy large parcels of residential properties. In both settlements, land allocated to streets can be small, but with different reasons; in the slum settlements, there is no sufficient land to allocate and people live in overcrowded houses while in the upper high-income settlements, there is huge land, but it is used for large residential properties. As illustrated in Fig. 3.7, one among of the largest slum in Africa, Kibera of Nairobi, with a density of more than 20,000 inhabitants per square km, and the wealthiest area of Nairobi, Runda with a density below 3000 inhabitants per square km, allocated the same amount of land to streets (3%).[53] For the former, public transport is inaccessible and most of its residents use their foot to access services risking their lives in a city where there is no space for pedestrians. While in the latter, the residents drive their private cars and the streets are often empty all day. Between the two settlements, we have the middle-income areas that enjoyed a relatively higher proportion of land allocated to streets and have the choice either to ride public transport or to drive their private car to the Central Business District (CBD) or elsewhere (Fig. 3.16).

In most African cities, urban expansion has taken the form of "peripherization" that is characterized by large peri-urban areas with informal or illegal patterns of land use, combined with a lack of infrastructure, public facilities and basic services, and often accompanied by a lack of both public transport and adequate access roads. Here, urban expansion is the consequence of poverty, not affluence, as informal unplanned settlements on the periphery spring up in response to a lack of affordable housing options within the city itself. In these cases, urban expansion results from a

[53] See Footnote 31.

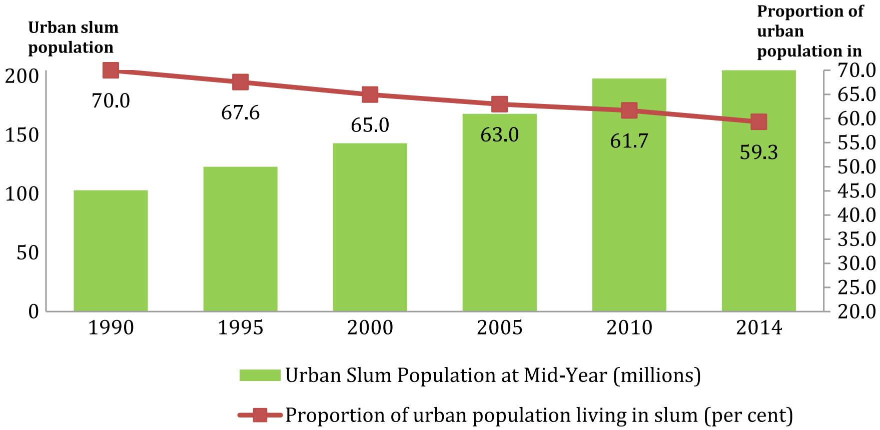

Fig. 3.17 Proportion of urban population living in slum areas and total urban slum population 1990–2014. *Source* Mboup (2015) [These figures do not represent the official publication of slum estimates by UN-Habitat (www.unhabitat.org)]

lack of policy attention to current urban challenges (slums, land, services, transport, etc.), and more particularly, an inability to anticipate urban growth, including through provision of land for the urban poor. Denial of permanent land rights to the urban poor is one of the main factors behind the "peripherization" associated with urban expansion in developing countries.[54]

Peripherization of urban growth is synonymous with slum growth in most African cities. Slums are characterized by the absence of basic services, such as improved drinking water and adequate sanitation, along with insecure tenure, non-durable housing and overcrowding in unplanned settlements. UN-Habitat estimates indicate that in 2012 slum prevalence—or the proportion of people living in slum conditions in urban areas—was highest in sub-Saharan Africa where 62% of the region's urban population lives in a slum, compared to 13% in North Africa and 33% globally. At the beginning of the MDGs in 2000, 67% of urban dwellers in Sub-Sahara Africa leave in slums, and the MDGs ended in 2015 with six out of ten urban dwellers is Sub-Saharan Africa were still living in slums conditions (Fig. 3.17).

In absolute terms, the number of slum dwellers continues to grow in Sub-Saharan African cities, due in part to the fast pace of urbanization in the absence of synchronised provision of basic infrastructures. The number of urban residents living in slum conditions is estimated of 205 million in 2014 compared to 103 million in 1990 and 143 million in 2000. Redoubled efforts will be needed to improve the lives of the urban poor in African cities and metropolises.

[54] UN-Habitat (2010b).

3.5 Use of ICT for an Inclusive Planning of African Cities

The weak African city foundation is part of the reason why digital dividends are still lagging behind in most African cities. ICTs alone cannot build smart cities, but in appropriate settings they can boost growth, expand opportunities and improve service delivery. The analogue settings such as urban planning, provision of basic infrastructures and land tenure are key for smart cities. For ICT to be transformational, there is a minimum requirement associated to the city foundation as well as to institutions and laws that establish the management and the administration of cities. For a city foundation to be smart, it must be inclusive at the onset of the urban planning and promote mixed neighbourhoods where social clustering is discouraged. Having all the poor living together creates slums and fuels instability and insecurity. Inclusive urban planning eases access to basic services (water, sanitation, housing, education and health) and to decent employment for all. A key element of smart urban planning is a smart street network that reduces travel time and encourages walking and social interactions. Smart urban planning enhances infrastructure development, environmental sustainability, economic and social development; makes cities resilient and prepared to overcome natural disasters; and promotes mixed neighbourhoods where services are walking distances from people's residences. ICT plays a crucial role in promoting a smart city foundation, by enabling inclusiveness in planning, policy and infrastructure provision processes such as through public participation; as well as creating enormous non-physically limiting opportunities to all city residents.

Numerous societal problems are explored and addressed in urban and regional planning agencies, including urban growth, unemployment and economic revitalization, transportation, environmental degradation and protection, neighbourhood decline and redevelopment, conservation of land and natural resources, provision of open space, parks and recreational facilities, etc. At the moment, urban planning in African cities has serious flaws and the most notable consequence of this failure is slums. Slums are the clearer evidence of the failures of urban planning in African cities.[55]

In order to cope with urban planning in African cities, it is crucial that we understand the mechanisms that contribute to these failures as well as the situation as far as informal activities and land tenure are concerned. One of the reasons for this is the lack of communication and information exchange between urban stakeholders. While planners are obligated to at least inform citizens of and, preferably, to engage them on land use issues through, for example, the comprehensive planning process, it is rare that African city planning takes into account input from their citizens.[56] This lack of active participation has created a challenge for city planners, who are responsible for engaging citizens in making decisions about the future of their communities.[57] The goal of citizen participation in planning is often to enhance

[55] Alexandre and Bolay (2010).

[56] Conroy and Gordon (2004). Cited by Conroy and Evans-Cowley (2010).

[57] Brody et al. (2004), Laurian (2004). Cited by Conroy and Evans-Cowley (2010).

the outcomes of policy and project decisions in a community.[58] Cities are integrated environments with various attractive places and space for different cultures. Planning them requires knowledge based on a "soft" understanding of places and the more detailed incorporation of hard, physical facts.[59]

New urban planning instruments are becoming available with the worldwide spread of ICTs. They make it possible to adopt innovative e-planning approaches, strengthen communication between urban stakeholders, and make communication available at various stages of the planning process. Local governments can engage their citizens with real-time information to gain support for policy initiatives, identify unforeseen concerns, and recognize potential conflicts.[60] Cities are dynamic living organisms that are constantly evolving. ICT has begun to turn some places into real-time cities. This rapidly changing society makes the assessment and anticipation of future needs of city dwellers in terms of services, including transport, water, energy, employment, education and health, even more problematic. Addressing the complex problems of city planning it is not sufficient just to be concerned with the physical structure of the city; the interplay of intangible economic, social and environmental factors needs to be considered as well.[61]

Use of models that show historic and present situations is also fundamental for an informed urban planning. Urban planners and designers have employed wide range of techniques in order to plan, model and simulate the outcome of urban planning and development processes. The main thrust of computing applications in urban planning is their contribution to sound decision-making and planning practices. During the last couple of decades many new computing tools and technologies, including geospatial technologies, are designed to enhance planners' capability in dealing with complex urban environments and planning for prosperous and healthy communities. The introduction of ICTs allows planners and planning departments to carry out new actions or to implement conventional practices through new tools, such as GIS, virtual reality technologies, e-participation devices, including public participation GIS applications, among other tools, with the aim of improving conventional decision-making processes. The provision of better planning and urban management services, more efficient, with lower costs and, at the same time, a more collaborative and participative, transparent and accountable planning decision-making process are some of the basic objectives usually associated with the move from conventional urban planning to e-planning.[62,63]

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[58] Conroy and Evans-Cowley (2010).

[59] Madanipur (2001, 2017).

[60] Conroy and Berke (2004), Conroy and Gordon (2004), Wild and Marshall (1999). Cited by Conroy and Evans-Cowley (2010).

[61] Chen et al. (2010).

[62] Silva (2010).

The Use of Social Media for Urban Planning: Virtual Urban Landscapes Created Using Twitter Data.

[63] Yigitcanlar (2013).

However, ICTs will not be equal to this challenge on their own. They must be accompanied by more extensive approaches that meet the key conditions of tackling the challenges of urban planning in African cities. ICT will not turn unplanned to planned cities, but it can ease the re-structuration of unplanned settlements through digital mapping. This will happen only if there is democratic political will that encourages public participation. Even though a great variety of web-based examples of e-planning currently exists, the socio-cultural and political context that conditions and shapes the appropriation of ICT and its eventual benefits in city planning and management remain central.[64,65]

3.6 Conclusion

African cities are densely populated—Three out of four African cities have a population density of more than 5000 persons per square km. There is no specific model associated to the variation of densities in Africa. There are cities where densities increase when moving from the city centre to the outskirts. There are also cities where density decreases first then increase. Lack of specific model of densities in African cities is associated with the lack of functioning master urban plan. Most African households settle first in unplanned settlements either at the outskirts or anywhere in the cities where there is space for settlements and then undertake legal steps for land regularization.

Though African cities are of high density, we should not overlook the fact that leapfrog and inclusion illustrate emerging trends in some African countries where cities are expanding in a discontinuous, scattered and low-density form that is not sustainable. A defining feature of these cities is an outward expansion far beyond formal administrative boundaries, largely propelled by land speculation. A large number of cities feature very land-consuming suburban sprawling patterns that often extend even to farther peripheries. However, every time rural land is converted for urban uses, there is an opportunity cost to be considered. There is an environmental cost including land degradation, loss of biodiversity and climate change as well as a huge economic for the farmers who depend on agriculture outcomes in economic and financial terms. Another urban development is the emergence of urban corridors, which present a type of spatial organization with specific economic and transportation objectives. In African countries, governments are also encouraging growth, convergence and spatial spread of geographically linked metropolitan areas and other agglomerations. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation.

[64] Horelli and Wallin (2010).
[65] Staffans et al. (2010).

In recent years streets have been recognized as an integral factor in the achievement of sustainable urban development. The state of streets in most African countries is quite different from that observed in cities of developed countries. While in most cities of developed countries, sufficient land is allocated to street (more than 25%), in most African cities, there are not enough streets (less than 15% of share of land), and those that exist are either not well designed or well maintained. African cities also share common characteristics: inadequate and deteriorating street networks; and poor facilities for non-motorized mobility (walking and cycling). One effect of these problems has been the further marginalization of the most vulnerable segments of society who rely the most on public transport and cannot afford private alternatives.

Providing security of tenure depends on a range of policies related to institutions and laws put in place to protect people against unlawful eviction, to ensure equitable distribution to basic services to all communities, and to put in place transparent and accountable processes of land regulation, key for secure land tenure. However, in most African cities, land tenure is neither well governed nor well administered. Poor land governance is surrounded by poor land administration characterized by a poor determination, recording and dissemination of information about tenure. In addition to being exposed to eviction, without legal proof of ownership, African households cannot enjoy the economic and financial opportunity associated with investment and saving using their property as collateral. At the community level, the municipality cannot also legally collect various taxes that can be used to improve basic infrastructures. Promotion of secure land tenure in African cities will boost investment in property development, increase municipal tax collection and in turn promote economic growth. In a smart city foundation, basic infrastructure such as piped water services, sewerage facilities electricity sources and solid management must also be considered along the city planning. However, in most sub Saharan African cities where there are few streets built, provision of basic infrastructures such as piped water services, sewerage facilities and electricity sources, were not factored during the city planning. In these cities, it is not surprising to note low coverage of basic infrastructures.

New urban planning instruments are becoming available with the worldwide spread of ICTs. They make it possible to adopt innovative e-planning approaches, strengthen communication between urban stakeholders, and make communication available at various stages of the planning process. Local governments can engage their citizens with real-time information to gain support for policy initiatives, identify unforeseen concerns, and recognize potential conflicts. However, ICTs will not be equal to this challenge on their own. They must be accompanied by more extensive approaches that meet the key conditions of tackling the challenges of urban planning in African cities. ICT will not turn unplanned to planned cities, but it can ease the re-structuration of unplanned settlements through digital mapping. Even though a great variety of web-based examples of e-planning currently exists, the socio-cultural and political context that conditions and shapes the appropriation of ICT and its eventual benefits in city planning and management remain central.

Annex: Methodological Consideration in the Measurement of Densities

Considering that the urban area may change from time to time, there is limitation in the monitoring of any change in density by comparing density between two periods. Let us consider two times of period, t_0 at the initial time and t_1 the final time, P_{t0} and P_{t1} being the population respective in each time. Let us also consider r being the annual between t_0 and t_1. Considering the population growth in a logistic form, the relation between P_{t0} and P_{t1} is expressed as follow: $P_{t1} = P_{t0}e^{r(t1-t0)}$ (1), in a stationary phase where the population is unchanged, i.e. r = 0, $P_{t1} = P_{t0}$. In the case the population of city is declining (shrinking), r is negative. The later is often in Europe, but it is not yet common in Africa.

Let us consider the total urban area of the city at t_0 and t_1 being U_{t0} and U_{t1} respectively, and the population in each time being D_{t0} and D_{t1}. The population density in the total urban area of the city can be expressed as:

$$D_{t0} = \frac{P_{t0}}{U_{t0}} \text{ and } D_{t1} = \frac{P_{t1}}{U_{t1}} \text{ respectively.}$$

The difference between the two densities can be assessed in terms of ratio and expressed as follows:

$$\frac{D_{t1}}{D_{t0}} = \frac{P_{t1}}{U_{t1}} \Big/ \frac{P_{t0}}{U_{t0}} = \frac{P_{t1} \times U_{t0}}{P_{t0} \times U_{t1}} \tag{2}$$

Using the relation between P_{t0} and P_{t1} as expressed in Eq. (1), this ratio can be expressed as follows:

$$\frac{D_{t1}}{D_{t0}} = \frac{P_{t0}e^{r(t1-t0)} \times U_{t0}}{P_{t0} \times U_{t1}} = \frac{e^{r(t1-t0)} \times U_{t0}}{U_{t1}} \tag{3}$$

$$\text{When } D_{t1} = D_{t0}, \frac{D_{t1}}{D_{t0}} = 1, \text{i.e. } \frac{e^{r(t1-t0)} \times U_{t0}}{U_{t1}} = 1 => U_{t1} = U_{t0}e^{r(t1-t0)} \tag{4}$$

This is possible only when the urban area grows at the same rate as the population. For instance to halve the density, we can either halve the population with invariable urban extent or double the urban extent in stationary population, or all combinations between the two. To double the density, we can either double the population density in a period of time, for instance with annual growth rate of 2.77%, the population will double in 25 years, without increase of the urban extent, the urban extent density will double. It is possible based on city population growth, which is known for many years to estimate the change of urban extent required to either increase, or decrease or leave unchanged the urban extent density. The urban extent population density is constant in the case where the urban extent has the same annual growth in logistic form as the population. However, the perfect fit of the urban extent growth in a logistic is difficult to forecast compared to the population growth where the parameters are known and well documented which are natural growth (fertility and mortality) and growth associated to migration. Based of the combination of natural growth and migration, UNDESA has been able for many years to publish urban and city population growth since 1990 for more 193 countries and more than 1000 cities from 1950 to 2050. However, regarding urban extent, little is known about its trajectory and form of growth. It depends on various variables on how population grows in the space such as filling the existing urban extent, or extending the urban extent or including other settlements or leapfrogging land. The association between these four variables is difficult to predict and varies across cities and countries. This limits the possibility to have a generalized model of the change in urban extent. Even in the same country the way urban extension affects the change in urban extent can vary from period to period. However, fertility and mortality needs a long period of time to experience significant change; this allows modelling and generalization over time.

Limitation of urban density trends analysis

The measurement of density may appear simple as an arithmetic formula where population is divided to area, being legal, urban agglomeration or metropolitan, but in terms of trends analysis it is imperative that what is compared overtime has the same meaning. In order to translate measurements into policy, it is necessary that the change is a real change and not change just due to change of definition. In a constant area, the density depends mainly on the change in population, which in turn depend on natural growth (balance of fertility and mortally) and net migration growth. In this case, monitoring population was largely enough to predict density. This is in general the cases in most countries where we cannot arbitrary increase or decrease the area. This is not case at the regional level, where politicians can change many times the boundaries of region/province due to political reason. In this case the density of the new region should not be directly compared to the density of the original region and conclude to a decrease or an increase of a density. With census data, it is always possible to reconstitute the new region in the past and produce comparable data. In cities, the situation is more complex. The complexity relies on the definition of the boundaries of the city. The most constant density is the core of the city, these changes occur rarely and it stays constant for a long period of times. However, when comparing densities calculated in each area, caution is called. Due to the development of certain zones which were with low density, their density increase until they are recognized as an urban and since they are linked to the previous urban extent, they are considered as part of the urban agglomeration. When adding this to the previous urban extent, we consider that the density of the urban extent has decreased. Trends analysis should be done with respect to these changes. If would like to perform trends analysis, we have the following options:

- Reconstitute the area in the past together and recalculate the density
- Calculate separate densities for previous urban extent and the area itself and look at their trends analysis.

When comparing densities over time, we will take into consideration the above methodological considerations and limitations.

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Chapter 4
Cities in the Context of Climate Change: Opportunities for Local Authorities in Climate Action in Africa

William Kojo Agyemang-Bonsu, Kusum Lata and Vintura Silva

Abstract Achievement of global emission reduction targets under Paris Agreement could be greatly enhanced with the active engagement of cities. Cities are one of the major contributors to global greenhouse gas emissions while providing habitation to more than half of the world's population. The Convention provides avenues for cities to identify, implement, monitor, report and gain recognition for the actions undertaken. This chapter defines what climate smart cities means, evolution of cities as actors of climate actions, and highlights some of the mechanisms and opportunities available under the Convention for which African cities could avail themselves of, including co-benefits associated with the implementation of these climate actions.

Keywords Convention · Paris agreement · Climate change · Climate smart cities Co-benefits · Climate actions

4.1 Introduction

> We are the first generation to be able to end poverty, and the last generation that can take steps to avoid the worst impacts of climate change. Future generations will judge us harshly if we fail to uphold our moral and historical responsibilities

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Ban Ki-moon, (former) Secretary General, United Nations (UN 2015a)

The global community is taking two pronged approaches to address the climate change imperative through implementation of mitigation and adaptation actions. With the Paris Agreement, global community agrees to collectively make efforts to hold the increase in global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels (UNFCCC 2015a).

Initially, most countries took top-down approach to deal with climate change. Once it became clear that efforts driven from national governments would be insufficient to address impacts of climate change, involvement of non-Party stakeholders became a necessary complement to national actions. Paris Agreement welcomes the efforts of non-Party stakeholders to scale up their climate actions, and encourages the registration of those actions in the Non-State Actor Zone for Climate Action platform (NAZCA) (UNFCCC 2015d).

Cities are recognized as one of the key non-Party stakeholders in climate change world, as they are responsible for over 70% of GHG global emissions and consume over two thirds of the energy (C40-Cities 2017). According to United Nations about 54% of the world's population lives in urban areas and it is expected that about 66% of world population will live in urban areas by 2050 surpassing about six billion by 2045 (UN 2015b). Much of the expected urban growth will take place in countries of the developing regions, particularly Africa. The consequences of impacts of climate change such as droughts, extreme temperatures and intense precipitation along with unplanned and unmanaged urbanization (UN-Habitat 2016) is building extra pressure on existing infrastructure of cities (DePaul 2012) and in turn is also further elevating the disastrous impacts on climate change. Cities, as local government or local authorities or municipal authorities, also have responsibility in managing emission intensive sectors including transportation, electricity, waste management, and buildings. These make them an important player in addressing climate change by taking actions to transit to low greenhouse gas emitting economy contributing to climate change mitigation; as well transforming cities to adapt to the impacts of climate change through the building of climate resilient cities; which often are jointly referred to as building low-carbon climate resilient smart cities.

What exactly does building smart city mean? In the context of climate change smart cities are often seen as low-carbon climate resilient cities which allow to connect (enhanced mobility through low carbon transportation), cool (protect from heat with green rooftops, parks and reduced energy consumption), absorb (improved storm water management), and protect (against rising sea levels, floods or droughts) (Climate-Smart-Cities 2017). Besides that, we have aspect of sustainability (e.g. through renewable energy) and contribution to sustainable development (through social and economic co-benefits). They are also seen as a cities which have capacity to absorb future shocks and stresses to its social, economic, and technical systems and infrastructures while still maintaining essentially the same functions, structures, systems, and identity (City.org 2017).

Paul Polman (CEO, Unilever) said "*The biggest risk for African growth is climate change*" (World Economic Forum 2015). Paradoxically Africa is the most vulnerable continent to the impacts of climate change and as such adaptation to the impacts of climate change, including building low-carbon climate resilient economies and cities, is no longer an option but a development imperative. African countries should not get locked-in into environmentally unfriendly technologies and investments while pursuing its development pathways. Although adaptation is a priority to survive and thrive in and for many African cities, mitigating climate change should also an embodiment of their development objectives. The IPCC fifth assessment report also highlights that any steps taken to build resilience and enable sustainable development can accelerate climate change adaptation; and development opportunities especially in energy, industry, buildings, waste management and transport sectors offer good potential for technology transfer to reduce GHG emissions (IPCC 2014). Therefore, renewable energy production, buildings efficiency, sustainable transportation, and other features become relevant for city level climate change mitigation interventions.

However, there are many complexities associated with transformation of existing cities to low-carbon climate resilient cities which municipal authorities across the world are grappling with through such activities as:

- Formulating and implementing climate change by-laws at city level (or adopting national level policies/laws as appropriate); and building capacities for enforcement;
- Developing and implementing regulatory frameworks and associated capacities for enforcement;
- Establishing and/or strengthening institutional and coordination frameworks;
- Establishing platforms,
  - for analytical work to inform policy development by encouraging interface between municipal authorities and the academia/research institutions;
  - for investment by fostering dialogue between municipal authorities and local and international financial institutions, private sector and the donor/philanthropic community;
- Enhancing stakeholder engagement/dialogue;
- Establishing and maintaining data management systems;
- Institutionalizing industrial eco-parks;
- Capitalizing on sister city alliances.

International policies are also contributing to creating enabling environment at national level which municipal authorities can adapt. Over 550 strategies have been adopted by cities to reduce their greenhouse gas (GHG) Emissions (Brown 2017). This includes actions voluntarily pledged by countries as part of their nationally determined contributions (NDCs) under Paris Agreement. Many African countries have pledged NDCs that have conditional as well as unconditional contributions. The conditional contributions target support (including financial, technology and capacity building support) from developed countries for their implementation, whilst the unconditional contributions are to be supported from domestic resources. The major share of conditional support sought for by African countries is financial. The processes under the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol (KP) and the recently adopted Paris Agreement together, referred to as 'the Convention' here after, continue to create a policy driven enabling environment that facilitate climate actions towards building low-carbon climate resilient cities with substantial sustainable development co-benefits.

The purpose of this chapter is to provide a review of opportunities which are available under the Convention to Africa as it seeks to build low-carbon climate resilient cities. The chapter also extends its scope to present other opportunities which exist outside the Convention due to the enabling environment created by the Convention. Specific information related to Africa has been detailed in each section as relevant. The remainder of this chapter is structured as follows: Sect. 4.2 is on "history" which focuses on evolution of multilateral and legal frameworks and other instruments under the Convention. This is followed by in-depth discussion on broad areas in Sect. 4.3 where the Convention has impacted climate actions for cities including through catalyzing finance for climate actions; catalyzing engagement of private sector and public-private partnerships; promoting climate technology development and transfer; building capacity and sharing experiences and best practices; providing platforms for recognition of actions taken and support provided; catalyzing stakeholder's engagement; enhancing the development of measurement, reporting and verification (MRV) systems that ensure transparency of actions and support and the building of trust in the multilateral climate change regime. Section 4.4 discuss the impacts of implementation of response measures. Finally, Sect. 4.5 is on "co-benefits from cities actions to climate change" which highlights other development and local benefits for cities.

4.2 Evolution of Role of Cities in Climate Action Under the Convention

The first milestone in the climate change negotiation was achieved when the UN Framework Convention to Climate Change was adopted on 9 May 1992 which came into force on 21 March 1994. The Conference of Parties (COP), which is the supreme body under the Convention and its subsidiary bodies, [i.e. the subsidiary body for implementation (SBI) and the subsidiary body for scientific and technological advice (SBSTA)] continue to further agree on decisions and conclusions to advance the implementation of the Convention. In order to advance the implementation of the Convention, Parties at their third conference of Parties (COP3) adopted the Kyoto Protocol on 11 December 1997 which also came into force on 16 February 2005 with its first commitment period of 2008–2012. Under the Kyoto Protocol, developed country Parties (Annex I Parties) agreed to undertake quantified emission limitation and reduction commitments based on individual countries capacities. After development of its rules and procedures, two of its key mechanisms i.e. Clean Development

Mechanism (CDM) and Joint Implementation (JI) started their operation in 2006 and 2008 respectively. These mechanisms allowed for developed countries with opportunity to support sustainable development of developing countries through assisting implementation of low carbon projects while using the emission reductions from these projects to meet their emission reduction targets using more affordable means. Close to end of first commitment period, Parties further agreed to the “Doha Amendment to the Kyoto Protocol” on 8 December 2012 with its second commitment period of 1 January 2013–2031 December 2020. The commitment of Parties to reduce GHG emissions changed from five percent against 1990 levels in first commitment period to at least 18% below 1990 levels in second commitment period. The latest milestone in the history to climate change negotiation is the Paris Agreement which was agreed by 195 nations on 12 December 2015 which entered into force on 4 November 2016 globally, less than one year after its adoption.

Other important milestones includes adoption of the Buenos Aires Programme of Work in 2004 and Nairobi Work Programme (NWP) in 2005 to address impacts, vulnerability and adaptation to climate change; adoption of the Bali Road Map, including the Bali Action Plan in 2007 which charted the plan for new negotiating process comprising of five main categories: shared vision, mitigation, adaptation, technology and financing; agreement to launch Adaptation Fund under the Kyoto Protocol and the Poznan Strategic Programme on Technology Transfer in 2008 (COP 14); and establishment of the Green Climate Fund (GCF), the Technology Mechanism and the Cancun Adaptation Framework in December 2010 (COP 16). Figure 4.1 summarizes these historical developments and important milestones.

Whilst mitigation and adaptation actions have always contributed towards reduction of emissions from cities and reducing cities’ vulnerabilities to climate change, cities only got lime light as non-Party stakeholder in climate change negotiations in 2014 when UN climate summit resulted in several city initiatives which among others include a global Compact of Mayors. This initiative brought together over two thousand cities, including over 200 cities with specific targets and strategies for greenhouse gas emission reductions, followed by a formal invitation by Paris Agreement to register them on NAZCA platform.

4.3 How the Convention Can Catalyze City Level Climate Actions in Africa

This section presents various instruments under the Convention that cities in Africa can avail themselves of as they formulate and implement climate change actions at the local level.

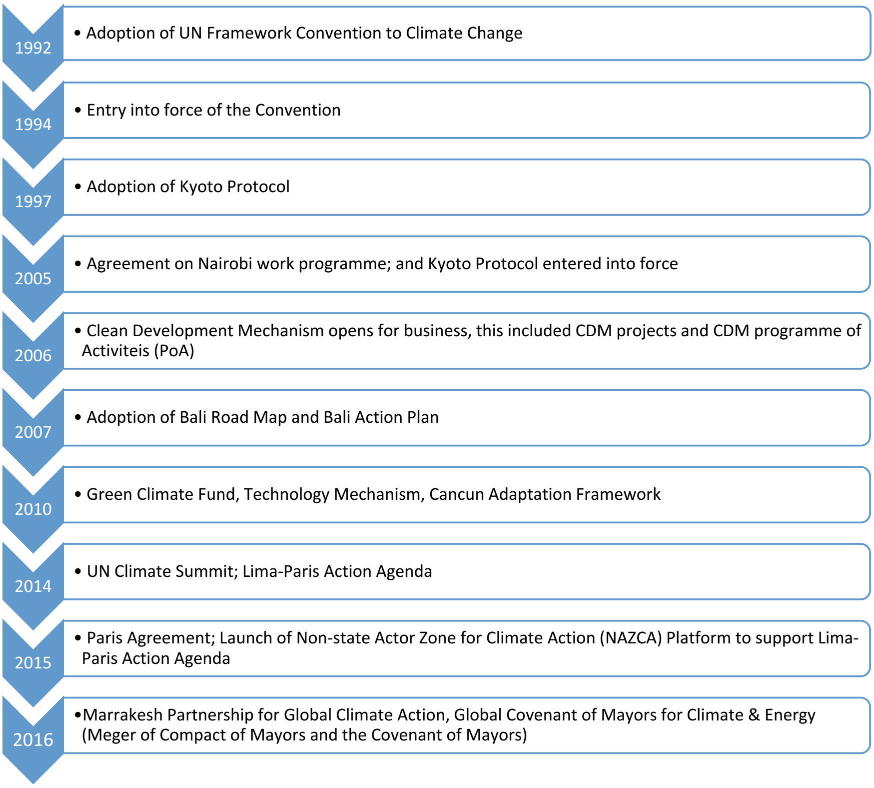

Fig. 4.1 Historical milestones of climate change negotiations relevant to cities. *Source* Created by authors from information available at UNFCCC, https://unfccc.int/

4.3.1 Opportunities for Climate Financing for Smart Cities Under the Convention

The NDCs pledged by African countries give a clear message that provision of support, in particular finance, is a critical factor that will determine the implementation of sustained, impactful and enhanced climate actions by African countries, since out of the 40[1] pledged NDCs about 80% of them are conditional requiring support including financial support for implementation. Under the Convention, developing countries generally can receive financial support in the form of public finance to support climate mitigation and adaptation interventions through the existing financial mechanism operated by the two operating entities, namely the Global Environment

[1]Of the 54 Parties to the Paris Agreement from Africa, 40 have submitted NDCs, or 74%. 38 were automatic conversions from the previously submitted INDCs, and 2 Parties, Mali and Morocco, submitted revisions. 2 Parties have ratified the PA, but are currently revising their NDC (Benin, Senegal). Status on 21 September 2017.

Facility (GEF) and the Green Climate Fund (GCF). Under the GEF the Convention also have other funds to support specific climate change actions, for example, the Special Climate Change Fund (SCCF), the Least Developed Countries Fund (LDCF) and Adaptation Fund (AF).

In addition to financial support available under the Convention, there are numerous multilateral, bilateral, private sector and philanthropic sources of finance which are geared towards supporting climate change mitigation and adaption actions. Some of these are provided by e.g. the World Bank, bilateral agencies that provide development assistance in the form of North-South Cooperation. Of late, some emerging economies are also providing support to other developing countries through South-South Cooperation. The Carbon Investment Fund (CIF), Clean Technology Fund (CTF), Global Climate Change Alliance (GCCA), Partnership for Market Readiness (PMR), Pilot Programme for Climate and Resilience (PPCR), Scaling-Up Renewable Energy Program for Low Income Countries (SREP) are a few of the multilateral funds[2] which provide support to developing countries including from Africa to prepare and/or implement climate changes projects/policies, including those for building climate resilient cities.

These funds not only contributed directly to projects but supported the countries to leverage private sector financing for projects also blending limited government resources for de-risking private investment, through policies or direct financial instruments/guarantees.

All these forms of financial support are collectively referred to as climate financing, which invariably adds value and contribute to national policy and regulatory reforms to support public and private climate investments, piloting technologies and business models to promote broader and scaled-up implementation, strengthening public and private institutional capacities, and providing grants and concessional financing to lower the risks of project financing schemes and facilitate their implementation.

During its sixth replenishment period (2014–2018) the GEF introduced a programme to promote integrated low-emission urban systems under the focal area "demonstrate systematic impacts of mitigation options". This program supports city level actions by providing financial supports to projects (GEF 2016b) in the following areas e.g. (a) urban initiatives that commit to GHG mitigation targets at the city level, which could utilize performance-based financing and incentives; (b) design and implementation of sustainable urban strategies, policies, and regulations, combining energy efficiency (buildings, lighting, air conditioning, transport, district heating systems), renewable energy development (solar, wind, co-generation, waste-to-energy), and other sources of GHG emissions reduction interventions (e.g. solid waste and wastewater management); (c) land use management, planning, and zoning, including the integration of land use planning with transport planning and transit-oriented development, for sustainable cities to reduce energy demand, enhance climate resilience, and improve living standards; (d) innovative policies and mechanisms for freight and logistics services with the engagement of the private sector,

[2]This is by no means an exhaustive list; and some of the funds are not exclusive to Africa.

including development of logistics platforms, reverse logistics, and low-emission zones; (e) urban sustainable transport infrastructure and systems that reduce demand for car travel through catalytic approaches, including road and parking policies and pricing, zoning and street/urban design codes, and congestion pricing, that are particularly relevant for urban, low emission development, and incentives for broader use of public transport, such as measures to enhance access and efficiency of public transport services and carpooling/car sharing programs; (f) initiatives to assess and reduce the impacts of short-lived climate forcers (SLCFs) at the urban level; and (g) initiatives to enhance broad community engagement and support for and use of emission reduction approaches and low-carbon technologies.

In 2016, nine sustainable transport and urban systems projects received funding from GEF. These projects contribute to design and planning of integrated urban systems, city wide energy efficiency improvement and green tourism. In addition, about nine projects in energy efficiency and 19 projects in renewable energy received funding. These projects promoted policy and regulatory reform; minimum energy performance standards for appliances; more efficient public housing; and innovative financing instruments to accelerate investments in energy efficiency projects; while projects in renewable energy included small hydro, waste to energy generation, wind power, solar photovoltaics, and biomass to energy (GEF 2016c).

It is important to note that the projects which relates to the mitigation and adaptation actions identified in the NDCs are getting increased focus under the climate financing.

Notwithstanding the availability of many avenues to receive financial support for implementation of climate change actions in developing countries, access to and absorption/utilization of climate finances continue to be a major challenge for African countries. The fifth review of the Financial Mechanism under the Convention indicated that African countries have made minimal use of the funds accessible to them. According to Climate Funds Update (Climate-Fund-Update 2016), 178 mitigation projects have received funding through various climate finances in Africa to date, with largest share being energy generation projects (Fig. 4.2). To address the challenge, the GEF has started engaging directly with countries to increase their awareness and understanding of its policies and procedures to facilitate access to GEF financial resources. Many Least Developed Countries (LDCs) and Small Island Development States (SIDS) including those in Africa still face challenges to access all their resources.

The acknowledgement of cities as non-Party stakeholders is expected to facilitate enhanced provision of financial support at the city level for climate related projects e.g. International Council for Local Environmental Initiatives (ICLEI-network of Local Governments for Sustainability) launched Cities Climate Finance Leadership Alliance (CCFLA) at United Nations Secretary-General's Climate Summit in September 2014. CCFLA is a coalition of more than forty organizations actively working to catalyze and accelerate investment into low-carbon and climate-resilient infrastructure in cities and urban areas (Alliance 2017). Following this, ICLEI further launched the transformative actions program in April 2015 as part of CCFLA. This program supports the development and implementation of climate projects to raise

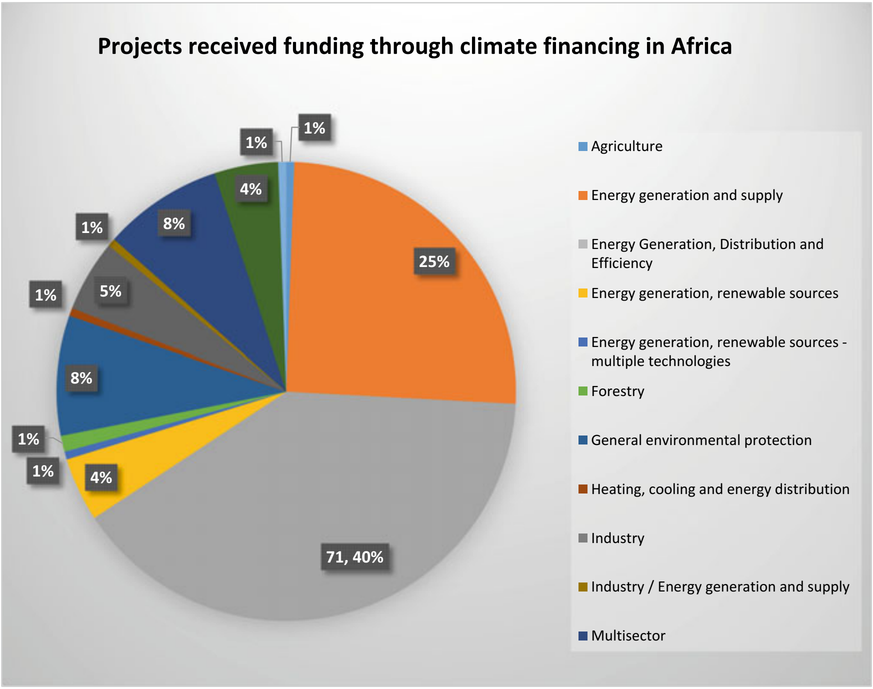

Fig. 4.2 Projects received funding through climate financing in Africa (till October 2016). *Source* Created by authors from climate funds update (Climate-Fund-Update 2016)

ambition at the city level. Through partnership, members of CCFLA are collaborating to mobilize investments into low emission and climate resilient urban infrastructure development.

4.3.2 Public-Private Partnership for City Projects

Municipal Authorities can also make use of the opportunities which are available to encourage involvement of private sectors in city-level projects development and implementation. Clean Development Mechanisms (CDM) is one of the first few initiatives under the Convention, more specifically under the Kyoto Protocol (KP) which facilitates engagement of private sector in development and implementation of mitigation projects mainly focusing on transport, waste, energy generation and energy efficiency (e.g. buildings).

In addition to individual CDM projects activities, the Executive Board of CDM started developing rules for Programme of Activities (PoA) in 2007. PoA allows registration of a coordinated implementation of a policy, measure or goal that leads to emission reduction comprising of unlimited components of project activities (CPAs) during course of PoA cycle. The progressive improvement of rules and flexibility regarding usage of multiple methodologies within a single programme promoted development of citywide CDM projects. Project developers including municipal authorities may propose city-wide CDM project activities to reduce emissions which could consist of energy efficiency in buildings, energy use, water use, waste management, transportation, etc. in one PoA. It allows for an integrated systems approach to emissions reduction and resource conservation e.g. Advanced Energy Solutions for Buildings (UNFCCC 2017a); BRT Bogotá, Colombia: Trans Milenio Phase II to IV (UNFCCC 2017b).

The development and implementation of nationally appropriate mitigation actions (NAMAs) further provides opportunity to engage local government and private sector in the implementation of city level climate actions. The concept of NAMA was an outcome of the Bali Action Plan in 2007 (COP 13) in which Parties agreed that developing country will take NAMAs in the context of sustainable development, supported and enabled by technology, financing, and capacity-building, in a measurable, reportable and verifiable manner. Two years later, as part of the Copenhagen Accord, many countries including developing countries communicated their nationally appropriate mitigation actions. This mechanism under the Convention resulted in the development of 33 NAMAs from Africa out of which six were specifically on transport, infrastructure and residential and commercial buildings in cities.

Majority of the African countries that prepared and submitted NAMAs focused on interventions within the energy, waste management, transport, infrastructure and residential and commercial buildings sectors. NAMAs by their nature could be designed to receive international support for their implementation as well. Till date support for NAMAs implementation amounts to 3.83 million USD for four renewable energy NAMA projects in Africa (derived from NAMA registry).

Development and implementation of national policies with an aim to achieve pledges made as part NDCs submitted by Parties under the Paris Agreement provide additional opportunity for non-Party stakeholders including cities to channel investments in city projects that can significantly contribute to achieving national level mitigation and adaptation commitments. These policies should incentivize the implementation of energy efficiency projects, low carbon technology development and promote engagement of private sector, removal of subsidies on fossil fuels, carbon pricing (e.g. carbon tax), feed-in-tariff, renewable energy purchase obligation, establishment of dedicated funds (e.g. renewable energy funds) etc. Cities in collaboration with the private sector could take advantage of the enabling environment created by these policies to develop city wide projects for low-carbon climate resilient cities.

Climate bonds (also called as green bonds) are another financial instrument which is used to promote private sector investment in environmental projects. Africa Development Bank (AfDB) is operating a Green Bond program (AfDB 2017b). West African development Bank also recently announced launch of Green Bonds to raise funding for low carbon projects including CDM projects (AfDB 2017a). Using this kind of financial instrument municipal authorities can raise money to fund public projects. However, the use of such innovative financing approach is yet to be utilized on a large scale in Africa. Only two cities Johannesburg (2004) and Lagos (2013) have issued a municipal bond to finance local investments (Halimi 2016). However, other cities which are planning to enter the bond market should learn from the unsuccessful experience of Dakar which issued its first municipal bond in 2015 (Gorelick 2017) and could not succeed due to external factors associated with local politics and constitutionality.

4.3.3 Promoting Climate Technology Development and Transfer

Another key area which cities can benefit from the Convention is the opportunities available under the technology mechanism of the Convention. Climate technology is any equipment, technique or practical knowledge or skill needed to mitigate climate change (reduce GHG emissions) or adapt to it. The Convention recognizes the need for technological shift and the need for technology development and transfer to combat climate change and to address the impacts thereof.

Technology Mechanism, operating since 2010 (initially operated as Technology transfer framework; with expert group on technology transfer), is served by Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) which serve as their policy and implementation arm respectively. Technology framework established two key tools i.e. Technology Need Assessment (TNA) followed by development national Technology Action Plan (TAP). Support for undertaking TNAs including others related to technology development and transfer are provided by GEF through Poznan Strategic Program on technology transfer. Countries are availing the support provided under this program for example, Côte d'Ivoire received a funding of 3.0 $ million from GEF for Construction of 1000 ton-per-day Municipal Solid Waste Composting Unit in Akouedo Abidjan. The project is also receiving co-financing of 36.9 $ million. This project was endorsed by the GEF CEO in October 2013 and is expected to start implementation soon (GEF 2016c).

While countries are receiving financial supports for developing TNAs and TAPs, municipal authorities can also take advantage of the information which has resulted from their respective country TNA and TAP to prioritize and develop projects based on country's priority and needs. Cities can also request technical assistance from CTCN in many sectors through their nationally-selected focal points or National Designated Entities (NDEs). The CTCN does not provide direct funding support, instead support is provided through experts on specific climate technology sectors. CTCN supports many sectors for mitigation and adaptation which includes energy efficiency, forestry, industry, renewable energy, transport and waste management for mitigation and infrastructure and transport, infrastructure and urban planning, and waste management for adaption among others. For example, Ghana, Kenya, Mauritius, and Namibia benefited from the Green Cooling Africa Initiative through CTCN to prepare for a transformational change towards sustainable cooling sector.

Through this initiative, these countries will develop clear understanding on how the cooling sector contributes to their national energy consumption and total GHG emissions—including emission related to the use of hydrofluorocarbons (HFCs), and where appropriate policy measures are required.

On the similar aspect, cities can benefit from the flagship activity of designing and development of Climate Innovation Centres (CICs) under the infoDev's Climate Technology Program (CTP). In African region Ghana, Ethiopia, Kenya, Morocco and South Africa are hosting CIC to offer seed financing, policy interventions, network linkages, and technical and business training to new enterprises in the climate change space.

4.3.4 Promoting Capacity Building and Experience Sharing

Another aspect which is supported by the Convention is to enhance the ability of individuals, organizations and institutions in developing countries through capacity-building frameworks established under Marrakesh Accords in 2001 (UNFCCC 2001a, b). The Convention established two frameworks for capacity-building that address the needs and priorities of two key groups: developing countries and countries with economies in transition. The frameworks provide a set of guiding principles and approaches to capacity-building, such as being a 'country-driven' process, involving 'learning by doing', and building on existing activities. They also contain a list of priority areas for action on capacity-building, including the specific needs of the least developed countries (LDCs) and small island developing States (SIDs).

African cities can enhance their capacity by taking advantage of the opportunities available under capacity building frameworks. This includes: (i) the Durban Forum for in-depth discussion on capacity-building which is an annual event to share experiences, good practices and lessons learned in building the capacity of developing countries to mitigate and adapt to climate change and; (ii) Capacity-building Portal as a database of capacity-building activities in countries across the world, activities whose focus is to better mitigate and adapt to climate change.

The Convention also has additional instruments for enhancement of capacities through experience sharing. This includes technical examination process (TEP) and private sector initiative (PSI). The TEP organize thematic technical expert meeting (TEM) on regular basis along with Subsidiary Bodies meetings. Under this initiative, in May 2017 a technical expert meeting was organized on urban environment which allowed for the showcasing of specific initiatives, good practices and policy options and focused in more detail on the role of planning in creating an enabling environment for action. 9th African carbon forum in 2017, Cotonou Benin recognized Urban settlements as one of the three key thematic areas (Agriculture and Energy being the other two) for Africa to focus on in terms of climate change mitigation and UNFCCC together with UN Habitat, ICLEI organized several sessions focusing on the challenges and solutions for African cities for a low emission development.

Several of the ministers attending also emphasized the key role of cities in African low emission development, stability, security and prosperity (UNEP-DTU 2017).

PSI is an initiative under Nairobi Work Programme (NWP) which provides a platform for Parties and stakeholders from a range of organizations to collaborate on mitigation and adaptation activities in various sectors, levels and regions, and to build and manage knowledge on adaptation. The initiative led to development of an online database featuring good practices and profitable climate change adaptation activities being undertaken by private companies, sometimes in partnership with NGOs or the public sector. Private sector from Uganda shared a city related adaptation case study "rainwater harvesting and storage technology" on this database. PSI aims to catalyze the involvement of the private sector in the wider adaptation community. This initiative can form an important part of the multi-sectoral partnership that is required between governmental, private and non-governmental actors.

More capacity building opportunities are expected in future under the Convention, as Paris Agreement has established the Paris Committee on capacity-building (PCCB) and capacity-building initiative for transparency. PCCB aims to addressing gaps and needs in implementing capacity-building in developing countries and further enhancing capacity-building efforts, including with regard to coherence and coordination (UNFCCC 2015c). The capacity-building initiative for transparency aims to build institutional and technical capacity and to support developing country Parties in meeting the enhanced transparency requirements of the Paris Agreement. The GEF supports the operation of the capacity-building initiative for transparency. Recently, the GEF upon invitation by the COP has established a Capacity Building Initiative for Transparency (CBIT) Trust Fund in June 2016 with the aim to strengthen the institutional and technical capacities of developing countries to meet the enhanced transparency requirements under the Paris Agreement (GEF 2016a).

4.3.5 Stakeholder's Engagement and Providing Recognition

Many cities are actively engaged in the Convention to showcase their contribution to climate change related activities and get recognition. Presently the Convention has three of such avenues namely NAMA registry, Momentum of Change awards and NAZCA platform to provide recognition to climate actions.

NAMA registry under the Convention has a special section for submitting NAMAs for recognition, thus to bring visibility to such national initiatives.

Momentum for Change Awards identify and honor some of the most innovative, scalable and replicable examples of groundswell of climate action around the world. Amongst the winners of this award were the Emerging and Sustainable Cities Initiative (ESCI) which seeks to address city level climate challenges through developing planning tools like greenhouse gas inventories and risk maps and action plans, as well as African project contenders like Mobisol Smart Solar Homes solutions in Rwanda and Tanzania. This platform also exposes the winners to a range of international media and interactions with policy makers, that provides more attention and support for the initiatives.

NAZCA (an initiative launched in COP 20, 2014) is a global platform that captures the commitments to climate action by companies, cities, subnational, regions, investors, and civil society organizations. The actions undertaken by cities got prominence for recognition under the Convention after the launch of NAZCA. The Paris Agreement further formalized the importance of non-Party stakeholders by calling on them to take action to address and respond to climate change and also invited them to scale up their actions and demonstrate them via the non-State Actor Zone for Climate Action (NAZCA) Platform (UNFCCC 2015d). Cities are amongst the leaders currently on the platform with commitments of over 2500 actions. The platform allows to search by locating cities on the map and have a dedicated portal for cities. The platform already has commitments from many African cities from Southern East and West Africa.

Cities can directly engage by demonstrating their commitments through NAZCA and by either communicating them directly to Compact of Mayors (COM) (On June 22, 2016, the Compact of Mayors and the Covenant of Mayors merged to the Global Covenant of Mayors for Climate and Energy) or registering them through the compact's standard reporting platform-Carbonn or CDP. COM is one of the initiatives which was launched by UN in its New York Climate Summit 2014. COM is a global coalition of mayors and city officials committing to reduce local greenhouse gas emissions, enhance resilience to climate change and track their progress publicly. It is an agreement by city networks—and then by their members—to fight climate change in a consistent and complimentary manner to national efforts. The Compact collects the significant climate action data that cities are already reporting in a consistent, transparent manner and makes that data available in a single place. The Compact builds on existing cooperative efforts, partnering with other initiatives to better measure and communicate the impact of city action. COM has founding partners namely Bloomberg (special envoy for cities and climate Change), the Cities Climate Leadership Group (C40), ICLEI-Local Governments for Sustainability, United Cities and Local Government (UCLG)-Global network of cities, local and regional governments and UN-Habitat. It also has reporting and data partners namely CDP-driving sustainable economies (formerly carbon disclosure project), Carbon registry and UNFCCC NAZCA-non-state actor zone for climate action. The Compact represents the greatest opportunity to bring attention to and quantify city actions.

Another important initiative which was initiated during UN Climate Summit 2014 is the Compact of State and Regions (regions and federated states) relevant to cities. The commitments under this compact are also included in the NAZCA platform. The Compact of States and Regions is an initiative driven by the Climate Group and CDP and provides platform for states, provinces and regions to measure and manage their greenhouse gas emissions. This compact is already collecting climate data from 62 governments representing 17% of the global economy (The Climate Group 2017).

Further, for catalyzing and supporting climate action by Parties and non-Party stakeholders in the period from 2017 to 2020, the Marrakech Partnership for Global Climate Action (GCA) was launched in 2016. GCA aims to support implementation of more climate action now, consistent with the achievement of the NDCs, and to foster greater ambition over time on mitigation, adaptation, and the delivery of finance, technology and capacity building to developing countries. GCA targets to facilitate convening of Party and non-Party stakeholders on an ongoing basis to enhance collaboration and catalyze the scaling up of efforts to collectively identify and address barriers to enhanced implementation, including through the technical examination processes on pre-2020 climate action and multi stakeholder high-level dialogues; Showcasing of successes and providing a platform for new initiatives and greater ambition through events; tracking of progress, through NAZCA, achieved by those actors and initiatives, aligned towards the achievement of the purpose and goals of the Paris Agreement, and supporting the delivery of NDCs and the SDGs; Reporting of achievements and options to enhance action to the COP.

Cities can also engage themselves as stakeholders through initiatives available through other organizations and can also benefit from these programs e.g. C40 Cities Finance Facility (technical and capacity building), UN Habitat Cities and Climate Change Initiative (capacity building), African Renewable Energy Initiative (financial), Urban-LEDs (for MRV), ICLEI's Green Climate Cities (GCC) (for access to tools, instruments, best practices and process management support) etc.

C40 is a network which has brought together more than 80 cities which are committed to addressing climate change. It supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change. Presently, it has seven peer-to-peer networks viz., energy, solid waste management, adaptation and water, transport, measurement and planning, urban planning and development, finance and economic development. C40 also launched another programme called C40 Cities Finance Facility (technical and capacity building) during New York Climate Summit in 2014.

On similar trend ICLEI, among other programs, is implementing GCC and Urban-LEDS project. GCC program supports local communities through a nine step process methodology to analyze, act and accelerate actions in addressing the challenges and opportunities of urban growth, exploring their green economy and green infrastructure and pursue low emission development trajectory. Urban-LEDs aims to promote low emission urban development strategies in emerging economies. This project also has Urban-LEDS city network comprised of model cities, satellite cities and experiences European cities- engaging them in useful south-south-north exchange and peer learning opportunities, as well as a chance to play an active role in the international advocacy process. This project includes model cities (Steve Tshwete municipality, KwaDukuza Municipality) and satellite cities (Mogale city, Nelson Mandela Bay, Saldanha Bay, Sol Plaatje, uMhlathuze) from South Africa.

Many other initiatives which were launched in New York Climate Summit September 2014 and for which cities can benefit from includes but not limited to:

- Cities: Compact of Mayors (commitment from cities), Cities Climate Finance Leadership Alliance (ability of cities to access finance for green infrastructure), Compact of State and Regions (regions and federated states), City Creditworthiness Partnership;

- Transport: International Union of Railways (UIC) Pledge, International Association of Public Transport Declaration on Climate Leadership, Urban Electric Mobility Initiative, Collaborative climate action across the air transport world;
- Renewable energy: SIDS Lighthouse Initiative (action plan for all islands within five years), African Clean Energy Corridor (meeting 40–50% of Africa's electricity needs with renewable energies), Global Geothermal Alliance (increasing the share of geothermal energy);
- Energy efficiency: SE4All Global Energy Efficiency Accelerator Platform which includes Global fuel economy initiative (halve CO_2 emissions from the global car fleet by 2050), enlighten (phasing out incandescent lamps), Global Partnership on Appliances and Equipment, Building Efficiency Accelerator, District Energy Systems Accelerator (urban heating and cooling networks).

4.3.6 Development of MRV and Other Planning Tools for Cities

Cities are also benefiting from various tools which are been developed to fulfill the requirement of measuring, reporting and verification (MRV) framework under the Convention and operationalization of market mechanisms under the Kyoto Protocol. The MRV framework for developing countries under the Convention consist of preparation and submission of national communications (NCs), including national greenhouse gas inventories, biennial update reports (BURs), by developing countries, and an international peer review mechanism dubbed international consultation and analysis (ICA) which comprises of two steps: (a) technical analysis of BURs, and (b) facilitative sharing of views (FSV) amongst Parties. The MRV tools which were developed to support MRV framework's implementation includes inventory tools based on IPCC 2006 guidelines for national greenhouse gas inventories which assist in estimating national and sectoral greenhouse gas emissions and CDM methodologies and tools for estimating emission reductions from mitigation projects, etc. For the purposes of building trust amongst Parties under the Convention, a common measurement, reporting and verification framework was agreed under the Paris Agreement (known as transparency framework). The transparency framework aims at providing a unified system to measure, report and verify progress on implementation of climate commitments and actions made as part of NDC under Paris Agreement.

The Market mechanism under the Convention has developed till June 2017, 97 methodologies which have been used to measure, report and verify emission reductions from various mitigation projects in cities. These methodologies include 24 for buildings (energy efficiency), 23 for waste, 14 for transport, and 36 for energy supply (UNFCCC 2016). The CDM methodologies are also used by many other initiatives under the Convention (e.g. joint mechanism) and other voluntary initiatives which required monitoring and reporting of emission reductions for emissions trading or for recognition e.g. gold standard, Joint Crediting Mechanism (JCM) carbon disclosure projects, etc. These voluntary schemes and regional trading schemes initially relied on market mechanism methodologies (CDM methodologies) but later started complementing them with their own MRV tools.

Various MRV tools have been developed by relevant organizations to facilitate globally consistent measurement and reporting of GHG emissions by cities. These include GHG quantification software with GHG inventory and action planning functions e.g. Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), Clearpath (now adjusted in line with GPC), HEAT+, Urban-LEDs; framework and checklists e.g. "MRV of Urban LEDS: ICLIEI's green climate cities handbook for local governments"; reporting platforms such as Carbonn® Climate Registry (the Compact of Mayors designated central repository). GPC has been accepted as the first global standard to measure GHG from cities. It has been jointly developed by ICLEI, the World Resources Institute (WRI) and C40, with additional collaboration by the World Bank, UNEP, and UN-Habitat. GPC provides global reporting standard for enables cities and communities to consistently measure and report GHG emissions and develop climate action plans and low-emission urban development strategies. Many local governments (Cities, towns) are reporting to Carbonn Climate Registry and Compact of Mayors using GPC (ICLEI 2017). Cities are also reporting their climate related data through Carbon Disclosure Project (CDP). About 533 cities disclosed their climate-related data through CDP's cities program, in 2016.

While the initial purposes of these MRV tools were to accurately measure and report emission reduction, they are enormously used by local authorities and individual stakeholders to get recognition. The development of MRV tools also extended to measure and report co-benefits from mitigation projects with regard to sustainable development.

The UN Habitat's *Guiding Principles for City Climate Action Planning* provides typical steps for climate action planning process at the city-level in light of a proposed set of globally applicable principles (UN-Habitat 2015). These principles were developed through a robust and open multi-stakeholder process, to support local officials, planners and stakeholders in climate action planning with the view to helping cities reduce greenhouse gas emissions and adopt low emission development trajectories, as well as adapt to the impacts of climate change and build local climate resilience. These *Guiding Principles* are intended to be applied flexibly to help city leaders and city planners to more effectively play their role in reducing greenhouse gas emissions and thereby contributing to achieving the global 2° temperature goal as set out in the Paris Agreement; help build climate resilience and above all meet other long-term goals such as socio-economic development and environmental protection.

4.4 Minimizing Adverse Impacts of Implementation of Response Measures

Whilst implementation of mitigation and adaptation actions remain the priority needs for Parties and non-Party stakeholders, there is also an emerging need for Parties and non-Party stakeholders to assess and address the impacts of implementation of mitigation actions (response measures) so as to ensure a more cohesive and robust sustainable development. Many governments are now waking up to the realization that they also face the impacts of mitigations actions taken to address climate change both within their own jurisdictions and as well as those taken outside their jurisdictions by other Parties or non-Party stakeholders. The most difficult challenge is how to address the impacts of cross-border mitigation actions.. These impacts including social, environmental and economic impacts, for example, the closure of some businesses like coal mines and coal power plants; or the transition to the use of zero or low carbon emitting fuels may not only have impacts that must be addressed at the country level but also at state and sometimes city levels within a country. Cities which are also home to export industries may experience economic impacts due to national and cross border climate change policies e.g. rent from exports due to implementation of carbon labelling standards and policies in trade relations. As indicated early this aspect of addressing the impacts of mitigation actions is still at nascent stages of development but will gain momentum due to higher mitigation ambitions under Parties may take under the Paris Agreement, as well as the importance of 360° sustainable development at global level.

The Cancun, Durban and lately the Paris Agreements have created a space, (forum on impacts of implementation of response measures), where Parties are now discussing how to address these impacts. Discussions are currently focused on economic diversification; and just transition of the work force and the creation of decent work and quality jobs. Cities are not insulated from these types of impacts that may arise due to the city's own mitigation actions taken or mitigation actions taken by other cities, states or actions taken at the national level. Cities can therefore benefit from the development taking place under the improved forum on impact of implementation of response measures under the Convention by developing relevant capacities to assess and address these impacts. The forum will also serve the Paris Agreement by enhancing cooperation amongst Parties on understanding the impacts of mitigation actions under the agreement and the exchange of information, experiences, and best practices amongst Parties to raise their resilience to these impacts (UNFCCC 2015b).

4.5 Co-benefits from Cities Actions to Climate Change

Due to the very nature of inter-linkage of the different elements contributing to sustainable development, it is important to view the actions taken with focus on climate change in relation to other elements of sustainable development to truly value the impact of the climate actions at city level. For most governments, what drives actions on climate change is not just to mitigate greenhouse gas emissions, but to ensure other, often equally or more important, societal, economic and environmental benefits are derived. In like manner, development of climate smart and climate resilient cities will have positive social, environmental and economic impacts linked to them. These positive impacts referred to as co-benefits of climate focused development, should be considered when evaluating the cost-benefits of climate actions at city level.

Under the Convention and its related instruments, this relationship is clearly recognized by linking climate action in developing countries always with support for sustainable development (Banuri 2009). Marginal greenhouse gas abatement costs demonstrate, for some of the technologies due to co-benefits give negative net costs for abatement, as the savings from co-benefits themselves will more than pay up the cost of mitigation efforts (Enkvist et al. 2007). Furthermore, several studies demonstrate the push for climate actions can be encouraged solely considering the local co-benefits (Bain et al. 2016).

Due to its political appeal from direct short term socio-economic impact that can be focused at local level, it is an easier for city authorities to sell co-benefits to their citizens than the climate change mitigation initiatives with long-term global consequences to which the African cities relative contribution are still negligible. As the citizens will experience the enhancements brought by climate change co-benefits in their daily life and work, support for the climate initiatives at city level will be greater even than that at national level.

Analysis of case studies by UN University indicate that most of the climate action at city level has been driven by economic development concerns mainly and catalyzed through climate focused action. An example is given of the first rail-based transport CDM project, of Delhi Metro rail system in India that was driven by the need for solution to the transport issue in the city (Oliveira et al. 2013). Hence, in context of Africa where capital, in general for climate action both for mitigation and adaptation are hard to come by, and the natural and social systems are fragile, it is important that addressing the climate challenges linked with city development is viewed holistically on how these actions contribute to wider sustainable development.

The UN university in its report (Oliveira et al. 2013) has used the term "urban climate co-benefits" to define the implementation of initiatives at city level (policies, projects, etc.) that simultaneously contribute to reducing the contribution to man-made global climate change while solving local environmental problems in cities, and in turn potentially having other positive developmental impacts, such as improvements in citizen health, energy security and income generation. IPCC further distinguish these intended actions (co-benefits) from un-intended positive benefits by terming the unintended outcomes as ancillary benefits. The UN university in its report (2013), further states that given the variable nature of co-benefits, promoting addressing of co-benefits will be more effective at city level as it is easier to identify, plan, implement and measure co-benefits at the city level rather than national level, as municipalities can link their local climate policy to their own local content, making local climate policy more visible, specific and recognizable.

It is important to note that the anthropogenic greenhouse gas generation inducing climate change as well as actions for adaptation to climate change at city level are intricately linked to the urban development needs in terms of poverty reduction and job creation, energy security, housing and shelter, transportation, food security, health and sanitation, industrial & technological growth etc. As development is the common driver it gives ration to view climate related action as a part of the bigger picture of sustainable development of cities and not as an isolated set of actions.

Recent research by London School of Economics (Floater et al. 2016) on co-benefits of climate change mitigation and adaptation measures at cities has broadly categorised the co-benefits of climate actions into 5 strategic sectors of health, mobility, resources, economy and buildings, considering policy areas where many city governments have strategic goals that resonate with urban citizens. These co-benefits in the 5 strategic sectors can be in all 3 pillars of sustainability i.e. social economic and environmental.

Health benefits whether mainly through improved air quality linked with climate measures in transport sector, or house hold energy generation or energy efficiency are most commonly covered topic in the literature on climate change mitigation co-benefits (Harlan and Ruddell 2011). These are also very relevant for Africa where indoor air quality through cooking fuels like charcoal/wood in urban areas is still an issue. Improved cook stoves also have a gender aspect linked to their focus on improvement focusing African women. On the other hand, transport and industry related air pollution is a major issue in the larger cities of Africa creating a heavy burden on the health care systems due to respiratory related health complications. Hence the climate change mitigation action related air quality improvements experienced at local level has proven level of major reductions in associated healthcare costs. Other mitigation related areas like waste management and promotion of non-motorized transport also contribute to improved health co-benefits due to improved living conditions and lifestyle changes. Adaptation measures also have their own linked co-benefits that are critical in African city context like the associated co-benefits in reduction of vector borne diseases, urban heat wave and flooding related health issues.

Mobility co-benefits are both experienced through climate actions in transport sector and land use change. Reduction of traffic congestion through climate action in introduction of improved public transport systems like the bus rapid transport can work well in many of the African capitals where traffic is contributing to reduced productivity. They also bring about reduced consumer costs for vehicle maintenance and favorable trade balance through reduction in importation of vehicles. Climate mitigation actions linked with changes in transport logistics, modal changes, freeing up land can also reduce the parking space issues experienced in almost all major African cities. Also, adaptation measures for storm water management can reduce congestion caused by inundation of transport routes during rainy season.

In the sector of resource co-benefits, reducing dependency on imported fossil fuels through renewable energy, fuel switching and energy efficiency measures is a solution for many of the African cities that are set to gain on improved energy security for their sustainable development. Another area of co-benefits that are critical for sustainable development of African cities is water and food security that have co-benefits in all three sustainability pillars. Climate change adaptation measures as well as mitigation measures (in waste management like composting, water purification, waste water treatment, climate friendly sub-urban agricultural practices) can create co-benefits in this sector.

Sector of economy besides being a major pillar in sustainability is highlighted here as a sector for policy as this being the major driver of the city growth. The climate change mitigation and adaptation efforts contribution to compact economic urban growth and urban regeneration through simulating the economy by influx of green jobs and revenue is a key factor for focus here. All climate projects and policies will create new jobs and investment opportunities if correctly managed and will also lead to the sustainability of these initiatives in the long run. Other areas like eco-tourism, resource efficiency and education related fields that are directly or indirectly boosted by climate actions will also play a critical role here.

The co-benefits in buildings sector for example through creation of smart energy efficient, climate resilient households and workspaces in African cities can provide more affordable and comfortable living and working space solutions to their citizens.

As discussed in the previous sections the importance of the topic of addressing climate change has taken high-level of attention at global level creating a flow of finance, technology and capacity building to African countries from the developed countries, incentivizing climate action. If African cities are to reap full benefit, it is critical to have strategic approaches on how to mainstream these actions to support the national and city level sustainable development. Climate finance and other linked development support while an incentive is not sufficient to drive the transformative scale of sustainable development needed in African cities without mobilizing the local public and private finance. For public sector to engage it is important to understand how these actions taken with the climate focus are linked to developmental priorities that the governing structures are pressed to bring about and their contribution to the developmental policy priorities so they can allocate public finance earmarked for such developmental issues. For the private sector to engage it should be attractive economically to invest in with high level of assurance of economic returns. Sustainability and transformative development cannot be achieved without mobilizing the large amount of money that private investment only can bring. While climate change mitigation or adaptation can have some direct returns like in case of renewable energy and energy savings, due to the high capital expenditure and associated risks most of these climate initiatives does not take place unless the climate finance can be supplemented by other de-risking instruments. Monetizing the co-benefits and their associated cost savings and transferring this to benefit the implementers have been identified as an approach to bridge this gap in investment to mobilize the climate initiatives through de-risking investment in climate action.

4.5.1 Achieving Sustainable Development Goals Through Climate Action by Cities

Adopted by the world leaders in the same years as the Paris Agreement in 2015, Sustainable Development Goals (SDG) came into implementation at start of 2016 succeeding Millennium Development Goals. Within the Convention negotiations there is an increased effort to identify how the climate actions can contribute to support countries meet their SDGs. As per the UN DESA (Department of Economic and Social Affairs) working Paper No. 141 the key improvement in this succession was the integration across sectors in terms of strategies, policies and implementation which was a pitfall in the MDGs specially resulting in underperformance with regard to environment related goals. Per this study goal 13 of the SDG—"*take urgent action to combat climate change and its impacts*", is directly linked with achievement of goals under six other SDGs including goal 11 on making cities and human settlements inclusive, safe, resilient and sustainable (ICSU and ISSC 2015).

While the lack of focus on sustainable development co-benefits have been one of the criticisms against clean development mechanism (CDM) of the Kyoto Protocol, targeting the compliance carbon market, this has been strong point of sale for the existing voluntary carbon trading schemes targeting corporate social responsibility. It is evident that there is an increased effort to bridge this gap with the slowdown of the compliance carbon market for which the CDM projects dependent on, as the Convention introduced a voluntary sustainable development declaration tool for CDM projects. Performance of co-benefits have always been an important aspect of NAMAs and many other bilateral and multi-lateral climate finance introduced under the Convention and there are studies already investigating how sustainable development can be integrated in future collaborative mechanisms (Dransfeld et al. 2017) under the Paris Agreement. In climate change adaptation, due to lack of consensus on measuring the reduction in vulnerability, measuring of performance of co-benefits in terms of job creation, improved health, improved environmental services and access to water etc. have been always prominent for monitoring performance of adaptation projects.

4.5.2 Quantifying Co-benefits of Climate Actions by Cities

In order to quantify the co-benefits, it is important to identify appropriate indicators and methods to measure them in a consistent, transparent and comparable manner. The process will be to identify the baseline scenarios for such indicators and then measure the changes due to impact of the climate measure versus the established baselines in a quantifiable manner.

Several initiatives like the Gold Standard have already taken steps to introduce tools to quantify co-benefits of climate mitigation action and create a premium for the emission reduction units generated at city level, thus increasing the project returns through their sale. However, more local/national level actions are feasible through performance based saving transfer system to the implementers of the climate actions to facilitate implementation of city level initiatives targeted to benefit from potential climate finance.

With the increased focus on co benefits for measuring the success and valorization of action standardization and use of widely accepted methodologies are becoming increasingly a need. Hence, there is a trending effort to broaden the MRV systems which focused only on the emission reduction aspects, to also consider co-benefits. The concepts of baselines and other tools are also customized to also consider performance of the action in co-benefits. In the mitigation world, voluntary emission reduction schemes like the gold standard or combinations of emission reductions with some of the other social certification systems like World Commission on Dams (WCD) assessment and Fair-Trade certification started introducing MRV aspects in co-benefits. However, it was the introduction of NAMAs and the need by most supporting agencies demonstrated transformative impacts of projects that initiated development of more robust MRV systems for co-benefits.

There are multiple frameworks introduced to address this, at city level (Floater et al. 2016) or those that focus on sector level activities energy generation and efficiency, transport, waste management, green buildings, water purification that are developed by UN, other international development organizations, academics, and sectoral associations as well as governments, for example, "Manual for the Quantitative Evaluation of the Co-benefits Approach to Climate Change" by the Ministry of Environment of Japan; Valuing the sustainable development co-benefits of climate change mitigation actions; etc. are at the disposal of African cities to consider (Santucci et al. 2015).

Next step will be find an acceptable methodology to monetize the expenditure that would have been needed to be spent to achieve that change in lieu of the project and transfer the saving to provide incentive to the climate change action implementer. For example, the savings on health benefits can be quantified by calculating the change in the disability-adjusted-life-year (DAILY) averted after the project/policy implementation versus the baseline figure and convert the difference based on the spending per unit. Once the economic saving is quantified and monetized there are several instruments at the local government disposal that this transfer can be done either as directly on performance-based payments or as subsidies and tax exemptions.

However, there are still multitude of complications that needs to be overcome in order to mobilize such a system. One is the intrinsic challenge of measurement that is cost effective and allocation of a formula for monetization acceptable to all stakeholders. Most of the methods that are available while may work for the mega cities in developing world context may be still a challenge for the cities in developing countries in Africa. Especially at city level with limited resources, means and methods for identifying and recording the necessary data.

Secondly the savings from co-benefits may not be directly experienced at the local government level that manages the city implementing climate action due to the cities not been closed systems. The cities are vibrant having interactions with its surrounding in order to sustain its growth. Whether it be the material for construction and production, food and water, human resources inflow from surrounding or energy and information flow from wider region or across the globe, to out flow of waste, trade and other material including pollutants out of the city limits, the cities are constantly interacting with their surrounding and growing. What this signify is that co-benefits of climate action by cities may not necessary be limited to city limits that are politically determined for governance, but will be impacting a wider surrounding area.

While even within cities where these transactions between various parties can be complicated, some of these savings may be hence relevant to national government budgets and in Africa the flow of funding between local governments where actions are implemented and national governments where benefits may be experienced has been always a challenge.

Finally lack of awareness levels of citizens at large specially on the environmental challenges as well as the strict implementation and enforcement of environmental regulations and standards are a big hurdle that the African city authorities are facing. Hence for African cities are to fully benefit from the opportunities presented under the Convention for climate actions at city levels with co-benefits, there an urgent need for capacity development focusing on institutional, systemic and human resource development and coupled with targeted education and awareness creation for all stakeholders, better regulatory systems, policies integrating that ensures national and local government interactions, more effective allocation of public finance, establishing and improving efficiency to deliver cross-departmental co-benefits, better institutional arrangements and improved information management systems.

4.6 Conclusion

Africa is rapidly urbanizing, becoming nodes of economic and population concentration. This growth, (fueled by increased energy consumption), on one hand leads to higher GHG emissions, and on the other leads to greater exposure to climate vulnerability and risks. The rapid urbanization provides opportunities as well as challenges for climate actions. This chapter reviewed the opportunities available for African cities under the United Nations Framework Convention on Climate Change for transformation to low-carbon climate resilient smart cities and how much African cities have benefited from these opportunities. In doing so, it analyzed how the Convention is encouraging public-private partnership, technology transfer, capacity building, stakeholder engagement and development of measuring, reporting and verification frameworks.

Notwithstanding the numerous opportunities that prevail under the Convention and its related instruments, African countries have generally least benefited from these opportunities. It is therefore not surprising that local or municipal authorities in Africa have also not been able to avail themselves of the provisions of support in the form of finance, technology, capacity building, development of measurement verification and reporting systems, recognition for implemented actions, etc. There is a need of more focused attention and targeted capacity building for local authorities within Africa during the period of implementation of Paris Agreement for them to actively engage and contribute to the global effort to address climate change and assist their constituencies to better able to adapt to the impacts thereof.

It is also observed that measures taken to respond to climate change could also have unintended positive and negative impacts. The positive impacts, often referred to as co-benefits, need to be enhanced and in fact could be used for further promoting ambitious climate actions, whilst efforts need to be taken to minimize the unintended adverse social, economic and environmental impacts especially on the most vulnerable communities and sectors.

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Chapter 5
Biodiversity for Smart Cities

Mohamed Imam Bakarr

Abstract The African continent is urbanizing at a rapid rate, and projected trends suggest that over 1.3 billion people will be living in urban areas by 2050. In most African countries, this means expansion of cities and increasing pressure on municipal governments to balance urban development needs with environmental sustainability. For cities located in the continent's biodiversity hotpots, the urban expansion will occur at the expense of biodiversity and fragile ecosystems. Because of the potential for urbanization to drive economic growth and prosperity in Africa, it is essential that cities and municipalities embrace a paradigm of urban development that is smart and sustainable, and as a result contribute toward safeguarding biodiversity. Such a paradigm will embody two key priorities to integrate biodiversity: (a) African cities must tackle threats to biodiversity from urban sprawl, including habitat loss, overexploitation of species, and degradation of ecosystem services; and (b) cities must harness ecosystem services by integrating components of biodiversity as livelihood assets and "green infrastructure" to enhance sustainability and resilience in the cityscape. Drawing on examples from across the continent, this chapter discusses these two priorities as basis for Africa's cities to integrate biodiversity conservation in their planning processes toward smart and sustainable growth. City and municipal governments must create appropriate institutional and governance frameworks to harness available data and information, promote integrated planning and management, and apply innovative tools and citizen participation for monitoring and assessment of biodiversity and ecosystem services. The role and importance of ICT is highlighted as key to advancing a science-based approach to integrating biodiversity in smart cities, which will foster collaboration by experts across a range of disciplines such as landscape ecology, wildlife biology, animal behavior, and sociology.

The views expressed here are solely those of the author, and do not reflect any policy or position of the Global Environment Facility.

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Green infrastructure · Landscape conservation

5.1 Introduction

While Africa is the least urbanized region in the world, its urban population is projected to more than triple from about 395 million in 2010 to 1.339 billion in 2050 (UN 2014). A recent assessment by Seto et al. (2012) has shown that the built-up area of urban Africa, which was 33,025 km^2 in 2010, will increase by 590% over the subsequent three decades. This growth and expansion will undoubtedly exacerbate the myriad of challenges already facing most of the continent's major cities, much of which is centered around balancing urban development needs (water, sanitation, housing, transport, jobs, etc.) with environmental sustainability (Güneralp et al. 2017). For most African countries, the projected expansion of urban areas will occur at the expense of biodiversity and fragile ecosystems. This will simply be too high a price to pay, and with potentially long-term negative consequences for people and the environment.

While the potential for urbanization to drive economic growth and prosperity in Africa has been recently highlighted (AfDB/OECD/UNDP 2016; Collier 2017; Lall et al. 2017), ensuring that the growth is smart and sustainable will be a major challenge for city leaders and municipal governments. With the growing availability of data and the penetration of information and communication technology (ICT) infrastructures across Africa, urban transformation that is smart and sustainable is certainly feasible. As noted, however by Barthel and Colding (2017), the smart city concept has tended to overlook the issue of ecological sustainability, or the role of ecosystem services in the cityscape. Because urban residents throughout Africa tend to depend on natural resources use for a diversity of needs (e.g. food, fuel and medicine), municipal governments must consider biodiversity and ecosystem services as priorities in their city planning and development processes. Through this effort, African cities will embrace a paradigm of smart and sustainable growth that is consistent with the need to safeguard biodiversity across the continent.

This paradigm of urban transformation will embody two key priorities, in line with approaches and perspectives emerging from the Convention on Biological Diversity (Puppim de Oliveira et al. 2011; CBD 2012). First, cities must tackle threats to biodiversity from urban sprawl, including habitat loss, overexploitation of species, and degradation of ecosystem services. This requires a deliberate effort by municipalities to identify and secure specific areas of the city-scape that are deemed critical for achieving biodiversity conservation goals. Second, cities must harness ecosystem services by integrating components of biodiversity as livelihood assets and "natural infrastructure" in the city-scape (Güneralp et al. 2017). Trends in African urbanization suggests that urban sprawl resulting from population growth in cities will increase pressure on natural resources, including land, biodiversity, biomass and water (Cobbinah et al. 2015), and potentially exacerbate vulnerability of cities to global environmental change (Parnell and Walawege 2011). Creating opportunities for efficient utilization and management of these resources is at the heart of "greening" Africa's cities (White et al. 2017), and will contribute to food and livelihood security as well as increase overall resilience of the cityscape.

This chapter discusses these two priorities as basis for Africa's cities aspiring for smart and sustainable growth to integrate biodiversity conservation in their planning processes. The overall objective is to highlight and discuss the need for a paradigm shift in urban development that integrates biodiversity and ecosystem services into planning for smart and sustainable growth. The chapter draws on examples from across the continent to highlight how such a paradigm shift can be pursued through integrated and holistic approaches. Following this introduction, the chapter is organized into five main sections as follows: first, it provides a broad overview of the links between biodiversity and urbanization, and highlights the need and opportunities for integrating conservation into urban development; second, it discusses approaches for identifying and prioritizing biodiversity conservation targets in planning for smart and sustainable growth; third, it describes the role and importance of ecosystem services in the urban space, including examples of how these services can be harnessed for smart and sustainable growth; fourth, it discusses how cities can advance landscape conservation strategies that include important targets in the peri-urban and rural areas; fifth, it outlines key priority needs that African countries must address in building smart cities for biodiversity conservation, such as availability of data and information, access to tools for planning, management, monitoring and assessment of biodiversity, and the application of ICT for biodiversity conservation in the urban space. The chapter concludes by emphasizing the need for city leaders and municipal governments to create the necessary framework to promote citizen participation in smart and sustainable city programs that integrate biodiversity.

5.2 African Biodiversity and Urbanization

The African continent is endowed with a rich biological heritage, with diverse ecosystems and a unique assemblage of species. But the need for smart and sustainable urban development that integrates biodiversity is particularly crucial in the continent's biodiversity hotspots (Myers et al. 2000).[1] The biodiversity hotspots are biologically distinct regions that have been identified as among the most threatened, of which there are nine across the African continent and its associated islands (Fig. 5.1). It has been shown that human population growth rates are substantially higher in the biodiversity hotspots than elsewhere in the world (Cincotta et al. 2000). These hotspots in Africa are home to many of the continent's major cities, some of which are

[1]The initial 25 hotpots identified by Myers et al. (2000) were later revised to 36 by Mittermeier et al. (2005). These hotspots together cover only 16% of the Earth's surface and yet contain at least 50% of the world's total plant species and 42% of the world's terrestrial vertebrates as endemics. Each of the hotspots have lost at least 70% of their original extent, and remaining habitats are under immense pressure from anthropogenic land uses.

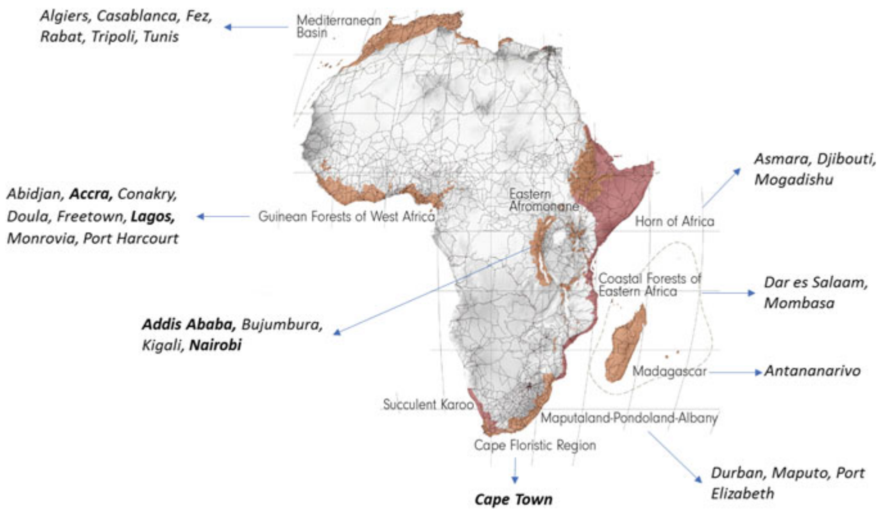

Fig. 5.1 Major cities in the African biodiversity hotspots (bold font indicates cities projected to sprawl into remnant habitats; map is from Weller et al. 2017 with information from conservation international and critical ecosystems partnership fund http://www.cepf.net/resources/hotspots/pages/default.aspx)

projected to sprawl into remnant habitats (e.g. Accra, Addis Ababa, Cape Town, Durban, Lagos, and Nairobi), further exacerbating threats to biodiversity and ecosystem services (Weller et al. 2017). In the absence of effective strategies to integrate biodiversity conservation priorities in the city-scape, the prospect of urban sprawl from rapid population growth will likely exacerbate habitat loss and species extinction risks in the hotspots (Seto et al. 2012).

Because of the high level of endemism in the biodiversity hotspots (i.e. plant and animal species that are found nowhere else on the planet), the risk of losing species through effects of urbanization is particularly high. Ten of the cities located within hotspots—Abidjan, Accra, Addis Ababa, Casablanca, Cape Town, Dar es Salaam, Durban, Lagos, Mogadishu, and Nairobi—are amongst the most highly populated metropolitan areas in Africa, with a combined total population of nearly 70 million. Two of the hotspots—*Eastern Afromontane* and *Guinean Forests of West Africa*—considered as relatively undisturbed by urban development in 2000 are among those projected to experience the highest rates of growth in urban area by 2030, with estimates of 1900 and 920%, respectively (Seto et al. 2012). The *Cape Floristic Region*, also considered a "floral kingdom" for its plant diversity, is home to the city of Cape Town whose population of 3.7 million in 2010 is increasing by 55,000 annually (Holmes et al. 2012).

In addition to loss of natural habitats from expanding settlement within and around cities, urbanization across the African continent will lead to overexploitation of species, expansion of agricultural land use, and deforestation in rural and peri-urban areas. This will be largely driven by demand for food, fuel (wood and charcoal), and wildlife products (e.g. bushmeat, herbal medicine) from urban residents. A study by Ahrends et al. (2010) showed that demand for forest resources (charcoal and timber) from the city of Dar es Salaam in Tanzania created concentric waves of forest degradation and biodiversity loss. Such progressive deterioration of the environment in peri-urban landscapes is inevitable as population of cities continue to rise. Under these circumstances, establishing clear targets for conservation of biodiversity and ecosystem services, and integrating them into urban planning processes must be a priority for municipalities aspiring for smart and sustainable growth.

5.3 Cities and Biodiversity Conservation

Over the last two decades, priorities for biodiversity conservation across Africa have been well established and documented at the level of biomes (Brooks et al. 2001; Burgess et al. 2006), within specific biomes such as for the Cape Floristic Region in South Africa (Cowling et al. 2003), and for specific taxonomic groups such as birds (Fishpool and Evans 2001) and plants (Marshall et al. 2016). Some regions and countries have used these continental level priority-setting processes to identify and target key biodiversity areas (Kouame et al. 2012); nearly 2000 key biodiversity areas have been identified to-date across the continent (BirdLife International 2018b). The biodiversity priorities have increased understanding on how areas of outstanding conservation importance could potentially conflict with increasing human populations and settlements across the continent (Balmford et al. 2001; Rondinini et al. 2006).

With the advances made in targeting biodiversity conservation actions and investments, African countries are now well-positioned to play their part in building a comprehensive global protected area system (Brooks et al. 2004). There are now over 8000 protected areas of different types and sizes across the continent, covering nearly 17% (4.4 million km^2) of the land mass (UNEP-WCMC 2018). Many of the protected areas are National Parks that play a major role in generating revenue through tourism, which accounts for a significant proportion of the annual gross national product in some countries. As a result, they provide indirect benefits to urban areas through job creation in the service industries that cater to needs of visitors. In some cases, the benefit is directly through proximity of the protected area to major urban centers, even though the proximity sometimes creates management challenges.

The multi-scale processes provide an adequate backdrop for African countries to promote biodiversity conservation in urban planning for development of smart and sustainable cities. Countries could establish clear targets for species and habitats that can be safeguarded within the city-scape and peri-urban landscape, including options for mitigating long-term threats to their survival. Even for those species that can adapt to urban environment, it is well established that anthropogenic stressors and disturbances can have long-term consequences on their fitness and survival (Ditchkoff et al. 2006). Patches of native vegetation in the city-scape can serve as important refuge for endemic species, and can be invaluable for foraging by birds and insects. If appropriately targeted, protection of such patches can also contribute to improved habitat connectivity and create corridors that some wildlife species can use to navigate the city-scape (Jarošík et al. 2011). In addition to their importance for species conservation, habitats such as wetlands and riparian forests in the city-scape can be invaluable for pollution control and flood management, which are important ecosystem services derived from biodiversity.

5.3.1 Protected Areas in Urban Landscapes: Case Study of Kenya's Nairobi National Park

Protecting biodiversity in urban landscapes poses a myriad of management challenges, but also opportunities for strengthening links between urban development and biodiversity conservation. Nairobi National Park in Kenya is one of few protected areas around the world that are located within proximity of a major urban center, and symbolizes many of the opportunities and challenges. It is located less than 10 km from Nairobi, the national capital city of the Republic of Kenya. The park covers 117 km^2 and was officially designated in 1947. The ecosystem is characterized by a unique combination of rolling grass plains, riverine woodlands and upland dry forests, which are part of the Athi-Kaputiei plains and home to Maasai pastoralists (Owino et al. 2011). Amongst the flagship wildlife species occurring in the park are lions, wildebeest, bufallo, Burchell's zebra, eland, giraffe, impala, and gazelles.

Within reach of a population of over 4 million in the metropolitan area, the park is one of Nairobi city's major assets for urban recreation. The park's unique ecology and proximity to Nairobi has made it a popular destination for residents and tourists visiting the country. The road infrastructure for game drives, a Safari Walk, an animal Orphanage, and several picnic sites are key features of the park that attract the city residents and visitors. Thus, the Kenya Wildlife Service, which has oversight for all National Parks in the country, is not only able to generate revenue from entrance fees, but also conduct major public outreach and awareness on its mandate: conserve and manage wildlife in Kenya, and enforce related laws and regulations.

Despite its strategic importance for biodiversity conservation, Nairobi National Park is increasingly plagued by urban sprawl. This has inevitably resulted in numerous cases of human-wildlife conflict, including incidences of livestock predation in nearby ranches (Gichohi 2000). Although a permanent fence on its northern, eastern and western boundaries is preventing encroachment from the city, the southern boundary opens to a larger wildlife dispersal area in the Athi-Kaputiei plains. The dispersal area is critical for the larger herbivore species, especially during the wet seasons when most spend significant time grazing and calving in the rangelands. With the urban sprawl and changing land use in the dispersal area, which is largely private or communal land owned by the Maasai pastoralists, seasonal movement by wildlife in Nairobi National Park will be increasingly constrained (Owino et al. 2011).

A recent assessment by Oyugi et al. (2017) has shown that degradation of the natural habitats and encroachments into the natural ecosystems in the southern wildlife migration corridor is attributed to urban built-up developments, which have also brought unprecedented fragmentation and isolation of the remaining natural ecosystems. Efforts to tackle this threat have therefore focused on incentivizing land owners to maintain rangelands for free movement of wildlife (Rodriguez et al. 2012). In 2000, a Wildlife Conservation Lease scheme was initiated to provide cash compensation to land owners that agree to the following conditions: to manage the land for the benefit of wildlife and sustainable livestock grazing; to leave land under lease open and not to install any perimeter fencing; no cultivation, mining or quarrying; keep land free of buildings or any other structures; and to protect indigenous plants and trees (Matiko 2014). Such a strategy offers the Nairobi municipal government the opportunity to integrate the migration corridor into a smart and sustainable growth strategy for the city.

5.3.2 Habitat Conservation in the City-Scape: Case Study of Biodiversity in Cape Town, South Africa

Because of the dynamic nature of cities, biodiversity can exist in a spatio-temporal mosaic as urban landscapes are developed and transformed (Kattwinkel et al. 2011). For cities located in the world's biological richest ecoregions, this reality can be factored into planning for biodiversity conservation in smart and sustainable cities. It presents an opportunity for city and municipal governments to engage urban residents and land owners as conservation stewards, and for potentially mobilizing finance to invest in conservation of local biodiversity within the city-scape. This approach is exemplified by the city of Cape Town, South Africa's most southwestern city located in one of the world's biodiversity hotpots, the Cape Floristic Region.

The city of Cape Town is home to some 3350 species of plants, including 190 of which are endemic to the city itself (Goodness and Anderson 2013). The city's unique biodiversity is a significant component of the globally important Cape Floral Kingdom, and an invaluable asset for economic development in the municipality (Rebelo et al. 2011). Yet it is under immense pressure from urban sprawl, invasive non-native species, and consequences of suppressed natural fire regimes. An estimated 61% of the city's natural vegetation has already been transformed by development, resulting in threats to its unique assemblage of plant species (Holmes et al. 2012). While urban expansion and development is a major threat to biodiversity, the municipality is also now playing an important role in advancing conservation of the globally important ecosystem.

By integrating management of its biodiversity into the city-scape over the last decade, Cape Town has emerged as a model for applying systematic conservation planning tools in an urban context. The approach and framework utilized high quality data on species and habitats to establish targets for conservation, identify critical areas for improved management and restoration, and inform policies and actions for various stakeholders in the municipality (Holmes et al. 2012). By combining science-based and data-driven decision-making process with innovative practices for urban planning, the city has been able to increasingly accommodate biodiversity priorities as part of its smart and sustainable growth strategy.

With the diversity and abundance of plant species in the city-scape, there are considerable opportunities to improve conservation of a wide range of animal species, including small mammals, birds and invertebrates, some of which are endemic to the city (Rebelo et al. 2011). As a result, the city can also contribute effectively toward safeguarding biodiversity in the entire Cape Floristic Region, which also includes Table Mountain National Park and several nature reserves.

5.4 Cities and Ecosystem Services

Establishing targets for species and habitat conservation in the city-scape and peri-urban areas is a major role that cities can play in safeguarding biodiversity. While the intrinsic value of biodiversity is an essential rationale for African cities to invest in conservation, an even greater justification lies in the "ecosystem services" that humans derive from nature in the city-scape. The Millennium Ecosystem assessment (2005) divided these services into four categories: *provisioning services; regulating services; habitat or supporting services;* and *cultural services*. Table 5.1 presents examples of the kinds of services under each of these categories, that are of major significance in African cities, including some useful references from across the continent.

As shown in Table 5.1, biodiversity and ecosystem services in cities are important in many ways, from the role of trees and green spaces in improving air quality, wetland habitats regulating hydrological flows (into and out), vegetative cover protecting against soil erosion, to habitats providing areas for recreation, cultural inspiration and spiritual fulfillment. According to TEEB (2011), a focus on ecosystem services can support the work of city authorities in at least three ways:

(a) Benefits derived from a functioning environment can be linked directly to delivery of a municipal service, such as access by urban residents to clean water flowing from a forest watershed in the per-urban landscape;
(b) Decision makers can use value of ecosystems services to assess costs and benefits of new developments in the city-scape; and
(c) Opportunity for effective communication between all line functions and with the public, about the environmental consequences and the wider economic and/or social implications of a decision on development within the city.

In the context of advancing biodiversity for smart cities development in Africa, two important priorities can be considered: "greening" of cities for multiple envi-

Table 5.1 Selected ecosystems services of significance in African cities (based on Bolund and Hunhammar 1999; TEEB 2011; and Cilliers et al. 2013)

Ecosystem service	Significance in African cities
(1) *Provisioning services: ecosystem services that describe the material or energy outputs from ecosystems*	
Food	Although much of the food consumed by city residents is from managed production systems in the rural areas, the urban and peri-urban landscapes of most African cities is also widely used to meet food and nutritional needs (see Smith 2001; Vermeiren et al. 2013; Sabiiti and Katongole 2016)
Raw materials	Vegetation in the urban and peri-urban landscape of African cities is a major source of raw materials for wood for construction, biomass fuel (firewood and charcoal), and in some cases traditional medicine (see Ahrends et al. 2010)
Freshwater	In most African countries, cities are associated with rivers or streams that serve as sources of water for drinking and other consumptive uses. For urban systems associated with watersheds, the quality and quantity of such flows is directly influenced by the forest ecosystem (see Jacobsen et al. 2012)
(2) *Regulating services: The services that ecosystems provide by regulating the quality of air and soil or providing flood and disease control*, etc.	
Air quality regulation	Trees and green spaces are common in most African cities, and play an important role in filtering pollutants and particulates from the air (see Mensah 2014; Cilliers et al. 2013)
Waste-water treatment	In some African cities, wetlands play a major role in filtering wastes and pollutants from water that flows into lakes or the ocean. The economic value of this ecosystem service is known to be quite significant for cities such as Kampala (see IUCN 2003)
(3) *Habitat or Supporting services: These services underpin almost all other services, and includes living spaces for plants or animals, and maintaining a diversity of plants and animals*	
Habitats for species	From forest patches to open green spaces, the city-scape provides home for a wide variety of plants and animals. Some habitats such as wetlands can be invaluable for wildlife (e.g. migratory birds) and at the same time support agricultural use (see IUCN 2003)
(4) *Cultural services: These include the non-material benefits people obtain from contact with ecosystems*	
Tourism and recreation	Securing natural habitats and biodiversity in the city-scape can play an important role in improving the quality of life for urban residents, and for attracting visitors. The city of Durban in South Africa is recognized as one of Africa's leading municipalities in harnessing its green space for tourism (see White et al. 2017)

ronmental benefits, and integration of biodiversity priorities in the cityscape as a conservation strategy. "Greening" presents an opportunity for cities and municipalities to harness ecosystem services and green infrastructure in the cityscape (White et al. 2017). Where loss of ecosystem services is a major challenge, Elmquist et al. (2015) have shown that restoration can generate significant social and economic benefits to cities and municipalities.

While greening is critical for promoting sustainability and resilience in urban development, it may not necessarily address the specific need for integrating ranges of endemic and threatened species into urban planning for improved conservation in the cityscape. As described earlier (Sect. 6.2.3), African biodiversity still warrants considerable attention for conservation, and cities have a major role to play in reducing threats from urban sprawl and increasing protection of species and habitats within the city-scape. It is essential therefore, that urban planning tools and strategies geared toward smart and sustainable growth take into full account these two important considerations.

5.4.1 Trees and Green Spaces in the Urban Landscape

Building on the connections between biodiversity and ecosystem services, most cities across Africa are well-placed to balance conservation needs with development priorities of the city-scape. Trees and green spaces represent the best opportunity for achieving such balance in the city-scape and peri-urban landscapes (Mensah 2014; Cilliers et al. 2013). Green spaces can range from open grassy fields designated for recreational use, to patches of natural vegetation (e.g. woodlands, forests, and wetlands) protected within the city-scape (Cilliers 2015). The protected natural open space and corridors make up what is referred to as "green infrastructure" in the city-scape (Hostetler et al. 2011). Among the many benefits contributed by trees and green spaces for people and the urban environment are the following that are particularly crucial for African cities:

- *Provision of raw materials*—Trees and green spaces in the urban and peri-urban landscape are invaluable sources of raw materials for city residents, such as poles for construction, fuel (wood and charcoal), and traditional medicine.
- *Improving air quality*: Trees and vegetation help to remove air pollutants and particulates from the air, most of which is generated by fossil fuel use in the energy and transportation sectors. In addition, they can also capture and store carbon, thereby contributing to reduction of greenhouse gas emissions.
- *Drainage and rainwater management*: Trees and green spaces help to reduce runoff and soil erosion by absorbing and filtering rainwater. Where wetlands are part of the city-scape, they can help improve quality of water flowing from cities into lakes and estuaries.
- *Supporting life and livelihoods*: Trees and green spaces are habitats for many species in the cityscape, including native biodiversity that may be found nowhere

else. The green spaces in some cities also double as gardens for production of vegetables.

- *Reducing vulnerability to natural disasters*: Trees and green spaces can help with flood management in the cityscape. For cities located in coastal areas, mangrove swamps play a major role in reducing erosion of the coastline.

Drawing on examples of urban and peri-urban forestry from across the continent, Conigliaro et al. (2014) showed that coherent efforts by governments and communities to protect and restore forests and tree cover in and around African cities, coupled with good governance policies, can make a real contribution to reducing poverty and malnutrition and in ensuring a sustainable exploitation of tree resources. This apparent multi-functionality of trees and green spaces (van Leeuwen et al. 2010) can help establish the foundation needed for cities to integrate biodiversity conservation priorities into urban planning (Goddard et al. 2010; TEEB 2011; Cilliers 2015). The challenge is for municipal governments to employ innovative spatial planning tools to design the city-scape in a manner that integrates these multiple needs. An integrated approach to urban planning will enable African cities to identify and manage potential tradeoffs in balancing environmental and development priorities, and harness synergies across spatial and temporal scales (Ahern 2013; White et al. 2017). This is particularly critical for wetlands in the city-scape, such as those in Uganda's capital city, Kampala.

5.4.2 *Wetlands as Natural Infrastructure: Case Study of the Nakivubo Swamp in Kampala, Uganda*

Wetlands are an integral part of the Kampala city-scape, and the city's evolution and development has had a profound effect on their functioning as ecosystems. According to a recent report by the World Bank, the City has relied on its wetlands for diverse ecosystem services, including serving as: (a) primary infrastructure for physically and biologically cleansing water, filtering out sediments and nutrients that enable the raw drinking water to be cost-effectively treated for human consumption; (b) primary sponge for absorbing storm waters, slowly releasing and cleansing waters by discharging into Lake Victoria or recharging groundwater flows; (c) predominant human waste processing function by receiving raw sewage and mechanically treated waste water, processing nutrient loads, and releasing waste water downstream with a higher degree of treatment; and (d) source of food, fuel, and building materials (IBRD/The World Bank 2015).

The economic value of ecosystem services provided by Kampala's wetlands has been quantified and documented through various studies (references in IBRD/The World Bank 2015). For example, the Nakivubo Swamps on the outskirts of the city functions as a buffer through which much of the city's industrial and domestic wastewaters pass before being discharged into Lake Victoria at Murchison Bay (IUCN 2003). It has been estimated that the services provided by Nakivubo would cost the city of Kampala USD 2 million annually if it was done by a sewage treatment facility with the same capacity (TEEB 2011). This amounts to a considerable amount of savings to the city and municipal governments. The ecosystem services are owed entirely to the swamp's natural infrastructure and functions, which includes high nutrient retention capacity and effectiveness in removing bacteria and microbes. The swamp also physically, chemically and biologically eliminates pollutants and sediments from the wastewater, reduces pollution through mineralisation and sedimentation processes, and removes phosphorus and nitrogen (IUCN 2003).[2]

The key to sustaining this invaluable natural asset is a deliberate effort by the municipal government to integrate Nakivubo into a long-term planning for a smart and sustainable Kampala city. Such an integrated approach will ensure that the city considers value of ecosystem services provided, and potential tradeoffs associated with competing demands in the city-scape (IBRD/World Bank 2015; White et al. 2017).

5.5 Cities and Landscape Conservation Strategies

Cities in general are part of wider landscapes that form part of a biologically distinct ecosystem. From a conservation perspective, Savarda et al. (2000) suggested that concepts related to biodiversity management such as scale, hierarchy, species identity, species values, fragmentation, global approaches can be used to manage urban biodiversity. In some cases, the landscape associated with the city often will include "upstream" and "downstream" elements. For example, an area of forest located on the upper slopes of a watershed or catchment can serve as sources of important ecosystem services for city residents located further down. The forest can help to maintain the quality of water that flows into the city, stabilize the land and soil, and reduce risk of erosion and sediment loading in streams and rivers in the watershed (Jacobsen et al. 2012; McDonald et al. 2016). The strategy for conservation of such watershed will not only focus on boundaries of the forest ecosystem, but also on sustaining all the ecosystem services provided in the watershed. For this reason, landscape conservation strategies must consider the prospects of urban sprawl, and consequences for securing important habitats in the larger ecosystem.

By building on a well-established practice of accommodating biodiversity and ecosystem services within the urban landscape, cities can promote upstream and downstream linkages at scales that will benefit biodiversity. A smart and sustainable city planning strategy will include watershed conservation as a priority to ensure that the ecosystem services provided to the city are sustained. Because of the economic value of those ecosystem services, the strategy will create opportunities for local biodiversity financing, such as through a payment for ecosystem services scheme (McDonald et al. 2016). Engaging cities in a strategy for conservation of an entire ecosystem or ecoregion is therefore a win-win opportunity for the city and biodi-

[2]The IUCN case study is adapted from: Emerton et al. (1999).

versity. This is a likely scenario for the Western Area Peninsular forests in Sierra Leone.

5.5.1 Forest Conservation in Urban Landscapes: Case Study of the Western Area Peninsular Forest, Freetown, Sierra Leone

The Western Area Peninsular forest is one of the last remaining intact blocks of pristine Upper Guinean ecosystem and represents the westernmost extent of the Guinean Forests Hotspot in West Africa (Mittermeier et al. 2005). The ecosystem includes a range of hills and steep slopes extending to the coastline of the Atlantic Ocean. The biodiversity includes several species that are endemic to the Upper Guinea forests, such as the Jentink's duiker, considered as Africa's rarest duiker (Davis and Birkenhäger 1990), and the globally threatened White-necked Picathartes or bare-headed rockfowl (BirdLife International 2018a). Because of its strategic importance for globally significant biodiversity (Kouame et al. 2012), the forests have been a focus of conservation efforts by the government and international community for the last four decades (Munro 2009). However, the fate of the entire forest ecosystem is tightly intertwined with dynamics and consequences of increased urbanization in the Peninsular.

The Western Area Peninsular forest is located within proximity of Freetown, Sierra Leone's capital city, and is surrounded by more than a dozen settlements, making it accessible to a population of nearly 1.5 million. A large proportion of this population depends directly on the forest resources for their livelihood, including income generation from building materials (timber and poles) and biomass fuel (wood and charcoal). The forest vegetation also plays an important role in the local climate, reducing risks of erosion and landslides, regulating flow and quality of water flowing to the surrounding communities. The entire Freetown municipality also depends on catchments in the Peninsular forest for drinking water. These ecosystem services have further reinforced the need for the government to step up efforts toward protecting the entire Peninsular forest. As a result, the Western Area Peninsular forest was in 2012 upgraded from a non-hunting forest reserve to the Western Area Peninsula National Park, covering a total land area of 17 km^2 (Fig. 5.2).

Despite the increased conservation status now accorded to the forest, the pressure from an increasing population in the municipality and settlements around the Peninsular continues to exacerbate threats. From expansion of housing and settlements to clearance for agriculture and exploitation of raw materials, deforestation is exposing vast areas of the hills and steep slopes. These threats were exacerbated by the decade long civil war that brought many internally displaced peoples to the Peninsular (Conteh et al. 2017). This is leading to degradation of vital ecosystem services from the forest, and increased vulnerability of residents to natural disasters such as flash floods and mudslides. The devastating mudslide in August 2017 was

Fig. 5.2 Freetown 2017. *Source* Author: Picture taken in 2017

partly a consequence of the uncontrolled urban sprawl, which has exposed thousands of people (especially the urban poor) to landslide prone areas (World Bank 2017).

With the designation as National Park, the Western Area Peninsular Forest is an ideal target for integrated landscape management in the context of sustainable urban development. While protection of the park is critical for safeguarding the biodiversity and ecosystem services, a smart and sustainable plan for the Freetown municipality is essential for reducing threats from urban sprawl. Such a plan can also include the potential for urban and peri-urban forestry to increase sustainability and resilience in the city-scape (FAO 2016). This approach will require collaboration between the national park authorities, the municipal government, and local leaders of all communities around the Peninsular.

5.6 Building Smart Cities for Biodiversity Conservation

Building smart cities presents both an opportunity and challenge for biodiversity conservation in Africa. On the one hand, conservation of biodiversity in urban and peri-urban systems contributes valuable ecosystem services for people and the environment. On the other hand, projected urbanization trends suggest that most cities will experience sprawl and as a result, exacerbate existing threats to biodiversity in the urban and peri-urban systems. Reconciling this opportunity and challenge is key to evolving smart cities that fully integrate biodiversity (Güneralp et al. 2017). Given the potential for cities to emerge as major hubs for sustainable development and wealth creation in Africa (Lall et al. 2017), there is clearly a need for city and municipal governments to have a stronger role in biodiversity conservation (Hostetler et al. 2011). Such an engagement will determine the extent to which cities integrate biodiversity into smart city planning processes, and as a result mobilize and direct financial resources toward conservation goals.

Mobilizing finance for conservation can be greatly enhanced by establishing connections between biodiversity and well-being of urban residents, such as through valuation of the myriad of ecosystem services generated in the city-scape (O'Farrell et al. 2012; Cilliers et al. 2013). Smart city planning in Africa should therefore consider the critical role of green infrastructure and nature-based solutions to addressing challenges of urbanization (White et al. 2017). For example, wetlands are a critical component of the natural infrastructure for regulating storm water and pollution in urban landscapes; trees and green spaces serve as sources of raw materials in addition to enhancing the "culture" and aesthetics of a city-scape. Knowledge of these connections will enable cities and municipalities to engage in the wider goal of safeguarding biodiversity at national, regional and continental level.

There are now a vast array of knowledge resources and innovative technologies that can be tapped by local and municipal governments in Africa for smart city planning to integrate biodiversity. These are considered in three categories—*data and information, planning and management*; and *monitoring and assessment*—and discussed below. In addition, the potential role and importance of ICT is highlighted as key to advancing a science-based approach to integrating biodiversity in smart cities. In addition, ICT will enable cities and municipalities to mobilize and engage experts across a range of disciplines, from landscape ecology to wildlife biology, animal behavior, and sociology.

5.6.1 African Biodiversity Data and Information

As discussed earlier in Sect. 5.2, biodiversity across the African continent has been extensively documented. As a result, there are now many datasets that can be freely accessed and used for spatial analysis and conservation planning. They include for example data on species (distributions and threat status), habitats (extent and protection status), and protected areas (types and extent). Examples of global data and information covering African biodiversity include the Global Biodiversity Information Facility (http://www.gbif.org/), the IUCN Red List of Threatened Species (http://www.iucnredlist.org/), Avibase—The World Bird Database (https://avibase.bsc-eoc.org/avibase.jsp), the Alliance for Zero Extinction Sites (http://www.zeroextinction.org/), Protected Planet (http://www.protectedplanet.net/), the Living Planet Index (http://www.livingplanetindex.org/), and the World Database of Key Biodiversity Areas (http://www.keybiodiversityareas.org/home).

In addition to the global databases, there are sources of data and information that are specific to African biodiversity. Examples include the Copenhagen Database for African Vertebrates (http://daim.snm.ku.dk/Databases-of-African-vertebrates) and the Albertine Rift Conservation Society Biodiversity Management Information System (http://arbmis.arcosnetwork.org/). Building on these global and regional datasets, many African countries have also created national level datasets to enable more finer scale decision-making processes (e.g. Kenya, South Africa, Uganda). Knowledge of and access to these resources will be invaluable for decision-making by city and municipal governments, on options to integrate biodiversity into urban planning. There is crucial need, however, for African countries to create enabling policies and institutional capacity that will facilitate the use of biodiversity data and information for decision-making (Stephenson et al. 2017).

5.6.2 Planning and Management of Biodiversity

As pointed out by the Secretariat of the Convention on Biological Diversity, *how biodiversity is managed or integrated into African cities will depend on whether it is positioned institutionally and topically as a priority in governance agendas, and whether the co-benefits provided by ecosystems are integrally recognized across general policy and action* (CBD 2012). With access to the available data and information resources, city and municipal governments will still face the challenge of applying innovative planning tools for integrating biodiversity in smart and sustainability cities (Lepczyk et al. 2017). Because biodiversity is part of a complex system that defines the urban form, there has been a call for integrated planning tools that can assist in monitoring current conditions and projecting future developments (Rotmans et al. 2000; Andersson et al. 2014). The integrated urban planning means the city planners must work together with biodiversity experts to ensure that priorities for achieving sustainability also contribute to conservation in the city-scape, and at the same time reduce or mitigate threats from sprawl in the peri-urban landscapes (White et al. 2017). In this regard, African cities aspiring for smart and sustainable growth can benefit from the following two important resources that will advance such integrated approach for biodiversity.

The first is "TEEB Manual for Cities: Ecosystem Services in Urban Management," created by the Economics of Ecosystems and Biodiversity (TEEB) together with ICLEI-Local Governments for Sustainability, to help cities incorporate a focus on ecosystem services into city planning and management (TEEB 2011). Because of the strong link between biodiversity and ecosystem services, cities and municipalities can prioritize and establish targets in line with their needs to generate revenue and create jobs from conservation (e.g. protected sites for unique habitats and endemic species), save on municipal costs (e.g. wetlands for water filtration), enhance quality of life (e.g. green spaces for recreation), and improving livelihood security (e.g. designating land for urban farmlands). The TEEB approach will help cities and municipalities to harness and value the ecosystem services, and ensure that the relevant institutional and policy framework is created to minimize negative tradeoffs (TEEB 2011).

Second is the IUCN "Guidelines for Urban Protected Areas," which sets out a series of best practices guidelines for creating and managing protected areas adjoining large population centers (Trzyna 2014). By embracing these guidelines, cities and municipalities can ensure that protected areas in the urban or peri-urban landscape are efficiently integrated into planning for smart and sustainable growth, including the need to create corridors to enhance movement and dispersal of wildlife (Aziz and Rasidi 2014). As stated in the guidelines, the integration will ensure that urban protected areas are managed effectively to safeguard biodiversity (i.e. mitigate threats to the wildlife and habitats) and harness associated ecosystem services. Urban protected areas have a crucial role that sets them apart from other protected areas: they provide opportunities for large numbers of urban people to experience nature, including any people who may not be able to visit more remote protected areas (Trzyna 2014). This connection with people can play a crucial role in building political support for protected areas as assets for sustainable development.

5.6.3 Monitoring and Assessment of Biodiversity

To ensure that planning and management objectives for biodiversity and ecosystem services are achieved, a smart and sustainable city will need to invest in appropriate tools for monitoring and assessment (White et al. 2017). With a well-developed strategy in place to both harness ecosystem services and safeguard biodiversity in the city-scape and peri-urban areas, smart and sustainable cities can identify appropriate indicators for monitoring habitats, species and ecosystem services within the city scape. The use of standardized indices has been proposed to enable cities to benchmark their biodiversity conservation efforts against the established baselines. One such standard is the Singapore Biodiversity Index, also known as the City Biodiversity Index (CBI).

The CBI comprises two parts: first, the “Profile of the City” provides background information on the city; and second, 23 indicators that measure native biodiversity in the city, ecosystem services provided by biodiversity, and governance and management of biodiversity (Chan et al. 2014). Since the index requires cities to conduct a baseline scoring, cities can prioritize indicators relative to their geographical contexts. Based on the choice of indicators, there are a wide range of tools available for the actual monitoring. They include tools for tracking movement and habitat use by wildlife (e.g. motion-triggered camera traps, acoustic monitors for animal sounds), and embedded sensors for monitoring environmental change.

The penetration of mobile phones across Africa presents a particularly invaluable opportunity to engage urban residents in biodiversity monitoring. Such involvement by people (especially the youth) can also help to create awareness about the importance of biodiversity and ecosystem services, and as a result empower them to play a major role in conservation.

5.6.4 ICT for Biodiversity Conservation

With the growing availability and application of Information and Communication Technology (ICT) for conservation, cities are now more than ever well-placed to integrate biodiversity priorities in urban planning processes. From the use of computers for spatial mapping and analysis of biodiversity data, to camera traps for monitoring wildlife movement in the city-scape, and mobile phones for advancing citizen science, the opportunity for application of ICT in development of smart and sustainable cities is quite promising. ICT application can foster efficient collection and appropriate use of biodiversity information to inform decision-making and actions on sustainable use and conservation of biodiversity (Maezawa et al. 2014).

The use of ICT has been instrumental for setting up biodiversity databases and information systems that are publicly available. The Global Biodiversity Information Facility (GBIF) is one such system, which was created in 2001 as a biodiversity informatics research infrastructure to enable free and open access to biodiversity data worldwide. The GBIF infrastructure provides an internet based, globally distributed network of interoperable databases containing primary biodiversity data, i.e. data records placing specific taxon at a specific place and point in time. GBIF now offers the most comprehensive portal to primary biodiversity data in the world, currently enabling access to more than 177 million biodiversity records and more than 1 million species names (Gilman et al. 2009). The data is invaluable for understanding species distribution patterns across spatial and temporal dimensions, and can be used by cities and municipalities to establish conservation priorities for their smart and sustainable growth planning.

The challenge lies in the cities having an appropriate institutional framework to fully harness ICT innovations for aligning development needs with the established priorities for biodiversity conservation. Such a framework should embrace data-driven and science-based decision-making, foster collaboration among relevant stakeholders, and engage citizens in advancing conservation actions. Arts et al. (2015) introduced the concept of 'digital conservation' to characterize this process, and described it as comprising five dimensions: data on nature, data on people, data integration and analysis, communication and experience, and participatory governance. This framework is particularly relevant to African cities because it will help underpin the paradigm of smart and sustainable growth that is holistic and inclusive.

5.7 Conclusion

The African continent is facing the prospects of rapid urbanization in the coming decade, which is likely to present challenges and opportunity for biodiversity conservation. Because of the continent's strategic importance for safeguarding the global commons, it is essential that efforts to promote smart and sustainable growth in cities accommodate biodiversity priorities and contribute solutions to emerging threats from urbanization.

This chapter discusses the need for a paradigm shift in urban transformation will embody two key priorities for African cities and municipalities: first, cities must tackle threats to biodiversity from urban sprawl by identifying and securing specific areas of the cityscape that are deemed critical for achieving biodiversity conservation goals; second, cities must harness ecosystem services by integrating components of biodiversity as livelihood assets and "natural infrastructure" in the city-scape. Examples from cities across the continent indicates that these two priorities do offer opportunities for advancing smart and sustainable urban growth that integrates biodiversity conservation.

With availability and access to data and innovative tools for planning, there is considerable potential for cities to tackle threats to biodiversity while at the same time harnessing ecosystem services as part of their smart, sustainable and resilient growth strategies. In addition to the vast array of publicly accessible databases on African biodiversity, there are innovative technologies to support decision-making on conservation actions and investments. This presents a timely opportunity for cities and municipalities to contribute toward safeguarding biodiversity on the continent as part of their urban development strategies. The challenge is for city and municipal leaders to create an appropriate institutional and governance framework that will foster collaborative engagement by city planners and biodiversity experts.

Finally, a growing urban population in Africa could mean an opportunity to tap a new generation of urban residents that is passionate about nature. City and municipal governments could take advantage of this new generation of urban residents that is also technologically savvy, to promote their participation and stewardship of biodiversity in the cityscape. The growing availability and application of ICT across the continent presents an invaluable opportunity for cities to establish the necessary foundation for implementation and monitoring of biodiversity conservation outcomes in smart city programs.

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Chapter 6
Wastes Management in African Cities

Ibrahima Sow

Abstract Wastes are considered as normal and inevitable output of production and consumption processes, but when they are poorly managed, they are potentially harmful to the environment, health and socioeconomic development. Waste management is indeed a major obstacle to sustainable development in most African cities due to various factors including high population growth, rapid urbanization, increasing economic activity, increasing need for consumer goods, and more importantly the lack of sustainable waste management strategies both at national and local levels, including lack of adequate policies. The combination of these factors creates significant amounts of waste whose management represents a major challenge for sustainable development of African cities. Sustainable solutions in waste management will require an integrated approach through a comprehensive urban planning system, use of Information and Communication Technologies (ICT), a strong and innovative financial mechanism, appropriate mechanisms for community participation and private sector involvement. This chapter focuses mainly on solid waste management in the context of African cities.

Keywords Waste · Production · Consumption · Management · ICT · Urbanization Africa · Solutions

6.1 Introduction

Wastes are considered as normal and inevitable output of production and consumption processes, but when they are poorly managed, they are potentially harmful to the environment, health and socio-economic development. Indeed, misconcep-

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tions and inappropriate management of solid wastes by traditional methods such as uncontrolled landfill, open burning practices, informal recycling, can possibly lead to health, ecological, economic and social disasters.

Inappropriate waste management is a major obstacle to sustainable development in almost all African cities. Various factors are involved: high population growth, rapid urbanization, increasing economic activity, increasing need for consumer goods, bad waste management practices, and more importantly the lack of sustainable waste management strategies both at national and local levels, including lack of adequate policies—legal and regulatory framework, lack of education and information on waste management. The combination of these factors creates significant amounts of waste whose management represents a major challenge for sustainable development of the cities in African countries. Nowadays, cities concentrate more and more human activities of all kind that generate large quantities of plastic, electrical and electronic waste, garbage and medical waste, etc. resulting in significant alteration of the city landscape.

Proliferation of these types of waste coupled with the difficulties of collecting them after use create significant negative externalities causing damage to human health and the environment. Uncontrolled landfills increase infiltration of toxic substances and infectious germs through runoff (heavy metals, bacteria…) in surface and ground waters and can also generate methane (CH_4). Landfills are the third largest anthropogenic source of methane, accounting for approximately 11% of estimated global methane emissions, or nearly 800 Mt CO_2 eq (C40 CITIES 2016). Open burning of solid wastes containing organic and plastic materials, produce carbon dioxide (CO_2), nitrous oxide (N_2O), black carbon and toxic pollutants including persistent organic pollutants such as dioxins and furans, which are known to be carcinogenic substances.

The lack of sorting, the ineffective collection, the open-air burning practices, as well as the uncontrolled disposal of waste are common practices in African cities. This situation has obviously negative impacts on the human health, the livestock, the agriculture, the economy of the household, the quality of life, the air, the soil, the water resources and the global environment (BOAD/GEF 2016).

Waste management is one of the greatest challenges urban authorities are facing today, with the amount generated exceeding their capacity both technical and financial to collect and dispose of in an environmentally sound manner. Barriers to sustainable waste management include lack of adequate policy and strategic choices in waste management; limited capacity at national and local levels; legal and regulatory, technical, financial, educational and social barriers.

Sustainable solutions in waste management will require an integrated approach through a comprehensive urban planning system, use of Information and Communication Technologies (ICT), a strong and innovative financial mechanism, appropriate mechanisms for community participation and private sector involvement.

Moreover, promoting environmentally sound management of waste through waste minimization, recycling, recovery and reuse as well as waste to energy programs is an important niche of jobs creation which is critical in the context of African cities.

Table 6.1 Solid waste composition in selected African cities

Waste composition %	Dares Salam (Tanzania)	Moshi (Tanzania)	Kampala (Uganda)	Jinja (Uganda)	Lira (Uganda)	Nairobi (Kenya)
Bio-waste	71	65	77.2	78.6	68.7	65
Paper	9	9	8.3	8	5.5	6
Plastic	9	9	9.5	7.9	6.8	12
Glass	4	3	1.3	0.7	1.9	2
Metal	3	2	0.3	0.5	2.2	1
Others	4	12	3.4	4.3	14.9	14
Percentage collection	40	61	60	55	43	65
Population	3,070,060	185,520	1,700,850	91,153	107,809	4,000,000

Source Okot-Okumu (2016) and Scheinberg et al. (2010)

6.2 Waste Generation and Impacts on Key Socio-economic Sectors

The amount of waste generated in sub-Saharan Africa is approximately 62 million tonne per year. Per capita waste generation is generally low in this region, but spans a wide range, from 0.09 to 3.0 kg per person per day, with an average of 0.65 kg/capita/day (World Bank: Urban Development series—Chap. 3).

The major composition of waste generated in most part of Africa is biodegradable materials as shown in Table 6.1 (Okot-Okumu 2016) .

However, the general trend of electric and electronic equipment which ultimately generates e-wastes is becoming a serious threat in Africa due to unsound practices such as manual dismantling and open burning to recover copper and other metals. These practices may release unintentional persistent organic pollutants (UPOPs) which are known to be cancerogenic.

Due to a lack of regulation and proper sorting, household wastes are often mixed with different categories of wastes that can be classified as hazardous. These include end-of-life vehicles (EoLV), biomass wastes in form of agriculture wastes and forestry wastes, health-care wastes, electric and electronic wastes (e-waste), packaging wastes, etc. The wastes generation for a country is dependent upon the population growth and the income. Moreover, income seems to be the driving factor for wastes generation because countries with high income but of a lower population show a significant amount of waste generation (Kabbashi 2016).

The city of Lagos, the largest in Nigeria as well as in Africa, due to its position as the country's commercial nerve center, has continued to experience rapid population growth (projected at 6–8% per annum), reaching over 21 million people in 2014. This results in increasing waste generation, currently estimated at about 10,000 metric tonne per day (C40 Cities 2016) (Fig. 6.1).

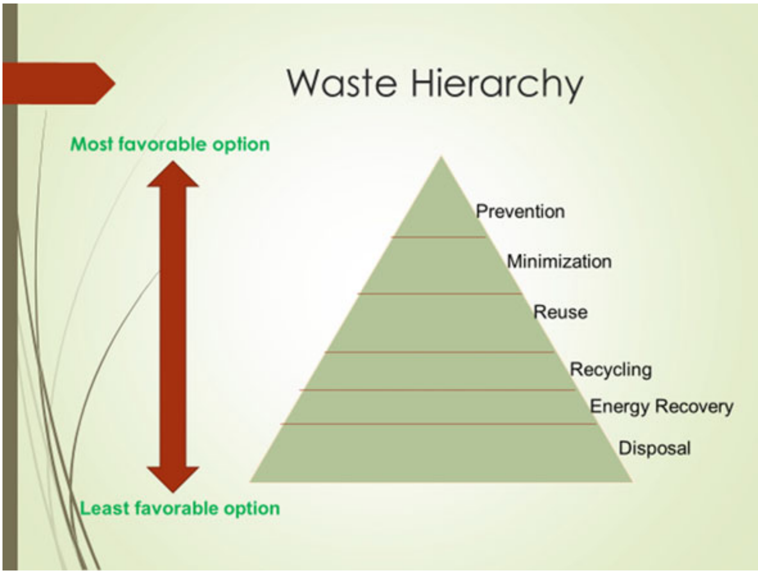

Fig. 6.1 Waste hierarchy. *Source* https://www.google.com/search?q=waste+hierarchy&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjn5cPAhcrdAhVPh-AKHWaDBeQQ_AUICigB&biw=1146&bih=643

Mixed municipal solid wastes, medical wastes, industrial wastes and hazardous wastes pose a great threat to the society because they are generally harmful and dangerous to people. Without proper management and landfill facilities, these wastes will not only become a sore in the eyes but will turn into something even more critical, possibly spreading an epidemic (Kabbashi 2016).

Improper waste management has negative impact on key socio-economic and social sectors including human health, agriculture, livestock, economy of the household, quality of life, air, soil, water resources and the global environment (BOAD/GEF 2016).

The growing practice of burning waste at landfill sites and in areas close to residential areas is a source of toxic emissions (UPOPs)—that cause cardiovascular, lung diseases and cancers, and contaminate the entire food chain with bio accumulative substances. Substances emitted from waste burning or infiltration of the items they contain are often: hydrochloric acid (HCl), ammonia, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides, hydrogen sulphides, dioxins, furan, mercury, lead, cadmium, beryllium, infectious human remains, syringes and used needles. All these are sources of serious diseases (BOAD/GEF 2016).

Compost from the dump sites in cities is often used as green manures for peri-urban vegetable crops and gardens of homes with fruit trees. This compost containing heavy metals such as lead, cadmium, mercury have negative effects on food production. The food chain is thus contaminated with serious implications for human and animal health (BOAD/GEF 2016).

Wandering animals are attracted by food residues contained in the bags that are thrown on rubbish dumps. They most often ingest these foods with plastic bags, which once swallowed, stays in the rumen and interferes with digestion. This therefore causes loss of productivity in milk and meat of the animal. Deaths of animals due to the ingestion of these types of waste are frequent as well as contamination of animal products with heavy metals (such as lead, mercury, etc.) which are transmitted to humans through accumulation in their bodies.

In countries where farming is the main source of income, economic losses due to the loss in animal production are huge. In addition, health expenditures incurred by affected households and the reduction of the work force due to poor waste management have decreased the purchasing power of these households (BOAD/GEF 2016).

Waste degrades the beauty of the living environment of cities with the proliferation of plastic bags in the environment. They also choke gutters, which facilitates the proliferation of mosquitos and unpleasant smell and contributes to flooding in cities and the degradation of public health.

In the absence of an efficient collection system, waste litter the floor. Dangerous elements (biological and chemicals) contained in such waste make the air unclean for breathing. Soil and water resources become unsuitable for use in homes (BOAD/GEF 2016).

Poor waste management causes the production of mercury, UPOPs, greenhouse gases including methane, carbon oxides, nitrogen oxides, etc. with negative impacts on the global environment.

6.3 Institutional Framework Governing Wastes Management in African Countries/Cities

In most countries, solid waste management in cities is the primary responsibility of local government (municipalities or district governments) as a result of the decentralization process put in place by many governments over the last years, shifting this responsibility to the cities. However, the decentralization process has not always resulted in a real delegation of authority. Municipalities face challenges associated with solid waste management such as financial resources, clearly defined powers as well as qualified personnel. In fact, the municipalities are assigned the responsibility to provide this service without having access to the necessary funding, while they have at the same time major competitive challenges such as security, street lighting, public transport, etc.

Furthermore, waste management policies and programs in most African cities were formulated and implemented by government agencies without significant public participation although socio-political changes across the continent and the founding of NGOs have enhanced the awareness of environmental issues among the public, not to mention the important role the private sector plays in some countries. In Abuja for instance, there are numerous private waste collection companies in operation. Each one has a specified route and specific time of arrival on a weekly or monthly basis (Bello et al. 2016).

6.4 Barriers to Sustainable Waste Management in African Cities

Solid waste management in African cities faces several challenges in terms of policy and regulatory framework, technical and financial support as well as educational and social challenges.

There is a general lack of waste management strategies at both national and local levels. Indeed, the national plans or guiding principles of cities and technical assistance to local authorities are limited to waste collection and disposal. Recycling of such waste is not adequately provided. Cities that have advanced in waste management have stopped at the creation of landfill sites. The strategies have not internalized waste management as a strategic response to environmental degradation through pollutant release reduction nor do they see it as an economic sector, source of employment and income, clean development and human health. The lack of specification of waste management means that all waste (plastics, electronics and appliances, etc.) are generated in the same way (collected and dumped in landfills) despite the varying degrees of danger these might pose (BOAD/GEF 2016).

In most African countries, there are several laws on the waste sector, but with very limited impact on sustainable management of the sector. These laws deal with waste in their entirety without any specification. At best, the existing laws are only punitive and does not often show the ways for the treatment, disposal and recycling of waste. Efforts are very limited when it comes to the specific rules for the management of the different categories of waste altogether. Generally, there are deficiencies and lack of enforcement of sustainable waste management approaches in the countries.

The indiscriminate disposal of waste does neither guarantee the protection of the environment or public health, nor promote economic and financial benefits that can be drawn from waste. Other negative factors influencing the sector include: (i) lack of systematic control; (ii) lack of impact studies on the management of waste in cities; lack of monitoring and evaluation systems of waste management policies; (iii) lack of periodic updates of reliable and official statistics, apart from a few general information available to municipalities; (iv) lack of or inadequacy of waste collection and treatment schemes; (v) inadequate training of waste management personnel (BOAD/GEF 2016).

There are financial constraints for the development of the waste sector. It is becoming increasingly difficult for the African countries, 36 of them are Least Developed Countries (LDC), to increase the financing necessary to cover the cost of solid waste management, which are rapidly increasing. Municipalities are often forced to focus on the urgent needs that are the cost associated with collection. In these circumstances, the sustainable management of waste cannot be envisaged. The private sector, including Small Medium Enterprises (SMEs), is facing huge challenges in obtaining financing, given that these activities are always considered a financial risk, while many operators are in the informal sector (BOAD/GEF 2016). The concept of an integrated sector, including all the players involved in a global vision of waste chain, is not yet sufficiently developed. At the same time, the regulatory environment is not robust enough to reassure investors.

Education could be an asset in improving practices of waste production and management at the grassroots. However it suffers from a number of constraints that include: (i) the lack of specific and ongoing public education programmes; (ii) the lack of communication between the citizens and the municipality for two reasons: on the one hand, citizens are often not organized themselves (i.e. through home owner associations) and on the other hand, the municipality reserves very little or sometimes no resources towards information and education; (iii) the existence of conflicting information between the municipalities and private operators (iv) the lack of participation of the population in improving the quality of collection and lack of participation in sorting and recycling activities (BOAD/GEF 2016).

6.5 Proposed Approaches and Solutions Towards Sustainable Solid Waste Management

6.5.1 The Waste Hierarchy

Good waste management systems are generally those that prioritize actions as per the waste hierarchy adopted by many countries with advanced waste management policy. The waste hierarchy is an evaluation of processes that protect alongside resource and energy consumption from most favorable to least favorable actions (C40 CITIES 2016) this hierarchy establishes preferred program priorities based on sustainability. The proper application of the waste hierarchy can have several benefits, including greenhouse gas emissions reduction, reduction of environmental pollution and energy consumption, resource conservation, jobs creation, and the development of green technologies. The waste hierarchy ranks waste management options according to what is best for the environment. It gives top priority to prevention in the first place. When the waste is created, it gives priority for preparing it for re-use, then recycling, then recovery and last of all disposal such as landfill (Guidance on applying the waste hierarchy 2016; C40 Cities 2016).

Choosing the right priority order for solid waste management approaches and building a good sustainable waste management system delivers many economic, health and social benefits.

Good waste management systems aim to extract the maximum practical benefits from products and to generate the minimum amount of waste. Effective waste management system can provide significant co-benefits beyond addressing emissions, which might serve as the main drivers for action in waste management. Some of the co-benefits include improvement of public health, air quality, poverty reduction and more social justice (C40 Cities 2016).

6.5.2 Development of a National Waste Management Plan

In many cities, waste is an important source of income for a significant part of the population and of raw materials for many sectors of the economy. Waste collectors in many cities operate on the streets and dumps, collecting, sorting, cleaning, recycling and selling materials thrown away by others. Cities' action can have a profound impact on the economic conditions and quality of life of those sectors of society involved in waste management. For example, by utilizing proper sanitary landfill disposal techniques, cities can avoid health hazard of open dump scavenging. Solid waste management is highly visible and affects people's perception of government and of society itself. Planning effective and sustainable investments in municipal solid waste management systems requires an understanding of the needs and preferences of a wide range of stakeholders in service delivery, cots and corresponding environmental and social impacts (UNEP/UNITAR 2013).

A national waste management plan solidly linked to the urban planning and public infrastructure systems should be developed by all countries to ensure sound and sustainable waste management to make cities attractive, smart and resilient. It is vital that national policy be developed in ways that recognize local needs, capacities, capabilities and practices. Imposing outside solutions or simply draining resources from other day-to-day priorities are to be avoided. A national policy should provide national level incentives, goals and targets, national and regional markets and economies of scale, and incorporate the flexibility required for informed and sensitive implementation at the local level (UNEP/UNITAR 2013).

Waste management is a multi-dimensional issue that engages multiple stakeholders with different and sometimes conflicting interest. A detailed understanding of whom the stakeholders are and the responsibilities they have in the waste management structure is required to establish an efficient and effective system. A successful waste management plan must consider best available technologies (BAT) and best environmental practices (BEP) along with environmental, socio-cultural, legal, institutional and economic linkages.

The waste management plan should be development following an inclusive process, and should involve Central government, municipalities, different ministries, Urban development, Energies, sanitation and health, environment, finances, private sector, academia, NGOS. It should be disseminated widely across the country and shared with development partners and updated on a regular basis to reflect changing in lifestyles, increased production processes and evolving technologies and rapid urbanization.

Other aspects, such as community participation, integration of the informal sector, or organization of service provision, are best handled locally. In case of the latter, citizen feedback and adaptation to local circumstances are likely to be crucial. Some actions, such as popular education on source separation, may involve both levels of government if coordinated effectively. Local government should also adopt specific plans and enact by-laws reflecting specifics of their regions. These by-laws should not contradict the provisions of the national plan and relevant regional and international agreements ratified by the country.

A participatory approach should be developed to include information exchange and communication activities between waste management players. Thus, through sensitization, radio and television stations, workshops, posters in local governments (city halls, departments, schools, and other relevant public places), press releases, populations and all the players will be widely informed of best waste management practices, of the existing legal and regulatory framework governing waste management.

6.5.3 The Use of ICTs as a Tool to Improve Waste Management

Cost-effective management of waste is a significant social, environmental and health challenge for modern society. Improving waste management practices through the uptake of new software technologies for efficient waste collection and transportation services is a relatively new phenomenon. Technology can provide visibility on route planning for garbage collection, resource optimization, efficient asset management, efficient maintenance, visibility of waste bins, air quality measurement (Prabhakar and Mehrotra 2015).

More broadly, ICTs can help to overcome most challenges related to solid waste management system. On the contrary, systems that are not using ICTs pose various limitations in terms of site selection, collection monitoring, intelligent recycling, inefficient waste disposal etc. ICTs provide an innovative way to address solid waste management issues because of their unrivalled capacity to offer information instantly from remote location at a comparatively low cost. An obvious motivation on using ICTs in accomplishment of comprehensive Solid waste management goals could allow municipalities to attain more sustainable cities. As noted by Prabhakar and Mehrotra (2015), key ICTs tools to improve waste management in cities include:

Online platforms: provide options and alternatives to the user to look into recycling and reusing old stuff. The existing user is also encouraged to consider options to sell and regain value from the product before discarding the product as waste;

Analytics: Accurate projections on total waste generated, waste type and identification of high waste generation areas enable effective planning and management of solid waste management services. Use of analytics during events with large citizen involvement such as festivals, muslim and Christian holidays and fairs can ensure smooth collection and transport of waste;

GPS devices and sensors on waste truck: GPS technology to route the waste collection trucks to optimize the collection efficiency and ensure contractors dump waste in designated places. This will also give a clear picture of the amount of waste generated per area;

Sensor-based-sorting: Sorting waste material with the use of sensor technology helps in smart sorting. The sensor technology can recognize materials based on their visible spectrum or color with infrared/ultraviolet spectra or based on their specific and unique spectral properties of reflected light, atomic density, conductivity, permeability or atomic characteristics;

Analytics-based landfill management: Accurate waste generation and collection projections along with breakup of type of waste enable smart landfill management;

Workforce and resource management: Leverage the workforce and resource management solutions to improve workforce engagement and task management, mobile applications to execute tasks and efficient performance management tools and;

Geospatial dashboard: Bin locations, landfill locations, waste management assets need to be mapped in geospatial systems.

However, in many developing countries, the barrier of adopting ICTs based systems are mainly the lack of financial resources, frequent power shortages, poor access to internet, shortage of skilled human capital and lack of proper policy. In these countries, adoption of ICTs can be gradual, starting with basic, simple and affordable tools such as GPS devices, online platforms and analytics with the view to fully utilizing the ICTs package to optimize the management of Solid waste management.

As urban areas continue to expand, waste managers will have to deal with huge and more and more complex waste stream. ICTs will become an inevitable tool to plan and design of modern solid waste management systems.

6.5.4 Financing Solid Waste Management in African Cities

Wastes generated in a community can be a valuable energy and material resource. Waste being a resource as well as a burden has generated some extremely creative and economically attractive opportunities (recycling, recovery, re-use, etc…). Waste management is a common concern of all communities because all communities produce waste. Thus, it is possible to make use of many of these wastes to make real profit in terms of the environment, economics, energy supply, conservation and material recovery.

Realistic and effective financial mechanisms should be designed to provide resources for the implementation of waste management programmes including collection, transfer, recycling, reuse, recovery and final disposal. These mechanisms include: waste generation fees, essentially similar to a utility, i.e. electricity, water, sanitation, etc., waste disposal fees; environmental product levy on items that are difficult to dispose of including bulky or hazardous items; deposit refund programs, involving a deposit/levy paid by the importer to the government, with a percentage of the deposit paid as a refund when the product is disposed of; and tax incentives and disincentives, including granting subsidies and concessions to businesses working on environmentally sound products and alternatives. The mechanism to recover the fees from household and private businesses should be designed carefully to ensure proper and regular recovery (UNEP/BRS 2013).

External financing to support waste management program should be explored through bilateral cooperation or dedicated multilateral agreements, i.e. Basel, Stockholm, Minamata Convention. However, countries need to ratify these instruments and consider waste management as a national priority—giving it visibility and explicitly defining national interests in waste management, both with respect to the provision of particular services, and as part of broader material resource management—otherwise, it would be challenging to attract funding from donors.

A national approach provides a level playing field for the private sector, with greater certainty and clarity, thus providing a better environment for investment. A national regulatory framework will be especially necessary for public-private partnerships. It is critical that Municipalities and Central Governments develop strong partnership with dedicated Private companies to foster the development of national recycling schemes and markets for recovered materials. Intervention of large companies will be more focused on investments such as establishment of infrastructure such as the landfill installation and the rehabilitation of small waste dumps while micro finance institutions can be deployed to support (through soft loan mechanisms) Small and Medium Enterprises (SMEs) working on waste collection, recycling and valorization, and also provide support to NGOs for the information and communication programme.

Without a good waste management system, you can't build a smart, resilient and sustainable city. To this end, it's extremely critical to put in place a reliable financial mechanism. Counting solely on external financing such as bilateral or multilateral aids to address waste issues is not a sustainable option. Central governments would need to establish a clear system to recover the cost of waste disposal from waste producers including households, private businesses and heath care facilities and more importantly to transfer these resources to local governments or entities in charge of waste management and make sure that these resources are effectively devoted to waste management needs.

6.6 Success Stories in African Cities

6.6.1 Waste to Energy (WtE) Facility in Addis Ababa

GEFSEC visit to Addis Ababa: August 2017

The Facility which is now in full operation is designed to treat 1400 tonne of municipal waste a day, It will help the city dispose of close to three quarters of its daily waste generation while producing an expected electricity production capacity

Fig. 6.2 Solid waste in the city of Addis Ababa. *Source* Sow (2017)—GEFSEC visit to Addis Ababa

Fig. 6.3 Facility for treatment of waste in the city of Addis Ababa. *Source* Sow (2017)—GEFSEC visit to Addis Ababa

of 185 GWh per year. The facility adheres to the strict European environmental standards for WtE and produce the following outputs (Figs. 6.2 and 6.3):

– 420, 000 tonne of wastes eliminated annually in an environmentally sound manner;
– 1,200,000 tonne of CO_2 averted annually;
– 3600 tonne of recycled metals per year;
– 3,000,000 bricks produced from ash per year;
– 30,000,000 l of water recovered from wastes per year.

The US$120 million facility is supported under the Cambridge Waste-to Energy-Fund. The Cambridge Waste-to Energy Fund was set up to develop waste-to-energy facilities in seven African countries with the first one being established in Addis Ababa.

6.6.2 Durban Buffelsdraai Landfill Closed Loop System

Example from Good practice guide: C40: Sustainable solid waste systems

The Buffelsdraai landfill management is a facility designed to improve waste management practices in Durban. It is managed as a closed loop system, i.e. anything comes onto site should not leave in any form. The landfill compacts and covers the waste every day to minimize the chances of odour or fly and vermin breeding. The leachate is collected and treated and the water is used for dust suppression, thus saving valuable drinking water. The landfill gas is extracted and used for flaring, thus destroying methane, a potent GHG. By extracting the gas and reducing methane emissions, the city is expected to reduce 10 million tonne of CO_2 equivalent over the life span of the landfill, which is nearly 50 years. In the future, the gas will be cleaned and used as a fuel for city's vehicles or electricity generation. The methane gas captured will be sufficient to produce the equivalent of 10–12 MWh of electricity.

The city also manages the buffer zone as a nature conservancy. There is currently a coastal forest reestablishment project, where the local community is given seeds and cuttings and they grow these to a predetermined size and return them to the landfill area, where they are exchanged for vouchers. The vouchers can be used for various items such as school fees, bicycles, food or any other service. In just five years, 723,000 trees have been planted and some 200 ha rehabilitated in coastal forest from previous land under sugar cane cultivation. This is expected to save more than an additional 55,000 tonne of CO_2 emission per year (Fig. 6.4).

Th co-benefits of the project include stronger community engagement and social capital (as the surrounding community is earning a living and improving their economic situation), environmental benefits (through the reintroduction of coastal forests which would otherwise be under threat from farming), and economic development (energy use and sale, local jobs). The project has already been replicated in Durban's other landfills.

The project's success is based on the strong involvement of the community in directly addressing the project's impacts on local livelihoods and seeing that as an opportunity for development. Multiple co-benefits, such as planned electricity production, also help reduce the long-term costs of the project.

Fig. 6.4 Aerial view of the Marianhill Landfill sites in Durban. *Source* 3D map from Google map in South Africa, 2018

6.6.3 Lagos—Private Sector Participation

Example from Good practice guide: C40: Sustainable solid waste systems

The city of Lagos, due to its position as Nigeria's commercial nerve center, has continued to experience rapid population growth (projected at 6–8% per annum), reaching over 21 million people in 2014. This results in increasing waste generation, currently estimated at about 10,000 metric tonne/day.

Over the last decade, the existing Private Sector Participant (PSP) programme for waste collection in Lagos was established under a franchising arrangement where PSP/SMEs were duly licensed for collection activities based on ward distributions across the State. However, the combined effects of poor cost recovery on operational overheads, low investment opportunities as well as return on investment, lack of public compliance with waste bill payments, among other market dynamics, resulted in operational deficiencies and the attendant backlogs across the city.

While it was necessary to revamp waste collection services through public education to create the right attitude and receptiveness towards individual responsibility, a more drastic intervention was required to overhaul existing practices for improved service efficiency.

The Lagos State government, through the Lagos Waste Management Authority (LAWMA) guided by a 10-year (2005–2015) market development strategy, facilitated finance and funding mechanism support for PSPs in collaboration with local banks, providing creditworthiness instruments for access to capital markets. Privatization models and cost recovery plans for different socio-economic group/areas within the city were also defined to assists PSPs to recoup capital investment and support debt repayment schemes for collection vehicles procured through government intervention. Further assistance was provided to develop public awareness and engagement activities to foster compliance from local communities, Government subsidy and debt buy-back were also provided for PSPS operating in low income areas.

The result was an increase in vehicle availability of over 800 trucks (100% increase) which has led to a recorded increase of over 60% in collection service efficiency, and about 55% in cost recovery, since 2005, with projections for further increase based on market potentials. Equipment opportunities are being enhanced through the extended participation of the private sector/SME in waste collection. Hence, the Lagos (waste collection) model is being adopted as a benchmark to improve collection efficiency in Nigerian/West African cities.

Building on the existing legislation as well as policy and regulatory instruments available at both national and state government levels, LAWMA adopted the "PSP Handbook" that set out public criteria/preconditions, and operating guidelines while also serving as a basis for performance evaluation for private sector (SME) participation in the collection and transport of MSW within the city of Lagos.

Technical assistance for local and overseas training for the PSP/SME representatives were facilitated to bridge knowledge gaps and enhance competency development in the sector. Institutional support was also rendered through LAWMA as a government agency to foster transparency and fairness in dispute resolution between PSPs and client entities.

Cities with vast population aiming to optimize waste collection and cleanliness across different socio-economic regions/areas while ensuring availability of required vehicle/infrastructure may adopt the Lagos approach, which also affords opportunity for economic growth through increased SME/private sector involvement, and attendant job creation (Fig. 6.5).

Fig. 6.5 Garbage collection trucks used in Lagos City as part of the PSP programme. *Source* City of Lagos (2017). City of Lagos/Private sector participany (PSP) trucks

Glossary

BAT	Best Available Technologies (BAT)
BEP	Best Environmental Practices
BOAD	Development Bank of West Africa
CH_4	Methane
CO_2	Carbon dioxide
CO_2 eq	Carbon Dioxide Equivalent
GEF	Global Environmental Facility
GHG	Greenhouse Gas
HCL	Hydrochloric Acid
EoLV	End of Life Vehicles
LAWMA	Lagos Waste Management Authority
LDC	Least Developed Countries
MSW	Municipal Solid Waste
NIMBY	Not-In-My-Backyard
NGOs	Non-Governmental Organization
N_2O	Nitrous Oxide
PSP	Private Sector Participant
SME	Small and Medium Enterprises
UNEP	United Nations Environmental Program
UPOPs	Unintentional Persistent Organic Pollutants
UNITAR	United Nations Institute for Training and Research
WtE	Waste to Energy

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Chapter 7
Smart Energy for Smart Infrastructure Development

Naledzani Mudau and Paida Mhangara

Abstract Energy forms part of our day to day life. Access to energy is required to support a number of social and economic activities including transportation, communication and production of goods. Without access to electricity, education and health services cannot operate optimally which may impact welfare and human capital development. Access to energy in Africa is lower that the world average with almost 70% of the population without access to electricity. In addition to lack of access, there is no guaranteed supply of electricity for those who have access which threatens economic growth. Access to energy in Africa has increased in recent decades, however, the electrification rate is lower than the population and urban growth. Africa is endowed with natural energy sources that remain untapped. Smart energy technologies provide opportunities to generate, transmit, distribute and use energy in a sustainable manner. This chapter reviews the status of smart energy development in Africa. Access to energy in Africa varies from country to country, with some countries like Egypt, Tunisia and South Africa having more than 80% of people with access to electricity while in other countries less than 10% of population have access to electricity. Implementation of smart energy systems relies on Information and Communication Technologies (ICTs). Smart energy is the solution for Africa to increase access and improve reliability of the energy supply in the continent. This chapter also appraises the status of ICT infrastructure and highlights some of the case studies on smart energy systems aimed at energy efficiency and smart grid development.

Keywords Smart energy · Electricity
Information and Communication Technology · Infrastructure
Sustainable development · Africa

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7.1 Introduction

Energy is a key enabling factor for sustainable development, poverty alleviation and human capital development and it plays an important role in all major development challenges that the Africa faces. To overcome some of its development challenges, Africa needs to increase access, and increase supply to reliable electricity. More than 40% of population in Africa is aged between 15 and 24 which makes it the youngest continent in the world. This number is expected to double in 2045.[1] Consequently, Africa has an opportunity to tackle current social and environmental challenges and improve the economic growth of the continent. Sustainable energy is critical for the countries and global community to achieve a number of the 17 United Nations Sustainable Development Goals (SDGs) 2030. SDG goal 7 in particular calls to "ensure access to affordable, reliable, sustainable and modern energy for all.

Though a lot of progress has been made in recent years towards achieving universal access to energy sources by 2030, about 15% of the global population did not have access to electricity in 2014.[2] Africa has a large share of population that does not have access to electricity despite being rich in energy sources. Africa has a severe shortage of essential electricity infrastructure which contributes to slow social and economic growth. According to International Energy Agency about, 68% of Africa's population did not have access to electricity in 2016 (amounting to more than 600 million people). A number of reports suggest that having access to energy infrastructure in Africa doesn't not guarantee reliable supply of energy. As a consequence, many countries in Africa are experiencing power blackouts which result in economic loss. According to a survey conducted by World Bank, Sub-Saharan Africa lost 4.9% of annual sales due to power outages in 2015 (see footnote 4). In addition to lack of access electricity by households, some schools, health facilities and small businesses do not have access to electricity. Higher percentage of rural population do not have access to electricity compared to urban areas and rely on wood or biomass for cooking and heating which threatens the health of the people through indoor pollution.

Additionally, a number of countries in Africa are already struggling to meet the demands of services and infrastructure required to promote economic growth and human capital development. Only 10% of Africa population has access to the electric grid which mainly reaches the wealthy, urban middle class and commercial sectors. Lack of access to electric grid makes is difficult and expensive to connect private energy sources to the grid. Smart energy infrastructure development is therefore crucial to connect more people to the grid and also to support future urban growth.

A number of studies suggest direct relationship between urbanisation and electricity consumption.[3] As urbanisation increases, the demand for land for housing, public

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[1] African Economic Outlook https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEO_2017_Report_Full_English.pdf.

[2] Worldbank (2017). *State of electricity access report*. http://documents.worldbank.org/curated/en/364571494517675149/pdf/114841-REVISED-JUNE12-FINAL-SEAR-web-REV-optimized.pdf.

[3] Sbia, R., Shahbaz, M., Ozturk, I. (2017). Economic growth, financial development, urbanisation and electricity consumption nexus in UAE. *Economic Research-Ekonomska Istraživanja*.

transport, basic services, health and social services also increase. Though urbanisation is a sign of prosperity and human development, urbanisation in Africa results in increased poverty, proliferation of informal settlements and increased inequality. Africa has been experiencing the highest urban growth (3.5% per annum) in the past two decades compared to other regions. It is expected that about 50% of Africa's population will live in the cities by 2030.[4] This presents a need to better manage urbanisation and to ensure that energy infrastructure requirements are taken into account during master spatial planning.

Achieving universal access to electricity while achieving the Paris Agreement's goal to reduce the risks and effects of climate change will require a major shift toward renewable energy and energy efficiency. Africa is rich in renewable energy. Africa is the sunniest continent in the world and therefore has the greatest solar energy sources. Wind power resources are also in abundant due to large coastline that Africa possesses. A number of countries in Africa are investing on long term renewable energy solution including solar, wind and geothermal. This presents Africa with opportunities to generate and use cleaner and sustainable energy sources.

The objectives of this chapter are two fold, firstly we aim to present a review of the status of smart energy development in Africa and highlight the progress being made towards the implementation of smart energy solutions on the continent. This will be achieved through presentation of selected case studies. In line with our first objective, we also aim to appraise the status of ICT infrastructure and highlight some of the case studies on smart energy systems aimed at energy efficiency and smart grid development. To achieve these objectives we have structured this chapter into the following sections: introduction, smart energy and sustainable development, access to electricity in Africa, energy efficiency in Africa, smart energy and ICT, smart grid initiatives in Africa, off grid energy solutions for Africa, geospatial technology and smart energy development and the chapter ends with a conclusion.

7.2 Smart Energy and Sustainable Development

Access to safe and sustainable energy is critical for sustainable development. Energy has a direct impact to social welfare, economic growth and environmental sustainability.[5] Achieving the UN SDGs 2030, African Agenda 2063 and national development plans will require improved access to energy, increased share of renewable energy in the energy mix and energy efficiency. Access to electricity increased by 0.3% globally between 2012 and 2014, however, a lot of people in sub-Saharan Africa especially in rural areas still live without electricity. The share of renewable energy

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[4] African development bank Group (2012). *Urbanization in Africa*. https://www.afdb.org/en/blogs/afdb-championing-inclusive-growth-across-africa/post/urbanization-in-africa-10143/.

[5] Smart Villages (2016). *Why energy is a priority in sustainable development*. http://e4sv.org/about-us/what-are-smart-villages/.

(solar, wind, and water) increased slightly and the world largest energy consumers had reduced their energy consumptions during the same period.[6]

Globally, electricity and heat production which includes burning of coal, natural gas and oil, are the largest source (25%) of greenhouse emissions. Increased greenhouse emissions contribute to climate change phenomena which result in extreme weather patterns. These phenomena may threaten sustainable development. Paris Agreement calls for each country to scale up efforts and actions to reduce emissions. Smart energy infrastructure can help the reduction of the emission by increasing the share of renewable energy mix and energy efficiency, as a result, national development goals for many countries have included energy efficiency and utilisation of renewable energy as priority areas.

Cities are on average responsible for 75% of the country's Gross Domestics Product (GDP), consume more than 75% of energy and account more than 50–60% of the global greenhouse gases. Energy in cities is required for activities such as transport, industrial and commercial activities, buildings and infrastructure, water distribution, and food production.[7] A number of studies suggest a direct relationship between energy consumption and urbanisation. With most urbanisation expected to take place in developing regions, there is a need to increase energy efficiency and utilisation of renewable energy in the cities. Energy efficiency and renewable energy are also critical to achieve UN SDGs11 (Make cities inclusive, safe, resilient and sustainable) and 7 (Ensure access to affordable, reliable, sustainable and modern energy for all).[8]

7.3 Access to Electricity in Africa

Africa is rich in energy sources but yet poor in energy supply. Adequate energy infrastructure remains a barrier for many countries especially in the Sub-Saharan Africa even though there has been significant progress in improving energy sectors governance in many countries in Africa. Even though there has been significant increase in electricity connections in Africa, the rate of electrification continues to be slower than the population growth rate in the continent.[9] The large area size and low density of Africa's settlements results in higher costs required for infrastructure development and maintenance.

Figure 7.1 above shows that Ethiopia, Kenya, Uganda and Tanzania have the highest population without access to electricity. South Africa has the highest popu-

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[6]United nations economic and Social Council (2017). *Progress towards the Sustainable Development Goals*. http://www.un.org/ga/search/view_doc.asp?symbol=E/2017/66&Lang=E.

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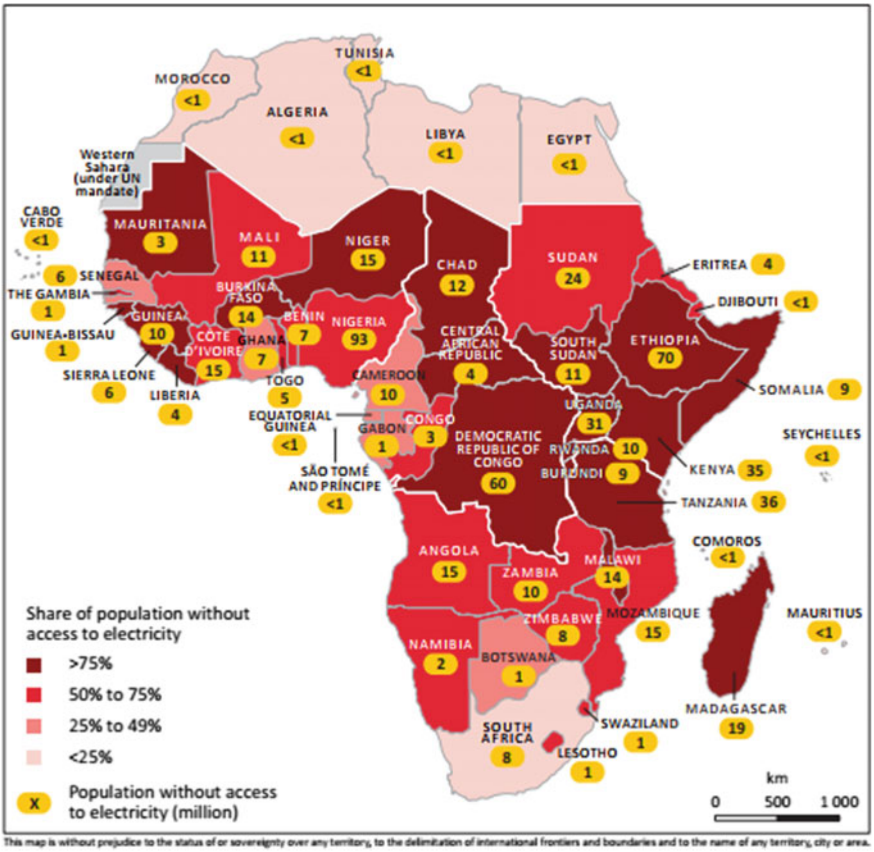

Fig. 7.1 Number and share of people without access to electricity in Africa. (International Energy Agency 2014). *Source* International Energy Agency 2014

lation with access to electricity in Sub-Saharan Africa. In the North Africa, Algeria, Morocco, Tunisia and Egypt have the least populations without access to electricity.

Electricity infrastructure is key to reaching African energy goals. Currently, electricity infrastructure is largely financed through public resources which create a gap due to financial constraints. Figure 7.2 shows the spatial distribution of electricity infrastructure in Africa.

Most of the electricity infrastructure in Africa was built in the 50s and 60s. A lot of investment is required to refurbish this ageing infrastructure. Forty-eight countries in Sub-Saharan Africa generate 68 gigawatts of which 25% of that capacity is unavailable because of aging or non-functioning plants and poor maintenance. The energy generated in this region is equivalent to what developed countries like Spain produce for its population. The involvement of private companies towards building or expansion of electricity infrastructure has proven to be successful in

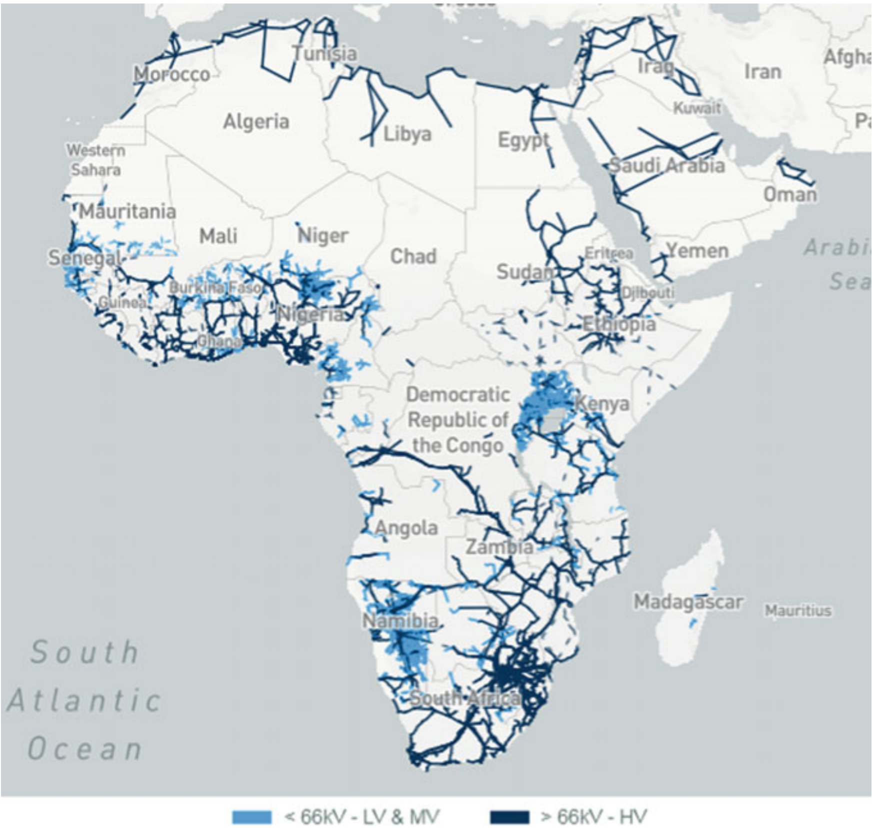

Fig. 7.2 Spatial distribution of electricity grid in Africa (Energy grid, http://africagrid.energydata.info/). *Source* Energy grid, http://africagrid.energydata.info

Latin America and Asia.[10] Developing frameworks and strategies to allow public and private partnership in Africa on infrastructure development can help improve access to energy resources in the continent. Barack Obama's Power Africa initiative provides opportunity for African governments, international and private sector to work together through generation and connecting people to clean, safe and efficient energy. A number of governments in Africa have developed Public-Private Partnerships (PPPs) to increase access of electricity and also to develop renewables energy systems. This type of collaboration may contribute towards development of reliable and sustainable energy infrastructure in Africa.

[10]ESI-Africa (2017). *World Bank calls for increased private participation in Africa's transmission infrastructure*. https://www.esi-africa.com/world-bank-electricity-transmission-infrastructure/.

7.4 Energy Efficiency in Africa

Changing the way energy is generated, transmitted, distributed and used will have an impact on the future of Africa. Due to lack of long term planning, aging and insufficient infrastructure, Africa is struggling to meet the energy demands. Energy efficiency is key to ensuring a safe, reliable, affordable and sustainable energy system for the future. Energy efficiency is the one energy resource that every country possesses in abundance and is the quickest and least costly way of addressing energy security, environmental and economic challenges. A focus on energy efficiency in Africa in parallel with new energy supply (central station power generation, mini-grids, and distributed renewable generation) can help reduce energy intensity, realize energy savings, lower the carbon footprint, create jobs and markets for energy efficiency related products and services, and allow electricity generation expansion to meet increasing demand in a timely, low-cost, and sustainable way. Energy efficiency solutions include the use of energy efficient equipment and appliances, promotion of efficient use of energy and building of smart buildings. With more than 60% of electricity supply in Africa relying on fossil fuels, energy efficiency has the potential to reduce greenhouse emissions and can enable supply to be expanded to meet increasing demand in a timely, low-cost, and sustainable way.

World Bank assessed 111 countries according to government policies and framework energy efficiency. According to this report South Africa and Tunisia are the only two countries in Africa that achieved a score of more than 67 in terms of national energy efficiency planning. This indicator assessed the existence of a national legislation of energy efficiency and action plan to reach the national and sectorial targets. The lower scores show that many countries in Africa are not paying attention to energy efficiency issues.[11] (Fig. 7.3).

In terms of energy efficient appliances, Ghana is the first country in Africa to establish appliance energy efficiency standards and labelling programme in 2000. This resulted in peak energy savings of over 120 megawatts (MW) and reduced CO_2 emissions.[12] A number of countries followed suit and establish appliance labelling standards. South Africa has also made great strides in labelling energy efficient devices and appliances. In 2012, South African Bureau of Standards introduced a product labelling standard for electrical and electronic appliances, lamps, light bulbs and all white goods in an effort to encourage consumers to use energy efficient products.

[11] World Bank (2017). http://www.worldbank.org/en/news/press-release/2017/02/15/world-bank-scores-sustainable-energy-policies-in-111-countries.

[12] Pielli, K., Dhungel, H., Mason, D., Tobin, D., Gottfried, D. (2014). *Examining energy efficiency issues in sub-Saharan Africa*. https://www.usaid.gov/powerafrica/newsletter/dec2014/smarter-power-in-africa.

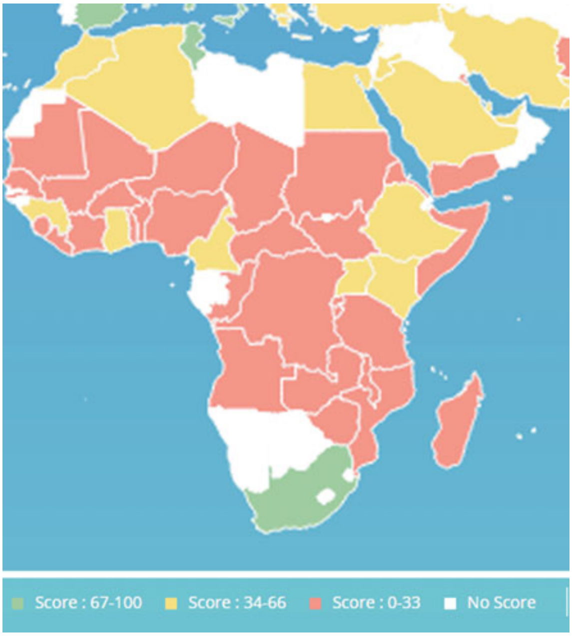

Fig. 7.3 Map showing energy efficiency scores in Africa (Banerjee et al. 2017). *Source* Banerjee et al. (2015)

7.5 Smart Energy and ICT in Africa

Information and Communication Technology (ICT) plays an important role towards implementing energy efficiency innovations. Smart ICT can contribute to a more economical use of energy and can help users manage their energy consumption and improve the communication with the energy providers. Internet plays a critical role in implementing smart energy technologies. There a number of energy innovations that are being implemented across the globe in an effort to reduce the consumption of energy and improve efficiencies. These innovations relies on ICT to enable energy to be dispatched only when needed.

ICT also helps the energy providers to forecast the demand of energy based on real time information received from the consumers and also the climate condition. This can also help the energy service providers to insure that the mini grids have sufficient energy to meet the demand in a particular area. The use smart phones allows the consumers get information on their consumption near real time and hence allow them to manage their consumption effectively. Digital connectivity remains one of the barrier of implementing smart energy innovation in Africa (Fig. 7.4).

The report by ITU Mauritius, Seychelles, South Africa, Botswana and Cape Verde were the only countries in Africa that registered higher ICT Development Index (IDI) between 2015 and 2016[13] (Fig. 7.5).

[13]International Telecommunication Union (2016). *Measuring the Information Society Report*. https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2016/MISR2016-w4.pdf.

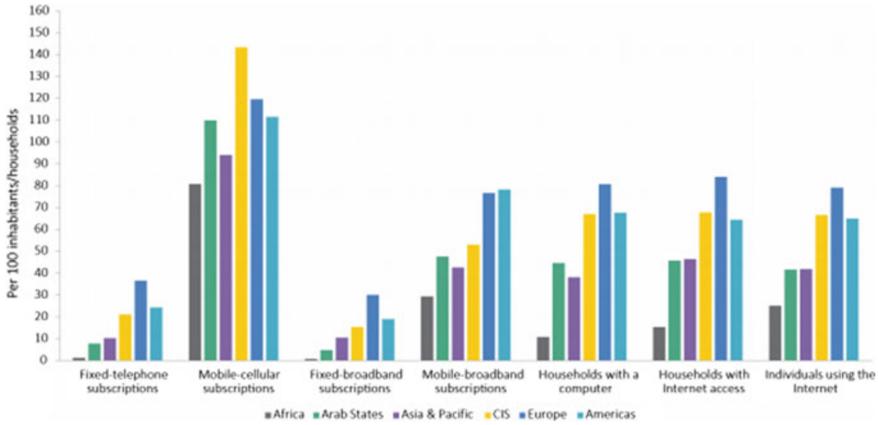

Fig. 7.4 ICT penetration levels, 2016, by region. *Source* International Telecommunication Union, 2016

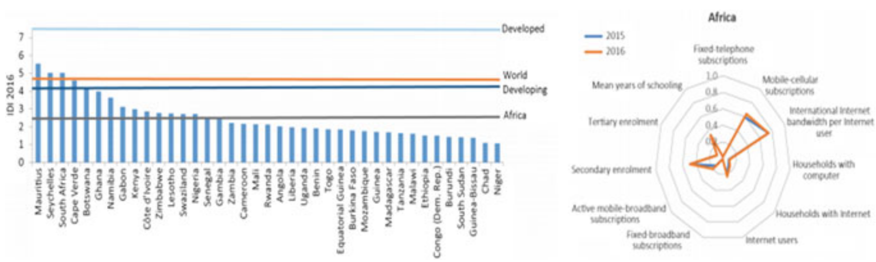

Fig. 7.5 IDI values for countries in Africa and average IDI values for each indicator (International Telecommunication Union 2016). *Source* International Telecommunication Union 2016

The spider chat shows that Africa had higher mobile cellular subscriptions and international internet bandwidth per internet users (0.6–0.75) in 2016 than other IDI values including number of internet users and households with internet. The number of internet users remains very low in Africa compared to the world average. According to International ITU, almost 75% of Africa's population are not using internet and only 15.4% have Mobile-broadband subscriptions[14] (Fig. 7.6).

Access to reliable connectivity is a major component of smart energy infrastructure. African Agenda 2016 aspires to have "*cities and settlements that are hubs of cultural and economic activities with modernized infrastructure, and people have access to affordable and decent housing including housing finance together with all the basic necessities of life such as, water, sanitation, energy, public transport and ICT and* inc*rease broadband penetration and connectivity*".[15] Through the Presiden-

[14]International Telecommunication Union (2016). *ICT facts and figures.* https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf.

[15]Agenda 2063, http://www.un.org/en/africa/osaa/pdf/au/agenda2063.pdf.

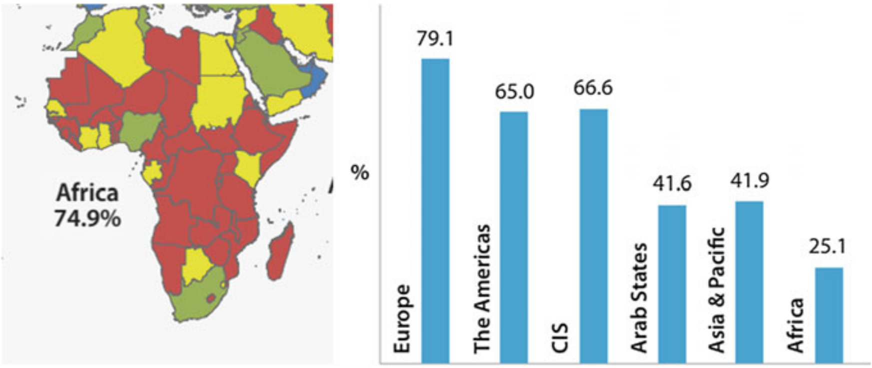

Fig. 7.6 Map showing percentage of individuals who are not using access and graph showing percentage of people with access to internet in Africa compared to other regions (International Telecommunication Union 2016). *Source* International Telecommunication Union 2016

tial Infrastructure Champion Initiative (PICI) of African Union, there are a number of initiatives in Africa that are aimed at ICT infrastructure across Africa. One such initiatives SMART Africa initiative which was adopted by Africa Union in 2014. This project is aimed at accelerating sustainable socio economic development on the continent through affordable access to broadband and use of ICT.[16] ICT can help reduce Co2, increased energy efficiency and energy saving. The following subsections will review some of the smart energy initiatives in Africa including smart grids, smart metering, smart buildings, smart appliances and smart transportation.

7.5.1 Smart Grid

A smart grid allows the use of digital communication between the utility and its customers and the sensing between transmission lines. Smart grids provide a number of benefits including improved efficiency, quicker restoration of electricity after power outages, reduced operational and maintenance costs, improved security, increased integration of large scale renewable systems.[17] Africa can improve access to electricity services by implementing smart grid technologies to meet the electricity demand of the future by integrating the grid with renewable energy systems. Lack of policies in smart grid, limited capital, inadequate infrastructure and lack of well-trained human resources are amongst some of the undermining factors of smart grid in Africa.

South Africa is one of the countries that have smart grid programme which is aimed at accelerating the implementation smart grids. In 2008, Eskom, the power

[16] SMART Africa, 2016, https://smartafrica.org/press-room/press-releases/article/smart-africa-oan-press-release.

[17] https://www.smartgrid.gov/the_smart_grid/smart_grid.html.

utility company in South Africa, approved a rollout of smart meters to 120,000 customers.The project was implemented between 2010 and 2012.The metropolitan municipalities in South Africa are responsible for the redistribution of electricity and manage and maintain the power distribution infrastructure. City Power, an independent municipal entity wholly owned by City of Johannesburg, was established in 2001 to provide electricity and energy solution to the city. City Power contributes to smart city initiatives through development of smart grid. The metropolitan municipalities are also responsible for the implementation of smart grid, renewable energy and energy strategies.

7.5.1.1 Smart Meters

A smart meter is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing. Smart meters enable two-way communication between the meter and the central system. Smart meters are the key component in smart cities.

Box 7.1 Smart meter initiatives in South Africa are picking up pace in cities than in rural areas: South African case study

As part of smart grid initiative, City Power, energy utility of city of Johannesburg, started installing smart meters (Advanced Metering Infrastructure (AMI) in 2011 to reduced energy loss due to levels of vandalism and meter bypassing improve safety of people and energy efficiency. AMI is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. The installation so smart meters resulted in increased revenue and reduced our operational costs. The use of smart meters also enables the city to communicate with the residents through sms to reduce power consumption at a particular time to reduce the demand of electricity or remind them to pay an outstanding bill. Another advantage of using smart meters is that City Power will be notified immediately when there is fault on the line. In 2016, about 75 000smart meters were installed in Johannesburg suburbs, business areas and townships.[18] Eskom, the power utility company in South Africa, has installed almost 6000 smart meters in Sandston and Midrand, Gauteng province, in 2016 to residential customers in its effort to improve reliability, reduction of public safety incidents and better management of energy consumption.[19] Efforts to improve

[18] City Power, https://www.citypower.co.za/city-power/Pages/Company-Profile.aspx.

[19] Eskom, 2016, http://www.eskom.co.za/news/Pages/Apr20.aspx.

better management of electricity are underway across the country through installation of prepaid meters.

Source City Power (see footnote 18), Eskom 2016.

City Power, https://www.citypower.co.za/city-power/Pages/Company-Profile.aspx.

Box 7.2 Electrification of rural areas in Mali using solar energy

The World Bank is committed to providing financial support to African governments for their reforms aimed at improving the energy sector and expanding access to users living in the most remote areas. As part of the Global Partnership of Output-Based Aid (GPOBA), the World Bank has also provided financing for projects to install new electricity meters in the commune of Sébékoro, in the Kayes region, to the west of Bamako. These meters are more affordable than those generally available on the market. The supply of electricity to the commune was also extended to run between 6 pm and midnight.[20]

Source World bank, 2017 (see footnote 20).

7.5.1.2 Smart Buildings

Internet of Things (IoT) technologies are advancing development of smart buildings. Smart Building innovation allows the owners or occupants to interact with their buildings and improve energy efficiency. These technologies use sensors to control heating, lighting, physical security, sanitation and other systems through building automation system. Smart commercial and industrial buildings and homes can improve energy efficiency, save costs and reduce greenhouse emissions. A number of countries in Africa are investing and promoting sustainable building development buildings starting with the government offices.

Box 7.3 Smart building initiatives in South Africa

In November 2014, the South African government launched the first energy efficient government building, Environment house, the green Headquarters of the Department of Environmental Affairs in Pretoria. It was the first government building to achieve a 6 Green Star rating from the Green Building Council of SA and is regarded as a landmark in energy efficiency. The building has

[20]Climate and Development Knowledge Network, PROJECT: ESMAP: The Lighting Africa Programme, https://cdkn.org/project/esmap-2-the-lighting-africa-programme/?loclang=en_gb.

photovoltaic cells line the roof; grey water is treated on site to use in the air-conditioning system, toilets and for watering the gardens; lights automatically light up or dim when people move in or out of an area; automatic sensors open and close windows depending on the temperature; there's a huge "green wall" of plants at the entrance; and the department's electric cars can be plugged into a solar power station to recharge. Solar energy contribute 10% of the total energy required to operate the building. The building green buildings saves on average 34 percent on electricity bills, 48 percent on water and 50 percent on waste to landfill sites.[21]

The use of energy saving lamps and low emitting diodes LED is offers energy efficient lighting. These light bulb can save up to 90% of energy compared to the traditional light bulb.[22] The South African Government has recognized the specific need for energy efficiency in the residential sector since at least 2005, with the publication of the National Energy Efficiency Strategy (NSS) 2005. In 2010 financial year, Eskom had installed more than 47 million compact fluorescent lamps in the residential sector in an effort to increase energy efficiency which brought the demand savings of 1958 MV. In 2017, more than 65 million were distributed to homes in the country.[23]

Smart lighting systems allows for automated control of lighting through sensing of occupancy or natural day light. Many new developments including shopping malls, airports and business areas are using smart lighting systems to reduce energy consumption.

Source IOL news 2014 (see footnote 21), Phillips, Energy efficient LED (see footnote 22).

7.5.1.3 Energy Efficient Appliances

Appliances such as refrigerators, washers, dryers, and water heaters consume most of the energy in homes. Energy efficiency appliances use less energy than the standard ones and hence, reduce electricity bills and energy demand. Many African countries offer consumers incentives to purchase to purchase energy efficient products. Ghana has made significant progress in regulating energy saving appliances.

[21] IOL news, 2014, Energy-smart building impresses, https://www.iol.co.za/news/south-africa/gauteng/energy-smart-building-impresses-1787385.

[22] Phillips, Energy efficient LED, https://www.philips.co.za/c-m-li/led-lights/eco-friendly-led-light.

[23] Eskom, COP17 fact sheet, http://www.eskom.co.za/OurCompany/SustainableDevelopment/ClimateChangeCOP17/Documents/Efficient_Lighting_Programme_involving_the_rollout_of_Compact_Fluorescent_Lights.pdf.

Box 7.4 Ghana Refrigerator Program

To improve energy efficiency, Ghana enacted 2 legislation aimed at regulating energy saving refrigerator, making it illegal to import refrigerators and phase out the use of inefficient refrigerators. Ghana refrigerator programme used rebate system was to get old fridges from homes and replace them with energy efficient refrigerators. The progamme was launched in the national capital in November 2012 and by December 2013, the scheme had been up scaled to all the 10 regional capitals. By December 2015 when the project was officially brought to an end, 10 000 new and efficient fridges had replaced the old and inefficient ones in the homes through the rebate scheme alone. Many others, who had the financial means, replaced their appliances without applying for the rebate. The share of new refrigerating appliances is now over 90% of the market. The annual emissions reductions increase linearly from 2010 from zero to approximately 100,000 tons/year in 2025.[24]

Source Hagan et al. 2006.

7.5.1.4 Smart Transportation

Transportation contributed 14% of 2010 global greenhouse gas emissions which is mainly from liquid fossil fuels.[25] Even though greenhouse emission in Africa has been lower than in other regions, the emissions are now slowly growing rapidly. Vehicle emission is a major source of air pollution especially around the cities. Lack of effective public transport and integrated planning and poor quality walking and cycling infrastructure are some of the causes of traffic congestions in the cities. Increasing number of vehicles in the cities has negative impact of the social, environmental and economic development. A number of countries have developed policies and standards to manage and reduce pollution form vehicles and hence reduce greenhouse emmissions.[26] Some of the strategies that are being implemented include extending rail network to provide reliable, safe, efficient and affordable transport services and provide infrastructure to promote the use of non-motorised transport.

Clean high speed trains can reduce environmental problems related to greenhouse emissions from vehicles. High speed train lines between the cities and between countries can also reduce journey times between cities and countries, consequently,

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[24]Ben Hagan, E., R. van Buskirk, A. Ofosu-Ahenkorah, M.A. McNeil (2006). *Refrigerator Efficiency in Ghana: Tailoring an appliance market transformation program design for Africa*. In Energy Policy, 35 (4).

[25]United States Environmental Protection Agency, Global Greenhouse Gas Emissions Data, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data.

[26]Stockholm Environment Institute, 2013, Transport and Environment in Sub-Saharan Africa, https://www.sei-international.org/mediamanager/documents/Publications/sei-pb-2013-africa-transport.pdf.

Fig. 7.7 Morocco's high speed train (Morocco World News 2018). *Source* Morocco World News 2018

contribute to economic development. Morocco is the first country in Africa to have a train of more than 200 km/h speed.[27]

Box 7.5 Morocco's Kenitra–Tangier high-speed rail line

Morocco will be launching the first high speed train in Africa in 2018. The 321 km/h train (double the speed of Gautrain) will connect Tangier and Casablanca. The Tangiers-Casablanca route is expected to generate a sharp increase in passenger numbers that will boost tourism, support wider economic growth in the cities, and recoup the investment on it[28] (Fig. 7.7).

Source Morocco World News 2018.

Other countries that have strategies to develop high speed trains include South Africa, Egypt, Algeria and Tunisia. In 2010, South Africa launched a 160 km/h speed train, Gautrain, which provides commuters within Pretoria and Johannesburg alternative transport system in an effort to reduce the use of vehicles within the province.

Box 7.6 Fast train in South Africa

Gautrain is an 80-kilometrecommuter rail system in Gauteng, South Africa, which links Johannesburg, Pretoria, Ekurhuleni and O. R. Tambo International Airport. It was built to relieve the traffic congestion in the

[27]Morocco World News, 2018, Morocco's High Speed Train to Become Operational in Fall 2018, https://www.moroccoworldnews.com/2018/07/250393/high-speed-train-fall-2018/.

[28]CNN travel, 2017, Morocco to get Africa's first high-speed train https://edition.cnn.com/travel/article/morocco-high-speed-tgv-trains/index.html?gallery=0.

Fig. 7.8 Gautrain. *Source* Geospatial World 2011

Johannesburg–Pretoria traffic corridor. Gautrain started operating in 2011.[29] Passengers buy a Gold Gautrain cards and load money for the train, bus and parking fares. A live system is available to check status of the line to allow commuters to plan their status. The rail system transports in excess of 60,000 passengers daily. Phase 2 of Gautrain is currently underway and will extend to townships including Mamelodi and Cosmo city[30] (Fig. 7.8).

Source Business tech 2017 (see footnote 30), Geospatial World 2011 (see footnote 29).

Africa is also in the process of constructing African Integrated High Speed Railway Network that will connect major cities and countries. This will promote intra-African trade[31] and also reduce CO_2 from vehicles.

Bus Rapid Transport (BRT) is a bus-based public transport system designed to improve capacity and reliability of the traditional bus system. The first BRT system started operating in Nigeria, Lagos in 2008. Morocco has 4 lines operating in Marrakech in 2016. The metropolitan municipalities in South Africa have started implementing the BRT system. BRT started operating in Johannesburg in 2009 while City of Tshwane Bus Transport System was launched in 2014. Plans to develop BRT in City of Ekurhuleni are currently underway. In Cape Town, BRT system started operating g in 2010. BRT system in Dar es Salaam started operating in 2016 (Fig. 7.9).

[29] Geospatial World, 2011, Gautrain, South Africa – An effective solution to Gauteng's traffic woes, https://www.geospatialworld.net/article/gautrain-south-africa-an-effective-solution-to-gautengs-traffic-woes/.

[30] Business tech, 2017, These are the new routes planned for the next phase of the Gautrain https://businesstech.co.za/news/finance/161169/these-are-the-new-routes-for-the-next-phase-of-the-gautrain/.

[31] **NEPAD, 2018, Progress on the African Integrated High Speed Railway Network,** http://www.nepad.org/content/progress-african-integrated-high-speed-railway-network.

Dar es Salaam Bus Rapid Transport System

Fig. 7.9 Dar es salaam bus rapid system (Africa 2017). *Source* Africa CGTN 2017

7.5.2 Renewable Energy

Renewable energy provides Africa with an opportunity to improve access to energy and hence help reduced poverty, promote economic growth and reduce greenhouse emissions. With the Africa's energy demands expected to rise by two third between 2016 and 2014, renewable energy provides can increase energy production, affordability, efficient and reliability.[32] Even though Africa is rich of renewable energy, the governments are not moving fast enough to uptake renewable energy with less than 1% of energy generated from renewable energy sources.[33] A number of African countries has policies and strategies that are aimed at increasing renewable energy share and energy efficiencies. These countries include Algeria, Morocco, Senegal, Ghana, Nigeria, Cameron, Ethiopia, Uganda, Rwanda, Tanzania, Zambia, Namibia and South Africa, refer to the Table 7.1 below for some of the existing policies and strategies:

Africa receives more hours of bright sunshine during the year than other continents. This provides the continent with solar energy sources that can be used for

[32]Engineering News, 2017, Renewable energy, critical to meeting Africa's energy needs by 2040, http://www.engineeringnews.co.za/article/renewable-energy-critical-to-meeting-africas-energy-needs-by-2040-2017-11-27.

[33]Joshua S Hill, Engineering news, 2017, Investment Vital To Unlocking Africa's Untapped Renewable Energy Potential https://cleantechnica.com/2017/02/17/investment-vital-unlocking-africas-untapped-renewable-energy-potential/.

Table 7.1 Policies and strategies for energy efficiency and renewable energy in Cameron, Ethiopia, Kenya and Uganda and Rwanda

Country	Sector	Policies and Targets
Cameroon	Efficiency/renewables/nuclear	• Vision 2035 • Increase production and deliver electricity with an emphasis on renewable energy • New framework to promote the implementation of renewable energy sources • Exemption of value-added tax for solar panels • Electrification master plan • Electrification of rural areas By 2020, the government aspires to reach electrification rates of 48% countrywide, with 75% electrification in urban areas and 20% in rural ones
Ethiopia	Efficiency/renewables/nuclear	• Increasing energy generation ca pacity from 2.26 GW to 17,34 GW and increasing the country's electricity service coverage from 60 to 90% • New law to focus on the proliferation of power purchase Agreements the development of off-grid systems, and the enactment of more efficient on-grid management policies • Power Africa initiative • Establishing 30,000 MW of energy generation capacity • Eastern Africa Power Pool {EAPP) • Facilitates cross-border grid connections and mandates the establishment of common codes and standards
Kenya	Efficiency/renewables/nuclear	• Set standards for electrical appliances • Set energy efficiency obligations for utilities • Energy bill 2014 provides for the creation of energy efficiency and conservation agency to enforce energy efficiency standards • Eliminate kerosene as a household fuel by 2022 • Requirement to install solar water heaters in buildings connected to the grid
Uganda	Efficiency/renewables/nuclear	• Global energy transfer feed-in tariff program • Premium payment mechanism • Security for facilities against off-takers and political risk • Privatefinancing mechanisms from Deutsche Bank
Rwanda	Efficiency/renewables/nuclear	• Increase access to electricity from 17% to at least 60% by 2020 and provide energy access to all schools and hospitals by 2017 • Reduce share of bioenergy in energy demand to 50% by 2020 • Expand the transmission network by 2100 km by 2017

Source Solar Plaza 2017

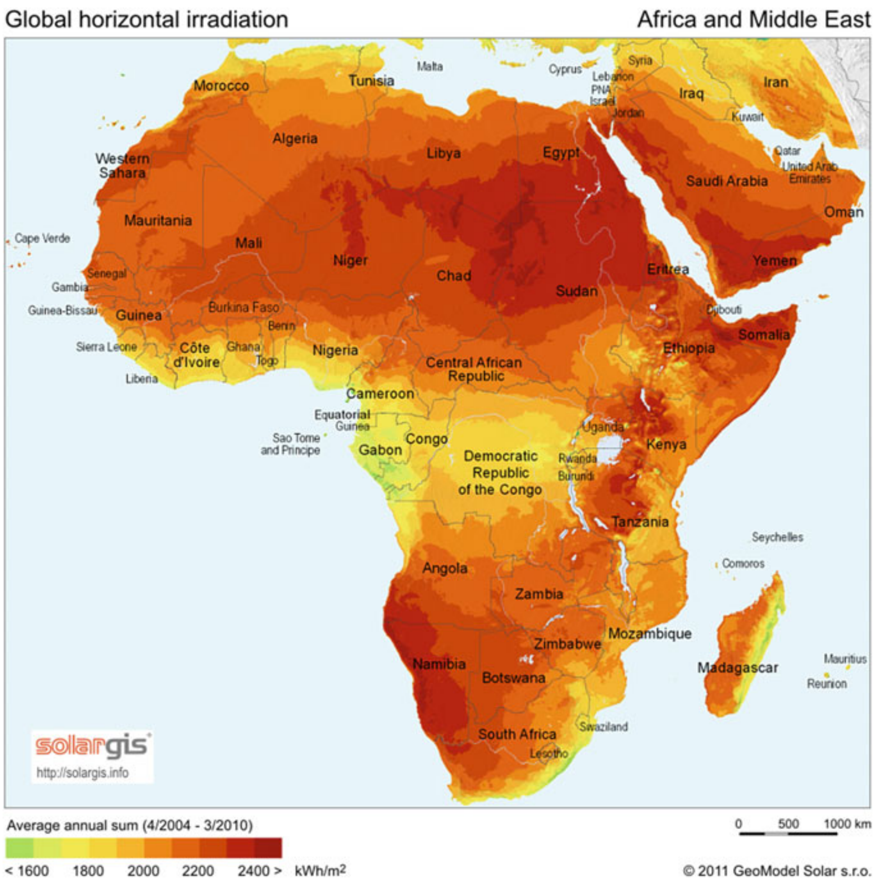

Fig. 7.10 Solar horizon irradiation, extracted from world map of global solar horizontal irradiation (SolarGIS). *Source* Solar GIS. http://solargis.info

lighting and cooking. Africa has a potential of generating up to up to 1100 gigawatts (GW) of solar energy (see footnote 33) (Fig. 7.10).

Box 7.7 Installation of solar geysers in South Africa

On 23 June 2009, the minister of energy stated in her budget speech that the department will ensure that 1-million solar water heaters are installed in households and commercial buildings over a period of five years. In 2010, the City of Johannesburg launched a solar heating programme to reduce electricity consumption which special focus to poor and low-income areas. The programme is part of the City's 2040 Vision to save energy and create employment through a low carbon infrastructure. In 2014, around 4 000 solar water heaters which

Fig. 7.11 Solar heater installation in new government housing projects (Engineering News 2017). *Source* Engineering News 2017

generate 22.5 GW of electricity per hour were installed in the city. By-laws regarding solar water heaters were recently approved City of Johannesburg council, and the city enforces the use of solar heaters in all newly built houses and in new building additions. Areas that have benefited from the solar heater programme include government building, townships and informal settlements. These areas include Devland, Lawley, Vlakfontein, Eldorado Park, Lenasia, Alexandra[34] (Fig. 7.11).

Source Engineering News 2017, Rennkamp 2012.

There are a number of renewable energy projects in Africa that are funded by the international donors and private companies such as Power Africa. These projects are also targeting the small towns and rural areas to improve access to energy using safe and clean energy sources.

Box 7.8 Electrification of rural areas using renewable energy: Niena case study

The World Bank Group is already implementing electrification projects in the rural areas in Mali, in conjunction with the Malian Agency for the Development of Household Energy and Rural Electrification (AMADER). In Niena also in

[34]Britta Rennkamp, 2012, South African approaches to MRV of mitigation actions: the case of installing solar water heaters\.

Fig. 7.12 *Solar field in NIENA,* Rural locality have benefited from a hybrid system (solar photovoltaic/diesel). This plant provides electricity to 538 customers. Installed power: 100 kva, Solar power: 50 kwc. *Source* World Bank 2017

the Sikasso region, Mali, 538 people are being supplied by a hybrid system (solar photovoltaic/diesel).Apart from the advantages similar to those observed in Zantiébougou, access to electricity has improved the security and quality of health centres and clinics. Teachers have also reported a marked improvement in their pupils' performance (see footnote 9) (Fig. 7.12).

At least 8 African countries are endowed with wind energy, however the energy generated through with technology in Africa is still less than 0.5% of the global capacity. Wind energy represents the smallest percentage of energy mix in Africa[35] (Fig. 7.13).

Coal and gas represent about 70% of the energy mix in Africa. Waste to Energy technology is a process of generating energy from treatment of solid waste. Even though Africa is the least urbanised continent with only 38% of the population living in urban areas, Africa is developing at a rapid rate, as a result, municipalities are struggling to manage the increasing amount of Municipal Solid Waste (MSW). Consequently, there is increase land, air and water pollution around urban areas. Increasing urbanisation and lack of infrastructure are some of the challenges faced by municipalities which result in a proportion of solid waste not collected. Waste

[35] Alli D. Mukasa, Emelly Mutambatsere, Yannis Arvanitis and Thouraya Triki, 2013, Development of Wind Energy in Africa, https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Working%20Paper%20170%20-%20Development%20of%20Wind%20Energy%20in%20Africa.pdf.

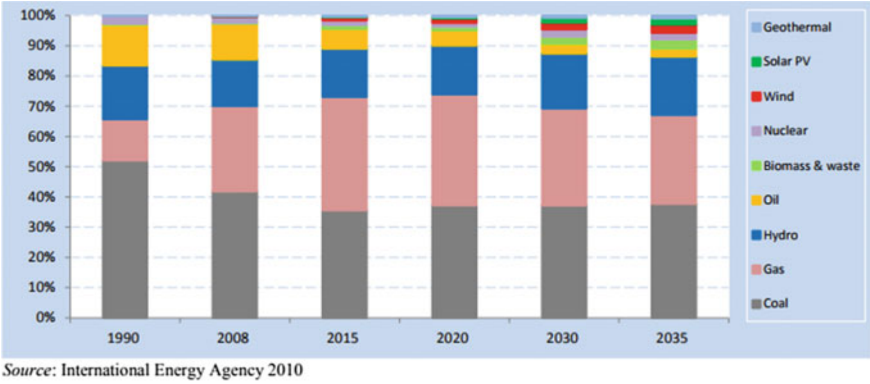

Fig. 7.13 Current and projected energy mix in Africa. *Source* Mukala et al. (2013)

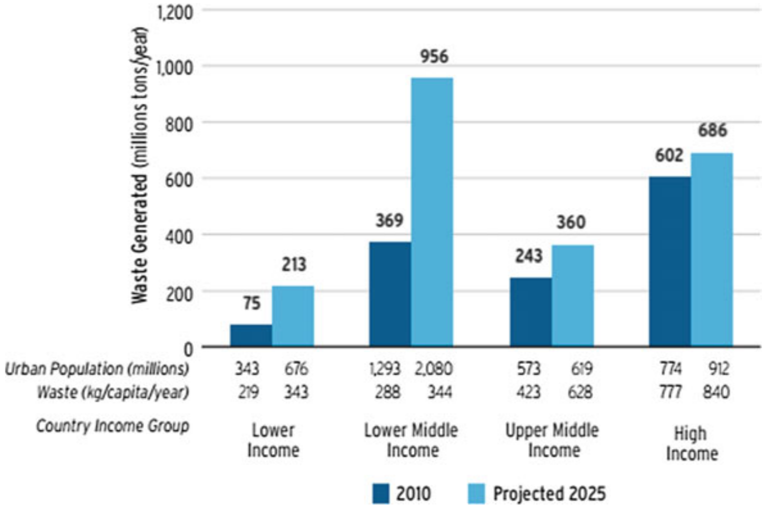

Fig. 7.14 Comparison of solid waste production per county income group (urban development series—knowledge papers et al. 1334). *Source* World Bank, Urban development series—knowledge papers (urban development series—knowledge papers et al. 1334)

to Energy technologies can help reduce the impact of MSW on the environment while providing an additional source of energy. Solid waste in developing countries is expected to increase rapidly in the next few years than in developed countries[36] (Fig. 7.14).

The current and projected increase in solid waste calls for an urgent need to manage and invest in technologies to create by-products from solid waste. A study

[36]World Bank, urban development series – knowledge papers, chapter 3, http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1334852610766/Chap3.pdf.

by Scartlat et al., 2015, showed that the energy potential of generated waste could have provided 1125 PJ of energy for the whole Africa in 2012 and this could reach 2199 PJ in 2025 but since collection rates in African cities are quite low, the energy potential of waste actually collected was estimated to be about 613 PJ in 2012 and 1508 PJ in 2025[37] (Fig. 7.15).

Waste to energy technologies are gaining momentum in Africa, with the first landfill gas to energy plant built in 2016 in Johannesburg and solid waste to energy plant in 2017 in Cape Town. Waste to energy station in Addis Ababa is expected to be operational in 2018.

Box 7.9 Waste to energy plant in Ethiopia

A new waste-to-energy plant is set to start operations in Ethiopia aiming to revolutionise waste management practices in the country. The Reppie thermal plant is being built in Ethiopia's capital, Addis Ababa, and when commissioned by the beginning of 2018, it will incinerate approximately 1400 tonnes of waste. This represents 80 percent of the city's waste generation, accounting for 400,000 tonnes per year. This means that with a capacity of 110 megawatt thermal (MWth) the power plant will provide electricity to 30 percent of its household electricity needs.[38]

Source Climate Action programme 2017.

Box 7.10 Waste to energy, cape Town, South Africa

Africa's first waste-to-energy facility has been opened in the Athlone Industrial, Cape Town. Speaking at the official launch earlier this week, Mayor Patricia de Lille called it a "very exciting addition to our city's green economy as the Mother City continues to build its reputation as one of the green capitals of the world.[39](Fig. 7.16).

Source Engineering news 2017.

[37]N. Scarlat, V. Motola, J.F. Dallemand, F. Monforti-Ferrario & Linus Mofor, 2015, Evaluation of energy potential of Municipal Solid Waste from African urban areas, Renewable and Sustainable Energy Reviews 50 (2015) 1269–1286.

[38]Climate Action programme, 2017, Africa's first waste-to-energy plant to be commissioned in Ethiopia, http://www.climateactionprogramme.org/news/africas-first-waste-to-energy-plant-to-be-commissioned-in-ethiopia.

[39]Engineering news,2017, Ground-breaking waste-to-energy plant opens in Cape Town http://www.engineeringnews.co.za/article/ground-breaking-waste-to-energy-plant-opens-in-cape-town-2017-01-24/rep_id:4136.

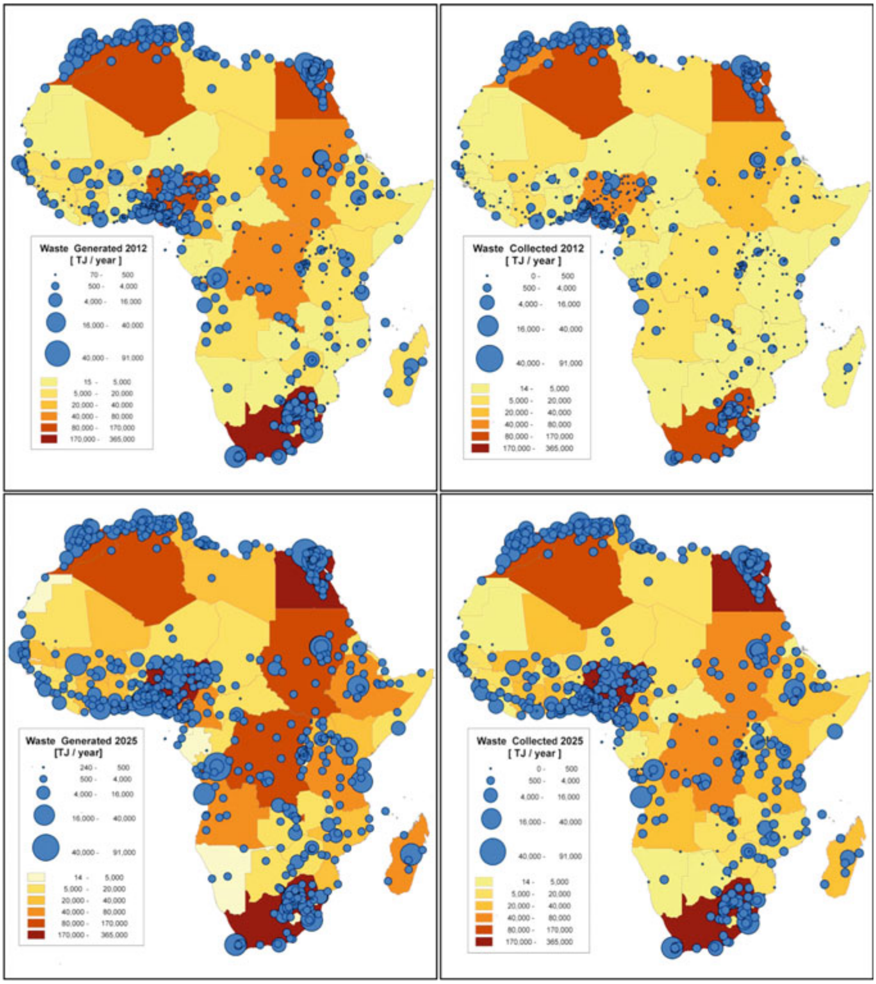

Fig. 7.15 Energy potential from waste generated (left column) and collected (right column) in Africa in 2012 (top line) and 2025 (bottom line) (Scarlat et al. 2015). *Source* Scarlat et al. 2015

Fig. 7.16 waster-to-energy plant in Athlone Industrial, Cape Town. *Source* Engineering news 2017

Fig. 7.17 Landfill gas to power facility in Johannesburg (Infrastructure News 2016)

Box 7.11 Landfill gas to power- Johannesburg, South Africa

South Africa's first independent landfill gas-to-power project has begun generation in Johannesburg providing 3 MW of renewable electricity. This is enough to supply more than 5500 homes. Project developer ENERGY Systems started operations at the project which is based at Robinson Deep landfill site in Johannesburg. This is the first stage of a £7,2 million (approximately R 130 million) investment in five landfill gas generation plants in Johannesburg, and is the largest project of its kind ever developed in South Africa[40] (Fig. 7.17).

Source Infrastructure news 2016.

7.5.3 Off Grid Energy Solutions for Africa

Off grid systems may provide cost effective solutions to connect homes and small businesses that are not connected to the grid using renewable energy sources. These systems can also be used by people who are connected to the grid to reduce electricity costs and improve reliability. These systems can be used to connect rural areas in Africa that are located far from the grid and create economic opportunities in rural areas and small towns.

Box 7.12 Off grid systems in informal settlement school in South Africa

The government of South Africa is committed to using safe and clean off grid systems to power schools. In 2016 the first solar off grid solution, PowerTurtle, was launched at school in the informal settlement of Palm Ridge in Gauteng, South Africa. The plan is to use off grid systems to power all schools that are not connected to grid and their surrounding communities.[41]

Source Infrastructure news 2016.

The World Bank, Global Environmental Fund, Energy Sector Management Assistance Program of some of the developed and semi developed countries and government have partnered on a Lighting Africa project which is aimed at ensuring that quality off-grid lighting products are accessible to energy-poor households in several regions in Africa (see footnote 20). "Since running its first pilot projects in Ghana and Kenya in 2009, Lighting Africa has already enabled 23.3 million people across Africa to meet their basic electricity needs (lighting and mobile phone charging)

[40]Infrastructure news, 2016, SA's first independent landfill gas-to-power project powers up, http://www.infrastructurene.ws/2016/12/15/sas-first-independent-landfill-gas-to-power-project-powers-up/.

[41]Infrastructure news, 2016, Off grid energy solution goes live in SA school, http://www.infrastructurene.ws/2016/03/02/off-grid-energy-solution-goes-live-in-sa-school/.

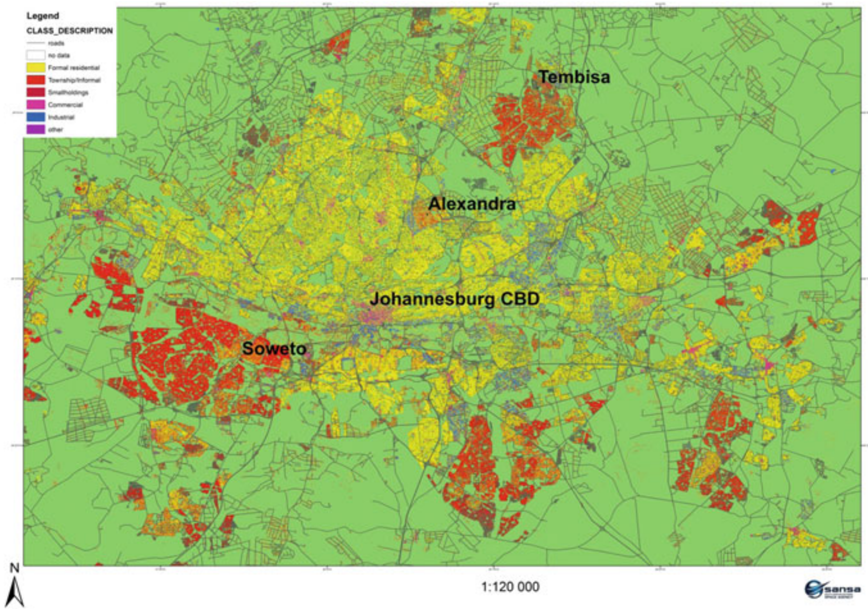

Fig. 7.18 Spatial distribution of human settlement types in Johannesburg, South Africa (South African National Space Agency 2017). *Source* South Africa National Space Agency 2017

through quality-verified off-grid solar products and aims to reach 250 million more people by 2030. Lighting Africa is currently operational in 11 countries: Burkina Faso, the Democratic Republic of Congo, Ethiopia, Kenya, Liberia, Mali, Nigeria, Rwanda, Senegal, Tanzania, and Uganda – with plans to continue to extend our activities across the continent.[42]

7.6 Geospatial Technology and Smart Energy Development

Africa's energy challenges require accurate and timely geospatial information on land use at various scales from regional to local scale. Remote sensing technologies provide dynamic data to help address energy challenges and data required to model energy demand. Information on spatial distribution of human settlements and urban growth patterns can be vital during planning of energy infrastructure (Fig. 7.18).

Figure 7.18 shows the spatial distribution of human settlement types around Johannesburg, South Africa. The location of townships and informal settlements (Red) in urban fringes is evident. This information is integral in supporting the development goals highlighted in various spatial development frameworks for municipalities.

[42]Lighting Africa, https://www.lightingafrica.org/about/.

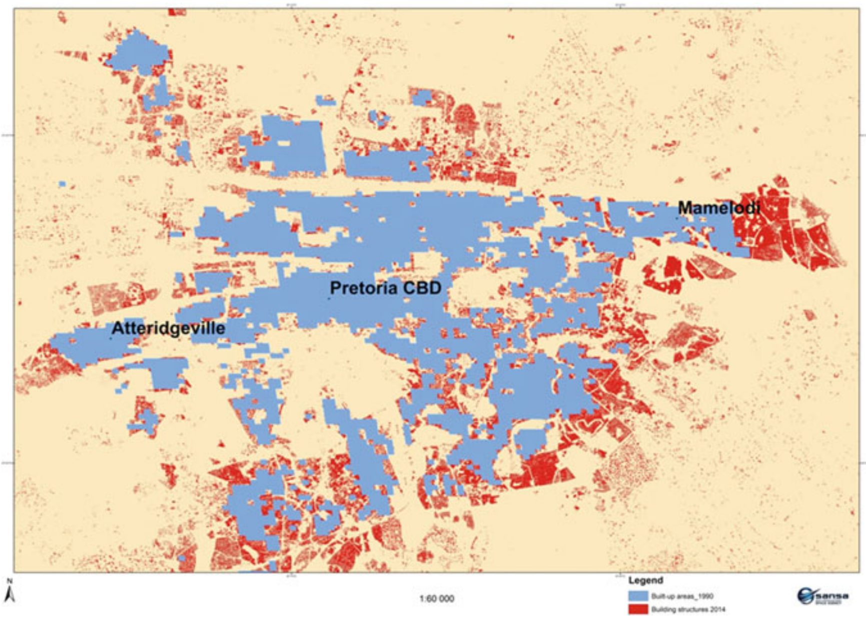

Fig. 7.19 Urban growth around City of Tshwane (formerly known as Pretoria), South Africa between 1990 and 2014 (South African National Space Agency 2017). *Source* South Africa National Space Agency 2017

Implementation of strategies such as Bus Rapid Transport System requires this information to identify effective route to commute people from townships to economic opportunities and reduce traffic congestion around the city (Fig. 7.19).

Figure 7.19 shows human settlement expansion around Pretoria that took place between 1990 and 2014. The 1990 built-up areas were mapped using Landsat 5 Thematic Mapper images and the 2014 built-up areas was mapped using SPOT 5 imagery. Analysis of geospatial data on the spatial growth of settlement and growth patterns provide intelligent information on energy infrastructure and capacity required to support the current and projected population. Settlements which do not have access to electricity infrastructure and services can also be identified using geospatial technology. Areas where renewable energy systems can be implemented can also be mapped and identified. Remote sensing technologies also provide data required to monitor the natural renewable energy. Geospatial provide base data for integrated land use planning and management.

7.7 Conclusion

In this chapter we aimed to review the status of smart energy development in Africa and highlight the progress being made towards the implementation of smart energy solutions on the continent and appraise the status of ICT infrastructure and highlight some of the case studies on smart energy systems aimed at energy efficiency and smart grid development. Our review of the status of smart energy development in Africa clearly highlight the importance of energy as key factor in ensuring sustainable development in Africa. In particular, the review notes that the achievement of sustainable development plans such as UN SDGs, Agenda 2063 and National Development Plans requires reliable and better access to energy through quantum improvements in the energy mix clearly targeted towards increasing the quantity of renewable energy on the supply side and improving energy efficiency at usage level. Energy is a key driver of economic growth and has direct impacts of to social welfare and environmental sustainability.

The review clearly reveals that while Africa is endowed with untapped energy resources, it is still faced with an acute shortage energy supply due to inadequate electricity infrastructure. At least 10% of the African population has access to the electric grid making it difficult for private energy suppliers to connect to the grid to improve the supply of electricity. The adaptation of smart energy infrastructure is therefore critical to improve this situation and support future population growth particularly in urban areas. Major African cities has been experiencing rapid rates of urbanisation of at least 3.5% per annum of the last two decades and it is projected that at least 60% of the African population will be urban dwellers by 2030. With this reality in mind, the need for smart energy infrastructure and diligent master spatial planning in inevitable.

The review also concludes that the exploitation of sustainable renewable energy resources such as solar, wind, biogas and micro hydropower stations provides Africa with a unique opportunity to boast electricity supply to support economic growth while simultaneously reducing greenhouse emissions. This approach will not only assist African countries in achieving universal access to electricity but assist them in reducing their greenhouse gases in accordance with the Paris Agreement targets. The implementation of smart energy infrastructure, energy efficient appliances and renewable energy is essential in the attainment of the UN SDGs such as goal 7 that aims to ensure access to affordable, reliable, sustainable and modern energy and goal 11 that seeks to make cities inclusive, safe, resilient and sustainable.

The role of Information and Communication Technology (ICT) in ensuring energy efficient innovations has been noted as critical. Smart ICT has been proven to be valuable in monitoring the economical use of energy and in improving the communication with the energy providers. Smart technologies such as the Internet, Internet of Things, Digital connectivity, and Smart phones can play a significant role in energy demand forecasting and near real time communication. The emergency of Smart buildings that integrate ICT and sensors was also considered as a valuable contribution in improving energy efficiency in Africa through automated systems that control heating, lighting, physical security and sanitation. The review also concludes that timely and accurate geospatial information is crucial in aiding spatial planning of electricity infrastructure in Africa. Geospatial data derived from remote sensing has been proven to play a key role in reducing the cost of surveys necessary in constructing electricity infrastructure such as powerlines. The implementation of smart grids that use digital communication was also considered beneficial in improving energy efficiencies. Other advantages for smart grids include shorter turnaround times for electricity restoration after power shortages, improved security and lower operational and maintenance costs.

Funding has been noted as a challenge in financing electricity infrastructure and most of the infrastructure has been funded using public finances. Considerable success has however been achieved in cases where Public-Private Partnerships jointly invest in sustainable renewable energy infrastructure projects aimed at increasing access to electricity. The review also concludes that changing the way energy is generated, transmitted, distributed and utilized will considerably impact Africa's ability to power its sustainable development needs.

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Chapter 8
Smart Urban Accessibility and Mobility for Smart Economy in Africa

Gora Mboup

Abstract Africa's rapid urbanization provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand for urban accessibility. For cities to act as integrated labour markets and match jobs seekers and employers, they need to make employment spatially accessible to all residents. Economies of scale and agglomeration are, indeed, greater in cities where mobility infrastructures are able to respond accessibility needs with higher access to markets and resources than those where people's mobility is impeded by deficient mobility infrastructures. Demand for accessibility and mobility depends first on how the cities are designed in terms of urban form and structure. Urban form and structure depend on how the cities are planned in terms of (mixed) land use, compactness, densities, and street planning and design among other factors.

Keywords Accessibility · Mobility · Transport · Streets · Connectivity Urban form · Public transport · Walking · Cycling · BRT · Finance · Municipality City

8.1 Introduction

Today, four out of ten Africans live in cites and towns (40.4% in 2018). In terms of absolute number, half a billion of African people live in urban areas in 2018, and it is projected that the African urban population will reach one billion in 2040. For over a century, a dramatic change has, indeed, been taking place in the distribution of African population with an accelerated concentration in large urban agglomerations. Rapidly increased urbanization levels from the 20th to the 21st century in Africa have also been accompanied by spectacular growth in city size. From only three

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cities (Cairo, Alexandria and Johannesburg) with a population of 1 million or more in 1950, the number of cities with a population of 1 million or more has grown to 54 in 2014. The number of cities with a population of between 300,000 and 1 million, now 133, is also rapidly growing. In 2014, 244 million people lived in the 187 urbanized areas, representing 52% of the total urban population of Africa. Megacities have also emerged in Africa with four cities—Cairo, Lagos, Kinshasa and Johannesburg—having more than 10 million inhabitants. By 2030, Dar-es-Salam and Luanda will also join the group of megacities, and a significant number of African cities will have a population of more than 5 million.[1]

Africa rapid urbanization provides opportunities for economies of scale and agglomeration, but it will also call for large investments in infrastructures to respond to the increased demand for urban accessibility. For cities to act as integrated labour markets and match jobs seekers and employers, they need to make employment spatially accessible to all residents. Economies of scale and agglomeration are, indeed, greater in cities where mobility infrastructures are able to respond accessibility needs with higher access to markets and resources than those where people mobility is impeded by deficient mobility infrastructures. Efficient urban mobility systems increase accessibility to markets, employment and investments and therefore provide better access of people to economic and social opportunities. Deficient mobility systems create negative externalities and are source of social inequalities in cities. Efficient mobility systems make mobility means accessible and affordable to all people, while deficient mobility systems exclude the urban poor from many urban advantages and opportunities. The mobility of people and freight reflects the level of accessibility of urban residents to the multiple economic opportunities that cities offer (Fig. 8.1).

Demand for accessibility and mobility depends first on how the cities are designed in terms of urban form and structure. Urban form and structure depend on how the cities are planned in terms of: mixed land use, compactness, densities and street planning and design among other factors. The first three elements were addressed in Chap. 3 showing that African cities are particularly dense, and most of them are monocentric with services far away from residential proprieties. During the urbanization process some cities had maintained their compactness easing accessibility others had lost their compactness making accessibility difficult. While these three elements will be referred here, the first section of this chapter is dedicated to streets as the basic element of the form and structure of a city and key for accessibility. Street planning and design determines in large the connectivity degree of cities. The second dimension of urban accessibility and mobility lies on the means of mobility: motorized means, walking or cycling. This second section had been for long time the main focus of urban transport studies, particularly the motorized means of movement. The section addresses particularly the public transport formal as well as informal and others types of mobility.

[1]Calculated by the author from the UN population Division, Department of Economic and Social Affairs, 2015. World Urbanization Prospects: The 2014 Revision. New York (USA).

Fig. 8.1 Means of accessibility to services. *Source* Conceptualized and designed by the author

8.2 Streets—Drivers of Urban Accessibility

In recent years streets have been recognized as an integral factor in the achievement of sustainable urban development. Connected streets enhance infrastructure development, environmental sustainability, and economic and social development. They make cities resilient and equipped to overcome natural disasters. A sustainable, inclusive, resilient and prosperous city expands multimodal transport systems with sidewalks and bicycle paths, ensures eco-efficiency of infrastructural systems, and supports density through integrated infrastructure development, thereby enhancing efficiency and access. In addition to accommodating all kinds of users (pedestrians, cyclists, motorists), sufficient land allocated to streets promotes connections to services that contribute to good health and productivity, such as clean water, sewerage facilities, drainage systems, power supply, and information and communication technologies. Streets that provide space only to motorists are characterized by congestion and high CO_2 emissions.

8.2.1 *Concepts and Measures of Street Connectivity*[2]

Connected streets accommodate both motorized and non-motorized modes of transport

The street plays a pivotal role in setting up of urban infrastructure development. The planning and design of streets as public spaces not only has a direct effect on transport modes, but it also has an impact on provision of basic services. The street provides the connectivity pattern for the city, which is fundamental for effective urban mobility. Amongst any city's most prized assets, the street network ranks high as it facilitates the movement of people, goods and services. Street networks and mobility patterns further facilitate access to jobs, commerce, health services and school facilities in the city. Good street connectivity not only reduces traffic congestion, commuting time, motor vehicle commuters, but also reduces fares, fuel consumption, traffic fatalities, and greenhouse gas emissions in cities.

However, poor maintenance of the road infrastructure characterizes most streets in African cities. In addition, the street networks in these cities have barely kept pace with urban growth. Also, infrastructure for non-motorized transport (e.g. pavements or sidewalks for walking and bicycle lanes for cycling) is often lacking, or poorly developed. This has led to high incidences of traffic fatalities involving pedestrians and cyclists.[3] The dysfunctional nature of road infrastructure in most African cities poses a major challenge to mobility and is an important source of traffic congestion, and hinders free movement and making travel frustrating and time-consuming.[4]

Connected streets safeguard environmental sustainability

The impact of pollutants on the ecological state of the city makes it imperative that streets as a "zone of maximum exposure" take centre stage when the study of environmental sustainability towards the achievement of sustainability, inclusion and prosperity is examined. Pollution emissions released on the street contribute to the most harmful effects on climate change, ozone depletion, ecological damage, street aesthetics, and human health. The idea that streets are a "green" public good and are public spaces is one that needs to be examined. Non-motorized forms of transport, pedestrianization, cleaner fuels and reduced traffic congestion are just some of the measures that can limit the damaging effects of motorized transport and traffic congestion. These should be considered when planning streets of the future. A connected street network helps to safeguard environmental sustainability in easing mobility and provision of basic services will low carbon emission. By promoting walkability and cycling, connected streets contribute to the reduction of air and water pollution and to the preservation of biodiversity.[5] Along with public parks, waterfronts and "green" areas for recreational and productive purposes, connected

[2]For more details refer to the main publication: Mboup (2013).

[3]Dahl (2004); WHO (World Health Organization) (2004); Pucher et al. (2007).

[4]Mboup (2013).

[5]Frank et al. (2010).

streets help to reduce fragmentation of natural systems and reduce the spatial footprint through the careful design of infrastructure networks and settlements.

Connected streets promote economic development

Connected streets promote economic growth through productivity, generating the income and employment that can elevate the living standards of the whole population. High street connectivity plays a key role in productivity. Connected streets harness the benefits of agglomeration economies; they improve access to productive advantages (knowledge, quality of the environment, etc.); they provide sufficient public space for circulation of goods and people and deploy adequate infrastructure; they encourage polycentric urban development; they allow synergies between centres and sub-centres; and they intensify urban nodes and corridors to maximize the benefits of concentration. Good street connectivity can increase economic productivity and competitiveness through increased transport system efficiency that reduces traffic congestion and commuting costs. Efficient and fast transport, in turn, can increase labour productivity by reducing commuting times, and increasing worker productivity. Streets also play an important role in direct economic activities, such as street vending. Businesses along streets have higher sales when there are more pedestrians and cyclists using these streets. Consequently, there is a rise in employment, income, property values and tax revenues. Well-connected streets attract both formal and informal businesses.

Connected streets enhance social development

Social development is increasingly associated with an inclusive, well-planned, healthy and supportive environment. Sustainable mobility systems, green open spaces and cultural and sports facilities are major factors contributing to asocial development, including better quality of life. They ease the provision of social and health services required for improved living standards. The ways in which we design and build streets have significant implications for health and quality of life. With the increased use of cars, a sedentary lifestyle is becoming more common among the urban middle and upper classes; this contributes to an increase in obesity, in addition to increasing air pollution and greenhouse gas emissions. Streets that promote walkability and cycling as elements of an active lifestyle contribute to healthy living, as well as reduction in vehicle emissions.[6] Many important quality-of-life benefits also arise when streets promote non-motorized transport. Increased outdoor activity and reduced air pollution translate into better public health.

Connected streets promote social inclusion, peace and security

Connected streets promote social inclusion by ensuring high quality public spaces that promote interaction among communities; by improving safety and security; and by promoting green spaces. It is in any city's best interest to promote use of streets as public spaces that promote social inclusion, equity and safety.[7] No city can

[6]See Footnote 5.

[7]See Footnote 4.

claim to be prosperous when large segments of the population do not have access to streets. Connected streets enhance access to a range of well–located, adequate public infrastructure and amenities (including education, health, recreation, etc.) for all groups, including the poor, the young, women, the old and the disabled. They also facilitate the creation of mixed neighbourhoods with a diversity of jobs and housing options; promote mixed-used land development, ensure involvement of marginalized groups; and improve connectivity between neighbourhoods and access to services.

8.2.2 Measures of Street Connectivity[8]

A variety of measures of street connectivity have been used in various fields, including transport, urban planning, geography, and landscape ecology. There are various indices that have been created to directly or indirectly measure street connectivity in an area. Stephan J. Schmidt and Jan S. Wells (Transit Village Monitoring Research, October 2005) recommend that for a best connectivity measurement, research should be done to construct a composite street connectivity index that includes the usual quantitative measures and other qualitative measures. Although all these indices are relevant to assess connectivity, we have selected only those that are relevant for policies and those for which large sets of data are available. These indices are: land allocated to streets; street density; intersection density; connected node ratio; and link-to-node ratio. These are likely to be highly, positively correlated to each other, and can be expressed through a composite index.

Composite Street Connectivity Index (CSCI)

Having data on the proportion of land allocated to streets is not sufficient to assess the connectivity of a street. A city (or neighbourhood) can have wide streets in a very limited street network and low intersection density, which does not always imply high connectivity. For example, a lengthy network and dense intersections on very narrow streets do not also promote high connectivity. A combination of the three variables is therefore required to capture the degree of connectivity of a street network. That is what a *Composite Street Connectivity Index (CSCI)* does.

CSCI is computed using the following five street indicators: (i) proportion of land allocated to streets; (ii) street density and; (iii) intersection density. The closer the CSCI is to 1, the more connected is the street network of a city. On the contrary, the closer the CSCI is to 0, the less connected is the street network of a city. The index is computed by using the geometric mean of the five dimensions as shown below:

$$\mathrm{CSCI} = \mathrm{X}_1^{1/3} * \mathrm{X}_2^{1/3} * \mathrm{X}_3^{1/3}$$

where: CSCI = Composite Street Connectivity Index; X_1 = Proportion of Land Allocated to Streets; X_2 = Street Density and; X_3 = Intersection Density.

[8]See Footnote 2.

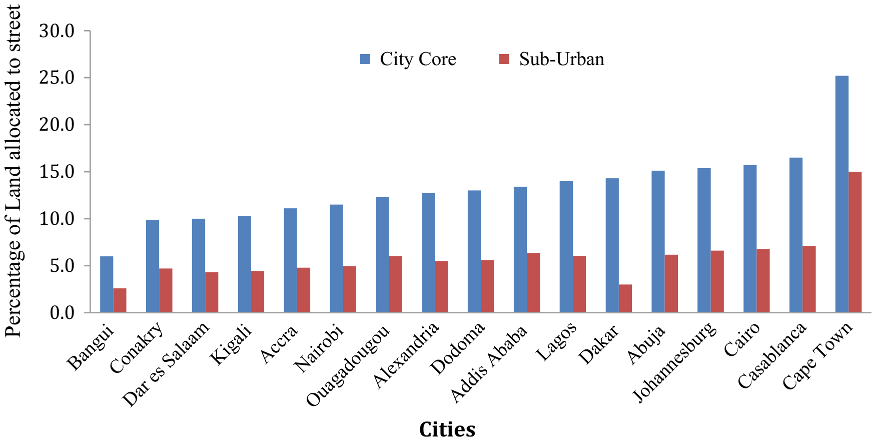

Fig. 8.2 Land allocated to street (LAS) in African cities. *Source* Mboup (2013)

Data and sources

Information on streets is scarce for most African cities, and when it exists it is diluted with data on transport. Indicators to assess the multi-functionality of streets is lacking for most African cities, where the focus is more on the mobility function of streets rather than their social and economic functions. The lack of reliable data on streets has held back the development of effective urban policies aimed to tackle lack of basic services and transport in African cities. The most common indicator for streets is street density, which measures the length of street networks per one square kilometre. This analysis of the state of streets in African is based on 44 cities. Fifteen cities are capital cities or large cities (more than one million inhabitants). Though they do not represent all cities of Africa, they allow us to analyse and to identify some regional variations in street connectivity. Seventeen cities are from the Lake Victoria Region allowing analysis of streets in small cities and towns compared to cities in their countries respective: Kenya, Tanzania and Uganda.

8.2.3 Street Connectivity in African Cities

Street connectivity is determined by the amount of land allocated to streets, the length of the street network and the number of intersections along the network. Having only either the information on the proportion of land allocated to streets or the length of the network is not sufficient to assess the connectivity of a street. A city can have wide streets in a very limited street network and low intersection density, which does not translate into high connectivity. A lengthy network and dense intersections, but very narrow streets, do not also promote high connectivity (Fig. 8.2).

Land Allocated to Streets

Except the city of Cape Town that allocated a relatively sufficient land to streets (25.2%) in the city core, all African cities allocated less than 20% to streets in the city core (between 14 and 16.5% in Lagos, Dakar, Abuja, Johannesburg, Cairo and Casablanca), and (between 10 and 14% in Dar es Salam, Kigali, Accra, Nairobi, Ouagadougou, Alexandria, Dodoma and Addis Ababa). Bangui is the only city where land allocated to streets in the city core is below 10% (6%) as it is observed in all suburbs of African cities, except the suburbs of Cape Town where the share of street is estimated as 15%, level similar to most African cities city core.

A large majority of African cities allocate a very small proportion of land to streets: out of the 18 African cities included in this study, 13 allocated less than 15% of land to streets, with the lowest level (6%) observed in Bangui in the Central African Republic. Other cities in this group have more land allocated to streets, but the levels are still very low, varying from 10% in Tanzania's major city Dar es Salaam to 14.3% in Senegal's capital Dakar. In addition, infrastructure for non-motorized transport (e.g. pavements or sidewalks for walking and bicycle lanes for cycling) is often lacking, poorly developed, or on the decline. This has led to high incidences of traffic fatalities involving pedestrians and cyclists. Lack of streets hampers severely a city ability to provide services such as safe water and adequate sanitation. Water and sewerage systems are usually planned along existing street networks, and when these are non-existent, they make it difficult for authorities to provide these services.

However, regardless of the level of connectivity in the city core, in the suburban areas of African cities, not only are there few streets built (with less than 5% of land allocated to streets), but those that exist are narrow and disconnected, except for one or two arterial streets passing through neighbourhoods. The city of Dakar offers a typical example: the proportion of land allocated to streets in the suburbs is more than three times lower than its level in the city core (3% vs. 14%). Out of the 18 African cities included in this study, only five cities belong to the group with low to moderate levels of land allocated to streets; these are Abuja in Nigeria, Cairo in Egypt, Casablanca in Morocco, Johannesburg in South Africa and Harare in Zimbabwe. The moderate levels of land allocated to streets in these cities facilitate the provision of other services, such as water and sewerage, which are normally laid out along the paths of existing streets. The provision of basic services is almost universal in these cities in general, with connections to piped water, as well as to sewerage systems. However, considering the high frequency of flooding in some of these cities, we can assume that the opportunity offered by the availability of streets is not equally exploited to set up adequate drainage systems (Figs. 8.3 and 8.4).

Street Networks and Widths: Components of Land Allocated to Streets

Land allocated to streets is determined by two variables: the length of the street network and the width of streets. A high proportion of land allocated to streets can be attributed to a lengthy street network with narrow streets or wide streets in a short street network. A ratio higher than 1 can be an indication that the streets are relatively

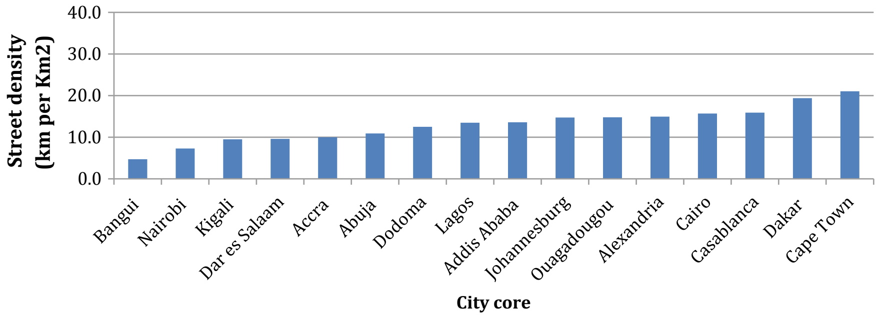

Fig. 8.3 Street density in selected African cities. *Source* Mboup (2013)

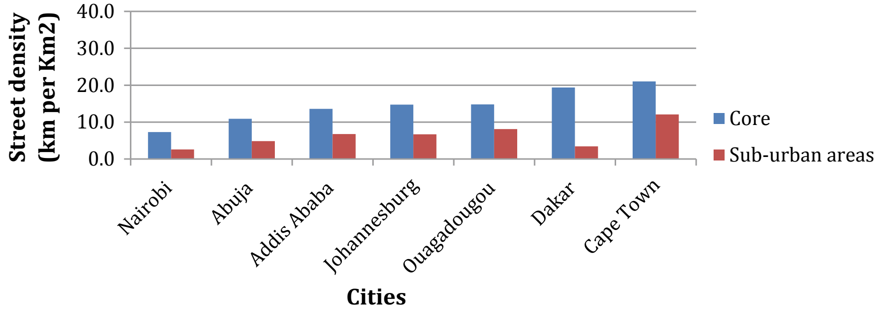

Fig. 8.4 Street density in selected African cities. *Source* Mboup (2013)

wide compared to the length of the network while a ratio lower than 1 can imply relatively narrow streets compared to the length of the street network.

Intersection Density and Street Connectivity

Intersection density is a fundamental element of walkability. The more intersection density there is in a street network, the more walkable the streets are. The predominance of cul-de-sacs in the expansion of cities or in the creation of new settlements has been observed and documents in most unplanned settlements in African cities. Cul-de-sacs have a negative impact on street connectivity. More traffic congestion has been associated with the predominance of cul-de-sacs in new settlements that make people from the same neighbourhood use the same arterial streets to connect to a highway.

The predominance of cul-de-sacs not only reduces intersection density but also reduces street density. Fewer streets are built and fewer intersections are allocated on those that have been built. The length of the street network per square km expressed in terms of street density is much lower in suburban areas than in city centres. As shown in Fig. 8.5, the street density in the city core is more than two times higher than the street density in the suburban areas of most cities. This trend is similar to what has been observed in relation to the proportion of land allocated to streets. In

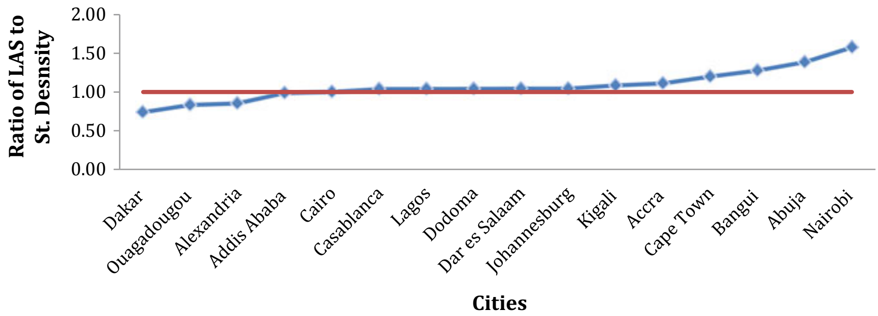

Fig. 8.5 Ratio of land allocated street to street density in selected African city cores. *Source* Mboup (2013)

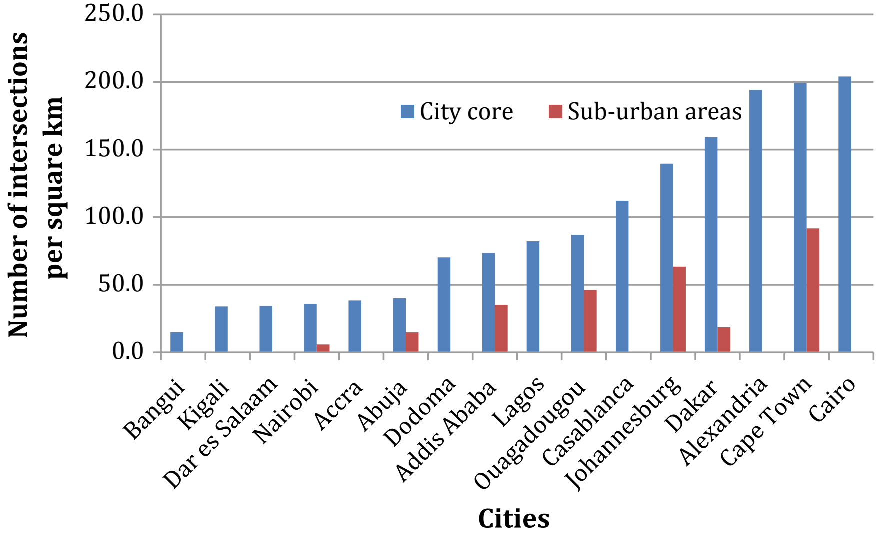

Fig. 8.6 Intersection density in selected African cities. *Source* Mboup (2013)

fact, the reduction of land allocated to streets in suburban areas could be associated with the fact that a large proportion of land in suburbs is allocated to residential plots, not to streets. This is clearly an indication of unconnected street networks that do not promote multiple options for the inhabitants to access services, such as work places, health centres and schools. Inhabitants of gated communities are obliged to use the same arterial streets that link them either to the centre of their neighbourhood or to highways that lead to main city centres. In addition, there may be congestion on most arterials serving as connectors (Figs. 8.6 and 8.7).

Lengthy street networks with sufficient street width are preferable to wide streets within short networks since they cover more neighbourhoods. Lengthy street networks can promote spatial and social inclusion. In fact, many social inequalities

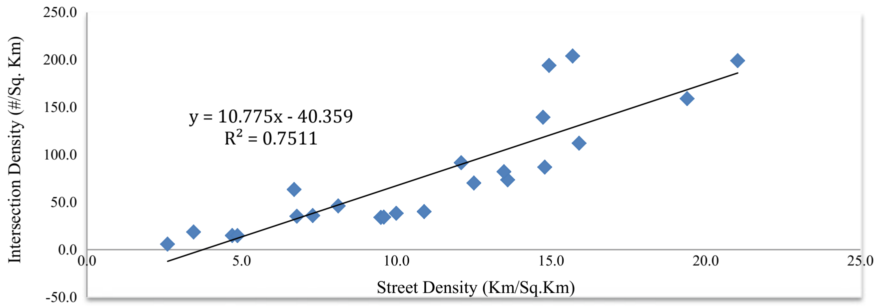

Fig. 8.7 Relationship between intersection density and street density in African Cities (Core and Suburban). *Source* Mboup (2013)

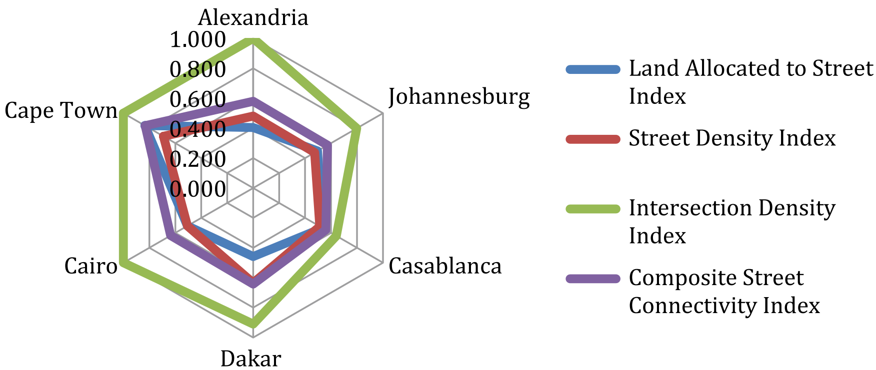

Fig. 8.8 African cities with CSCI higher than 0.500. *Source* Computed by the author from data of Figs. 8.2 and 8.3

observed in cities are the result of the way cities are planned. Some areas have many and wide streets while other areas have few and narrow ones. This is the main criticism of urban plans of new cities or expanding cities that are based on master plans that divide the city according to the social or economic status of residents. Street networks thus have an impact of the wellbeing of people, as discussed later in this chapter.

The Composite Street Connectivity Index (CSCI), presented in Fig. 8.8, builds on the combination of the three variables, and aims to assess connectivity of a street considering its width, its length and the number of intersections, all in relation to the total land area of a city.

The Composite Street Connectivity Index: Land Allocated to Streets, Street Density and Intersection Density

The *Composite Street Connectivity Index* (*CSCI*) aims to assess the connectivity of a street considering its width, its length and the number of intersections, all in relation to the total land area of a city. The CSCI has only been calculated for 36 cities where information is available for each of the three variables. However, there are other elements of connectivity which are not captured by the CSCI, such as, for instance, those associated with the design of streets (e.g. lanes for pedestrians or cyclists), the condition of the streets (e.g. state of the road and pavements and levels of maintenance), and whether there are lights for crossing, etc. It also does not consider whether the street is designed in a way that all users, namely, motorists, pedestrians and cyclists, equitably share it.

Cities have been classified and analysed based on the values of their CSCI. These cities have been grouped as follows:

(1) Cities with a CSCI equal to or above 0.800;
(2) Cities with a CSCI of between 0.600 and 0.800;
(3) Cities with a CSCI of between 0.500 and 0.600;
(4) Cities with a CSCI of between 0.400 and 0.500;
(5) Cities with a CSCI below 0.400.

Cities with a CSCI equal to or above 0.800: One African city, Cape Town, features in this group. Cape Town has high street connectivity in its city core. It has streets sufficiently wide to accommodate all types of users, sufficient to reach all neighbourhoods and corners, and sufficient intersections to accommodate all users. If well designed, the streets of Cape Town could be better public spaces, thereby improving these cities' liveability.

Cities with a CSCI of between 0.500 and 0.650: Five African cities feature in this group, Dakar Cairo, Alexandria, Casablanca and Johannesburg. Their level of connectivity in the city core is sufficient to promote infrastructure development and to ease connections to basic services, such water, sanitation facilities as well as drainage systems. However, their suburban areas are very poorly connectivity, with a CSCI of below 0.300.

Interestingly, some cities in this group have low levels of land allocated to streets, but higher intersection density (ID) increases the value of their CSCI. For instance, most cities of this group have a moderate LAS index, but due to its high ID, it has a CSCI similar to the other cities in the group, they have a better CSCI. For instance the cities of Alexandria, Dakar, are planned in grid pattern that favours good connectivity. This shows clearly that the same amount of land allocated to streets in different cities can lead to different CSCI for these cities, depending on how the streets are planned. If the city, for instance, has many cul-de-sacs, its connectivity will be lower than cities with the same amount of land but planned in a grid pattern.

As noted in other groups, the suburban areas of these cities are disconnected and fragmented with levels of CSCI below 0.500 (Fig. 8.9).

Cities with a CSCI of between 0.400 and 0.500: Except for the city of Ouagadougou, cities in this group share similar levels of land allocated to streets (LAS), street density (SD) and intersection density (ID). However, it is important to note that Ouagadougou belongs to this group, thanks to its relatively moderate level of intersection density compared to the other cities, which has more land allocated to streets, but lower intersection density. This also indicates that the grid pattern of Ouagadougou city has made optimal use of the land allocated to streets. In cities

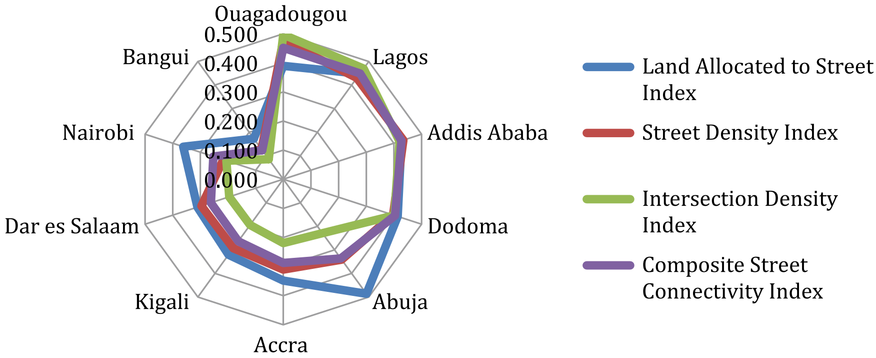

Fig. 8.9 African cities with a CSCI below 0.500. *Source* Computed by the author from data of Figs. 8.2 and 8.3

where connectivity is low or moderate, much of the land is "wasted" as it comprises cul-de-sacs and irregular street patterns. ***Disconnected streets are wasted streets***.

Cities with a CSCI of below 0.400: Cities in this group have very poor street connectivity due to low levels of land allocated to streets, low street density and low intersection density. Their CSCI is less than half the highest level of the CSCI, which is 1. Cities with the lowest levels of land allocated to streets in this group, such as Yerevan, Bangui and Dhaka, also have the lowest CSCI. This group includes other cities with moderate levels of land allocated to streets but low intersection density, such as Abuja. The city of Abuja has a land allocated to street index of 0.500, but an intersection density index of 0.200 that lowers its CSCI. Similar trends have been observed in Accra, Dar es Salaam and Nairobi. In these cities, specifically in slum areas, which are mainly in unplanned settlements, provision of basic services as well as means of transport remain a challenge. Comprehensive city planning programmes are needed in these cities to improve the lives of urban dwellers.

8.2.4 Conditions of African Streets

Besides the low level of land allocated to streets, the street networks in most African cities are generally substandard. Streets lack service lanes, pavements and are poorly maintained, with limited street lighting. The street planning and design had not anticipated the polycentric form of cites and the rapid increase in the use of private cars. In most African cities, few streets are paved and most lack sidewalks. For instance, in Ouagadougou (Burkina Faso) and Kigali (Rwanda), only 11 and 12% of the streets are paved, respectively, reducing accessibility for buses in densely populated neighbourhoods and outlying areas. Data from the un millennium cities database on paved street density measured by the length of paved streets in metres per 1000 inhabitants shows that in most African cities, the paved street density is

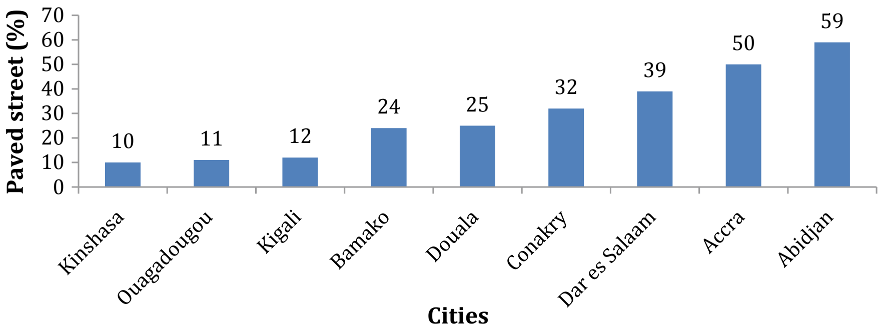

Fig. 8.10 Percentage of Paved roads for selected African cities. *Source* Mboup (2013)

less than 300 m per 1000 inhabitants. This level is very low compared to cities in other regions where the average level of paved street density is at least 1000 m per 1000 inhabitants. The data also shows that there are no sidewalks in 65% of the street networks in Africa. In some cities, sidewalks are quasi inexistent; only few streets, mainly in the central business districts, have sidewalks. In many residential areas, streets are not even paved, let alone have sidewalks. Where they do exist, sidewalks are poorly maintained and contain open drains. It is also common in African cities to find properties encroaching on sidewalks, forcing pedestrians onto the streets where they have to face careless motorists. Pedestrian crosswalks and bridges are not provided, except in the city centre. Although crosswalks without signals are provided in some places, such as the central business district, they are seldom respected by motorists or enforced by the authorities (Fig. 8.10).[9]

8.3 African Urban Mobility—Levels, Trends and Perspectives

Cities have a high level of *accumulation and concentration* of economic activities and are complex spatial structures that need to be supported by efficient transport systems. However, the larger the city, the greater is its complexity and the potential for disruptions, particularly when this complexity is not effectively managed. The most important transport problems are often related to urban areas and take place when transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility. The Sustainable Development Goals (SDGs) recognizes that sustainable transport is crucial for urban economic development. With Goal 11 of the SDGs "*Make cities and human settlements inclusive, safe, resilient*

[9]Kumar and Barrett (2008); Vivien Foster and Cecilia Briceño-Garmendia (Editors), 2010. Africa's Infrastructure—A time for Transformation; UN-Habitat (2013b); International Association of Public Transport (UITP), and Vivier (2001).

and sustainable", member states have committed themselves to, by 2030, "enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries. Member States have further committed to support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning, and by 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, …".[10] They are also committed to, by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to invulnerable situations, (SDG 11, Target 2). The New Urban Agenda recommends the Alignment of national urban policies with national and sectorial development plans and policies at all territorial levels to harness the transformative power of urbanization with urban plans (e.g. energy, water, transport and other infrastructural corridors). It further recommends Alignment with sector development plans and policies (housing, land management, transport and mobility, infrastructure, public spaces and urban parks, energy, water, sanitation, waste management, economic development, environmental sustainability, health, urban security) at all territorial levels.

Though transport data is crucial for informed mobility policies, information on transport is scarce in most African cities, and when it exists it is poorly documented; metadata providing definition, method of measurement and sources of information is rarely available. The lack of reliable data on transport has held back the development of effective urban policies aimed to effectively tackle deficient transport systems in African cities. The most common available statistics are the distribution of trips by transport modes (large buses, minibuses, private cars, motorcycles, and walking). However, this information does not make distinction on the type of trips. Are they for going to work, to the health centres, to the school, to the market, or all together.[11] In the era of data revolution, this information must be processed, analysed in association with social, economic and demographic information and used to guide transport policies and planning in an open platform accessible to all stakeholders including the public. This information will help to overcome transportation challenges in African cities through informed planning, real-time monitoring and management that take into account multidimensional variables beyond the transport sector.

[10]"United Nations (2015).

[11]Information used here are from different sources such as the Street report of UN-Habitat in 2013, the International Association of Public Transport, the Global Human Settlements Report of UN-Habitat (2013b), Kumar and Barret (2008) and Lall et al. (2017).

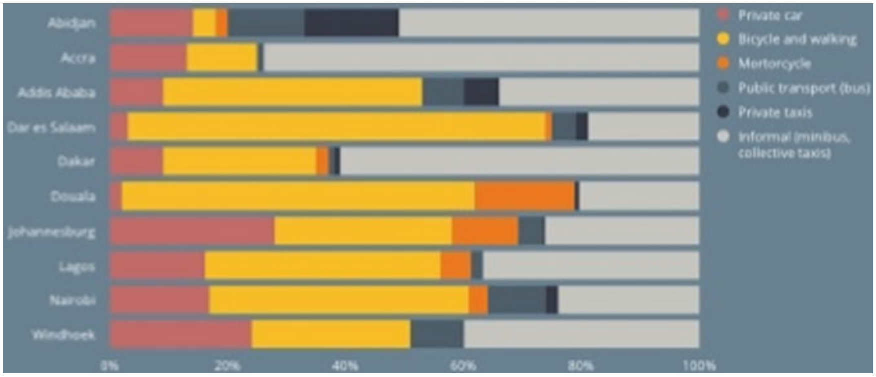

Fig. 8.11 Distribution of trips in selected African cities by modes of transport. *Source* From Lal et al. (2017) citing international association of public transport 2010

8.3.1 State of Urban Mobility in Africa

Available statistics show that in most sub-Saharan African cities, people have limited mobility choice in getting to work: either they ride minibuses or they use their foot. The share of minibuses in the public transport often exceeds 90% in most African cities. Despite various efforts taken by national and local authorities to boost the formal public transport, it remains with a very low share in most African cities, less than 5% in the total public transport. Most of the formal public transport sector is composed with few medium-sized buses in a limited street network; they are barely seen in the streets submerged with the informal motorized means of transport. As illustrated in Fig. 8.11 with ten African cities (Abidjan, Accra, Addis Ababa, Dar es Salam, Dakar, Douala, Johannesburg, Lagos, Nairobi and Windhoek), the share of minibuses is particularly high in Accra and Dakar, 73 and 63% respectively in all mobility modes. Among the motorized means of mobility, these figures represent 81 and 89% respectively. Except Abidjan where the share of the formal public transport is about 15%, in most cities covered here, the share of formal public transport is less than 5%.

A low share of formal means in the public transport sector results from poor infrastructures conditions as well as from the weak capacity of city authorities to plan and manage the transport sector. The efficiency of the public company has faced, indeed, various difficulties to be sustainable in terms of supply as well as in terms of demand: lack of institutional coordination between the city council and the transport company; structural deficit associated to the gap between the affordable fares and the operating costs leading to operating deficit; and poor operational and commercial performances associated to public service obligations without the corresponding resources. Other constraints are low commercial returns in congested roads, low productivity of employees, and attempt to serve the whole urban area without having enough buses. We are, however, witnessing few examples of emerging trends and conditions with respect to the introduction of BRT in Africa. This must be assessed and emulated in the continent.

Considering the lack of capacity by the formal public transport systems to meet the mobility demand of urban residents, dominance of the informal sector operators will remain the only option to move urban residents to their work place and others locations. The informal transport sector, is largely composed of minibuses and small-scale economic activities with unregulated employment, represents from 70 to 95% of the public transport. It supplies small-vehicles with low investment and minimal public support, low-performance services that fill the niche between formal taxis and the formal public transport. They are mainly composed of minibuses called, for example, "Car Rapide" in Dakar and "Matatu" in Nairobi. Their operational status is legal, as the vehicles are licensed for the purpose of public transport with a specific capacity limit. They can be a lifeline to making a living where poor municipal public transport resources have led to limited or no service to outlying residential areas and high fares. Finally, they represent the only accessible means available to the poor providing affordable services in instances where scarce municipal resources have led to a deteriorating service and higher fares.[12]

However, minibuses as means of public transport come with enormous externalities that authorities must not overlook in the transport planning process. Minibuses contribute significantly to congestion, air and noise pollution and traffic accidents. In addition, in minibuses, passengers, particularly women are exposed to harassment from the bus operators and other passengers. Violence against women is, indeed, common in the public transport sector.[13] However, prohibiting informal transport may not be a viable solution as it is the only option for many urban poor that cannot afford their own car when the distance are not walkable. Studies have shown that people who do not have access to public transport miss the opportunities to access decent jobs. A combination of valuing the minibuses service and regulating them can be effective in managing related issues, such as traffic congestion, accidents and pollution.

Use of private motorized means of mobility

In absence of affordable, reliable public transport, various options exist depending on the level of economic conditions or purchasing power. People that can afford it will own a car or ride a taxi, while those that cannot afford it, who constitute the majority, will use their foot to access services. The perceived advantages of convenience, privacy and status continue to make the private car or taxis attractive means of transport in African cities, particularly in the upper middle class and the richest households. The rate of motor vehicle ownership in African cities has significantly increased during these past 20 years. For instance, in Dakar, this rate increased from 5% in 1995 to 13% 2014. The major factor behind the growth of car ownership in

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[12]Xavier (2011). Thematic Study for the UN-Habitat's Global Report on Human Settlements 2013, Nairobi (Kenya).

[13]Xavier (2011), unpublished regional study prepared for the Global Report on Human Settlements 2013, www.unhabitat.org/grhs/2013.

African cities is the cost of vehicles, which is becoming affordable for middle class households.[14] With the continuous urban growth, the risk is that African cities will progressively become exclusive individual-motorized cities if the public transport is not reinforced and mixed neighbourhood promoted. Use of private increased use of land for road space and parking. It will also increase air pollution. Emissions of pollutants in African cities seem to be higher than the thresholds defined by international standards. A city submerged with cars is also prone to more accidents, which generate economic and human costs. Estimates of safety costs from the World Bank show that in African cities these costs can reach 2.7% or more of the national GDP.[15] Without adequate public transport systems coupled with effective urban planning in place that reduces transport demand and increase connectivity and proximity, congestion, pollution and energy consumption are expected to remain in the rise along with in car ownership. However, as it is practices in other regions, African city can introduce rules and regulations such as road pricing, parking management and circulation policies to reduce car demand to reverse the growing trends on ownership of private cars rise.[16]

Economic costs of traffic congestion and low coverage of formal public transport—Case of Nairobi—About 90% of the cost comes from the value of the time lost by drivers, 7% from the fuel consumed and 3% from gas emissions.[17] Traffic congestion costs the city of Nairobi approximately USD 500,000 per day in lost productivity and excess fuel consumption. It has further been established that transportation in Kenya accounts for 40% of the costs of doing business. Working with the estimated cost of congestion per day, the overall cost of investing in an efficient network would save the city at least USD 120 million per year, which can significantly improve the city's economic standing both locally and internationally.[18] In addition to economic costs, congestion causes significant numbers of early deaths from respiratory illnesses, stress and physical and mental fatigue. It also degrades green areas which, in turn, diminish their carbon sequestration properties.

Walking conditions in African cities

Despite lack of comparative data, it seems that the share of walking to access services remains the first option in African cities due to two main factors, namely:

[14] Xavier (2011).

[15] World Bank (2005).

[16] Road pricing policies have been implemented in Singapore, London (England) and Stockholm (Sweden) where drivers pay to enter the city centre or use special lanes. Parking management has the potential to modify demand on an area-wide basis yet, despite being relatively easy to implement, is often under used. Rationing policies, which restrict cars with licence plate numbers ending in specific numbers during rush hour, have been implemented in Bogotá (Colombia), La Paz (Bolivia), Santiago de Chile (Chile), São Paulo (Brazil) and Quito (Ecuador).

[17] www.wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/10/07/000356161_20101007005655/Rendered/PDF/569540NWP0Tran10Box353751B01PUBLIC1.pdf/access on 15 January 2016.

[18] A 2012 study by IBM identifies Nairobi as having some of the world's worst traffic congestion; see also Mwaniki (2017).

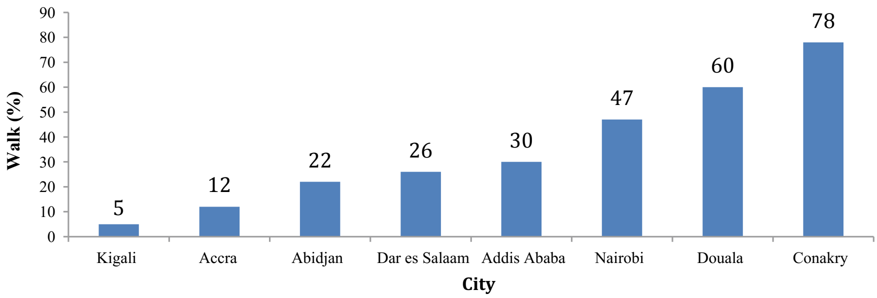

Fig. 8.12 Proportion of people walking to work for selected African cities. *Source* Kumar and Barrett (2008)

low coverage of public transport infrastructure, on one hand, and unaffordability of public transport, on another, particularly for the poor where transport demand compete with various other household needs such as food, education, housing, health, etc. For instance, low-income households in Abuja, Kano and Lagos spend 49, 40, and 33%, respectively, of their household budgets on public transport. These high costs relative to household budgets are unaffordable for poorer households, leading to travel patterns dominated by walking, greatly limiting access to economic opportunities.[19] While in cities of developed countries, it is assumed that a walkable street is more attractive to people for various reasons and even defines the "liveability" of a city, in most African cities walking is not a choice, but a necessity due to lack of other affordable transport alternatives. While walking promotes environmental sustainability, slum dwellers walk to access services due to lack of affordable transport alternatives, using narrow, unpaved streets without sidewalks. They are exposed to car accidents, which sometimes claim their lives (Fig. 8.12).[20]

Considering the fact that in most African cities, slum dwellers live far from the job market, walking offer limited job opportunities compared to use of public transport to access services. People that use their foot in African cities are de facto excluded from jobs far away from their residence. If they accept these jobs they will encounter several days of absenteeism, and they end up by quitting these jobs. For cities to act as integrated labour markets and match jobs seekers and employers, they need to make employment spatially accessible to all residents. African cities are failing to do so. Inaccessibility to public transport, indeed, limits the access to formal jobs for many people that rely on minibuses or their foot. For instance, in Nairobi, within 45 min, only 10% of minibus riders or pedestrians can access to formal job. Even with 60 min, the figures remain low with only 10% of pedestrians and 20% of minibus and pedestrians can do it. This means that people who count on their foot or on minibus are excluded from several formal jobs, unless they accept to be in the minibus for hours or to walk hours in order to reach their work place. Though

[19]The World Bank (2015) in Abuja (2013), Kano (2012), and Lagos (2009, 2012).

[20]See Footnote 7.

most people with cars (96%) can access their formal workplace within an hour, this figure drops to 77% when the traffic is congested, particularly during pick hours when everybody is rushing to reach their workplace.[21] This shows that poor street connectivity associated with poor transport infrastructures limit job opportunities among the urban poor. They cannot also relocated to where jobs are due to high cost of rental proprieties in Nairobi.

Cycling in African cities

Cycling is not yet a common practice in many African cities as it is in cities of developed countries. In African cities, as noted in household budget consumption surveys and other household surveys, very few households own a bicycle (less than 10% in most cities) compared to nearly universal ownership in cities of developed countries. For instance, less than 5% of the population of cities in Lesotho, the Democratic Republic of the Congo and Liberia own a bicycle.[22] While in cities of developed countries, cycling for leisure is common, and now an increasing number of their residents are cycling to workplaces, in African cities cycling is still uncommon. However, there is a growing use of motorcycles in some African cities. For instance, in Ouagadougou a large proportion of people use bicycles and motorcycles to reach services such as work places, health centres, and educational facilities in unpaved streets with no facilities for cycling and motorcycling.[23] Like pedestrians, the cyclists are pushed off the street by cars. This is the cause of a high number of accidents involving cyclists.

8.3.2 History of Urban Public Transport in Africa from the UITP 2008 Review[24]

The history of urban public transport development in Sub-Saharan Africa varies from one country to another, but it is common that most African countries have ever put a public transport authority in place. Public transport companies were created in most African countries but, as noted by UITP in its 2008 review, the vast majority of them have failed. Public transport operators in African countries have been confronted with numerous problems, one of the most crucial being the insufficient and inadequate transport infrastructures. Technical maintenance issues also represent an important share of the difficulties of the public transport companies and a main source of their failures. The transport sector remains indeed poorly organised across the continent. Based on UITP 2008 review, we are presenting here case studies of the history

[21] Statistics re-calculated by the author from Lall et al. (2017).

[22] UN-Habitat, Global Urban Observatory 2013 Database cited by Mboup (2013).

[23] Mboup (2013).

[24] UITP—International Association of Public Transport, TRANS-AFRICA Consortium, 2008 Overview of public transport in Sub-Saharan Africa.

of public transport in seven selected African countries: Cameroon, Cote d'Ivoire, Ghana, Kenya, Senegal, Tanzania and Uganda.

Cameroon

Facing rapid urban growth and a lack of public transport, the Cameroon government decided in 1973 to create the public transport company "SOTUC" (Société des Transports Urbains du Cameroun) owned both by central government and the municipalities of Douala and Yaoundé respectively. SOTUC experienced a prosperous period before falling gradually into a deep crisis for various reasons, including mismanagement that led to an irreversible bankruptcy. SOTUC was dissolved in 1995 and the Cameroon government decided to liberalise public transport services in the cities of Douala and Yaoundé to stimulate competition between operators that would foster self-sufficient urban public transport without the financial intervention of the public authorities. Since then motorised urban transport in these cities has been characterised by the operation of private vehicles namely shared taxis, minibuses and motorcycle-taxis which, unfortunately, do not effectively meet demand in quantity and quality, especially during peak hours.

Cote d'Ivoire

Organized public transport was first introduced in Abidjan in the early 1960s. In 1950 traditional informal transport was operating in Abidjan with traditional small unit boats, small vans of around 6–7 seats with some minibuses called "gbakas". Just after the independence of Côte d'Ivoire the public transport company called SOTRA (Société des Transports Abidjanais) was introduced in 1960 with official monopoly status of the city public transport. The informal means of transport such "gbakas" and "woro-woro" were only authorized to serve different markets. But with the strong demand boosted by demographic growth, this market service turned into a fully-fledged urban public transport service despite several measures taken by the government to prevent it. The combination of this demand and the economic crisis during the 1980s led the rapid development of the informal sector despite the monopoly of SOTRA, which in parallel was experiencing a decline in its activities. The spectacular proliferation of informal transport in a context of an insufficient supply by SOTRA resulted in the degradation of the urban transport system, causing congestion, unsafe roads and pollution. In this context, the Government of Côte d'Ivoire has enforced measures to restore the viability of the transport system including creating a transport authority (AGETU) established in 2000. During that period, SOTRA met no more than 20% of the total demand for public transport in Abidjan. In 2007, SOTRA innovated in the Sub-Saharan public transport domain with the launch of a bond issued in the UEMOA (Union Economique et Monetaire Ouest Africaine) sub-regional financial market in order to finance its investments.

Ghana

Since independence, Ghanaian governments have established bus service companies such as the Omnibus Services Authority (OSA), State Transport Company (STC), City Express Services (CES), and lately Metro Mass Transit (MMT) Ltd. The informal sector also operated transport services alongside the formal sector. But, road transport services provided by operators in both the formal and informal sectors have been characterized by very harsh environmental factors which have contributed to the low levels of these services. In addition to that, operators like STC, CES and OSA in the formal sector have not fared well, and this compelled the Ghanaian government to divest STC and CES and to liquidate OSA in the 1990s. With the aim to improve public transport in Ghana mainly in the cities of Accra and Kumasi, the government has conducted urban transport projects including the Ghana Urban Transport Project (started in 2007) supported by the World Bank of which the flagship was the implementation of a Bus Rapid Transit (BRT) system. The outcomes of this BRT corridor were expected to be attractive and sustainable. However, the public transport in Accra, Kumasi and other main cities of Ghana is still characterized by the fundamental paradox of a market with proven excess demand and shortage of supply with over 90% of the public transport from the informal sector.

Kenya

Until 1973, the Kenya Bus Services (KBS), a formal company with a fleet of large buses and minibuses, was granted the public transport service monopoly by the City of Nairobi within its area. But since 1973, due to its incapacity to effectively meet the demand of the growing population of the city, the matatus transportation means was officially recognized by a presidential decree enabling operation without obtaining the formal permits to which KBS were subject. Private operator has therefore essentially run the public transport system in Nairobi as the City Council opted for a liberalized market in line with national policy. However, in early 2000, as KBS was still encountering financial difficulties, its fleet was progressively reduced encouraging other bus companies with larger capacity such as the Citi Hoppa to form and enter the market. Between 2003 and 2006, KBS encountered multiple financial difficulties, facing a myriad of challenges and was bound for bankruptcy due to the cost of compliance with new legal requirements and subsequent losses of business. It finally evolved in a franchising and Management Company namely KBSM established in June 2006 to take over the operations of KBS albeit without owning any proper rolling stock. On July 2006, the first batch of a franchisee's buses was operated in the new KBSM franchising arrangement concept. The ministry of Nairobi Metropolitan is proposing the formation of a transport authority to oversee the development and provision of reliable transport services focusing on the government objective for vision 2030.

Senegal

Despite various efforts taken by national and local authorities to boost the formal public transport, it remains with a very low share (10%) in the total public transport, which is heavily dominated by informal means of mobility. There was a subsidized public transport with the public company SOTRAC with buses in early 1970. But it was discontinued during the structural adjustment period imposed to Senegal as in many African countries by the IMF and the World Bank in mid 1980s. However, in 2001 public transport was reinforced with the introduction of newly public transport company named "Dakar Dem Dikk" (3D), with the share of three quarters from public resources and the rest from private investors. The 3D is essentially composed of few medium-sized buses that must follow a specific itinerary, but they are barely seen in the streets submerged with the informal motorized means of transport. Other formal public transport means is the railway composed by the urban train created in 1998 "Petit Train de Banlieue" with a little share (less than 1% in 2009) to the total public transport. Efforts to modernize the urban train under the Urban Mobility Improvement Programme, "Programme d'Amélioration de la Mobilité Urbaine- PAMU" included transfer of track provision and maintenance to Transrail, a new autonomous body for operation, track improvement, and building fences along the track (compensated by new footbridges). Despite all these efforts, the share of the railway in the public transport remains little compared to the demand of passengers from Dakar to its suburbs.

Tanzania

The dominant mode of public transport in Dar-es-Salaam is bus transport, which accounts for about 60% of the modal split. There are over 7000 minibuses, popularly known as "dala-dala", which dominate motorised public transportation in Dar-es-Salaam. The majority of people in the city depend on this mode of transport. Nevertheless, the existing public transport system is mainly characterised by congestion and delays, poor vehicle condition and increasing road accidents; in addition, the bus fare level is too low to cover operating costs. As a response to the threat of the increasing congestion of its urban traffic, the Dar es Salaam City Council (DCC) decided to embark on the implementation of a bus rapid transit (BRT) system. The system is regulated and managed by the Dar es Salaam Rapid Transit Agency (DART) which was established by government order on May 25, 2007. The buses will be procured and operated by private bus operators that will enter into agreements with the DART agency.

Uganda

In Kampala, the privately owned Uganda Transport Company (UTC) held the exclusive franchise for bus services until its nationalization in 1972. At that time its only competition came from shared taxis based on saloon or estate cars. Following its nationalization, and the period of national chaos prior to the establishment of the present Government in 1986, UTC both contracted and focused more closely on its long-distance services. The market for urban transport services in Kampala became open to private sector operators, mostly using small minibuses though a few Kenyan-sourced minibuses were also deployed. Early market entrants earned high returns that then attracted additional investment until the market saturated. At that stage, the Uganda Taxi Operators and Drivers Association (UTODA) emerged to bring order to the market through self-regulation and control of the terminals. The UTODA benefits from strong political patronage.

Key facts of the public transport in African cities

It is clear that most African countries have ever put a urban public transport authority in place to support the movement of people across locations either to reach workplaces or access other services such as schools, health centres, markets, etc. Public transport companies were created in most African countries, but the vast majority of them have failed. The efficiency of the urban public transport company in most African countries has indeed faced various difficulties to be sustainable in terms of supply as well as in terms of demand such as: lack of institutional coordination between city councils and the transport companies; structural deficit associated to the gap between the affordable fares and the operating costs leading to operating deficit; and poor operational and commercial performances associated to public service obligations without the corresponding resources. Other constraints are low commercial returns in congested roads, low productivity of employees, and attempt to serve the whole urban area without having enough buses.

Public transport in most African cites has been characterized by weak regulation, scarcity in supply, poor quality and the predominance of informal sector operators. Poor coordination between the numerous institutions involved in urban transport lead to problems in developing unified and integrated urban transport policies to formalize informal means of transport. Many ministries are involved through actions, which sometimes prove to be contradictory. In most of African countries, and notwithstanding positive developments—such as the setting up the Executive Council of Urban Transport in Dakar, Senegal, the Lagos Metropolitan Area Transport Authority in Nigeria, and the introduction of coordinated urban mobility plans in South Africa—poor coordination between the numerous institutions in urban transport prevail. This has led to problems in developing unified and integrated urban mobility policies. The fact that (too) many ministries are involved in the urban transport sector at the local level contributes to actions that can prove contradictory.[25] It is, for instance, crucial to take mobility planning and city planning hand and hand though they fall under the responsibility of different entities such the line ministry of transport and the line ministry of urban development.

While playing a critical role in the public transport sector in African cities, the informal motorized means of transport also face a number of constraints, ranging from administration and managerial issues to financial obstacles. Efforts should be made to interlink them with the formal transport systems. Rather than discouraging informal operators, national and local governments can set incentives and regulations that capture the benefits they may bring while mitigating negative factors, such as road safety and pollution. Some actions already taken by some countries and cities must be reinforced including the formalization of minibuses' activities. This also includes assisting in creating better conditions for loans to transport operator such as creating financial structures that can make car loan possible to operators. Subsequent formalization occasionally occurs through aid-financing arrangements,

[25] UN-Habitat (2013b).

for instance through trust funds guaranteeing credit lines for vehicle purchase, as in Dakar (Senegal), Johannesburg (South Africa) and Lagos (Nigeria).[26]

8.3.3 Emerging Large Public Mobility Systems in African Cities

To meet the demand for urban mobility in large agglomerations, it is proven that development of public transit system that can carry a large number of people is central. Public transport is also space efficient in terms of area per traveller, which can free significant amounts of land in prime locations that would otherwise be allocated for uses.[27] It increases people's mobility with fewer vehicles, less energy and smaller space consumption. It contributes to environmental sustainability with lower emissions of airborne pollutants and greenhouse gases. It also has several social, economic and environmental effects on city smartness. It is also demonstrated that people with access to public transportation work more days annually than those without such access. Access to jobs, education, health services and other facilities through an affordable public transport is central to social inclusion for the urban poor, and particularly for the youth who have limited financial resources to cover most of their needs. With affordable public transport, youth can travel independently, and in some cases, delay their decision to drive private motorized vehicles. Community cohesion through interactions between people is also eased by public transportation. Public transport tends to increase physical activity as most trips include walking or cycling links.[28]

High-capacity public transport modes include s metro, light rail and BRT systems. They have the potential to move people across places while safeguarding the environment. Though buses are adaptive to the spatial structure and require low investment in infrastructure, they are generally slower than the other means and they have limited capacity to move million of people daily in large agglomerations. In the last decade, BRT has arisen as a popular means to alleviate congestion and streamline public transit in African cities as experienced in others developing countries. The BRT runs on semi-exclusive lanes and has a higher passenger capacity than buses. After the pioneering experiences in Curitiba (Brazil) and Bogota (Colombia), BRT systems have been implemented in hundreds of cities around the world and adapted to local circumstances on all continents. Recently, African cities have made remarkable strides in developing BRT as part of their public transport systems. Since this past decade BRT has been embraced in Algeria, Egypt, Ethiopia, Morocco, Nigeria, South Africa, Tanzania, Tunisia, and Uganda; and several other African countries are exploring the option of BRT to enhance their public transportation system. Light rails and metro systems require higher infrastructure investment but are very reliable

[26] See Footnote 25.

[27] Mboup (2017).

[28] See Footnote 20.

and have a high capacity. Rail transport induces more intensive land development around nodes and is low emissions if running on electricity.[29]

The financial requirements of investment in urban structures are enormous and call for thinking ahead, as is necessary for African urbanization. As an illustration from the UN-Habitat's Global Human Settlements Report 2013, "to live decently at the standard appropriate for middle-income countries, their average per capita income will need to be at least $5000, so the income of such a city would be around $25bn. To put this in context, the typical African country currently has a sovereign bond market worth around $2bn, and annual aid inflows are around $1bn. No African government, and no individual company, could afford to finance the cost of building an entire city. The future financing of Africa's urban structures will rely primarily upon tapping into financial markets, domestic and international, and tapping into them on such a scale is not a trivial matter. To cover this expenditure the authority will need to issue debt, and for this debt to be serviceable, the infrastructure will need, directly or indirectly, to generate a substantial revenue stream". Making public transport affordable to the urban poor will also require huge subsidies to make transport Here it will be important that the PPP be encouraged.

Examples of emerging trends and conditions with respect to the introduction of BRT and other large public means of transport in Africa, and challenges

Box 8.1 BRT in South African cities

In South Africa, the Public Transport Strategy aims to improve public transport by establishing an integrated rapid public transport network that comprises of an integrated package of rapid rail and road corridors. Through BRT, the government aims to link different parts of a city into a network and ensure that by 2020, most city residents are no more than 500 m away from a BRT station. The BRT systems are being implemented through public–private partnerships, whereby cities build and maintain the infrastructure for the operation of the buses, stations, depots, control centres and a fare collection system. Private operators, by contrast, own and manage the buses, hire staff and provide services on a long-term contract. Johannesburg is the pioneer in BRT in the African continent. "As soon as the BRT was introduced and operational in 2010, a robust but affordable bus management system was required, as there are many financial gains that can be made with the successful implementation of such a system. Today four other South African cities—Cape Town, Durban, Tshwane (Pretoria) and in Rustenburg have adopted the BRT and have also introduced the ITS for transport planning, management and monitoring. Eight other South African cities are planned to adopt BRT or alike for efficient pubic mobility. All buses are equipped with free wi-fi on the trunk route, full air conditioning, low-floor technology which supports Euro V emission lev-

[29] UN-Habitat (2013a).

els, vehicle stability and a cashless automated electronic system that is fully monitored by camera and censors.

Source: UN-Habitat (2013a). www.itssa.org.

Box 8.2 Public transport in Casablanca

Casablanca opened its tram in 2012 covering a street network of 31 km and 48 stop stations that link some of main neighbourhoods. Trams run frequently, with at least one train every ten minutes during daylight and early evening hours. In addition to that many bus companies run through the city with specific itinerary. Casablanca has also introduced a train connecting every hour the city to the international airport. In addition to a fair urban transport system, Casablanca are linked to most Moroccan cites through the train operating on an hourly basis. Tunis has a relative abundant and diversified transport system, organized around a single public company responsible for the management of passenger transport on the bus and light metro networks of the agglomeration. The public transport carries 460 million passengers each year in 35 lines. Microbus-based artisanal transport only plays a role for suburban and interurban services. This diversified and complementary network (tram metro light bus etc.) requires only evolving towards a fully integrated system of Urban Transport.[30]

Source: https://planbleu.org/sites/default/files/publications/cahier9_mobilite_urbaine.pdf.

Box 8.3 Challenges of Public Transport in Megacities—Case of Cairo

In Egypt, Cairo's metro has been operational and expanding since 1987. In Cairo, public trans port (formal and informal) accounts for more than 75% of daily-motorized trips. Despite Cairo is the first African city with a metro since 1987, the city is still facing traffic congestion. With the first metro carrying more than 1 million travellers daily and reaching its capacity limits, the city of Cairo introduced a second metro that carries 500,000 travellers. In 2001, the share of metro in the trips within the agglomeration was estimated at 17%. With its 80 km of network coverage, the metro constituted the most efficient public transport in Cairo. The expansion of the metro system with the phase 1 and 2 of third line was completed in 2013. Due to the fact that the formal public transport has not been able to meet the demand in urban mobility, there is a proliferation of "informal" private minibuses and private taxis. Overall there

[30] https://planbleu.org/sites/default/files/publications/cahier9_mobilite_urbaine.pdf.

are 80,000 minibuses and 60,000 taxis in the Cairo agglomeration. The Cairo experience calls for African cities that are moving to large cities in 2030 to plan well in advance their growth in order to avoid being in a chaotic situation.

UN-Habitat (2013a).

Box 8.4 Challenges of Public Transport in Megacities—Case of Lagos

The city of Lagos is another African megacity that suffers from traffic congestion despite huge investment in public transport. In a bid to reform the chaotic public transport system in the city, the Lagos State Government in collaboration with the World Bank initiated the Lagos Urban transport Project (LUTP) in 2001, to create an efficient and effective integrated inter-modal mass transit system in the State. The Lagos Metropolitan Area Transport Authority (LAMATA) was also established in 2002 to coordinate the transportation policies and activities of all transport related agencies. In its effort to improve the public transport system LAMATA deliberately eased out the old para-transit buses popularly known as 'Molues' to give way to brand new and more comfortable buses known as Bus Rapid Transit (BRT) and LAGBUS plying over dedicated lanes within the metropolis. In 2008, Lagos (Nigeria) launched a BRT 'lite' corridor (a high-quality system that is afford able in the local context, while retaining as many of the desirable BRT characteristics as possible). This marked the first substantial investment in public transport for the city. In 2011, the BRT had in its fleets 270 buses transporting about 120,000 passengers per day. Between 2008 when it commenced operation and January 2010, the BRT moved more than 114 million passengers. Commute times also drastically reduced, as well as the percentage of household income spent on transportation. On an environmental level, BRT has reduced carbon dioxide emissions by about 13% and greenhouse gases by about 20%. Projects are underway to extend BRT service to other parts of the city, including system and highway improvements and the expansion of expressways.[31] However, the BRT was insufficient to satisfy the large population that composes the Lagos Metropolitan Area, traffic congestion is still on course. Finally, the public-sector bus company failed under the weight of low fares and unsustainable subsidies, its mobility role taken over by danfos, midi-buses providing frequent and affordable services, but characterized by over crowding and aggressivedriving.

Olokesusi et al. (2017).

[31] Olokesusi et al. (2017).

8.3.4 Turning Challenges to Opportunities: Streets for People—Drivers of Sustainable Urban Mobility

With the 40–70% of people that are already walking in their limited street network, African cities are indeed in a good position for a healthy society in a sustainable environment. However, in order to sustain this advantage, it is high time to give to pedestrians their right share in the transport infrastructure. Providing adequate infrastructures to pedestrians is cost-effective considering the enormous benefits from walking. Walking is usually the most common access mode to public transport and requires an adequate environment, with protected, well-lit, signalized and surfaced sidewalks. Design should consider the needs of the most vulnerable users: children, the elderly and people with disabilities. It is important to build these spaces according to good practices, but perhaps seven more important is to keep such spaces clean and free of encroachments. Whereas the management of sidewalks is often outside the jurisdiction of public transport agencies, adequate coordination with other responsible agencies is important to ensure safe and pleasant travel for public transport passengers who are walking to and from the train and bus stations. Based on this, many motorized cities of developed countries in some developing countries such as Cape Town have been changing their street planning and designing to promote public transport, reduce private motorized use and boost walking and cycling.

Despite challenges, walking has enormous economic, social and environmental advantages. African cities of the 21st century must be planned as walkable with affordable means of public transport. Walking is an enabler of social cohesion and environmental sustainability with enormous social, economic and environmental benefits. It is now recognized and advocated that walk is the most efficient means of mobility for environmental sustainability as expressed in global agendas such as Rio+20 (2014), SDGs (September 2015), COP21 (December 2015) and the New Urban Agenda in 2016, and the Africa Agenda 2063. In addition to its social and economic benefits, walking has a major advantage in reducing energy consumption, greenhouse gas emissions and pollution (air, water and noise) substantially, as it does not rely on fossil fuels unlike other modes of transport in cities. Furthermore, as walking requires significantly less road space and parking, it enables the preservation of natural habitats and open spaces. Walking also provides the daily physical activity required for a healthy lifestyle.

8.3.5 Transport Systems and Infrastructures Planning: Case Studies from the Smart Metropolitan Regional Development: Economic and Spatial Design Strategies: Dakar, Conakry, Abuja, Johannesburg, Nairobi

Emerging trends in the urbanization in Africa are urban policies promoting development of metropolitan regions. We have just concluded a book on Metropolitan Regional development: Economic and Spatial Design Strategies covering five African Metropolitan Regions: Dakar, Conakry, Abuja, Johannesburg and Nairobi. Connecting different urban centres are crucial to fully take opportunities of economy of scale and agglomeration that offer large metropolitan regions.

Box 8.5 Dakar: Creation of Digitally, Economic and Socially Served Urban Centres: from Monocentric to Polycentric Dakar Metropolitan Regional Development[32]

While developing urban policies and projects to tackle flooding and traffic congestion in the agglomeration of Dakar, national authorities have taken bold urban policies with the creation of six polycentric urban centres in the outskirts. The creation of these urban centres aims to decongest Dakar; this will also mark the transition of big cities to digitally connected towns (of less than 1 million people). This represents a new form of urbanization, the digital urbanization where digitally connected towns offer urban advantages traditionally only found in big cities with high densities, such as economies of scale, agglomeration of economies, diffusion of ideas, innovation, and participation to political affairs.

Overall seven urban centres are planned to take place in the first phase of the programme. These urban centres are created to support economies of scale and agglomeration. Among these urban centres, features the Urban Pole of Diamniadio, which is already under implementation as part of the Plan Senegal Emergent (PSE), representing the first sustainable city model with the integration of climate risk resilience. For instance, the Special Economic Zone of Diamniadio will constitute a multifunctional platform for most of the income-generating activities (industry, crafts, clothing, equipment, infrastructure, etc.). It is part of the national policy to encourage companies to relocate and diversify their activities outside the agglomeration of Dakar and attract new investors, notably with: the creation of a manufacturing unites with high added values; Assembly and processing industries; Construction of several logistics platforms (transit, storage) to streamline internal and regional transport flows; Creation of two zones dedicated to export services, integrated and connected.

Another urban development is the emergence of urban corridors, which present a type of spatial organization with specific economic and transportation objectives. In Senegal, the government is indeed encouraging growth, convergence and spatial spread of geographically linked metropolitan areas and other agglomerations. These are emerging trends linking Dakar-Thies-Mbour, turning into spatial units that are territorially and functionally

[32]Mboup et al. (2018).

bound by economic, political, socio-cultural, and ecological systems. It expected that the Dakar master include Thies and Mbour. In order to constitute a large economic output, combining large markets, skilled labour and innovation the triangle Dakar-Thies-Mbour may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication.

The government of Senegal has realized that the creation of urban centres and urban corridors will be achieved only through the development of efficient mobility means. In the PSE, it is indeed, planned: (a) the construction of road infrastructures (1170 km of paved roads, at least 4000 km of rural roads, 7 bridges and Art, modernization of bus stations); (b) the construction of maritime infrastructures (restoration of inland ports of new infrastructures and port platforms) and; (c) the construction of railway infrastructures (rehabilitation of 573 km of railway line, construction of a new standard gauge line) and airport facilities (rehabilitation of regional aerodromes), a tramway is also under development. The newly created international airport, located in the urban centre of Diamniado, is expected to have a capacity of 6 million passengers by 2020 and 10 million by 2035 (Fig. 8.13).

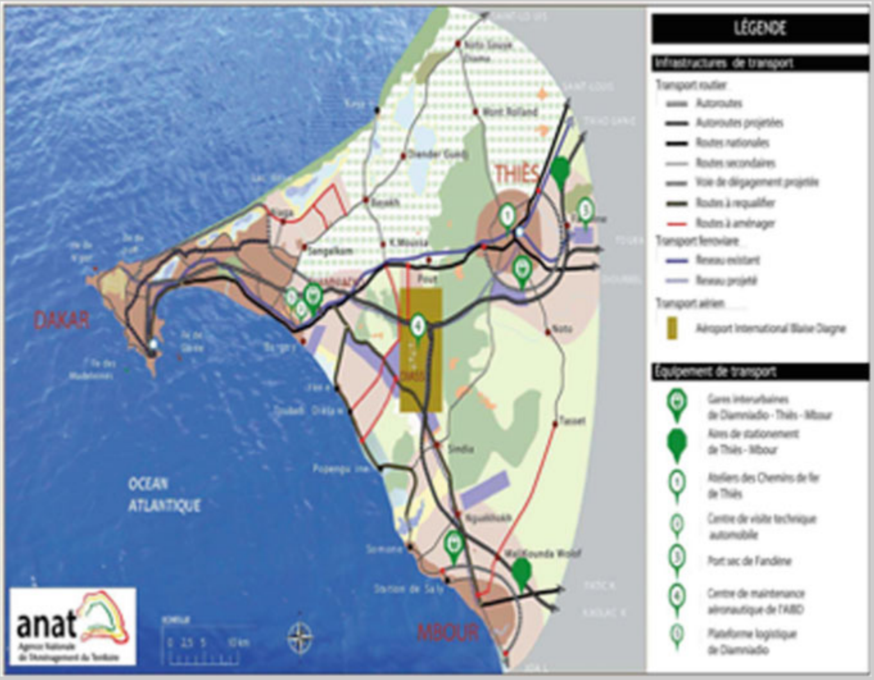

Fig. 8.13 Planning and management of transport infrastructures in the Dakar metropolitan region (road, ail, air and Water). *Source* Republic of Senegal, 2014. Plan National d'Amenagement du Territoire

Under the Senegal Sustainable Cities Initiatives, in addition to developing transport infrastructure, the government of Senegal has introduced the model of multiple connectivity choices as presented in Fig. 8.14 “multiple choices of access to services”. Interpretation of Fig. 8.14 is as follows:

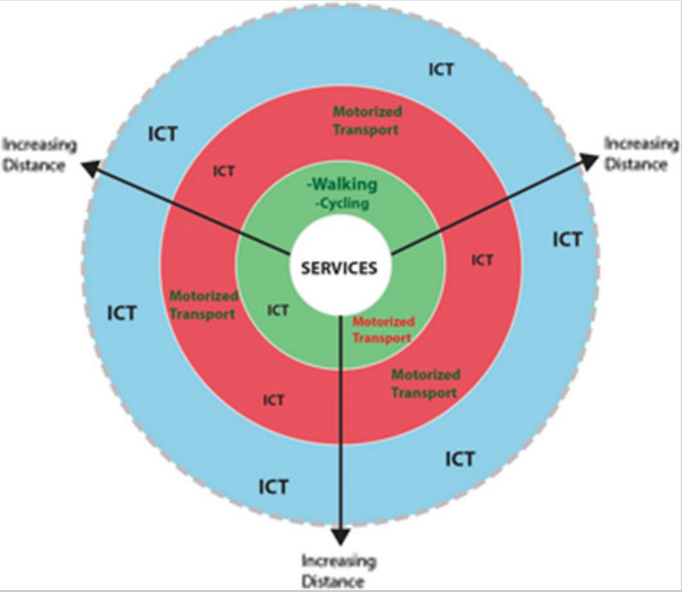

Fig. 8.14 Multiple choices of access to services

(1) The green panel illustrates a situation of mixed land used or alike where services are walking distance from residence (threshold to be determined). Here we can walk, drive and use ICT, <u>but walking along with the use of ICT to access services is sufficient and then highly recommended</u>;

(2) The red panel illustrates the situation where services are far away from residence, in a distance making it impossible for people to effectively walk to reach most services, but are in a reasonable distance (threshold to be determined) where people can use motorized means of transport with the benefits that can offer an Intelligent Transport System; They can also use ICT to perform work outside their workplace or to access other services. This situation includes telecommuting as well as all other forms of ITS;

(3) The third scenario with the blue panel illustrates a situation where the services are very far (threshold to be determined) from residence making it difficult for people to use motorized means of transport every day to services, here the convenient option is the use of ICT to effectively reach services. This third scenario represents a complete substitution of movement of people by the use of ICT to perform work outside workplaces,

such as in an offshore call centre and to access services far away from their producer and distributer location such e-banking, e-commerce, etc. This is usually the case where people reside outside the city where a company they are working with is located; this can be, for instance, the situation of the urban corridor Dakar-Thies-Mbour.

Mboup et al. (2018).

Box 8.6 Conakry: Grand Conakry Vision 2040[33]

Considering that the population of Grand Conakry will double by 2040 to reach 5–6 million inhabitants, the Government of Republic of Guinea commissioned a study for the "Grand Conakry Vision 2040". The study proposes various scenarios of territorial settlements. These scenarios are aimed at preventing disasters that can hamper ecological, social, economic and urban development. Based on a structured dialogue within a Technical Committee and a Steering Committee with the Representatives of various ministerial departments, a consensus was reached on "a synthesis, balanced and controlled scenario" which is structured around three levels of intervention: (1) at the metropolitan level to develop and strengthen urban polarities; (2) at the agglomeration level to channel and structure urban extensions and; (3) at the peninsula level to renew the city (urban renewal). Recognizing that the Master Plan of the city of Conakry has become obsolete to tackle the challenges the city is facing, the government has commissioned a study for the "Grand Conakry vision 2040", which is the first step towards developing a new generation of master plans: the master plan of the great Conakry and the national land use planning scheme (SNAT) (Fig. 8.15).[34]

[33] See Footnote 32.

[34] Under the Ministry of the City and Territorial Planning in collaboration with: the Ministry of Economy and Finance, the Ministry of Territorial and Decentralization Administration, the Ministry of Planning and International Cooperation, The Ministry of Transport, the Ministry of Public Works and the Ministry of Environment, Water and Forests. The Study was funded by the European Commission.

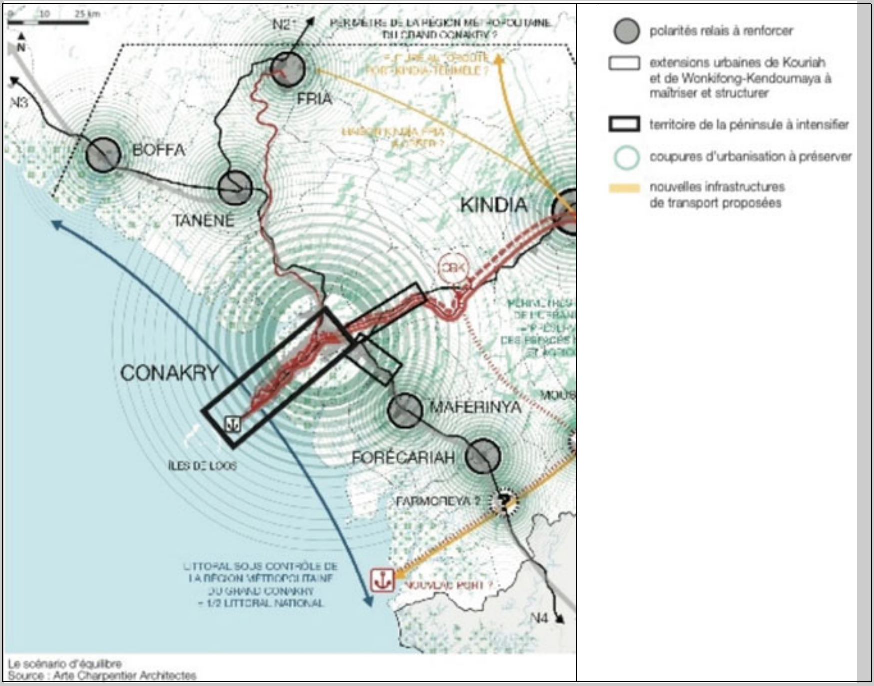

Fig. 8.15 A balanced scenario—Polarized and controlled urbanization to preserve the environment. *Source* Republic of Guinea, European Union and Louis Berger, 2016. Grand Conakry Vision 2040

Existing urban poles to be part of the Grand Conakry Metropolitan Regions are: (a) Kindia (140 km from PK36) that has some potential in terms of tourism development but also, and above all, a strong potential for agricultural and agro-industrial development. The realization of new transport infrastructures such as the future highway Conakry-Mamou and the future railway Conakry-Kankan will reinforce this potential; (b) Fria (120 km from PK36), the old mining industrial city: the announced revival of its aluminium factory closed since 2012, combined with strategies for diversifying economic activity, could mark the rebirth of the city and stimulate a new development facilitated by the upgrading of existing transport infrastructure (railway Conakry-Fria, Nationale 21 and even Katourou airport); (c) Tanéné (65 km from PK36): the city of Tanéné is a crossroads city located at the junction of the National 3 (Conakry-Boké-Guinea Bissau) and Nationale 21 (Tanéné-Fria); This particular cross-city situation and the dynamism it generates could serve as a basis for economic development in relation to the flow of goods and encourage the development of agricultural activities; (d) Boffa (120 km from PK36): the town of Boffa has a diversified economy (fishing, agriculture, solar salt, tourism, mining, etc.), which continues to be dynamic and which could thus contribute to fixing some of the growth expected demographic growth as a result of these many employment sectors; (e) Maférinya (40 km from PK36): the town of Maférinya has developed agricultural production and in particular its pineapple production. This rich natural environment and its proximity to the capital, could allow it to develop productions dedicated to both domestic consumption and exportation with the planned airport; and (f) Forécariah (65 km from PK36): the town of Forécariah also develop many agricultural activities, some of which are dedicated to export (banana, pineapple, mango, oil palm, etc.).

It is important to note the spatial design of the metropolitan is aligned with the needs for transport, most of the urban pole to strengthen or to develop are related through the road network PK36. At the Transport and Mobility sector, strategies include: (a) Establishment of traffic restriction; (b) Development of a fleet of taxi boats; (c) Structuring a road network at the scale of the Greater Conakry metropolitan area; (d) Create a bus station at PK36; (e) Reinforcing the railway; (f) Organize maritime connections; (g) Develop a BRT system on its own site and improve the existing urban network; (h) Make accessible the districts of the peninsula; (i) Implement strategies for stationing; (j) Gather typologies of structures and modes of maintenance of the road network. At long term (2020–2040), strategies will include: (a) deployment of a network of peninsular-scale secondary roadside stations (associated with the markets) and relay polarities; (b) the completion of the metropolitan road network and the organization of interurban public transport; (c) the continuation of the improvement of accessibility in neighbourhoods in relation to urban renewal actions; and (d) Structuring of the passenger rail mode.

Source: Mboup et al. (2018).

Box 8.7 Johannesburg: Inter-City Public Transportation to Make the Gauteng City Region works[35]

To create economies of scale and agglomeration within the Gauteng City Region, an efficient, timely transport system is needed. Without efficient public transport, economies and scale and agglomeration that can generate the GRC with its 13 million will be jeopardized. The Gauteng province introduced, indeed, the Gautrain in 2002, a Rapid Rail Link connecting Pretoria, Johannesburg, and Johannesburg International Airport (JIA, now OR Tambo International Airport) as one of eleven Spatial Development Initiatives (SDIs). Two spines were also built: the west–east spine has a commuter service linking

[35] Mudau et al. (2018).

Sandton to the East Rand (through Rhodesfield, in Kempton Park) as well as an airline passenger service between Sandton and the city's international airport. The south–north spine links the Johannesburg and Pretoria CBDs.[36] In 2007, the province launched the Gauteng Freeway Improvement Project (GFIP), the country's largest road scheme, which aimed "to upgrade and expand the provincial road network through freeway widening, building new roads, upgrading interchanges, installing traffic-management systems (cameras and electronic signs) and an automated toll system".[37] In addition to easing economies of scale and agglomeration, these inter-city public transports were supposed to reduce traffic congestion and reduce the commuter time. Other elements such as traffic accidents and pollution associated to private cars and minibuses were also expected to reduce.

In 2007, the National Cabinet also approved the Bus Rapid Transit (BRT) scheme as a road-based component of the Public Transport Strategy (SACN 2011). This was to be funded by national government, but delivered by the metros. It was designed to be more transformative and scale-able. It had modern buses running on dedicated lanes along the middle of main roads (Van Ryneveld 2010). The City of Johannesburg's BRT system, named Rea Vaya, was operational from October 2013. The buses provide residents of Soweto and the southern parts of Johannesburg with direct access to the inner city and surrounding areas. The routes run from Soweto through Noordgesig, New Canada, Pennyville, Bosmont, Coronationville, Newclare, Westbury, Westdene, Melville, Auckland Park and Parktown, to the CBD. The Tshwane BRT system, named A Re Yeng, started operating in 2014 (SA Yearbook 2014). The R2.6-billion project, part of the city's revitalisation project, consists of 80 km of bus lines and about 340 buses, some of which are powered by gas, serving 62 bus stops. It runs from Mabopane through Pretoria CBD, past Menlyn, and on to Mamelodi (City of Tshwane 2014).

Through BRT, the government also aims to link different parts of a city into a network and ensure that by 2020, most city residents are no more than 500 m away from a BRT station.[38] The BRT systems are being implemented through public–private partnerships, whereby cities build and maintain the infrastructure for the operation of the buses, stations, depots, control centres and a fare collection system. Private operators, by contrast, own and manage the buses, hire staff and provide services on a long-term contract. Johannesburg is the pioneer in BRT in the African continent. "As soon as the BRT was introduced and operational in 2010, a robust but affordable bus management system was required, as there are many financial gains that can be made

[36] GDPTRW (Gauteng Department of Public Transport, Roads and Works) (2002).

[37] Turok (2012). Cited by Sihlongonyane (2018).

[38] See Footnote 25.

with the successful implementation of such a system. Today four other South African cities—Cape Town, Durban, Tshwane and in Rustenburg have adopted the BRT and have also introduced the ITS for transport planning, management and monitoring. Eight other South African cities are planned to adopt BRT or alike for efficient pubic mobility. All buses are equipped with free Wi-Fi on the trunk route, full air conditioning, low-floor technology which supports Euro V emission levels, vehicle stability and a cashless automated electronic system that is fully monitored by camera and censors.[39]

Source: Mudau et al. (2018).

Box 8.8 Abuja: Expansion and Modernization of Road Network[40]

The city of Abuja has a fairly detailed and comprehensive Transport Master Plan originally developed to improve on the awkward experience of Lagos. The objectives of the plan are to: (a) Maximize public transport mobility for residents who do not own cars (Captive Riders); (b) Provide high quality attractive transit services to hire those with cars (Choice Riders); (c) Minimize traffic movement passing through the various development sectors; (d) Provide multiple highway paths between development sectors thereby avoiding network bottlenecks and; (e) Achieve maximum self—containment within the outlying sectors.

At the moment, efforts are currently on going to meet these targets, but available evidences suggest that the city can be said to have a fairly good network of roads comprising Expressways, Arterials, Parkways and Collectors. But surprisingly most of these are concentrated on phase 1 which comprises only 95 out of the 208 districts of the FCT.

From the Table 8.1, it is obvious that for over thirty years of the existence of the Abuja, development has concentrated mostly on phase 1 area and the satellite towns, a situation which is now challenging mobility in the territory. There also is a steady decline in the numbers of roads constructed in Abuja and revealed a lot of backlog meeting the road infrastructural needs of Abuja municipal and its environs. Also, the early relocation of the seat of government ahead of the proposed date changed the socio-economic data upon which traffic demand forecast in the plan was based relative to time and spatial distribution and thus diminishing the transportation system capacity to develop into an efficient flow. Another major challenge is the non-development of the public

[39] www.itssa.org.

[40] Olokesusi et al. (2018).

transit ways which link all the major activity centres, markets, and offices. There is also the problem of not introducing the Light Rail Transit and the Rapid Rail Transit even as the threshold population and development levels have since been surpassed. This implied that Abuja city lacks an integrated intermodal transport system thereby making all movements within the metropolis road-based thus leading to overstretching of the existing road infrastructure.

Expansion and modernization of road network: The most ambitious of the road projects are the Airport Road (re-named Umaru Yar-Adua Expressway) −37.5 km in length; the Kubwa/Zuba Expressway (Outer Northern Expressway) which is 39.76 km; and the Southern end-the Nnamdi Azikiwe Road. These are 10–lane super multiple carriage highways with full accompaniments of street lights, drainages, pedestrian bridges and flyovers, lays-by, culverts, telecommunication ducts and interchanges, etc. The Airport and Kubwa/Zuba Expressways have been able to reduce travel time to the City Centre from 3 h to 30 min (over 100% reduction) and billed for completion in 2014. The Southern Parkway from the Inner Southern Expressway to Ring Road completes the 10 lane ring, and completed in 2014. There is also the reconstruction of the 72 km Lower Usuma Dam—Gurara Dam—Jere Road aimed at creating an alternative route for vehicular movement out of the city (Abuja) to Kaduna through the Bwari axis.

The 3.8 km Inner Southern Expressway to Southern Parkway is now over 80% completed and it's aimed at reducing traffic congestion induced by the North-eastern vehicular traffic at the AYA roundabout. Some internal roads completed are roads B6, B12 and Circle Road in the CBD with the aim of reducing travel time.

The Metro System: The development of the Light-Rail mass transport system is one of the highlights of the Federal Capital transit initiative. Provision was made for the Abuja Metro project in the Abuja Master Plan but was not implemented until 2007. The Master Plan made provision for six light rail routes, totalling 300 km long. Construction of two of the routes (1 and 3) has begun and was expected to be completed in 2015, but it is still on going. The remaining four routes are to be financed through the Public/Private Partnership arrangement. The rail network, when fully operational, is expected to employ 20,000 people in the FCC and to convey 700,000 passengers daily. The Metro System is to be complemented by the Intra-and Inter City transport terminal. For efficiency and ease of accessibility by the poor, this should be extended to the proximal satellite towns surrounding the FCC, namely, Nyanya/Mararaba, Kubwa/Bwari, Kuje/Gwagwalada, and later to the southern-most parts of the FCT. Indeed, in the ultimate, the Metro System should be linked to the North-South West national rail line at Lokoja and the North East—South East national rail line at Gudi in Nasarawa State.

Source: Olokesusi et al. (2018).

Table 8.1 Stages of development of phase 1 Abuja city

Stages	No. of districts	Planned period of completion	Length of roads so far constructed (km)	% of planned road lengths (%)	Remarks
I	10	1990	263.77	90	With fairly adequate parking facilities
II	20	1995	77.2	35	Only in Wuye, Jabi, Utako and Mabushi areas
III	23	1998	53	25	Only in Gwarimpa I and II, Kado, Lugbe
IV	42	2006	10	5	Essentially link roads to the areas

Source Olokesusi et al. (2018)

Box 8.9 Nairobi: Transport Connectivity in the Nairobi Metropolitan Region[41]

Centres within the Nairobi Metropolitan Region (NMR) are relatively spread out. This implies that people, goods and services are required to travel long distances between centres, underlining the need for enhancing connectivity. Transportation within the region is majorly by road which remains key in connecting economic centres in the NMR. Major connections include: Thika road, an A2 class road linking Nairobi and Thika road; Mombasa Road, an A 109 road that is part of the link between Nairobi and Machakos town; and Nairobi-Kajiado link which takes two routes, one trough Kiserian and another through Kitengela along Mombasa road. There are other numerous roads connecting other centres, for example, Kiambu road which branches from Thika road to Kiambu town. Within Nairobi city, attempts to divert through traffic from the core metro led to the establishment of the Northern Bypass (connecting Thika Road and Limuru Road); the Southern Bypass (connecting traffic from Mombasa road to Kikuyu through Langata and Ngong); and the Eastern Bypass (connecting Ruiru and Mombasa Road). Other notable projects for improving connectivity within the core metro include construction of Outering road, and rehabilitation of several other roads.

[41] Githira et al. (2018).

In terms of mass-rapid transit, the NMR lacks a metro rail, a light metro, a high-speed mobility 'skytrain', and even a high-capacity bus system. Public transport is majorly by low-capacity busses and vans which do not have dedicated lanes. The public vehicles share routes with private vehicles, often on very congested roads. Rail transport is limited to a few routes, and only operates in the in the morning and evening hours when people travel to and from work. Inter-modal traffic transfer plan is often lacking, and this compels train commuters to walk long distances to and from the stations.

The region has currently invested hugely on road expansion, particularly on routes connecting major business nodes. Traffic has in effect been moving faster; while this is commendable, heavy traffic jams are experienced at the slightest disturbance of traffic, for example due to a road accident or weather change. Balance in transport modes is lacking in the NMR, with private transport unfavourably competing for carriageway with public transport. Walkability of streets has only received limited attention, and walkable and pleasurable streets only exist in few areas, majorly in the central business district and affluent neighbourhoods. In addition, the NMR does not have bicycle infrastructure, and only a few road users prefer this green mode of transport. This is attributed to poor road safety for cyclists. In a nutshell, it is observed that while the NMR had an evolving economy, people, environment and living, mobility is among the key areas where progress has been acutely limited.

The Nairobi Metropolitan Area Transport Authority (NAMATA) Bill, 2017

This is a bill whose ultimate aim is to be an ACT of Parliament to give effect to Article 189 (2) of the Constitution: to establish the Nairobi Metropolitan Area Transport Authority; to provide for an integrated and sustainable Public Transport System within the Nairobi Metropolitan Area; and for connected purposes.

Due to mobility and connectivity challenges NAMATA bill is handy in changing the negative transport connectivity bedevilling the region. Initiatives such as the proposed five (5) Bus Rapid Transit (BRTs) routes will go along away in improving mobility and flow of goods and services within the metropolis which will definitely catalyse development for the region given that studies have shown that Nairobi Metropolitan Area controls over 50% of Kenya's Gross Domestic Product (GDP) and it is estimated that USD 1 Billion is lost annually due to congestion.

Kenya's Vision 2030 is the current long-term development blueprint for the country. The aim of Vision 2030 is to realize "a globally competitive and prosperous country with a high quality of life by 2030." It aims at transforming Kenya into "a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment". The Vision is anchored on three key pillars: economic; social; and political governance.

To achieve vision 2030 the Government identified the following infrastructure projects, among others, for implementation:

(1) Developing a 50-year Integrated National Transport Master Plan which is linked to the National Spatial Plan. It will ensure that the investment and location of transport infrastructure and services are consistent with other public policies. Also, it will ensure optimal transport infrastructure investment to position Kenya as the most efficient and effective transport hub of the East and Central African region and promote national aspirations for socio-economic reconstruction and development. It will also facilitate improvement and expansion of transport infrastructure in a manner that will reduce transport costs and also open new frontiers for economic development.
(2) Developing Nairobi metropolitan region Bus Rapid Transit System to cover three transport corridors
(3) Development of light rail for Nairobi and its suburbs. It is projected to serve at least 150,000 passengers daily.

Integrated National Transport Policy

The INTP guides the development of all the sub-sectors including: road, rail, aviation, maritime and inland water transport and pipeline transport system.

The Integrated National Transportation Policy (INTP) covers key challenges related to transport infrastructure planning, development and management, legal, institutional and regulatory framework for the sector, safety and security, funding, gender mainstreaming, utilization of Information and Communication Technology (ICT), and environmental considerations, among others. Its aim is to provide a policy that is conducive to the stimulation of rapid development and efficient management of a safe, widely accessible transport system that responds to modern technological advancement in a rapidly changing and globalized environment.

Source: Githira et al. (2018).

8.4 Conclusion

The street plays a pivotal role in setting up of urban infrastructure development. The planning and design of streets as public spaces not only has a direct effect on transport modes, but it also has an impact on provision of basic services, access to jobs, commerce, health services and school facilities. Well connected streets reduce traffic congestion, commuting time, motor vehicle commuters as well as fares, fuel consumption, traffic fatalities, and greenhouse gas emissions in cities. However, African cities are not benefiting from all these numerous advantages of streets. Their street networks have barely kept pace with urban growth, and infrastructure for non-motorized transport (e.g. pavements or sidewalks for walking and bicycle lanes for cycling) is often lacking, or poorly maintained. This has led to high incidences of traffic fatalities involving pedestrians and cyclists. The dysfunctional nature of road infrastructure in most African cities poses a major challenge to mobility and is an important source of traffic congestion.

Available statistics show that in most sub-Saharan African cities, people have limited mobility choice in getting to work: either they ride minibuses or they use their foot. A low share of formal means in the public transport sector results from poor infrastructures conditions as well as from the weak capacity of city authorities to plan and manage the transport sector. The efficiency of the public company has faced, indeed, various difficulties to be sustainable in terms of supply as well as in terms of demand: lack of institutional coordination between the city council and the transport company; structural deficit associated to the gap between the affordable fares and the operating costs leading to operating deficit; and poor operational and commercial performances associated to public service obligations without the corresponding resources. Other constraints are low commercial returns in congested roads, low productivity of employees, and attempt to serve the whole urban area without having enough buses.

Considering the lack of capacity by the formal public transport systems to meet the mobility demand of urban residents, dominance of the informal sector operators will remain the only option to move urban residents to their work place and others locations. While playing a critical role in the public transport sector in African cities, the informal motorized means of transport also face a number of constraints, ranging from administration and managerial issues to financial obstacles. Efforts should be made to interlink them with the formal transport systems. Rather than discouraging informal operators, national and local governments can set incentives and regulations that capture the benefits they may bring while mitigating negative factors, such as road safety and pollution.

Turning Challenges to Opportunities: Streets for people—drivers of sustainable urban mobility—With the majority of people that are already walking in their limited street network, African cities are indeed in a good position for a healthy society in a sustainable environment. However, in order to sustain this advantage, it is high time to give to pedestrians their right share in the transport infrastructure. Providing adequate infrastructures to pedestrians is cost-effective considering the enormous benefits from walking. Walking is usually the most common access mode to public transport and requires an adequate environment, with protected, well-lit, signalized and surfaced sidewalks. Design should consider the needs of the most vulnerable users: children, the elderly and people with disabilities. In addition to its social and economic benefits, walking has a major advantage in reducing energy consumption, greenhouse gas emissions and pollution (air, water and noise) substantially, as it does not rely on fossil fuels unlike other modes of transport in cities. Furthermore, as walking requires significantly less road space and parking, it enables the preservation of natural habitats and open spaces. Walking also provides the daily physical activity required for a healthy lifestyle.

Strengthening sustainable transport and mobility call for technology and communication networks and infrastructure to be underpinned by planning instruments based on an integrated urban and territorial approach. This calls for the establishment of urban and territorial transport infrastructure and service funds at the national and local levels, based on a variety of funding sources ranging from public grants to contributions from other public entities and the private sector, ensuring coordination among actors and interventions as well as accountability.

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Chapter 9
Air Quality in African Cities

Aminata Mbow-Diokhane

Abstract Air pollution has become a major environmental issue in African cities during the last decade. Rapid urbanization, traffic congestion combined with old cars and low quality fuel, open-burning of waste and biomass, dust and sandstorms are the major sources of air pollution. These anthropogenic and natural sources are responsible for emissions of particulate matter (PM), Nitrogen dioxide (NO_2), Carbon monoxide (CO), sulphur dioxide (SO_2), Volatile Organic Compounds (VOCs) that can affect human health. The comparative analysis of urban air pollution in Africa shows that very few cities measure air quality in Africa. In sub-Saharan Africa region, only South Africa and Senegal have setup continuous air quality monitoring system. Some other countries such as Nigeria and Ghana conducted air quality monitoring programs in 2011 and 2004 respectively. In the 2016 WHO urban air pollution database, 41 cities of 12 sub-Saharan African countries reported their data. The analysis shows that all these cities exceed the WHO guidelines for PM10 and PM2.5 annual concentrations. A case study for Dakar (Senegal) presents the distribution of the air quality measurement network around the city, the monitored pollutants and the Air Quality Index (AQI) that daily informs people and decision markers about the air quality. The AQI is unhealthy (orange) to very unhealthy (red) during the dry season (mid-November to April). During the rainy season (June to October), the AQI is good (green) to moderate (yellow). Air pollution in Dakar is mainly due to particulate matter (PM10 and PM2.5). Annual mean of these PM exceeded WHO guidelines from 2010 to 2017. To tackle air pollution, regulations and measures are taken by Senegalese authorities to reduce emission from transport, industries and energy. For the transport sector, renewal of old cars and promoting of mass transport are the major projects. For other sources (industry, waste and energy), environmental law provides for preventive measures and energy efficiency programs are on-going.

Keywords Air pollution · African cities · Air quality index · Particulate matter Air quality monitoring system · Sub-Saharan Africa

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9.1 Introduction

Air pollution in Africa has become a public health concern during the last decade. According to a recent World Health Organization report, 9 cities out of 10 in low- and middle income countries with more than 100,000 inhabitants do not meet WHO air quality guidelines (WHO 2016[1]). About 600,000 deaths every year across the continent are associated with air pollution (UN-Environment 2016[2]).

Air pollution occurs when a high quantity of harmful gases and particulates released into the air. These pollutants are mainly emitted by transport, especially with diesel cars, open burning of agricultural/municipal waste, industrial activities, etc. Air pollution can be also from natural sources such as dust from Sahara desert that affects many African countries.

The pollutants include:

- Nitrogen Oxides (NO_x)
- Ozone (O_3)
- Particulate matter with an aerodynamic diameter of 10 μm (PM10)
- Particulate matter with an aerodynamic diameter of 2.5 μm (PM2.5)
- Carbon monoxide (CO)
- Sulphur Dioxide (SO_2)
- Volatile Organic Compounds (VOCs).

The rapid urbanization and motorization in Africa combined with poor urban planning are worsening air pollution. Several cities in Africa are facing mobility crisis characterized by use of old cars, poor quality of fuel, and unorganized public transport.

This chapter aims to analyse the urban air pollution issue in African cities, overview and outlook with emphasis on the sub-Saharan African region. It presents the existing monitoring stations and cities air quality levels, especially for particulate matter (PM10 and PM2.5) in respect with the WHO guidelines.

Section 9.2 of this chapter presents a comparative analysis of urban air pollution in Africa mainly based on pollution source diagnosis, WHO database and case studies. Section 9.3 focuses on air quality measurement tools for the city of Dakar, the level and trend of air pollution and an overview of policies that impact air quality in Senegal.

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[1] Public Health, Environmental and Social Determinants of Health (PHE). http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/.

[2] Air Pollution: Africa's Invisible, Silent killer. https://www.unenvironment.org/fr/node/20803.

9.2 Comparative Analysis of Urban Air Pollution in Africa

The main sources of air pollution in African cities are:

- The transport, characterized by a large concentration of vehicles in cities, traffic congestion, obsolescence of the vehicle fleet, poor quality of fuel, is a major source of PM, NO_2 and CO;
- The industries (power plant, cement plant, mining, fertilizer production, agricultural and fish processing, etc.) that use fossil fuel and mainly concentrated is the urban areas, are responsible for PM, SO_2, NO_x emissions;
- Outdoor open-burning of waste and biomass which is a common practice in many African cities can be a source of health impairing emissions such as dioxins and furans due to the waste composition (plastics, waste tires, and other organic/inorganic materials);
- Sand and dust storms, especially in the Sahelo-Saharan zone are important source of PM.

In addition to ambient (outdoor) air, pollution from indoor sources is also a large contributor to the negative health effects of air pollution in Africa. The use of wood and traditional cooking stoves for cooking is worsening the indoor air quality particularly urban areas where households are generally overcrowded.

9.2.1 Air Quality Monitoring in African Cities

Continuous air quality monitoring networks are minimal in Africa. In sub-Saharan Africa, air quality data are not sufficiently representative due to inefficient monitoring of air pollution. Apart from Dakar (Senegal) and Cape Town (South Africa), very few African cities have continuous monitoring stations. In North Africa, some cities in Morocco, Tunisia, Egypt, and Algeria have air quality monitoring stations.

The following analysis of air quality monitoring status in Africa is adapted from Camara's report on air pollution issue in sub-Saharan Africa, the state of monitoring networks (2014).[3]

In South Africa, the air quality program started in 1969 with the establishment of the National Association for Clean Air (NACA) which is a non-profit organization with more than 500 members including corporate environment managers, consultants, policy makers and government representatives, research scientists, project managers, industry environment officers, and individuals all with a common interest—to promote clean air (NACA[4]).

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[3]Camara Fodie Sidi (2014) Question de la pollution atmosphérique en Afrique sub-saharienne (Transports), Etat des lieux des réseaux de surveillance. Master I TMEC Université de Bourgogne. http://climatologie.u-bourgogne.fr/documents/theses_master/2014/CAMARA.pdf.

[4]National Association for Clean Air. http://www.naca.org.za/.

A common platform for managing air quality information in South Africa has been implemented through the South African Air Quality Information System (SAAQUIS).[5] SAAQUIS makes data available to stakeholders including the public and provides a mechanism to ensure uniformity in the way air quality data is managed i.e. captured, stored, validated, analysed and reported in South Africa.

The city of Cape Town and its suburbs have 3,740,000 inhabitants with a density of 1530 inhabitants per sq. km (SSA[6]). It is among the sub-Saharan African cities equipped with “Air Quality Monitoring Network” (AQMN) of 14 stations (Fig. 9.1).

In Cape Town, the main sources of visible air pollution are vehicle emissions (Fig. 9.2a, b), industry and wood-burning (IOL[7]).

In West Africa, Senegal is the only country that has set up a continuous “Air Quality Monitoring Network” (AQMN). The program started in 2009 within the framework of the Urban Mobility Improvement Program (Programme d’Amélioration de la Mobilité Urbaine – PAMU).

The monitoring network became operational in 2010 with 5 stationary stations installed in the city of Dakar and a van mobile laboratory. The number of monitoring network stations increased to 6 in November 2017 (Fig. 9.3a, b).

However, Dakar does not have as many stations as Cape Town but this should be noted that the area of Dakar is 5 times smaller than the area of Cape Town (551 km^2 vs. 2455 km^2). In addition, the Senegal air quality management program is relatively recent. Even if Senegal is an example in the West Africa sub-region, many other cities such as Diourbel and Thiès, with 1,543,646 and 1,838,366 inhabitants respectively (ANSD 2014[8]), have no monitoring stations.

In other African countries, most of the air quality measurement activities have been done within the framework of pilot projects and programs.

In Lagos, there is no formal air quality network known with continuous monitoring but an air pointer for short-time air quality monitoring have been set up by the Environmental Law Research Institute (ELRI). The city of Lagos, former capital city of Nigeria, have more than 10,000,000 inhabitants, on a land area of 9999 km^2 (NBS[9]). It is the second most important city in Africa after Cairo. Results are presented in a document entitled “Clean Air for Lagos” and published in 2011 on behalf of ELRI.

Accra, the capital city of Ghana has 2.4 million inhabitants on a land area of 187 km^2 (GSS[10]). In 2004, USEPA, USAID and UNEP selected the Ghanaian capital in the framework of an air quality assessment capacity-building project. There is no

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[5] South African Air Quality Information System. http://www.saaqis.org.za/.

[6] Statistics South Africa. http://www.statssa.gov.za/.

[7] Cape Town air among the worst—expert. https://www.iol.co.za/news/cape-town-air-among-the-worst-expert-1468544.

[8] Situation économique et sociale régionale 2014, Agence Nationale de la Statistique et de la Démographie (ANSD) – Sénégal.

[9] National Bureau of Statistics. http://www.nigerianstat.gov.ng/.

[10] Ghana Statistical Service. http://www.statsghana.gov.gh/.

Fig. 9.1 Air quality monitoring network in Cape Town. *Source* Camara (2014)

formal air quality monitoring network but Accra have private consulting such as SGS operating in air quality through environmental impact assessment.

Many other big African cities, most of which having more than 1,000,000 inhabitants do not monitor air quality. This is the case with Kinshasa, Abidjan, Cotonou, Addis-Ababa, Douala, Nouakchott, etc.

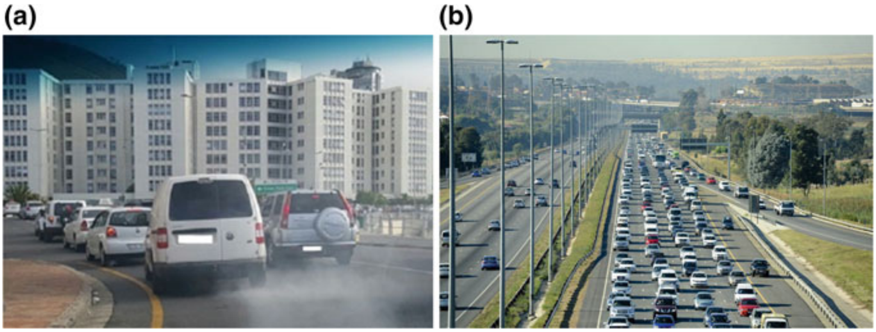

Fig. 9.2 **a** Smoking cars in the city of Cape Town. **b** Traffic jam in the city of Cape Town *Source* http://www.capetowngreenmap.co.za/blog/city-cape-town-health-lobbies-healthy-cars, https://citizen.co.za/news/south-africa/394213/city-of-cape-town-traffic/

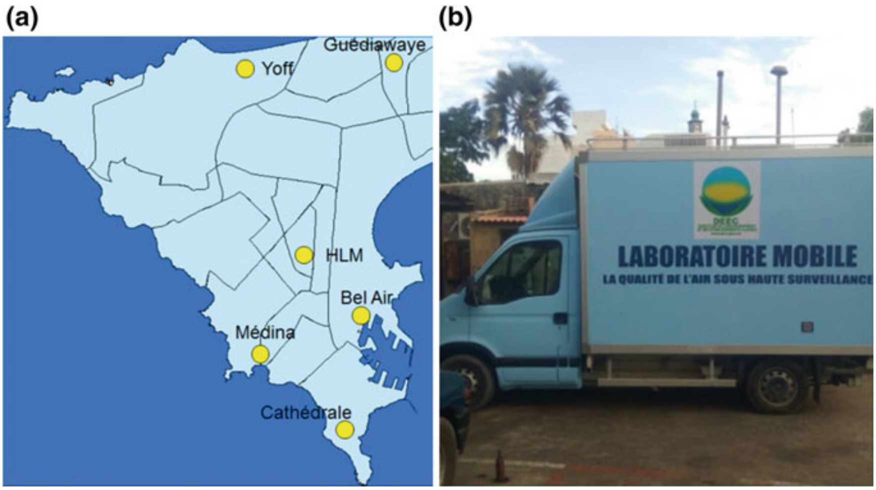

Fig. 9.3 **a** Air quality monitoring stations location in DAKAR. **b** Mobile van laboratory in DAKAR (Senegal). *Source* Centre de Gestion de la Qualité de l'Air (CGQA), Dakar, Senegal

9.2.2 Particulate Matter Concentrations in African Cities

Assessment of urban air pollution and its health impacts is done by WHO using PM10 and PM2.5 annual mean concentrations. WHO annual limit values are 20 and 10 $\mu g/m^3$ for PM10 and PM2.5 respectively. In Africa, only 10 countries reported their PM data into the WHO 2016 database (Fig. 9.4).

The Fig. 9.3 above shows that all countries that have reported data into WHO database exceeded the limit value of 20 $\mu g/m^3$. Nigerian cities topped the ranking with a maximum of 594 $\mu g/m^3$ in Onitsha. It is followed by Uganda (170 $\mu g/m^3$ in Kampala), Senegal (146 $\mu g/m^3$ in Dakar) and Cameroon (104 $\mu g/m^3$ in Bamenda).

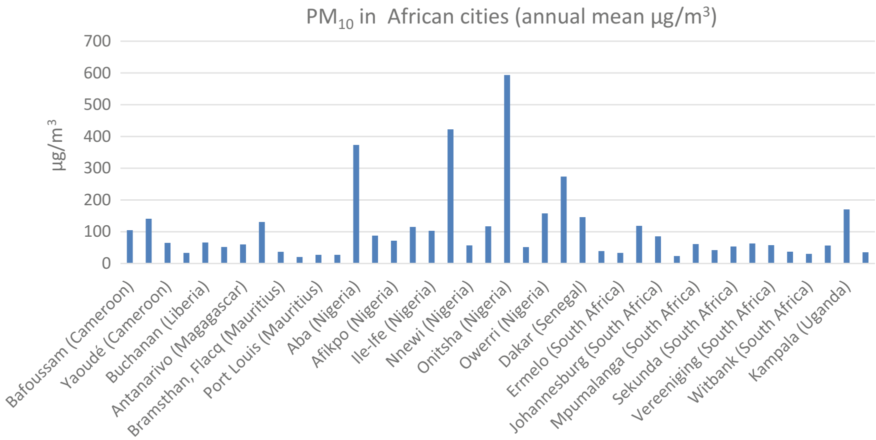

Fig. 9.4 PM10 concentrations in African cities [*Source* WHO 2016 (WHO Global Urban Ambient Air Pollution Database (update 2016) http://www.who.int/airpollution/data/cities-2016/en/)]

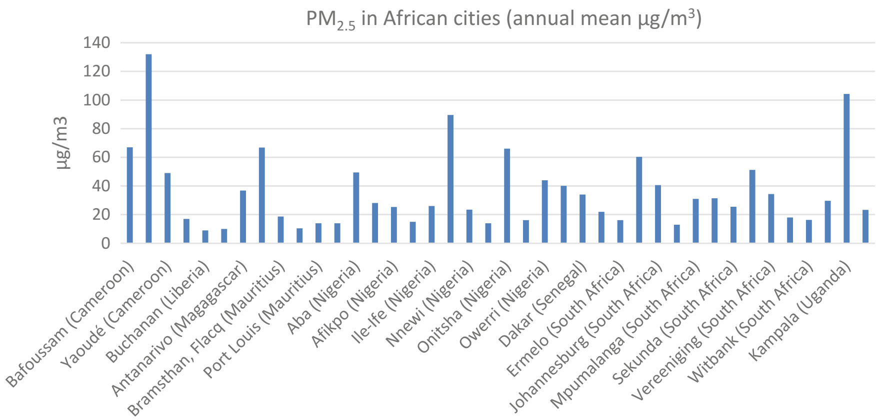

Fig. 9.5 PM2.5 concentrations in African cities (*Source* WHO 2016)

Kenya, Liberia, Madagascar, Mauritius, South Africa and Tanzania, registered less PM_{10} concentrations but values are still above WHO guidelines.

Concerning PM2.5, the maximum value is 132 $\mu g/m^3$ in Bamenda (Cameroon) followed by 104 $\mu g/m^3$ in Kampala (Uganda), 90 $\mu g/m^3$ in Kaduna (Nigeria). For other cities, almost all PM2.5 annual mean exceeded the WHO guidelines of 10 $\mu g/m^3$ (Fig. 9.5).

PM2.5 are more harmful than PM10. It is able to bypass lungs and enter the blood stream as well, owing to its smaller size. Hence, it can cause cardiovascular diseases much more dangerous than a treatable lung problem (Particulate Matter[11]).

[11]Particulate Matter. https://www.quora.com/Which-is-greater-PM10-or-PM2-5-Why.

The health hazard due to particulates matter is real. Indeed, according to WHO, the mortality risk in short-term increases to 2.5% with daily mean concentrations greater than 100 $\mu g/m^3$ for PM_{10} and 50 $\mu g/m^3$ for $PM_{2.5}$. This risk raise to 5% concentrations greater than 150 $\mu g/m^3$ for PM_{10} and 75 $\mu g/m^3$ for $PM_{2.5.}$

In long-term, the risk of mortality due to prolonged exposure to PM is 15% with annual mean concentrations of 70 $\mu g/m^3$ for PM_{10} and 35 $\mu g/m^3$ for $PM_{2.5}$ (WHO 2005[12]).

Finally, it should be noted the lack of continuous air quality data in Africa on a long run. In the WHO database, measurements are not up-to-date. Only Senegal and Mauritius have recent data from 2015. Senegal reported its data from 2013 to 2016 while for other countries, data are available for just one year between 2008 and 2014 which may suggest that these are selective measurement rather than continuous air quality monitoring. However, measurement in countries such as Cameroon, Liberia, Mauritius, Nigeria and South Africa was done in different cities of these countries, unlike Senegal where monitoring is limited to one city. In addition, for many cities, PM2.5 are not directly measured but converted on the basis of PM10 and vice versa.

North African countries such as Morocco, Tunisia, Algeria and Egypt are not included in this analysis because they are classified in the East Mediterranean region by WHO.

9.3 Case Study: Monitoring Air Pollution in Dakar

The city of Dakar occupies only 0.3% of Senegal total area but concentrates most of the economic activities (a population of 3.1 million, 310,000 registered vehicles, 70% of the industrial plants). Therefore air pollution became a key issue due to rapid urbanization and industrialization (Fig. 9.6).

9.3.1 Tools Put in Place for Air Pollution Monitoring Including Use of ICT

To address the air pollution issue, ministries in charge of transport and environment set up in November 2009 the Center for Air Quality Management (Centre de Gestion de la Qualité de l'Air – CGQA) with a network of 5 air quality measurement stations around the city of Dakar and a reference laboratory.

[12]WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, Global update 2005, Summary of risk assessment. http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=217667EA36B404E8D849AA23837D8F58?sequence=1.

Fig. 9.6 Air pollution in a street of Dakar

Table 9.1 Ambient air analysers used for air quality monitoring in Dakar

Analysers models	Methods of measurement	Pollutants
API 200E, AC32M (for the 6th station)	Chemiluminescence	Nitrogen oxides (NO_x)
API 400E, API T400, O342E (for the 6th station)	UV photometry	Tropospheric ozone (O_3)
GC 955	Gas chromatography	Benzene, Toluene, Xylene (BTX)
BAM 1020, MP101M (for the 6th station)	Beta attenuation	Particulate matters (PM10 and PM2,5)
API 300E, API T300, CO12E (for the 6th station)	IR correlation	Carbon monoxide (CO)
API 100E, API T100, AF22E (for the 6th station)	UV fluorescence	Sulphur dioxide (SO_2)

Source Centre de Gestion de la Qualité de l'Air (CGQA), Dakar, Senegal

This network has increased recently to 6 stations and a mobile van laboratory is also available for measuring the levels of air pollution at any point (especially in areas not covered by the fixed stations).

Air quality monitoring stations are equipped with ambient air analysers, which allow continuous measurements (Table 9.1).

The pollutants measured are:

- Nitrogen Oxides (NO_x)
- Ozone (o_3)
- Particulate matter 10 μm in diameter (PM10)
- Particulate matter 2.5 μm in diameter (PM2.5)

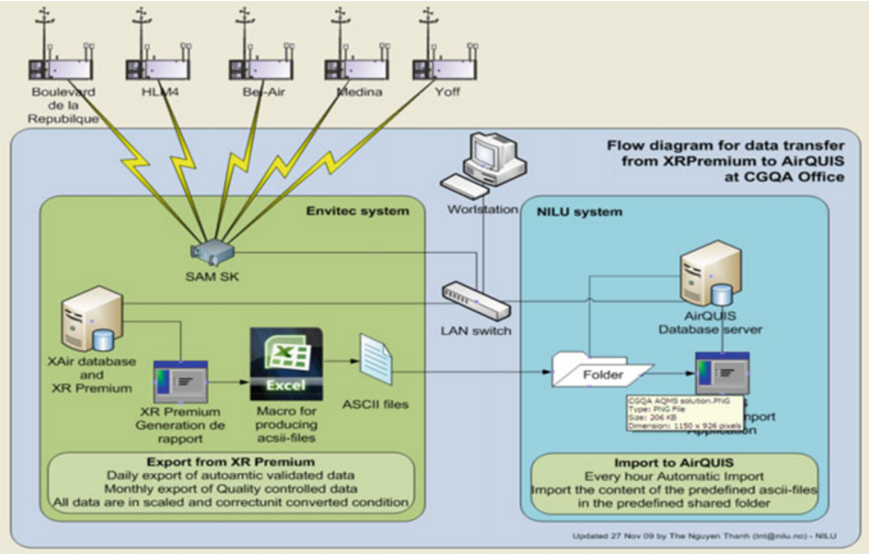

Fig. 9.7 Data transfer diagram for air quality data in Dakar (*Source* CGQA)

- Benzene, Toluene, Xylene (BTX)
- Carbon monoxide (CO)
- Sulphur dioxide (SO_2).

Monitoring stations are located in Dakar region, specifically in Dakar and Guédiawaye departments (Fig. 9.3a).

Data captured in the 6 monitoring stations every fifteen minutes are sent through Internet ADSL connection to the central laboratory server (Xair) every hour. A second server running the Airquis software is used for Air Quality Index calculation and other statistics (Fig. 9.7).

9.3.2 *Level and Trend of Air Pollution in Dakar*

From the collected data, the daily air quality status is estimated through an Air Quality Index (AQI). AQI is calculated for five major air pollutants (NO_2, SO_2, PM10, CO, O_3) regulated by WHO and Association Sénégalaise de Normalisation (ASN—Senegalese Standardization Agency) using the formula below:

$$\mathrm{AQI} = \frac{\text{Pollutant concentration}}{\text{Pollutant limit value}} \times 100$$

The AQI informs about the level of pollution and possible health effects after few hours or days of exposure to the atmospheric pollution. It is sent daily to the general public and decision-makers for information and awareness, through electronic mail and internet (http://www.air-dakar.org and http://www.denv.gouv.sn).

The AQI value is a number in the range 0 through 500. Value less than or equal to 50 means a low pollution level while AQI value greater than or equal to 100 corresponds to a high pollution level. Four colours are used to symbolize the Air Quality Index (Table 9.2).

There is a seasonality of atmospheric pollution in Dakar. Indeed, the air quality is good to moderate during the rainy season from May to October. The period from late-October to mid-November is a transition period, and from late-November to May, the air quality is unhealthy to very unhealthy. The pollution episodes are mainly due to PM10 and PM2.5 from anthropogenic (diesel cars, biomass and waste burning, industries) and natural (dust from the Sahara desert and sandstorms) sources (Fig. 9.8).

PM10 and PM2.5 annual average exceeded WHO and Senegalese limit values from 2010 to 2017 (Figs. 9.9 and 9.10).

9.3.3 *Measures Taken by the Authorities to Reduce Air Pollution*

The creation of a laboratory for air quality monitoring (CGQA) is a first step on air pollution management in Senegal. This allows to continuously inform people about the air quality in order to reduce short-term health impacts of air pollution.

In addition to the monitoring system, regulations are put in place and policies and programmes are implemented to reduce emission from transport, industries, open burning of agricultural/municipal waste (Fig. 9.11a, b).

Table 9.2 Senegal air quality index ranges

Air Quality Index (AQI) values…	Levels of Health Concern	Colors
When the AQI is in this range…	… air quality conditions are:	… as symbolized by this color:
0 to 50	Good	Green
51 to 100	Moderate	yellow
101 to 200	Unhealthy	Orange
200 to 500	Very Unhealthy	Red

Source Centre de Gestion de la Qualité de l’Air (CGQA), Dakar, Senegal

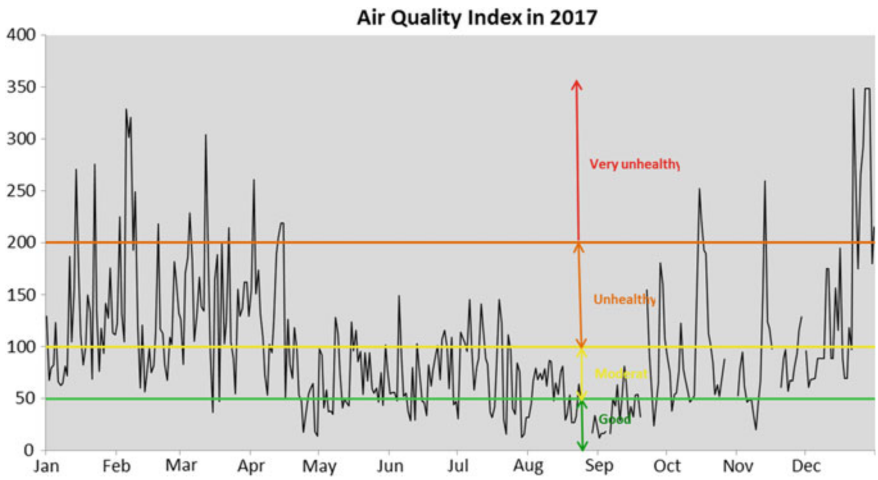

Fig. 9.8 Air quality index trend in Dakar (2017). *Source* CGQA (Suivi de la qualité de l'air à Dakar, Rapport annuel 2017 http://www.air-dakar.org/images/pdf/bulletins/rapport_annuel_2017.pdf)

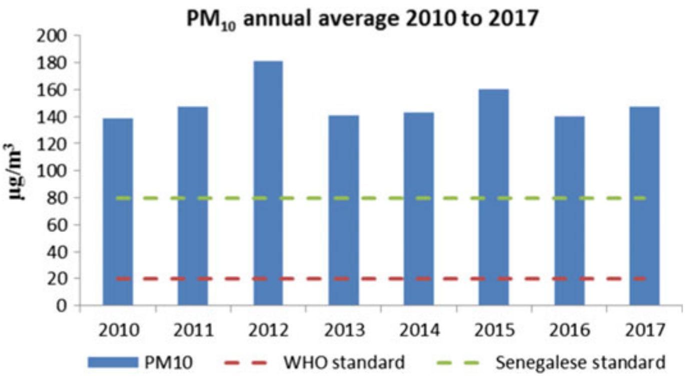

Fig. 9.9 PM10 annual average for Dakar (2010–2017). *Source* Centre de Gestion de la Qualité de l'Air (CGQA), Dakar, Senegal

9.3.3.1 Reducing Emissions from Transport

In terms of regulations, the NS-05-060 standard set the limit values for exhaust gas emissions. Regulated pollutants are carbon monoxide, hydrocarbons (gasoline car) and smoke opacity (diesel car). In addition, fuel sulphur content is restricted to 5000 ppm and gasoline is out of lead since 2005. There is a restriction on used car importation limited to 8 years and a pre-importation inspection is required for road worthiness.

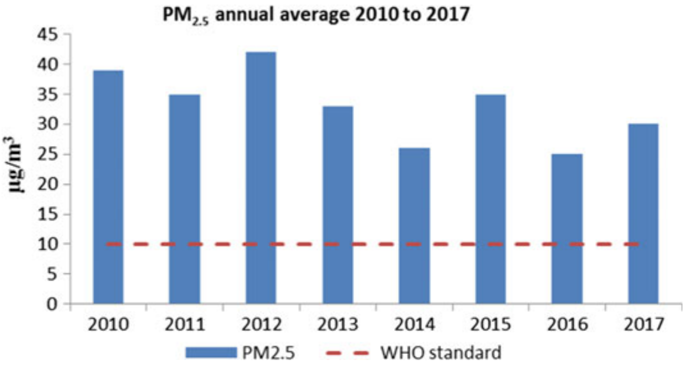

Fig. 9.10 PM2.5 annual average for Dakar (2010–2017). *Source* Centre de Gestion de la Qualité de l'Air (CGQA), Dakar, Senegal

Fig. 9.11 **a** Open-burning of waste in an open landfill site of Dakar. **b** Open-burning of biomass on the coastal road in Dakar

Various actions are in progress to improve urban mobility and promote public transport and mass transit. This is especially:

- the realization of the regional express train (TER);
- the implementation of the BRT project (Bus Rapid Transit);
- the renewal of the urban bus fleet.

For promoting non-motorized transport, the completion of cycle paths on the ridge west of Dakar and wide sidewalks are in progress.

9.3.3.2 Reducing other Emissions (Industries, Open Burning of Waste, Etc.)

Emissions from industries are regulated by the Environmental code of 2001 through its chapter I. The NS-05-062 standard (2003) set the threshold values.

In the energy sector, strategies for promoting renewable energy investment are defined in the policy development letter 2012–2017 which aims the diversification of energy sources by introducing coal and natural gas with an objective of 20% in installed electrical capacity from renewable energy in 2017.

National program to reduce emission through energy efficiency achieved in the building sector aims to establish a thermal regulation and to produce thermal insulation material using Typha.[13] The Environmental Code controls waste management through its Chaps. 3 and 5 of its Title 2 termed: "Preventing and combating pollutions and nuisances", Title 3 on the protection and implementation of receptors and its Title 4 dealing with diverse sanctions and provisions.

In April 2015, Senegal's National Assembly unanimously prohibited the production, importation, possession and use of plastic shopping bags.

9.4 Conclusion

This chapter has analysed the urban air pollution levels and trends in African cities, especially for PM10 and PM2.5. The study consisted of a comparative analysis in African cities showing a lack of air quality monitoring system in most African cities. For the few cities where data are available, most of annual mean of PM concentrations exceed the WHO guidelines. The case study has shown the air quality monitoring program for Senegal with the technology used to measure air pollution, the information to public through the Air Quality Index (AQI) and levels of PM during the last 8 years that exceed the WHO guidelines.

Air pollution is the single largest environmental risk to health globally. It increases the risk of stroke, cardiopathy, lung cancer and acute respiratory diseases, especially asthma and causes more than 3,000,000 deaths annually around the world, according to WHO. Besides outdoor air pollution, WHO estimates that domestic smoke represents a serious health hazard for approximately 3 billion of people who cook their meals and heat their homes with fuel based on biomass and charcoal. In many African countries, this anthropogenic outdoor and indoor air pollution is worsened by natural sources such as dust from Sahara. However, there are lacks of data for a better estimation and understanding of air pollution and studies linking this to health.

The WHO database shows that more than 90% of African cities do not meet the guidelines for particulate matter (PM10 and PM2.5) concentrations. Urbanization in Africa is at the highest growth rates making effective air quality management an environmental emergency for Africa. Like Cape Town and Dakar, continuous monitoring of air quality should be encouraged in big African cities. This will enable to alert people about pollution peak in order to reduce the short-terms effects on their health. In the longer term, this provides reference data useful in the development of policies and programs in the fields of transport, industry, public health, etc.

[13]Projet PNEEB/Typha. http://www.pneebtypha.org.

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Chapter 10
Smart Disaster Prevention and Resilience in Africa

Femi Olokesusi and Femi Ola Aiyegbajeje

Abstract Disaster is a sudden accident or a natural catastrophe that causes great damage or loss of life. Disaster risk management is a very crucial ingredient for the social and infrastructural development which involves taking prevention and control measures and building resilience of cities and its citizens. Metropolitan cities are confronted with an array of disaster challenges such as flooding, ocean surge and building collapse. Disaster management is often on the concurrent list of most African countries, so, both the national and sub-national governments are involved. This chapter therefore examines the nature of disaster in selected African cities while focusing on the extent to which Lagos metropolis has adopted smart strategies and initiatives especially information and communication technology to address the issues of disaster prevention and resilience. It concludes that greater adoption of ICT, public education and awareness and engagement constitute imperatives for more effective disaster resilience and prevention in Lagos and other African cities.

Keywords Governance · Stakeholders · Government · Local · Institutions Policies · ICT

10.1 Introduction

Disaster refers to an emergency caused by natural hazards or human-induced actions resulting in a significant change in circumstances over a relatively short time period. Disaster constitutes a grave disruption of the functioning of a society, triggering widespread human, material, or environmental losses which exceed the ability of affected community to cope using only its own resources (Van Niekerk et al. 2002). Based on experience, disasters could be sudden (flash floods) or progressive

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(drought). The interaction of humans with their environment culminates in disasters. Some disasters are death, displacement, disease, and loss of crops, damage to physical and service infrastructure, depletion of natural and social capitals, a general disruption of economic and social activity. A disaster results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk (UN International Strategy for Disaster Reduction (ISDR) 2002). Some of the attributes of disasters include the fact that they are dramatic, sudden, unscheduled events that are often accompanied by large losses of human life, suffering and affliction to a society or a significant part of it, and a temporary breakdown of prevailing lifelines and systems (Otero and Marti 1995). The global community has been experiencing an unparalleled rise in both the frequency and intensity of disasters in recent decades. Over the last quarter century, the number of reported natural disasters and their impact on human and economic development worldwide has been increasing yearly (UNDP 2004). Disaster now represent one of the most important challenges to human development effort in several countries of the world. More than ever, curbing the incidences of environmental hazards and disaster risks is of critical importance for achieving major societal objectives, such as the Social Development Goals (SDGs). Disasters either triggered by natural or anthropogenic sources put smart cities development gains at risk. The destruction of infrastructure, the erosion of livelihoods, damage to the integrity of ecosystems and architectural heritage, injury, illness and death are direct outcomes of disasters. Disaster losses also aggravate other stresses and shocks such as a financial crisis, political or social conflict, diseases and environmental degradation.

In several parts of Nigeria and Africa (See Figs. 10.1 and 10.2), natural hazards have continued to trigger disasters. Available statistics indicate that, from an average of about 25 disaster events in 1975, there has been an increase, with a mean of 130 in 2000. On the other hand, the mean number of disasters experienced on the continent between 2003 and 2012 is 164. Comparatively, there has also been an increase in the number of people affected by these events. Globally, between 1980 and 2000, over 1.5 million persons perished due to natural disasters. Out of these deaths, 160,000 are associated with earthquakes while 833,000, 251,000 and 170,000 deaths were associated with drought, cyclones and floods respectively. Between 2003 and 2012, about 1.5 million died from disasters while about 2.17 million people were affected and the estimated cost of damage is US$1.57 trillion. With particular reference to Africa, 38,997 persons died, 303,910 persons affected and damage estimated to be US$13.17 billion (Societies 2013).

It is worth noting that the United Nations International Strategy for Disaster Reduction have championed and charted the path for disaster risk management since the 1990s. Due to the increasing concern about the impact of disasters, the UN General Assembly declared 1990–1999 the International Decade for Natural Disaster Reduction (IDNDR), under the theme ‘Building a Culture of Prevention’, which led to the greater awareness of the social and economic consequences of natural disasters (ISDR 2004). The importance accorded to socio-economic vulnerability in disaster risk analysis informed the crucial role of human action in reducing vulnerability. At the same time, it is acknowledged that the achievement of disaster reduction as

Fig. 10.1 Map of Africa showing major cities. *Source* Google Image, 2018

a social and economic imperative required a long-term perspective (ISDR 2004). However, instead of managing underlying risk drivers for disaster risk reduction, many African cities focus on managing disasters. Hence, the Sendai Framework for Disaster Risk Reduction: 2015–2030, again the reiterating the key message of the preceding Hyogo Framework that, disaster risk reduction should be conceived as managing the risks inherent in social and economic activities, instead of just mainstreaming disaster risk management to protect against external threats such as floods and other natural hazards. Some pertinent priorities under the Sendai DRR Framework are: Priority 3—Investing in DRR for resilience; Priority 4: Enhancing

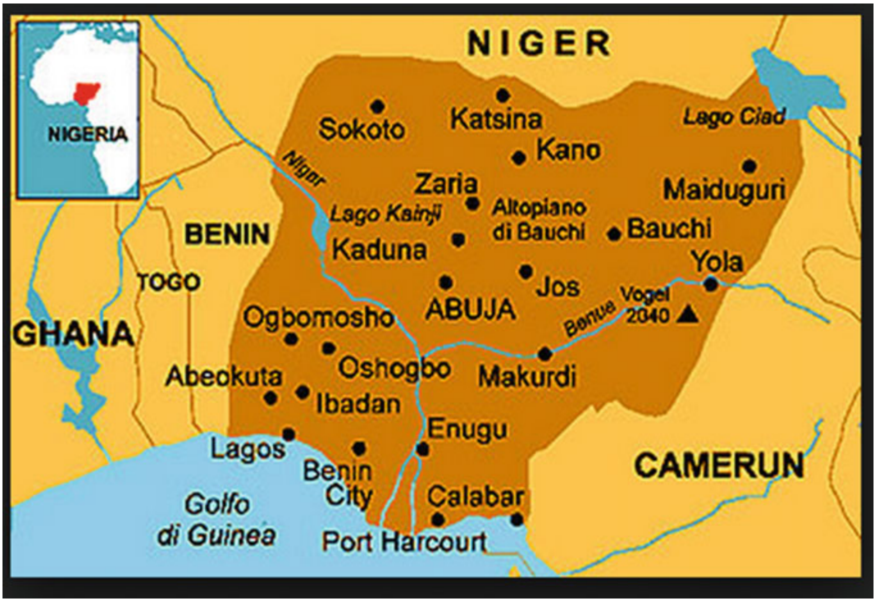

Fig. 10.2 Map of Nigeria showing major cities. *Source* Google Image, 2018

disaster Preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction. Contingency plans and policies.

This implies that disasters ought not to be overwhelming destructive always as they can be prevented or their impacts substantially reduced with appropriate preparedness and disaster risk reduction measures. This is with the understanding that disasters are not mere singular occurrences but rather are outcomes of years of accumulated risks due to unsustainable developmental decisions and practices. The ISDR defines disaster risk reduction as the systematic development and application of policies, strategies and practices to minimize vulnerabilities and hazard risk in communities through prevention, mitigation, preparedness and effective response to the adverse impacts of hazards. It entails a paradigm shift from an undue emphasis on disaster response to a more proactive disaster risk management. Disaster risk reduction interventions and programmes are conceived with a resolve to build societies that are resilient to hazards and to ensure that development activities do not unwittingly increase vulnerability to these hazards, resulting to an increasing recognition of the need to address risks in a holistic manner focussing on both the social and economic developmental activities including but not limited to policies, plans, strategic frameworks, institutional structures and projects (Ojo 2016).

Consequently, disaster risk reduction focuses on policies and practices that diminish disaster losses by addressing interventions in three broad areas of *hazard minimization, reducing exposure and susceptibility;* and *enhancing coping and adaptive capacity* (Van Niekerk 2004). The objective of DRR is to provide organizations and communities with tools and practices that will reduce the level of incidence and negative impact of disasters on societies (Trocaire 2009). DRR entails a paradigm shift from an undue emphasis on disaster response to disaster risk management through the *factoring* of prevention and disaster reduction into sustainable development. Its success is premised on partnership building between governments, non-governmental organizations, international organizations, academic institutions, the media as well as other relevant disaster reduction stakeholders (Ayeni 2016). Also, the African Union Special Emergency Assistance Fund has since 1984 disbursed US$40 million for risk reduction and relief activities. In June 2012, African Union (AU) decided to establish the African Risk Capacity Secretariat with objective of developing a disaster risk insurance scheme for African Countries (GFDRR 2016).

Undoubtedly, failure to prevent and prepare for risks has catastrophic impacts usually culminating in widespread loss of life and property. Mortality is generally higher in developing nations because they tend to be more exposed to natural disasters, possess structurally weak buildings and infrastructure coupled with low disaster prevention capacity. Proactive risk management has proven to prevent or reduce destruction. Early Warning Systems (EWS) have the capability to minimize the damage from natural hazards by relocating people to safer locations and advance preparation of shelters and infrastructure. The Lessons learnt during the hurricane disaster in Louisiana, and the east coast of the United States of America in and in late 2015 helped the government and people of Florida to minimize devastation when hurricane Irma struck in September, 2017.

Fortunately, advances in information and communication technologies provide an array of tools for disaster risk management. For example, the DesInventar is very useful in the analysis of disaster-related information for applications in planning, risk mitigation and disaster recovery purposes. The software can also be utilised to simulate disasters and study their impact. Throughout the world, EWSs have been set up to avoid or reduce the impacts of hazards such as forest fires, volcanic eruptions, floods, storms, earthquakes etc. Effective EWSs are designed as "end-to-end" warning systems, that is, they span all steps from hazard detection to community response.

10.1.1 Types of Early Warning Systems (EWS)

There are different types of early warning systems to avert or reduce the negative impact of any form of disaster either human or natural disaster. The numerous types of EWS are listed and discussed below.

i. The Cell Phone Broadcasting Service is a collaborative project between governments and telephone service providers. The CBS mobile phone EWS broadcasts disaster information to mobile phone users with a special receivable ID at the base station transceiver subsystem.

ii. Emergency Communication Mechanism: Hazard Monitoring Telecom Systems promote residence of existing critical infrastructure, water transport, telecommunication, education, hospitals, and land use planning. The Africa Risk View designed by AU for member countries is meant to enable risk modelling at the national level and it is customisable to specific need of each country (Global Facility for Disaster Reduction & Recovery 2015).
iii. The UNISDR has supported the African Regional Climate Organization (ACMAD) to establish alerts based on anticipated risk and weather patterns to enhance early warning systems for climate—related events in the continent. ACMAD now produces severe weather forecasts and flood alerts, which aids preparedness planning more than 40 cities including Kampala, Johannesburg, Nairobi, Arusha, Dakar, Maputo, Yaounde and Addis Ababa have signed up to the UNISDR Making Cities Resilient Campaign. This is an indication that local action is crucial for preparedness (Global Facility for Disaster Reduction & Recovery 2015).
iv. UNISDR facilitated the development of the ECOWAS Programme of Action for the Implementation of the ECOWAS Policy for DRR: 2010–2014. UNISDR also provided support for the Implementation of the Africa Regional Strategy for Disaster Risk Reduction: 2006–2015 (Global Facility for Disaster Reduction & Recovery 2015).
v. The African Regional Strategy for Disaster Risk Reduction by GFDRR was approved in 2005 by African Heads of State. Also, the GFDRR through the European Union-funded Risk Financing Programme is collaborating with countries to develop multi-risk African Disaster Risk Financing Initiative (Global Facility for Disaster Reduction & Recovery 2015).
vi. The CBS system can transmit messages nationwide or to specific communities. It has broadcast 57 warning messages to over 19 million mobile phone users in South Korea. The system provides multi-hazard early warnings. Its low-cost is an advantage.
vii. The Automatic Verbal Notification System is an EWS that relies on automatic voice notification equipment located at the local disaster management agency office. It can issue warnings using fixed or mobile telephones villa broadcast amplifiers and other suitable communication tools.

    In South Korea, the system uses 32 exclusive emergency communication networks.
viii. The Electricity Bulletin Boards System is a EWS that utilises electronic bulletin boards to display disaster information and warnings. The size of the boards varies, depending on the location.
ix. In July 2005, The Western Cape Town province developed a hazard assessment model which forms part of Risk and Vulnerability Assessment RAVA process. (1st of 3 phases.) This macro hazard assessment is utilized by municipalities to develop own micro assessment. The DM IT System (GMC3) is developed and deployed to be utilized by line function departments/municipal structures as their day to day software programme. (Call taking and dispatch–ambulance/traffic/fire etc.). On a higher IT platform, the Disaster Man-

agement Information Management System (DMIMS) is developed to co-ordinate disaster management activities (activating procedures/resource management/contingency, response and recovery plans/exercises). This data will be incorporated to serve as Disaster Management Plans as required in legislation (Dmisa Western Cape 2005).

x. Also, the Western Cape Town province developed strategic disaster management (DM) implementation plan. This plan is to act as a co-ordinating, monitoring and supporting authority, which is to ensure the creation and maintenance of a safe province which will provide to all its residents an integrated and co-ordinated approach to disaster management (Dmisa Western Cape 2005) focusing on:

   - Vulnerability reduction in disaster prone areas, communities and households with the emphasis on disaster prevention and mitigation (risk reduction activities) (Dmisa Western Cape 2005).
   - Efficient and effective disaster management preparedness, response and recovery activities through the necessary structures, systems and mechanisms (Dmisa Western Cape 2005).

xi. The Radio Disaster Warning Broadcasting System is also a EWS that has three main sub-systems: Control, Transmission and Warning Broadcasting Panels. It's operated by electric power or solar energy. The system relies on radio data system encoder.

xii. Telemetric EWSs have been deployed around several rivers in Nicaragua, El Salvador, Argentina, Colombia and others. Cuba, Jamaica and Ecuador among others in Latin America and the Caribbean operate weather radars for floods.

xiii. The Automatic Rainfall Warning System is an EWS that can measure rainfall in the upper stream analyse discharge and velocity of river flow in a specific river basin and calculate the water level downstream. Anytime the water level exceeds some specified criteria, early warnings and evacuation orders are issued. The observation station is powered by batteries and sunlight (solar power), is computerised.

Based on the above background, the study aimed to examine the nature of disaster in selected African cities while focusing on the extent to which Lagos metropolis has adopted smart strategies and initiatives especially information and communication technology to address the issues of disaster prevention and resilience. To achieve this aim, specific objectives were outlined. These are to identify the types of disaster peculiar to African cities; Its effects on cities' socio-economic development; examine the adopted strategies in managing disaster in selected African cities; examine the disaster risk prevention and resilience and proffer solutions for cities' administrators on how to manage disaster. The chapter is structured into six sections. Section one constitutes the introduction. The second section provides a detailed argument on the conceptual framework while section three provides an overview of disasters in Nigeria and other African cities. The fourth section discusses the smart disaster prevention and resilience in Nigerian using Lagos as a case study. Section five focuses on risk prevention and response while section six concludes the chapter.

10.2 Conceptual Framework

10.2.1 Conceptual Framework

Figure 10.3 shows our conceptual framework, which in turn guides the discussion in the chapter. The structure of the paper is as follows.

Risk is usually associated with the inability of human beings to manage hazard events that may eventually lead to negative consequences like destruction of the environment, socio-economic activities, properties and losses of lives. It can be defined as the probability of harmful consequences (UN International Strategy for Disaster Reduction (ISDR) 2002), or expected losses (lives lost, persons injured, damage to property and/or the environment, livelihoods lost, disruption of economic activity or social systems) due to the interaction between humans, hazards and vulnerable conditions. Risk is therefore the possibility that a particular hazard might exploit a particular vulnerability (Van Niekerk et al. 2002). It is the production of the possible damage caused by a hazard due to the vulnerability within a community. In other words, risk is usually due to hazard events exploiting the vulnerable situation of an environment or community. The poorer communities are more at risk because of their high vulnerability to hazard situations due to their low coping capacities. The perception of risk and causes vary from community to communities and culture to cultures. Two elements are essential in the formulation risk: the probability of occurrence of a given threat (e.g. a hazard); and the degree of susceptibility of the element (e.g. a rural community) exposed to that source vulnerability (UN International Strategy for Disaster Reduction (ISDR) 2002).

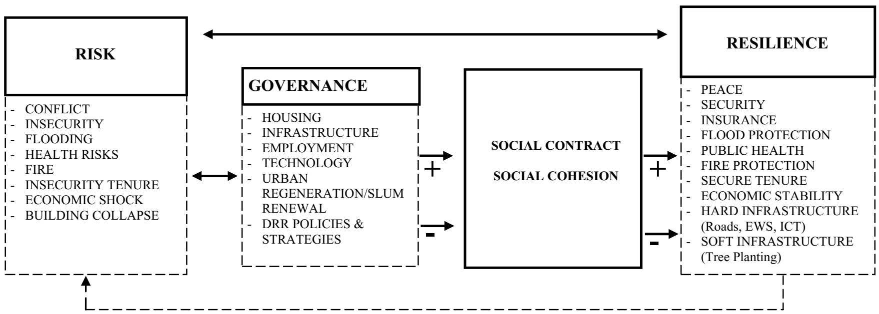

Fig. 10.3 Conceptual framework. *Source* After Kounkuey Design Initiative (KDI)/International Alert

A hazard can be defined as a potentially damaging physical event, phenomenon or human activity which may cause the loss or life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include hidden conditions that may represent future threats and can have different origins. These include natural (geological, hydro-meteorological and biological) and/or induced by human processes (environmental degradation and technological hazards) (UN International Strategy for Disaster Reduction (ISDR) 2002). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity and probability.

Vulnerability and risks are related to the political decisions a society has taken over time and therefore, depend on a country's, region or city's development. Vulnerability refers to a set of prevailing or consequential conditions ensuing from physical, socio-economic and environmental factors, which raises the susceptibility of a city to the impact of hazards (UN International Strategy for Disaster Reduction (ISDR) 2002). It can consist of physical, social, economic, environmental and/or political factors that adversely affect the ability of cities to respond to events (Jegillos 1999). Blaike et al. (1994) conceives vulnerability as the characteristics of person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a particular hazard.

A disaster is a function of the risk process as it results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk as expressed in the equation below (UN International Strategy for Disaster Reduction (ISDR) 2009).

$$\text{Disaster Risk} = \frac{\text{Vulnerability} \times \text{Hazard}}{\text{Capacity}}$$

10.2.2 Dimensions of Risks

There are several dimensions of risks as shown in Fig. 10.3 Disaster risk reduction is defined as the systematic development and application of policies, strategies and practices to minimize vulnerabilities, hazards and the unfolding of disaster impacts throughout a society, in the broad context of sustainable development (UNISDR 2004). The Sendai Framework's seven targets focus on substantial reductions in (1) disaster mortality, (2) number of affected people, (3) direct economic losses and (4) reducing damage to critical infrastructure and disruption of basic services. The Sendai Framework also seeks a substantial increase in (5) national and local disaster risk reduction strategies by 2020, (6) enhanced cooperation to developing countries, and (7) a substantial increase in multi-hazard early warning systems, disaster risk information and assessments.

The World Bank (1992: 1) described governance as "the manner in which power is exercised in the management of a country's economic and social resources for development". Currently, description of governance now encompasses decision making, power and control, democracy and legitimacy, accountability, women empowerment and thee legal framework (Lamour 1998). In 1999, UN-Habitat initiated the Global Campaign on Urban Governance to support the implementation of the Habitat Agenda goal of “sustainable human settlements development in an urbanizing world.” The goal of the campaign is to contribute to the eradication of poverty through improved urban governance, building on the emerging international consensus that good governance is a crucial prerequisite for poverty eradication. The campaign aims to increase the capacity of local governments and other stakeholders to practice good urban governance and to raise awareness of and advocate for good urban governance around the world. The campaign focuses attention on the needs of the excluded urban poor. It promotes the involvement of women in decision-making at all levels, recognizing that women are one of the biggest levers for positive change in society. In so doing, the campaign aims at making a significant contribution to implementing the Habitat Agenda and the United Nations’ objective of halving extreme poverty by 2015.

In addition, the United Nations Office for Disaster Risk Reduction (UNISDR) Strategic Framework: 2016–2021 regard “disaster risk as part of the DNA of social and economic development, rooted in poverty and inequality, evolving over time. Consequently, managing disaster risks cannot be separated from the broader governance of social and economic development. Successful disaster risk governance relies on accountable institutions, appropriately resourced local governments, functional judicial systems, and low levels of poverty and social inequity (UNISDR 2016: 1). The Sendai Framework for Disaster Risk Reduction: 2015–2030 represents a major paradigm shift from managing disasters to managing and reducing disasters and establishes resilience—building as a common denominator of the 2030 UN Agenda.

Thus, disaster risk management is the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards (UNISDR 2009: 10).

Resilience has been defined as the capacity of an entity (community, society, or society) susceptible or vulnerable to affliction by social, environmental and economic stress, shock or disaster (e.g. flooding) to recover by returning the undesirable subsystems to either the *status quo ante* (i.e. accepted conditions that existed before the disaster) or improved system. Scholars (Adger 1999; Turner et al. 2003; Leurs et al. 2003; Tompkins and Adger 2004) have recommended that resilience is an appropriate way of contributing towards resolving disaster problems afflicting social and ecological systems. The 100 Resilience Cities Programme supported by Rockefeller Foundation defines urban resilience as the capacity of individuals, communities, institutions, business, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experiences (www.100resilientcities.org).

This chapter conceives social contract and social cohesion are as mediating variables in the link between risk, governance and resilience. This is supported by extensive research on conflict, and specifically the literature on urban fragility, resilience building and social vulnerability in urban contexts, which demonstrates, and importance of strong bonds both within and between communities, and between communities and governance providers, for resilience and sustainable peace (Askew 1999; Akintola 1982; Aderogba et al. 2012; Taiwo 2008; Olokesusi 2006a).

Social contract is a process by which people in political community consents to state authority, thereby limiting some freedoms, in exchange for the state's protection of their universal human rights and security and for the adequate provision of public goods and services (Aderogba et al. 2012). Thus, social contract emerges from the interaction between key factors such as: expectations that a given society has of a given state; state capacity to provide services, including security, risk management measures; and direct state resources and capacity to fulfil social expectations especially those of the vulnerable.

Social cohesion could be explained as "the willingness of members of a society to cooperate with each other to survive and prosper" (Odjugo 2009), as Stanley describes it. Social capital is a major competent of social cohesion, and refers to the networks and relationships among people that enable a community to function effectively. This contributes to community resilience by providing an informal buffer to those affected by disaster, overcoming challenges to adaptation through coordinated local processes, and enabling transformative change by strengthening the community's collective voice.

Disaster risk management actions in the pre-disaster phase are aimed at strengthening the capacities and resilience of households and communities to protect their lives and livelihoods, through measures to avoid (prevention) or limit (mitigation) adverse effects of hazards and to provide timely and reliable hazard forecasts. In the response phase, communities and relief agencies focus on saving lives and property. In the post-disaster phase, the focus is on recovery and rehabilitation. In reality, the shift between these phases is fluid, in particular, between the stages in which communities move from rehabilitation to development, integrating aspects of hazard mitigation into their developmental activities (FAO 2008). Essentially, disaster risk preparedness has four main elements: Forecasting events and issuing warnings; taking precautionary measures in response to warnings; improving response by organizing and strengthening capacity to deliver timely and effective rescue, relief and assistance and taking risk transfer measures such as flood insurance.

Disaster preparedness therefore has two main aims: to help people to avoid impending disaster threats; and to put plans, resources and mechanisms in place to ensure that those who are affected receive adequate assistance. It is assumed that some people and property will be vulnerable to disasters, despite mitigation measures, and that agencies will have to deal with the disaster's impact. Since disaster risks cannot be totally eliminated, the remaining economic risks need to be shared, spread or financed so that individual people, companies, communities and countries are not forced into poverty or bankruptcy if a catastrophic event occurs. Mechanisms for financing or transferring risk represent a crucial aspect of comprehensive risk management (World Bank 2014). Risk financing involves the retention of risks combined with the adoption of an explicit financing strategy to ensure that adequate funds are available to meet financial needs should a disaster occur. Such financing can be established internally through the accumulation of funds set aside for future use or obtained externally through pre-arranged credit facilities. The banking sector, capital markets and international lending institutions are sources of risk financing. Risk transfer on the other hand involves the shifting of risks to others who, in exchange for a premium, provide compensation when a disaster occurs, ensuring that any financing gap that might emerge is partially or fully bridged. Risk transfer may be obtained through insurance policies or capital market instruments such as catastrophe bonds (Olokesusi 2006a, b; UN-Water 2011).

Reliable information and communication system is another crucial component of prevention and resilience. Information about risks can aid people better understand and appreciate the nature and likelihood of potential risks, thereby minimizing uncertainty. Knowledge also entails utilizing information obtained to assess potential risks and thereafter decide what to do and how to do it purposively. The significance of information management and communication include the following:

- Information is the most valuable commodity before and during emergencies.
- Information obtained from vulnerability assessment, risk and hazard analyses etc. will help in the process of emergency preparedness, multi-action and prevention.
- Every stakeholder needs information for decision making.
- Information is very crucial to how national and international resources are mobilised for pre- and post-disaster programmes.
- Information management involves beneficiary involvement, coordination, delivery of relief assistance, monitoring and evaluation, marketing and external relations.

For effectiveness, information and communication system should be characterized by the following:

- **Inclusiveness**: Information and communication management should be predicted on a system of collaboration, partnership and sharing. Active community participation and ownership is key.
- **Inter-operability**: All the data to be made available should be in usable formats during search/retrieval.
- **Accountability**: For the sake of integrity, the sources of data should be provided.
- **Accessibility**: Information should be readily available to all stakeholders. Such information should be in English and translated versions.
- **Availability**: Such information should be available online and offline.

Disaster prevention includes activities and initiatives that prevent or mitigate the adverse effects of extreme natural events, technological and anthropogenic disasters, above all in the medium and long term. These include on the one hand, political, legal and administrative and infrastructure measures to address the hazard situation. Structural (e.g. drainage channels) and non-structural measures (e.g. land use planning, zoning and development control regulations). These are supposed to influence the lifestyle and behavior of the endangered population in order to reduce their disaster risk.

10.3 An Overview of Disasters in Nigeria and Other African Cities

In Nigeria, flooding, land slide, drought, desertification and erosion are some of the most prominent natural disasters threatening its environment. Indeed, the amount of economic damages affects a large proportion of people in the southern Nigeria, other low-lying coastal areas of the country and other areas at risk of flooding and extreme weather condition.

10.3.1 Flood Disasters

According to (UN-Water 2011), floods, including urban flood is seen to have caused about half of disasters worldwide, and 84% disaster deaths in the world was attributed to flooding. It was reiterated by (Askew 1999) that floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters. It is displeasing to note that, Urban areas in Nigeria are particularly vulnerable to flooding due to indiscriminate waste disposal, poor waste management by the government and the citizens, inadequate drainage system; changes in ecosystem through the replacement of natural and absorptive soil cover with concrete; and deforestation of hillsides, which has the effect of increasing the quantity and rate of runoff, and through soil erosion and the silting up of drainage channels. Low-lying coastal areas such as Lagos, Calabar, Port-Harcourt, and Yenagoa, where the flood-plains have been abused due to haphazard physical development, illegal erection of buildings and other structures as well as unhealthy habit of dumping refuse and solid wastes in open channel drainage systems are particularly prone to flood disasters.

In 2012, the country experienced a flood disaster like no other one before with more than 26 out of 36 states affected. The worst hit cities were Lokoja, Makurdi, Yola, Port-Harcourt, Warri, Benin and Onitsha. The comprehensive Post Disaster Needs Assessment conducted from November 2012 to March 2013 placed the estimated combined value of damages and losses resulting from the 2012 flood disaster at US$16.9 billion. The disaster, led to 363 deaths, and affected seven million people, displaced 2.3 million others and damaged 597,476 houses (Federal Government of Nigeria 2013).

The major causes of flooding in African cities include inadequate drainage system; changes in ecosystem through the replacement of natural and absorptive soil cover with concrete; and deforestation of hillsides, which has the effect of increasing the quantity and rate of runoff, and through soil erosion and the silting up of

Fig. 10.4 Flood in Lagos Metropolis. *Source* Odjugo (2009)

drainage channels. Also, the low-lying coastal areas such as Lagos (see Fig. 10.4), Port-Harcourt, Calabar, Abidjan, Accra, Monrovia, Freetown, Dar es Salaam, Durban and other cities like Addis Ababa, Nairobi, Ibadan, Abeokuta among others where the flood-plains have been abused due to haphazard physical developments are particularly prone to flood disasters. In addition to the above causal factors of flooding, there are other anthropogenic factors largely due to the negligence of the residents and the relevant government agencies. These peculiarities include illegal erection of buildings and other structures as well as unhealthy habit of dumping refuse and solid wastes in open channel drainage systems.

Another contributory factor flooding is climate change. This phenomenon has been attributed to that human factors (industrialization, technology development, urbanization, deforestation and burning fossil etc.) and natural factors (solar radiation quality and quantity, astronomical position of the earth) are notable causes of climate change (Odjugo 2009). Climate change is making weather less predictable, especially

Plate 10.1 Windstorms removing roof-top of a house. *Source* https://www.google.com.ng/search?biw=1366&bih=659&tbm=isch&sa=1&q=flood+in+Lagos&oq=flood+in+Lagos&gs_l=psyab.3..0l2j0i24k1l2.80339.83338.0.83789.11.10.0.0.0.0.741.1870.2-1j0j2j0j1.4.0….0…1.1.64.psy-ab..7.4.1867…0i67k1.mI9mqLrQOxw

in developing countries like Nigeria where facilities to predict and manage weather conditions are inadequate.

10.3.2 Windstorms

The occurrence of windstorms (see Plate 10.1) is largely associated with the indiscriminate felling of trees that are supposed to serve as wind-break to forestall windstorm. The indiscriminate removal of trees is as a result of human activities which include construction of buildings, roads and the use of trees for domestic purposes particularly for cooking. Most African cities often experience windstorms at the beginning of raining season and towards the end of it.

10.3.3 Drought

Drought is defined as the protracted absence, deficient or poor distribution of precipitation in a region over a period of time—a season, a year, or several years. It is the inability of rainfall to meet the evapo-transpiration demands of crops resulting in general water stress and crop failures.

The Nigerian Sudano–Sahelian region is characterized by considerable fluctuations and periods of diminishing annual totals especially in recent years. Large areas of Northern Nigeria, Mali, Burkina Faso and Benin Republic falling within the Sahel and Sudan ecological zones between latitude 9°N–14°N are prone to recurrent droughts in one form or the other. The area is estimated to be about 38% of the total land area of Nigeria and it is the grain belt of the country populated by small scale subsistence farmers and nomadic livestock herders. The underlying causes of most droughts can be related to changing weather patterns manifested through the excessive build-up of heat on the earth's surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates. Some of the cities affected are Kano, Niamey, Ouagadougou, Bamako, Katsina, Daura, Sokoto, Maiduguri, Damaturu and Yola. Drought is a major cause of forced human migration and environmental refugees, food insecurity, destruction and loss of biological diversity, socio-economic instability, and conflicts arising over the use of dwindling natural resources, poverty, loss of biodiversity, impoverishment of ecosystem and climatic variability (Olokesusi 2015).

10.3.4 Human Induced Disasters

Human induced disasters otherwise known as anthropogenic disasters include: oil spillage especially in the Niger Delta, ethno-religious and resource-based conflicts, and fire disasters among others.

10.3.4.1 Ethno-religious Conflicts

Nigeria is a plural society, implying that the country is a melting pot of ethnic nationalities, class, regions, religions and other socio-cultural markers. Since independence, its pluralism has shaped and continued to manifest in its politics till date. The political class, in collaboration with their religious counterparts has exploited ethnicity and religion as symbols of mobilization and instrument of negotiation for patronages and sharing of national resources. Hence, most conflicts which ordinarily could have been seen as distribution based had assumed ethnic and religious dimension. These conflicts are virulent and had caused destruction of lives and property of innocent Nigerians. The conflicts have also undermined the peaceful coexistence among the Nigerian peoples, thus scuttling the integration efforts of the country. The lack of cohesiveness in the nation's polity has greatly manifested itself in the present democratic dispensation because of the unimaginable influence of social media.

10.3.4.2 Resource-Based Conflicts

Nigeria is a country rife with conflict, and disputes over land and resource-based issues constitute a significant number of conflict events and the violent deaths that result from them. Land issues vary from region to region, although there are some cross-cutting themes; pastoralists (Herdsmen) and farmers in the Northern, Middle-Belt and the Southern regions of Nigeria, clashes between communities and oil companies in the Niger Delta. Many of the conflicts are influenced by several factors ranging from politics, legal issues, and increasingly, by climate change.

Another important area of resource-based conflicts is the Niger-Delta region which is the oil producing region of the country. The battle over land rights in this region has mostly centered on oil: communities in these areas have been battling the authorities and international oil companies for land rights and mineral rights, in addition to conflicts arising over environmental degradation of land used for fishing and farming due to oil spills. For example, Shell in 2011, spilled 40,000 barrels of crude oil from its Bonga platform. Chevron's gas rig blew up and fire raged for one month during the same year. Before then in 1979, Forcados an offshore terminal operated by Shell spilled 570,000 barrels of oil (Bassey 2017).

This agitation has led to incessant bombing of oil pipelines, kidnapping of oil workers for ransom and total shut down of oil production at will which has been greatly affecting the country's gross domestic product.

10.3.4.3 Fire Disasters

Fire occurrence in and around human living spaces is inevitable due to the twin inescapable human errors of commission and omission. Fire disaster (as shown in Plate 10.2) could render a whole family homeless in a blink of a moment, a government building totally inhabitable and vital document completely burnt, and even sustainable private and public housing effort might be threatened by unexpected fire disasters. In recent years there have been cases of fire disasters leaving behind irreparable loses of lives and property. The result of most fire disasters leaves behind unforgettable experiences in the minds of victims. Box 10.1 shows some major fire disasters in the country.

Box 10.1 Some Selected Fire Disasters in Nigeria

- ***Pipe line explosion in Jesse, Delta State***: Casualties 1082 persons died and hundreds injured.

- ***Multiple bomb explosions at the Nigerian Military Cantonment, Ikeja, Lagos in*** January 27, 2002, casualties about 800 persons, and thousands homeless.
- ***Pipe line explosion, Abule Egba, Lagos***: *O*ccurred in December 26, 2006 about 700 persons lost their lives and several undefined persons injured.
- ***Bombing activities in Nigeria particularly in the cities in North-east Nigeria***: Since 2009, has left hundreds of people dead and several properties destroyed.
- **Cocoa House Fire in Ibadan in the late 1980s**-some deaths and extensive damage to the property. Constructed in the early 1960s by the Western Region Government, it is the first high rise building in Nigeria.
- ***In 2012 Abuja the Federal Capital witnessed many fire accidents***: Casualties not fewer than 69 persons were killed and property worth 765 million naira destroyed (**extract** from the Federal Fire Service magazine).

Source Various publications.

Plate 10.2 Fire disaster in Lagos. *Source* https://www.google.com.ng/search?biw=1366&bih=659&tbm=isch&sa=1&q=flood+in+Lagos&oq=flood+in+Lagos&gs_l=psyab.3..0l2j0i24k1l2.80339.83338.0.83789.11.10.0.0.0.0.741.1870.2-1j0j2j0j1.4.0….0…1.1.64.psy-ab..7.4.1867…0i67k1.mI9mqLrQOxw

10.3.5 Accident-Related Disasters

The incidence of fatal road accidents in Nigeria is phenomenal. According to (UKOJI 2014), the trend analysis of fatal road accidents between June 2006 and May 2014 from the Nigeria Watch database shows that 15,090 lives were lost to fatal road accidents in 3075 events. The highest fatality occurred in 2013 (2061 deaths), a 2.8% increase from the 2012 record of 1652 deaths. The paper however, opined that the probability of a high fatality record in 2014 remains high considering the 964 deaths already recorded between January and May 2014. On the national scene, the paper reported that Lagos recorded the highest number of fatalities (1579 deaths from 620 events), while FCT (Abuja) has the highest relative number of deaths (0.6 deaths per 100,000 population).

Several traffic accidents were experienced in the 1990s and early 2000s. Examples are the 1992 C-130 plane crash, the EAS crash of 2002, the Bellview/Sosoliso, ADC and Dana air crashes of 2005. Building collapse in major cities such as Lagos and Port Harcourt have also been a major concern. As recent as 25 July, 2017 Lagos witnessed the collapse of a four-storey building on Lagos Island leading to more than 10 dead, while 24 others were rescued (www.guardian.ng "Death toll rises to eight in collapsed building, 15 rescued" accessed on 27 July, 2017).

10.4 Smart Disaster Prevention and Resilience in Nigerian Cities

This section discusses the disaster management strategies which include prevention strategies adopted in tackling both natural and human-induced disasters, and the resilience towards disaster in Nigeria. Disaster prevention in the country is multi-faceted because it involves the use of legal and institutional frameworks and the National Disaster Management Strategic Plan. This chapter examines the smartness of these strategies in the national disaster management document.

10.4.1 Smart Disaster Prevention

Disaster management begins with effort at preventing it from occurring. Several state governments provide series of awareness campaigns in this regards, and an Early Warning System (EWS) has been put in place at the national level. EWS places emphasis on the before situation through Prevention, Mitigation and Preparedness in the Disaster Risk Management Cycle. Modern EWS include the following: Forecasting and Modelling; Remote Sensing and Geographical Information System; Satellite Communication Technology and Mobile phone technology.

The Nigeria Metrological Agency (NIMET) has in place Doppler Weather Radars to monitor natural disasters. Physical parameters such as Temperature, Wind, Precipitation and Ocean wave are monitored on regular basis. NIMET in collaboration with the National Hydrological Agency collects and analyse rainfall data early in the year following which rainfall prediction are made and publicised. NIMET's rainfall prediction is the most notable Rainfall and Flood EWS in Nigeria. People living along river channels are warned to evacuate, even though government is not proactive enough by preventing people from erecting their buildings close to the river channel and drainages. NIMET also has Air Quality Monitoring Stations in Lagos, Kano, Abuja, Enugu, and Maiduguri. NIMET information is disseminated to the public through the following media:

- Electronic media-daily weather forecast on the electronic media.
- Print media-publications in the national dailies.
- Publications-seasonal rainfall prediction, Nigeria climate review bulletin, Marinemet, Bulletin, Hydromet Bulletin and Annual Climate Review.
- Press conferences.

NIgeriaSat-1 is a satellite operated by the Nigerian Space Research and Development Agency for monitoring natural disasters, and land use changes in and outside the country. It was useful after the Asian Tsunami some years ago. One major prevention strategy that has been seen to be very effective is the federal and state fire service. Each state of the federation has a Department of Fire Service that swiftly responds to fire disasters.

10.4.2 Disaster Risk Prevention and Resilience in Nigeria

The Federal Government of Nigeria established the National Emergency Management Agency (NEMA) in March 1999, with headquarter at Abuja and one office for each of the six Geo-political zones in the country. In the same vein, the 36 state governments have established state emergency management agencies in the name of their respective states. NEMA builds resilience through several strategies. It raises awareness by educating people on how to prevent different kinds of disasters. These are done using both the conventional media and the social media. NEMA's mandate includes the following:

(a) formulate policy on all activities relating to disaster management in Nigeria and co-ordinate the plans and programmes for efficient and effective response to disasters at national level;
(b) co-ordinate and promote research activities relating to disaster management at the national level;
(c) monitor the state of preparedness of all organisations or agencies which may contribute to disaster management in Nigeria;
(d) collate data from relevant agencies so as to enhance forecasting, planning and field operation of disaster management;

(e) educate and inform the public on disaster prevention and control measures;
(f) co-ordinate and facilitate the provision of necessary resources for search and rescue and other types of disaster curtailment activities in response to distress call;
(g) co-ordinate the activities of all voluntary organisations engaged in emergency relief operations in any part of the Federation;
(h) distribute emergency relief materials to victims of natural or other disasters and assist in the rehabilitation of the victims where necessary;
(i) liaise with State Emergency Management Committees established under section 8 of this Act to assess and monitor, where necessary, the distribution of relief materials to disaster victims;
(j) liaise with the United Nations Disaster Reduction Organisation or such other international bodies for the reduction of natural and other disaster.

Figure 10.5 shows the institutional framework for disaster risk management in Nigeria. NEMA Zonal offices collaborate with State Emergency Management Agencies (SEMA) on DRR issues and post-disaster efforts. For instance, it provides a focus for interagency and intergovernmental emergency preparedness, planning, training, exercising, coordination, and information exchange. The agency also spells out the process and methodology for implementing and managing Federal recovery and mitigation programmes and support/technical services. Each SEMA also work with and coordinate activities of Local Emergency Management Committees (LEMA). Several public and private organizations are involved in both pre- and post-disaster operations.

With the active involvement of relevant stakeholders in disaster management has put in place to assist it in its role as a coordinator. NEMA has produced the National Disaster Response Plan (NDRP) in 2001. The Plan provides a framework for interagency and inter-governmental emergency preparedness, planning, training, exercising, coordination and information exchange. The plan also indicates the scope of Federal Government response assistance that a state is most likely to require under the 13 Support Service Areas (SSAs), each of which has a designated primary agency that acts as lead in the Support Service Area. The NDRP provides assistance to a major disaster or emergency which includes a natural catastrophe; fire, flood, or explosion, regardless of cause; or any other occasion or instance for which the President determines that Federal assistance is needed to supplement State and local efforts and capabilities. In addition, NDRP covers the full range of complex and constantly changing requirements following a disaster: saving lives, protecting property, and meeting basic human needs (response); restoring the disaster-affected area (recovery); and reducing vulnerability to future disasters (mitigation).

Several response plans and agreements within which NEMA currently operates and year of introduction include the following:

- The Integrated National Avian and pandemic Influenza Response Plan—2007
- Search and Rescue and Epidemic Evacuation plan (SAREEP)—2009
- National Contingency Plan on Infrastructural Resuscitation (NCPIR)—2010
- National Disaster Management Framework (NDMF)—2011

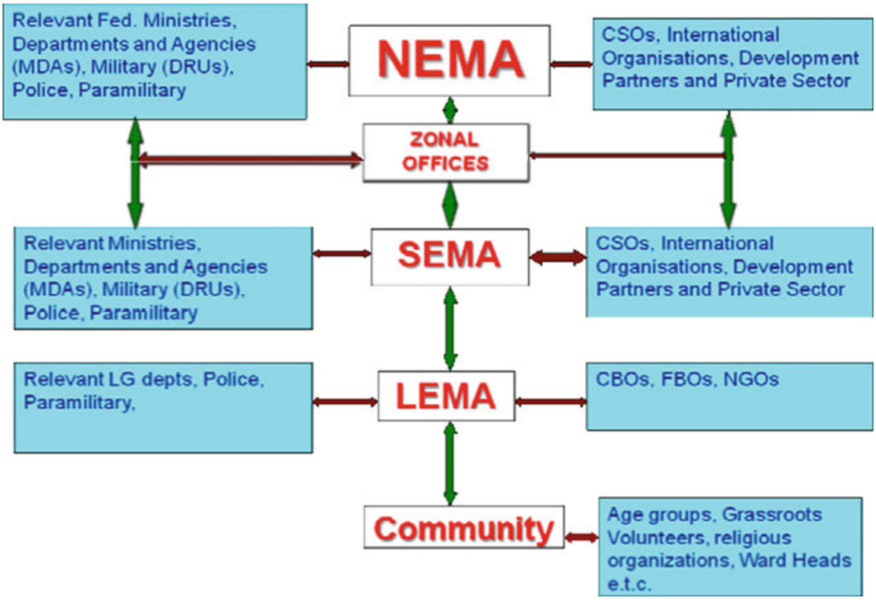

Fig. 10.5 Horizontal and vertical coordination of disaster management in Nigeria

- National Contingency Plan (NCP)—2012
- National Emergency Management Agency Standard Operating Procedures—2012
- Guidelines for use of Military Assets and Personnel During Disasters—2012
- Memorandum of Understanding between National Orientation Agency (NOA), NESREA and NEMA—2013.

Furthermore, NEMA has created Disaster Response Units (DRUs), Nigerian Mission Control Centre (COSPAS-SARSAT), Emergency Response Teams (ERTs), Establishment of Early Warning Unit (the Unit is composed of a Geographic Information System (GlS), remote sensing laboratory and a data bank).

10.5 Risk Prevention and Response: Case of Lagos Megacity

The choice of Lagos megacity is premised on its unique features which makes it quite vulnerable to emergency incidences. The unique features include localization and concentration of industries (about 70% of the country's industries), presence of two airports, sea ports, largest petroleum tanker depots in the country, coastal location with an appreciable portion below sea level and the ubiquitous fuel tanker/articulated trucks accidents and array of disaster events usually impacting on the ecological dynamics of the state. Furthermore, in its desire to attain the Smart City status Lagos has signed a Memorandum of Understanding with Dubai Smart City Inc. in 2016 and is at the vanguard of applying modern technologies for disaster risk prevention and reduction in Nigeria.

10.5.1 Legal and Institutional Framework

In response to these challenges and in pursuance to Decree 12 of 1999 as amended by Act No. 50 of 1999 which established the National Emergency Management Agency (NEMA), the Lagos State government established the Lagos State Emergency Management Agency (LASEMA) in 2008. LASEMA Law 16 of July 22nd 2008 established the Agency for emergency and disaster management in the State. The Agency which is a parastatal of the Lagos State Ministry of Special Duties and Inter-Governmental Relations, is responsible for the overall co-ordination of emergency management in Lagos State, working closely with all its Stakeholders. The law empowers the Agency to coordinate all the first responders namely-the Lagos State Ferry Service, Ambulance Service, and the State Traffic Management Agency. The Agency's key mandate is provision of adequate and prompt response as well as sustaining intervention in all forms of emergency/disaster situations in the State. It performs this onerous task through Emergency/Disaster prevention, preparedness, mitigation, recovery and relief. Also, the law empowers the Agency to coordinate the activities of all its stakeholders and non-governmental organizations (NGOs) that are categorized into Primary, Secondary and Tertiary responders in management of all emergency and disaster situations as well as also to build their capacity toward increasing response capability.

Since its inception, LASEMA has been providing functions such as: the umbrella body co-coordinating the activities of relevant agencies in prevention and management of disasters in the State; development of loss prevention programmes and procures necessary technology to mitigate identified emergency situation; prompt and adequate response as well as sustained interventions in any form of emergency or disaster in the State; co-ordinates activities of stakeholders and NGOs who jointly carry out strategies for emergency/disaster management in the State; provides relief materials/financial assistance to victims of various disasters in the State; and respond promptly to any emergency at hand, which includes but is not limited to the following; fire-fighting (co-ordinate with fire services), flood control, collapsed building, evacuation, search and rescue operations, environmental pollution, crowd control/cordon off affected areas, public enlightenment on safety issues, perform general life saving activities including provision of relief materials and remove objects that constitute the carcass or remains of incidents. It also collaborates with NEMA on capacity building and disaster response activities.

10.5.2 Mainstreaming ICT into Risk Prevention and Resilience

The Lagos State Government has recently stepped up her plans towards improving the impact of emergency/disaster management through effective and efficient use of Closed Circuit Television (CCTV) cameras, establishment of additional dispatched centres and stepping up of Monitoring and Surveillance Unit of the Lagos State Emergency Management Agency (LASEMA). LASEMA has acquired over 13,000 Cameras to be installed in the major flash points across the megacity to complement efforts of the Agency.[1] The installation of the 13,000 cameras means that the Agency, apart from responding to calls from Lagosians on emergency cases, can adequately monitor from the Command and Control Centre activities across the State to activate emergency response where and when necessary in order to make Lagos safer. Existing Dispatch Centers are in Lekki, Oshodi, Cappa, LASEMA Response Unit and State Secretariat in Ikeja. The Agency has 112 emergency telephone lines. Geographic Positioning System (GPS) technology would be installed to complement the CCTV with a view to tracing the caller or incident and send the nearest available trained and equipped responder.

In addition to the available dispatch centres in the city, approval has been given by the Lagos State Government for the establishment of additional Dispatch centres at Lekki, and Ikorodu Road to complement the existing dispatch points located at the LASEMA Response Unit, Cappa, Oshodi and the Command and Control Centre, Alausa, thereby improving the response time of emergency management in the State. Presently, the Agency is upgrading activities of its Monitoring and Surveillance Unit in preventing unnecessary loss of lives and property, through technology driven monitoring and surveillance activities in domestic, industrial and public facilities in the State which is a paradigm shift from the orthodox strategy. The Agency is adopting this approach as a part of its disaster risk reduction strategy and curtail the huge expenses borne by the State Government on emergency intervention and relief assistance to victims of various emergencies in the State. While Lagos responds to the Early Warning Alerts issued by NIMET and the Hydrological Agency, it has installed electronic Early Warning Systems along the Atlantic Ocean coastline, Lagos lagoon and major rivers such as the Ogun and Iya Alaro. The EWS develops the capacity of the communities in the city for both ex-ante and ex-post disaster events of the Disaster Risk Management Cycle.

The Agency constantly require members of the public to partner with the Lagos State Government in mitigating, preventing and consequently reducing hazards, risks and vulnerability by ensuring that distress calls on emerging hazards and risks are relayed to the Agency through the toll free lines 112 and 767 for prompt attention.[2] The use of conventional media (electronic and print media) to educate people on how to prevent flooding, fire incidence and other disasters are constantly placed on these

[1] https://lagosstate.gov.ng/blog/2017/01/17/lagos-to-step-up-emergency-management-in-the-state/.

[2] See Footnote 3.

media. Beside all the efforts stated above, the government also discourages building of houses on canals, river channels and drainages by demolishing buildings found on them. In mid-2017, an Aquatic Unit was recently approved for LASEMA by the State government. The Unit is meant to strengthen rescue mission on waterways. The Unit would complement other responders like State Waterways management Agency, the Marine Police. A new boat has been acquired by LASEMA for the Unit.

10.5.3 City Planning and Disaster Risk Prevention and Resilience

Resilient cities require proper land use planning and design of buildings and infrastructure. This informed the State Government to produce a new law and institutional framework for the purposes of planning the metropolis in 1999. This led to the creation of the State Ministry of Physical Planning and Urban Development (MPP&UD) responsible for policy formulation and major programme implementation such as the planning standards and preparation of city model plans was established. To guide and control physical development, the Lagos State Urban and Regional Planning Law was produced in 2010, followed by new agencies such as the Lagos State Urban Renewal Authority (LASURA), Lagos State Physical Planning Permit Authority (LSPPPA), Lagos State Building Control Agency (LSBCA). While LSPPPA vets and approves development permit applications, while LASURA is responsible for slum improvement across the State and LSBCA ensures structural soundness of buildings and development control. MPP&UD is in regular consultation with critical stakeholders on ways and means of improving the livability of the city.

A digital map of the entire Lagos State was completed over eight years ago so as to fast-track urban planning and land use administration. Since 2016, applications for building development permits and land sub-divisions, as well as land title search can be done on-line. New physical development plans for major developed districts as distinct but inter-related entities have been produced. Examples of such plans are: Lekki Master Plan (2011–2031); Ikeja Model City Plan (2012–2032); Apapa Model City Plan (2012–2032); Mainland Model City Plan (2012–2032); Agege Model City Plan (2013–2033); and Ikoyi-Victoria Island Model City Plan (2013–2033). However, the absence of urban planners on the payroll of the Local Government Areas has created a gap in service delivery.

10.5.4 Environmental Management and Climate Change Adaptation

In spite of the fact that improper solid waste disposal contributes significantly to flooding, Lagos was infamous for its poor environmental sanitation and waste management. But by 2000, the Lagos State Waste Management Authority (LAWMA) was turned around. LAWMA introduced Private Sector Participation (PSPs) strategy and also adopted modern technology. Over 624 PSPs are currently licensed to collect and transport household waste, streets and markets to designated landfill sites at approved fees payable by serviced clients. In mid-2017, there was a paradigm shift in environmental management and solid waste management with the formulation of the Lagos State Environmental Management and Protection Law with a view to re-engineering the sector in general and building resilience so as to reduce the city's vulnerability to natural and health disaster risks in particular.

A major section of the new law is devoted to the Cleaner Lagos Initiative (CLI) which comprises various components among which are solid waste infrastructure, solid waste collection, waste treatment, waste recycling and waste energy. CLI is also meant to revitalize the Solid Waste Management Sector and eradicate the inadequacies in sanitation of the environment as well as accelerate seamless cleaning of the city. One of the objectives of CLI is to engender a financially viable and technology driven waste management sector thus, the Government has created an environment for the private sector to harness international best practice in the vital area of solid waste management and consequently free public funds for other beneficial uses. And the law is now being implemented in phases. To address the burning issue of inadequate finance, the Government is raising through bond market US$142,450 (₦50 million). Towards this end, CLI and Visionscape and a strategic partner has formed a Special Purpose Vehicle (SPV) branded as Municipality Waste Management Contractors Limited. The 50 million naira would later be mobilized in two tranches with 27 million naira to be mobilized now at 17.5% with a tenor of five years to be followed the second tranche of US$65,527 (₦23 million). (http://environment.lagosstate.gov.ng—Accessed on 15 August, 2017).

The Under CLI, the Marine Waste Collection, and Mechanized Sweeping have been launched just as the environmental sanitation outfit- Kick Against Indiscipline (KAI) Brigade has been transformed into Lagos Environmental Sanitation Corps (LAGESC) was inaugurated in July, 2017. Marine Waste Collection facility at Ebute-Ero, in the city is meant to ensure the regular cleaning and evacuation of all forms of debris and litter from navigable waterways such as Lagos lagoon, creeks, and rivers while mechanized Sweeping will make sure regular cleaning of major highways in the city.

Residential waste collection and processing has therefore been concessioned to a reputable and competent multinational Waste Services Company. Also, 600 brand new compactors and 900,000 electronically tracked bins have been purchased and put to service. The solid waste generated by the commercial sector would be handled by licensed waste management operators. Furthermore, for efficient collection and disposal operations, the State has concessioned three Transfer Loading Stations/Material Recovery Facilities at Agege, Oshodi and Simpson as well as three Waste Depots at Mushin, Ogudu and Simpson with the aim of rehabilitating, remodeling and retrofitting these facilities to world class standards. Similarly, Engineered Sanitary/Engineered Hazardous Landfills are being constructed across Lagos State under the Build, Finance, Operate and Transfer (BFOT) model has also been transformed to the Lagos Environmental Sanitation Corps (LAGESC) to assist in the enforcement of the payment of Public Utility Levy. The Lagos Waste Management Authority (LAWMA) is being repositioned to focus on its primary regulatory roles while the Public Utilities Monitoring Assurance Unit (PUMAU) has been established to coordinate the modalities of billing, revenue assurance and enforcement of the Public Utility Levy (PUL), an annual levy which replaces the monthly PSP levy.

Both disaster prevention and resilience thinking are being incorporated in the policy making and initiatives across domains of Lagos government, including across social, physical and economic programmes. In this context, the government intends to be at the vanguard in Nigeria in the clean energy transition thereby supporting the global political agreements through COP21 Paris. In 2001, the government of Lagos State under public-private partnership arrangement with Enron Ltd. Of the United States of America generated over 50 MW of energy from natural gas. Since then, several gas powered generating facilities have been procured, installed and commissioned. Since 1999, tree planting has become a state policy known as Operation Green Lagos (OGL). This is a key strategy to build city resilience especially for adapting to climate change. More than a million trees have been planted while over 10,000 jobs were created. The heavily congested, lackluster and unsafe Oshodi market has been redeveloped and it is cleaner and safer with reduced crime level.[3] However, the various construction works resulted in the forced relocation of some home owners, tenants and traders which were well addressed by LASG and equitable compensation paid.[4] Lagos is the only state with a Climate Change Policy and has therefore been able to put in place some adaptation measures. One of the strategies to build resilience is the construction of structures in order to minimize Atlantic Ocean surge and flooding. In 2012, the government appropriated about US$183.67 million (₦36 billion) for the phased construction of 18 sea breakers at intervals of 400 m in the Atlantic Ocean. The first phase commenced in 2013 while the entire project would be in 2017 (UNDP 2004; Davis 1998).

10.5.5 Building of Emergency Shelter

As part of the preparedness strategies, well-equipped emergency shelters capable of accommodating over 10,000 during disasters have been constructed in and around the city. Facilities available in each of the emergency centres include water, toilets, electricity, health care and police post.

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[3]Resettlement of Market Traders-Alausa Alert-January 2010, pp. 1–7 retrieved on August 7, 2010.

[4]See Footnote 2.

10.6 Conclusion

The chapter's conclusion relied strongly on the findings and observations based on the objectives of the study which are to identify the types of disaster peculiar to African cities; Its effects on cities' socio-economic development; examine the adopted strategies in managing disaster in African cities; examine the disaster risk prevention and resilience and proffer solutions for cities' administrators on how to manage disasters. The study employed a detailed and explicit conceptual framework to guide its discussion. It also provided an overview of disasters in Nigeria and selected African cities by identifying numerous types of disasters (both natural and humanly induced) in most African cities. These types of disasters include flooding, land slide, drought, desertification, erosion, windstorms, ethno-religious conflicts, resource-based conflicts, fire disasters, and accident-related disasters. The study also discussed the smart ways of preventing disaster and the resilient nature of the cities. Out of the numerous smart ways of preventing disaster is the early warning systems that tend to give early warnings to residents about an imminent disaster. This is done in case of flooding and erosion. Also the use of satellites and the mainstreaming of ICT into risk prevention and resilience in the management of disasters represent additional tools for disaster management.

The study concludes that most African cities need to step up their smart strategies and initiatives especially information and communication technology to address the issues of disaster prevention and resilience. It also concludes that apart from greater adoption of ICT, public education and awareness and engagement constitute imperatives for more effective disaster resilience and prevention in Lagos and other African cities.

10.6.1 Recommendations

10.6.1.1 Proposals for Better Coordination Towards Smart Disaster Prevention in African Cities

The various city administrators in Africa are advised to properly coordinate the various emergency agencies that provide disaster emergency services. Various types of ways for better coordination of emergency services include the followings:

- Continuous dialogue between emergency management agencies at local, provincial/state and national level.
- Establishment of a Coordination Platform at the provincial/state and local levels.
- Adoption of Bottom-Up-Approach especially by actively involving CSOs. This will enhance community participation.
- Effective media management to prevent mis-information. This will also create awareness about the situation and the kind of aid required.

- Improved budget allocation for disaster risk reduction.
- Strong political will on disaster risk reduction issues by the three tiers of government
- Development of minimum standard operating procedures to increase effectiveness.
- Preparation of contingency plans by the three tiers of government in each country.

10.6.1.2 Use of Insurance Services

This section presents strong argument for effective use of insurance policy to strongly mitigate the ugly effect of disaster. Two types of insurance programs are identified. It includes the formal and informal insurance programs that are very important in managing post-disaster crisis. This provides a brief understanding of the role of insurance company in disaster management. Formal insurance programs are insurance programs which includes any instruments that transfer resources between good and bad times (savings, formal insurance contracts, loans, credit lines, hedging instruments); and informal insurance programs is the transferring of resources to those particularly in need in bad times (social safety nets, community support, or other risk-pooling mechanisms).

Types of Insurance: There are two types of insurance for managing insurance. These are non-catastrophic insurance and catastrophic insurance.

1. Non-Catastrophic Insurance
   - Non-Catastrophic insurance are risk transfer mechanisms meant to insure lives, property and assets including income generating assets such as factories and farmlands, etc.
   - These are not widely subscribed to in Nigeria and most African countries despite the associated benefits such as:
   - Provides financial protection for those living in disaster—prone areas
   - Furnishes victims with rebuilding assistance and emergency living expenses
   - Reduces income losses in the event of a disaster
2. Catastrophic Insurance
   - This is a fairly old funding mechanism in USA, France and a few other countries. An example is the Federal and State Flood Insurance Programmes in the US.
   - It provides coverage to homeowners and SMEs for specific catastrophic risks.

From extant literature and African perspectives, there are two fundamental catastrophic insurance problems. These are:

(i) the limited number of people who purchase catastrophic insurance because of poverty, myopic perception of loss reduction as a bad investment
(ii) the limited capacity of the insurance industry in Africa to handle huge losses.

10.6.1.3 Other Efforts to Mitigate the Negative Effect of Disaster

There are several other effect of disaster in our cities and other communities. These efforts includes the establishment of national disaster risk reduction trust fund, creation of disaster information management system, public awareness and advocacy on disaster risk reduction, possible channels of communication.

(i) Establishment of National Disaster Risk Reduction Trust Fund

A National Disaster Risk Reduction Trust Fund should be created with a view to mobilizing resources towards prevention, mitigation and resilience building. Proposed sources of revenue to the Fund are:

- Special levy of US$1 per barrel of crude oil sold in the world market.
- Lotteries and other fund raising events
- Special levy of 1–2% on air fares for domestic and international flights,
- Special levy of 2% on all import duties collected by the Nigerian Customs Service.

(ii) A Disaster Information Management System should be developed to help risk response and resilience building. The system would include the following among others.

  - Hazard Assessment
  - Vulnerability Assessment
  - Demographic Dynamics and Physical Distribution
  - Infrastructure, Lifeline and Critical Facilities
  - Logistics and Transportation Routes
  - Human and Material Response Resources
  - Communication Facilities.

(iii) Greater attention should be paid to public education and awareness of disaster risk reduction.

  - Identification of zones which are prone to floods, forest fires, landslides etc.,
  - Location of emergency shelter, health facilities etc.
  - Awareness regarding use of safe routes
  - Information on conservation of ecological resources e.g. wetlands, forests etc.
  - Availability and type of Early Warning Systems.

(iv) Possible Channels of Communication

  - Print Media/Channels: textbooks/monographs, journals, educational aids/training materials, public interest promotional literature.

Non-print media: Audio-visual resources e.g. radio station, television station, social media channels (Facebook, Instagram, YouTube, Whatsapp, Google, and Twitter etc.); Video tapes (visuals of the incidents, rescue operations; videos for training); Cartographic resources (showing locations of different types of hazard zones, safe zones); Database of emergency services (fire stations, ambulance services).

(v) Research/Survey reports

- Newspaper Articles
- Grey Literature (usually from CSOs).

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Chapter 11
Smart Peace and Security in Africa

Romanus Otieno Opiyo

Abstract The importance of considering Information and Communication Technology (ICTs) in the study of conflict formation and escalation has been widely recognized and researched. This is despite a widespread conviction that ICTs bears similar potential to contribute to peacebuilding and security. This chapter therefore seeks to explore the nature of conflicts in Africa cities and urban areas and thereafter seek to build a framework for understanding the possible way of linking digital platform with attainment of peace and security in African cities. The chapter's discussions is reliant on analysis of various literature focusing on the major areas of practical and theoretical relevance initiatives that address smart peace and security globally and in Africa.

Keywords Digital · Youth · Leadership · Africa and peace

11.1 Introduction

World peace and security is becoming more dynamic, complex and transnational, with intensified and increasing flows of information, people, capital and goods. States continue to be the dominant security actors, but SIPRI Yearbook 2011 underscores the growing importance of non- and quasi-state actors in shaping the global and regional security scene. While non-state actors could contribute more to peaceable outcomes, some have had a debilitating effect on peace and security.[1] This shows that attainment of peace and security in Africa does not necessarily require guns or vengeance violence, but use of other peaceful tools and technologies such as ICTs to counteract conflict.

[1] Stockholm International Peace Research Institute (SIPRI) (2011).

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At the global platform, issues addressing peace are well covered under Sustainable Development Goal (SDG) 16, which is focusing on promotion of peaceful and inclusive societies for sustainable development, providing access to justice for all and build effective, accountable and inclusive institutions at all levels. The goal is informed by recognition that violent conflicts have increased in recent years, and a number of high-intensity armed conflicts are causing large numbers of civilian casualties and driving millions of people from their homes.

In adopting the 2030 Agenda for Sustainable Development, world leaders resolved to build peaceful, inclusive societies as a foundation for ensuring lives of dignity for all. Sustainable development also depends fundamentally on upholding human rights and ensuring peace and security. Leaving no one behind also means reaching those most at risk, and strengthening our resolve to prevent conflict and sustain peace. It is recognized in the SDG reports that more citizen-generated data are also being used to monitor the needs and progress of vulnerable groups, which is boosted by the fact that coverage by a mobile cellular signal has become almost universal enabling people living in previously unconnected areas to join the global information society.[2]

Along with the "Sustaining Peace" resolutions adopted by the General Assembly and Security Council, the world now has, in its hands, roadmaps for reducing vulnerability, increasing resilience and averting armed conflict in a bid to attain peace.

African Continent vision as espoused in Agenda 2063 is defined as; "building an integrated, prosperous and peaceful Africa, driven by its own Citizens and representing a dynamic force in the international arena". A peaceful and secure Africa is the fourth out of seven aspirations listed by African Union. By 2023, AU commits that, all inter and intra national conflicts would have ceased and the target of silencing of all guns on the continent would have been attained. Local and national mechanisms for conflict prevention and resolution would be entrenched and functioning for the cause of peace. The African Stand by Force, the Defence and Security Policy and the African Peace and Security Architecture in general will all be in place and be contributing towards the preservation and maintenance of peace in the continent and around the world.[3]

On addressing smart platform, AU commits to increase electricity generation and distribution by at least 50% by 2020, double ICT penetration and contribution to GDP, realize at least 70% increase in broadband accessibility by 2020, and attain 100% mobile penetration by 2020 (AU 2015). From these commitments, it is clear that the Continent is keen on addressing the digital divide problem, which has disadvantaged the continent when it comes to dealing with various challenges facing the continent including the area of its adaptability in addressing critical areas of food security and conflict. This chapter will highlight the historical background of peace and security status in Africa which is assumed to have great impacts on peace in African cities, initiatives taken to attain peace and security in the continent, and lastly how ICT and related technology has been applied in attainment of peace and security in African cities.

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[2] United Nations (2017).

[3] African Union (AU) (2015).

The chapter's main objective is to map out Africa's peace and security landscape in relation to application of digital and technology platforms in promoting peace and security in African cities and urban areas.

The chapter's scope in discussing peace and security in African cities and urban areas is limited to 'Peacetech'[4] initiatives such as GIS based security applications, online platforms, blogs, crisis mapping, crowdsourcing platforms, social media and mobile phone Short Message Service (SMS) which are really transforming how conflict and violence are addressed in African cities and globally. The chapter is also alive to the fact that these digital platforms also can and have been used and abused by many individuals and groups in creating conflicts whose result is disturbance of peace and security in Africa.

The rest of the chapter is divided into six parts. The next Sect. 11.2 provides the conceptualization of the chapter by discussing framework of smart peace and security, Sect. 11.3 gives an overview of drivers of threats to peace and security in Africa which is followed by Sect. 11.4 which consolidates discussion various impacts associated with conflicts in Africa, this is followed with Sect. 11.5 which brings in the discussions of mitigation to conflicts including highlighting the application of smart applications in seeking peace and security in Africa, this is succeeded with Sect. 11.6 which analyses the application and potential of ICT in African cities and urban areas.

11.2 Conceptualizing Smart Peace and Security

Due to the difficulty in forecasting the onset of large-scale violence, it is important to better understand and conceptualize new approaches to measuring the risk of it. As the Global Peace Index (GPI) has recorded in the past, the global trend in peace has been deteriorating due to the large conflicts in the Middle East, increased terrorism and historic displacement of people, which is having profound impacts on global peace and stability. While some risks can be foreseen and planned for, profoundly destabilizing events such as civil unrest, conflict onset and the collapse of entire countries have, all too often, caught the world by surprise (IEP 2017a).[5]

The basic starting point for any writings on peace is conflict. For one to appreciate how smart peace can be achieved it will be important to first have a glimpse of the nature and character of conflict in Africa. As noted by McCandless and Bangura (2007) this implies two things: an identification of the salient issues and adoption of the appropriate methods.[6]

On the question of peace and security attainment, some of the important subject of discussion to consider might be: the causes of conflict, the nature and dynamics of conflict, the patterns of conflict, the effect of conflict among others. There are

[4]Farrah et al. (2017).

[5]Institute for Economics & Peace (2017a).

[6]McCandless and Bangura (2007).

Table 11.1 Framework for conceptualizing smart peace and security

	Marginalization	Hegemony	Empowerment
Role of ICTs	Ignored and denied funding/attention; non-virtual peacebuilding	Denying access; rhetorical tool: policy legitimation	Active support through donors and agencies: ICTs producing policy input
Risks	Neglecting the potential of ICTs to reach out to broader audiences	Reinforcement of top-down dynamics	Reinforcing local power imbalances and systems of exclusion

Source Adapted by author from Tellidis and Kappler (2016)

several patterns of conflict in Africa. Thus, we have conflicts of secession, ethnic nationalism or self-determination. In discussing conflict literature in African cities in relation to ICT in order to unpack peace and security, the chapter will also rely on the **Global Peace Index** (**GPI**) which measures the relative position of nations' and regions' peacefulness. As documented in the Institute for Economics and Peace (2017b), the GPI gauges global peace using three broad themes: the level of societal safety and security, the extent of ongoing domestic and international conflict and the degree of militarization.[7]

The chapter also acknowledges that Africa is the fastest growing region in the World in terms of internet penetration, with a growth rate in internet users of 16.05% between 2013 and 2014 (more than twice as high as the global average growth of 7.85%). Of relevance to focus on Africa cities, it is noted that internet use in Africa is mainly an urban phenomena for example in South Africa only 24% of internet users are rural.[8]

Discussion of smart peace and security in African cities will therefore be conceptualized by examining the dynamic roles and potential of ICTs in attainment of peace and security. Some of the dynamics are summarized in Table 11.1 as borrowed from Tellidis and Kappler (2016), who concluded that ICTs in the field of peacebuilding, has a lesser determining role than commonly expected, they represent a tool which needs to be activated and used by those capable of and willing to use it. This conclusion will be contextualized by initiatives taken by various countries to use ICTs in search for peace.

11.2.1 Marginalization: ICTs as an Under-Explored Tool

This may be because of a lack of knowledge in terms of how to use ICTs for peace-related purposes. This does not mean that ICTs are not used at all, but instead that they

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[7]Institute for Economics and Peace (IEP) (2017b).

[8]Guerriero (2015).

are used in a rather static and one-way form. In other instances, ICTs are not explored to their full potential because of fear that their impact cannot be controlled, or because of a belief that these media are not suitable to bring about change, or indeed because ‘proof’ of their impact is difficult to measure (Shoemaker and Stremlau 2014).[9] This shows that the improvement in statistics in terms of internet penetration and growth in cellular phone ownership should be tapped into useful tool of addressing conflicts and developing a culture of peaceful citizenry in African cities.

11.2.2 ICTs as a Tool for Hegemony

ICTs can serve as a platform on which hegemony can be promoted and existing power imbalances be reinforced, shifting the balance towards powerful institutions if the latter are able to strategically use ICTs as legitimating tools. Post-conflict Sri Lanka is one such case where the state sought to impose a victor’s peace (Richmond and Tellidis 2012) by controlling new social media, which the former President’s brother and Defence Secretary has branded ‘a threat to national security’.[10] This is a threat to cultivation of peaceful culture and co-existence in any environment.

Information and communication technologies may be used as a hegemonic tool even in cases where there is no explicit strategy to impose a victor’s peace. In South Africa, for example, the emergence of township journalism through blogging in informal settlements (Siyakhona 2011) like Khayelitsha (near Cape Town) is a striking example that reflects the extent to which internet access can help circumvent censorship in the public sphere and give a voice to marginalized communities on the one hand. On the other hand, it must be noted that while Khayelitsha benefits from access to electricity, other townships nearby (such as Malawi Town) have been denied electricity and are thus unable to participate in the use of ICT-based communication. Thus, besides the fulfilment of basic human needs, political voice is also denied to certain groups and communities.[11] This may as well represent a political strategy of keeping contestation and deviance under control. The marginalization of ICTs in broader society is in this case not only a result of ‘not-knowing’ or a lack of technical skills, but equally a deliberate (hegemonic) strategy of keeping certain populations at bay and under control by denying them a platform of empowerment.[12]

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[9] Shoemaker and Stremlau (2014).

[10] Richmond and Tellidis (2012).

[11] Siyakhona (2011).

[12] Tellidis and Kappler (2016).

11.2.3 ICTs as a Tool of Hybrid Peace Building

The UNDP has increasingly been accepting ICTs as catalytic enablers both for e-governance as well as for the promotion of peace and development (UNDP 2013).[13] To that effect, it is now seeking to exploit the potential of games and apps in building peace and fostering positive relations between communities and between communities and institutions (Kahl 2014).[14] This approach points to the recognition that the use of ICTs can considerably enhance hybrid forms of peace as conceptualised in recent literature (Mac Ginty 2010[15]). They can do so by fomenting local access to formal peacebuilding practice(s) and thus challenge existing power biases of institutions. In that sense, ICTs can serve as platforms of resistance for actors that had previously been excluded from formal politics. This is evident in the case of Cyprus, where NGOs and the bi-communal peace formation movements have been quite isolated since the 1990s (Richmond 2012)[16] from the general public (physically, ideologically, and in terms of their approaches to the transformation of the conflict). All these platforms and initiatives use new social media (blogs, Facebook, Twitter) to organize and disseminate their activities, and to mobilize people from both sides of the island through new social media.

Such usage of ICTs does not necessarily iron out power imbalances, but can instead further cement dividing lines in society, at grassroots level. This is particularly the case in situations where certain local actors have strategies to better access ICTs and international support in this context, while others remain at the sidelines of such practices, either through a reluctance to engage with ICTs, or alternatively a lack of infrastructure or funding (digital divide). The implications of this are that ICTs should not per se be considered as agents of social change (Welch et al. 2015) in general, and peacebuilding in particular. Instead, ICTs have to be viewed in a continuous tension between disempowerment, marginalization and empowerment, and activated in different ways by the agents controlling and using them.

This chapter appreciates the continuous analogy of ICT in assessing its potential in addressing conflicts hence attainment of peace and security. The interest is on its empowerment function, where citizens in Africa cities are well positioned to take the advantage of the digital dividends courtesy of higher internet penetration rate and mobile ownership as compared to the rural areas in enhancing attainment of peace and security in the cities and to a larger extent the African continent as envisaged in Africa 2063.

[13] UNDP (2013).

[14] Kahl (2014).

[15] Mac Ginty (2010).

[16] Richmond (2012).

11.3 Overview of Drivers of Threats to Peace and Security in Africa

It is widely accepted that the major threat or great disturbance to peace and security is conflict. According to Olaosebikan (2010) conflicts in Africa may be said to have been caused by a multiplicity of factors such as: arbitrary borders created by the colonial powers, heterogeneous ethnic composition of African states, inept political leadership, corruption, negative effect of external debt burden and poverty.[17]

Africa continent is rich in natural resources such as mineral oil, diamonds, rubies and gold and with a natural abundance of flora and fauna. However the wealth of Africa as noted by Oduaran and Nenty (2008) does not translate into much in terms of development due to a concerted display of violence, some of which have tainted solutions.

Rather than take its rightful place among the rapidly developing continents of the world, African development is lagging behind due to endless civil wars, border conflicts, weak structures of democratic governance, economic mismanagement and harsh climatic conditions resulting to draughts and other natural incidents amongst others.[18] Obi (2005) probed the general root causes of conflicts, which are a threat to peace and tranquility in Africa and noted that these are located in:

1. The arbitrary manner with which colonial boundaries were imposed on Africa;
2. Misrule and authoritarianism;
3. Socio-economic and political contradictions.

These have caused violent conflicts to what Obi (2005) has identified as the sudden release of pent-up grievances and rage that had been suppressed by authoritative regimes backed by the World's super powers.[19] DFID (2001)[20] identified four distinct types of conflict in Africa namely;

a. **Conventional Warfare-Wars of Attrition**

This refers to a type of war which makes extensive use of expensive technology such as heavy artillery and jet fighters. It is fought with regular troops along a defined series of fronts. A good example is the conflict between Ethiopia and Eritrea.

b. **Factional Warfare**

In such wars, there is rarely a defined front line and fighting is frequently opportunistic rather than strategic. Frequently these conflicts move rapidly from the original cause to revolve around the exploitation of commercial, mineral and natural resources. Factions will seek to involve, exploit and control a significant proportion of the civilian population in order to sustain the conflict. Countries currently that have been

[17] Olaosebikan (2010).
[18] Oduaran and Nenty (2008).
[19] Obi (2005).
[20] Department for International Development (DFID) (2001).

affected by factional warfare are Somalia, Liberia (internally), Uganda (internally) and Namibia.

c. **Genocide and Ethnic Based Conflict**

Centrally directed and involving the virulent use of propaganda, these conflicts spread like wildfire and leave a huge death toll, massive displacement, fear and confusion. Ethnic and genocidal fighting tends to be extremely low tech using knives, machetes and occasionally small arms. A distinguishing characteristic is the speed with which genocidal attacks take place and the high degree of central organization and planning involved. Examples of countries to have experienced genocide and ethnic based violence are many; Rwanda, Nigeria, Burundi and Kenya among others.

Another emerging concern which is closely related to ethnic conflict is xenophobia violence. As noted by Adjai and Lazaridis (2013), In South Africa, this occurs in urban informal settlements, owing to the socio-economic circumstances, where black South Africans establish homes in the informal settings surrounding major cities. Likewise migrants, particularly refugees struggling to access housing and experiencing delays in gaining refugees status also end up setting homes in those urban informal settlements. The presence of the foreigner, who is in close proximity, is deemed a threat to black South African's access to resources, particularly in the informal sector.[21]

d. **The "New Warfare"—Regional Conflict**

All three elements of warfare have coalesced into what can be described as Africa's "new warfare"—regional conflict. In this type of conflict, conventional state forces are frequently engaged in the protection of key installations, or may find themselves engaged in capital intensive, attritional warfare with other states. Extensive use is also made of factional forces that act as proxies and as a forward line of protection for conventional forces. These proxy forces are encouraged to be self-sustaining through the exploitation of natural resources. The war in the DRC involves the armed forces of eight countries while the DRC has sought to take the war back into Rwanda, Burundi and Uganda.

e. **"Youth Bulge" and Conflict in African Cities**

Though not listed by DFID as distinct type of conflict in Africa, the youth explosion in Africa in relation to conflict and attainment of peace require special attention. This is given by the fact that the youth in most African cities make up at least 60% of the urban population, yet most programs in these cities rarely address their needs for employment, recreation, health, education and other specific problem. During wars or conflict, most of them are vulnerable hence can radically transform the nature of the conflict since they have nothing to lose, since they feel unwanted and un-provided for by the existing authorities.

According to IEP (2017b) youth development policies often increase budget funding for education and thereby improving the High Levels of Human Capital Pillar.

[21] Adjai and Lazaridis (2013).

However, unless the economy can absorb graduates into the labour market, this runs the risk of building a highly educated yet idle youth cohort. Flooding the labour market with university graduates when the economy cannot absorb them, may have a radicalizing effect and is one of the push factors used by militant organizations in recruitment of youth in Middle East and North Africa (MENA). De Benitez et al. (2003) notes that marginalized urban youth tend to be unpopular with other members of urban society, including government officials, in Africa and elsewhere. They may not be viewed as vibrant, dynamic contributors to a city's culture and daily life, being perceived instead as carriers of disease and crime. They are easily be lured to conflict situation for example the assault on Freetown by the child and youth soldiers of the Revolutionary United Front (RUF) in January 1999 dramatizes how youth alienation and furor can be manipulated to terrible and devastating effect.

11.4 Global Terrorism Index and Global Peace Index

Terrorism is an emerging conflict concern in Africa and more so in cities and urban areas. According to the Institute for Economics and Peace (IEP) (2017c) there is a particular focus on how both political terror and conflict act as drivers of recruitment for terrorist groups. The vast majority of terrorism occurs in countries that are involved in an armed conflict with terrorism in these countries accounting for 95% of all deaths and 91% of all attacks in 2016.[22]

The Global Terrorism Index (**GTI**) scores each country on a scale from 0 to 10; where 0 represents no impact from terrorism and 10 represents the highest measurable impact of terrorism. Countries are ranked in descending order with the worst scores listed first in the index.

IEP (2017c) notes that over the two years there is a decrease of 22% compared to the peak of terror activity in 2014. Terrorism deaths have fallen significantly in Syria, Pakistan, Afghanistan and Nigeria. Terrorist attacks are deadlier in conflict-affected countries where there is an average of 2.4 fatalities per attack in 2016 compared to 1.3 fatalities in non-conflict countries.

From Table 11.2, the vast majority of terrorism occurs in the Middle East and North Africa (MENA), South Asia and sub-Saharan Africa regions. Collectively these regions account for 84% of all attacks and 94% of deaths. In contrast, Central America and the Caribbean accounted for the lowest levels of terrorism with only 0.05% of attacks and deaths. Sub-Saharan Africa has been the most deadly region in terms of fatalities per attack with an average of 4.8 deaths per attack in 2016.

Further analysis shows that out of the top 36 countries having a GTI score of 5 and above, 15 of them were African Countries, which is approximately 41.6%. As shown in the table Nigeria, Somalia and Libya rank among the top ten countries globally and top 3 in Africa in terms of GTI.

[22]IEP (2017c).

Table 11.2 Global terrorist index for countries scoring GTI 5 and above

Country	GTI score	Global rank	Africa rank
Iraq	10	1	
Afghanistan	9.441	2	
Nigeria	9.009	3	1
Syria	8.621	4	
Pakistan	8.4	5	
Yemen	7.877	6	
Somalia	7.654	7	2
India	7.534	8	
Turkey	7.519	9	
Libya	7.256	10	3
Egypt	7.17	11	4
Philippines	7.126	12	
DR of Congo	6.97	13	5
South Sudan	6.821	14	6
Cameroon	6.787	15	7
Thailand	6.609	16	
Ukraine	6.557	17	
Sudan	6.453	18	8
Central African Rep.	6.394	19	9
Niger	6.316	20	10
Bangladesh	6.181	21	
Kenya	6.169	22	11
France	5.964	23	
Ethiopia	5.939	24	12
Mali	5.88	25	13
Saudi Arabia	5.808	26	
Lebanon	5.638	27	
Burundi	5.637	28	14
Colombia	5.595	29	
Palestine	5.551	30	
China	5.543	31	
USA	5.429	32	
Russia	5.329	33	
Chad	5.269	34	15
United Kingdom	5.102	35	
Israel	5.062	36	

Source Compiled from IEP (2017c)

In 2016, sub-Saharan Africa was the fourth worst performing region with 51 different terrorist organizations carrying out at least one attack in the region. There were a total of 1,450 attacks that resulted in 4,715 deaths. Since 2002, Sub-Saharan Africa has also seen the second largest deterioration in its GTI score in deteriorating by 60%. At the same time, the region has witnessed the biggest improvement in terms of GTI with Angola improving its score by 98%, from a score of 6.382 in 2002 to 0.154 in 2016. Since 2002, 14 of the 44 countries in sub-Saharan Africa have improved their terrorism scores while nine saw no change and 21 deteriorated.

Nigeria and Somalia have experienced both the highest numbers of attacks and the highest death toll in the last 15 years primarily due to Boko Haram and al-Shabaab. Of the 35,559 people killed in terrorism attacks since 2002, 65% of the fatalities and 70% of the attacks occurred in these two countries.

Global Peace Index (GPI) for Africa

The GPI covers 99.7% of the world's population, using 23 qualitative and quantitative indicators from highly respected sources and measures the state of peace using three thematic domains: the level of Societal Safety and Security; the extent of Ongoing Domestic and International Conflict; and the degree of Militarisation. All scores for each indicator are normalized on a scale of 1–5, whereby qualitative indicators are banded into five groupings and quantitative ones are scored from 1–5, to the third decimal point (IEP 2017b).

IEP (2017b) indicate that since 2015, the Middle East and North Africa was the least peaceful region in the world and deteriorated further, although less noticeably compared with the past two years. It is also instrumental to note that Mauritius is ranked as the most peaceful country in Africa at number 22 with GPI of 1.547 as compared to the most peaceful country globally Iceland with GPI of 1.111. Only Eight countries from Africa namely; Mauritius, Botswana, Sierra Leone, Zambia, Madagascar, Malawi and Namibia are among the top 50 countries globally.

In sub-Saharan Africa, 24 of the 44 countries became less peaceful, with the largest deteriorations occurring in Ethiopia, Burundi, Mali, and Lesotho. The five worst-performing countries are all in the sub-Saharan Africa and the Middle East and North Africa regions. Ethiopia's score has suffered as a result of violent protests that led to a state of emergency giving the government significant powers to crackdown on dissidents. A similar story can be seen in Burundi where the government appears to be drifting towards authoritarianism. Mali continues to struggle to implement a 2015 peace treaty and remains under threat by jihadists, despite a UN and French military presence. Finally, Lesotho has suffered from political instability and internal security issues following a failed coup in 2014.

From the GPI computations and complexity of causes of conflict it is clear that the solution will require a pragmatic multi-disciplinary, multi-stakeholders/players approach where ICT can play a critical role in facilitating attainment of peace and tranquility in Africa cities and the entire continent. As such, policies to counter or prevent conflict in African should consider embracing of ICT and also be tailored to the specific drivers of conflict in each context.

11.5 Impacts of Conflict

From the 2017 GPI, the least peaceful countries were mainly from Africa. This scenario has been noted to have serious negative impact on the continent's development. The scale and nature of the conflict have directly affected the lives of many millions of Africans.

Various studies and reports have categorized impact of conflicts into the following;

a. **Loss of Human Lives**

Globally there has been a very significant increase in the total number of deaths from internal conflict, rising from 35,988 in 2006/2007 to over 285,000 in 2015/2016 which is 732 percent increase. Globally, deaths from terrorism rose from just over 11,000 in 2007 to over 29,000 in 2015, with the number of deaths peaking in 2014 at 32,765 (IEP 2017c).

War in Africa causes increasing suffering for civilians. They suffer death and injuries and the indirect consequences of famine and epidemic disease that have followed in the wake of war.

b. **Injuries and Deformities**

Conflict situations can lead to injuries and deformities. IEP (2017c) estimates that the number of those injured as a result of terrorism attack in the year 2016 is 14,593, with the Islamic State of Iraq and the Levant (ISIL) contributing to 50% of the total reported cases of injuries.

c. **Economics and Livelihoods**

The global economic impact of terrorism in 2016 was US$84 billion. While this is a significant number in its own right, it is important to note that the economic impact of terrorism is small compared to other major forms of violence. This amount is only one per cent of the total global economic impact of violence, which reached $14.3 trillion in 2016 (IEP 2017c). According to IEP (2017b) this figure is equivalent to 12.6% of the world's economic activity (gross world product), or $1953 for every person, and is three per cent lower than in 2015. Peacebuilding expenditure is estimated to be approximately $10 billion, or less than one per cent of the cost of war.

Violent conflict can deny people access to their land at critical growing or planting periods, increase the costs of agricultural inputs, disrupt markets and restrict sales of produce. The use of landmines for example, in countries like Angola has severely limited access to land for the long term. Agricultural production and family livelihoods have suffered dramatically as a result.

d. **Refugees and Displacement**

The global number of refugees under UNHCR's mandate was estimated to be 16.1 Million at the beginning of 2015. With 4.4 million individuals, the Sub-Saharan Africa region hosted the largest number of refugees. Refugees originating from five countries (Somalia, South Sudan, the Democratic Republic of Congo, Sudan and the Central African Republic) accounted for 3.5 Million (80%) of the total refugee population residing in this region by the end of 2015.[23]

According to De Benitez et al. (2003) from Angola to Sudan and the Democratic Republic of the Congo to Sierra Leone, hundreds of thousands of people displaced by wars have sought refuge in capital cities. For example, Freetown, the capital of Sierra Leone, saw its population rise from 384,499 in 1985 to an estimated 837,000 in 2001 (Africa South of the Sahara 2002, 926). This 217 percent increase mainly took place during the decade of civil war (1991–2001) and may not have accounted for internally displaced persons (IDPs) living in the Freetown area, which were thought to have reached 500,000 by 1995 (Synge 2002, 920) and remained a significant population throughout the latter stages of the war.[24]

Internal displacement and refugee flows have a serious effect on the economy and the environment. The denial of access to the land by military factions has led displaced people to congregate in cities and surrounding areas. Uprooted populations lose access to any means of production and put enormous pressure on government services. Refugees and the internally displaced put pressure on fuel and water resources. The World Bank estimates that in Africa the total direct cost of refugees to their hosts is in the region of $530 million per year.

e. **Loss of Infrastructure and Services**

War has seriously damaged Africa's infrastructure. Roads, rail, ports, airports, electricity, water supply, sewers and telecommunications have all been affected. During war there has been a dearth of investment in and maintenance of infrastructure. Over the past twenty years Africa has lost over fifty per cent of its transport infrastructure, many of the losses due to conflict. This loss has both an immediate and a long term impact on African economies. In immediate terms, it increases impoverishment. For example, South Sudan has almost no viable road network as a result of years of civil war.

Recent wars have also led to the destruction of the basic social infrastructure. Schools and health centres are increasingly the targets of military activity. During the fifteen-year war in Mozambique, over 40% of health centres and schools were destroyed. The situation is similar in most conflict-affected countries.

f. **Governance and Investments**

Changes in the quality of governance resulting from conflict further contribute to the economic losses of war. It is common for armed crime to increase substantially during a period of conflict. Business then concentrates on reducing its exposure to risk by supporting those activities that require no long-term investment and by making strategic alliances with armed groups either for protection or gain. This is followed by a downward spiral in both domestic savings and inward investment. The economy becomes dependent on the exploitation of easily extractable natural resources.

[23] UNHCR (2016).

[24] De Benitez et al. (2003).

g. **Child Soldiers**

Children have become one of the main targets of violence and in turn are being used to perpetuate it. Children are deliberately indoctrinated into a culture of violence and used as a specific instrument of war. Militia groups and irregular armed forces such as the Lord's Resistance Army in Uganda, the *Interahamwe*[25] in Rwanda/DRC, the *RUF*[26] in Sierra Leone, UNITA[27] in Angola, and formerly *Renamo*[28] in Mozambique, have made a practice of forcibly recruiting children and initiating them through acts of violence against their own community. There are several reasons why children are recruited as soldiers. They are more docile, complain less and are easily moulded into ruthless fighters. They can easily carry and use lightweight but high-powered weapons.[29] According to IEP (2017b), child soldiers' prevention and demobilization is identified as one of the peacebuilding expenditure line under core peace building in addressing basic safety and security.

h. **International Impact**

Conflict also has a major effect on the environment through uncontrolled exploitation of natural resources. Organized crime also benefits from conflict in Africa, through arms deals, money laundering and drug smuggling. Europe in particular has to cope with the consequences of the increasing flows of asylum seekers and economic migrants from Africa (DFID 2001).

11.6 Response to Conflicts

Peacebuilding involves a range of measures aimed at preventing a country from falling or relapsing back into violent conflict by strengthening a specific set of capabilities. Peacebuilding activities are defined under three priority areas: basic safety and security, supporting the political processes, and supporting core government functions. This is distinct from peacekeeping and peace-making activities, which broadly involve the activities aimed at ending violence and establishing security (IEP 2017b).

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[25] Is a Hutu paramilitary organization. Originally the youth wing of ruling party of Rwanda, the MRND, during the Rwandan Genocide the term "Interahamwe" widened to mean any civilian bands killing Tutsi.

[26] A terrorist group formed in the 1980s in Sierra Leone; seeks to overthrow the government and gain control of the diamond producing regions; responsible for attacks on civilians and children, widespread torture and murder and using children to commit atrocities.

[27] An Angolan nationalist movement founded in 1966 by Jonas Savimbi (1934–2002) to fight Portuguese rule. After independence was achieved in 1975 UNITA continued to fight against the ruling Marxist MPLA; a ceasefire was agreed in 2002.

[28] Is a militant organization and political movement in Mozambique.

[29] http://www.un.org/esa/socdev/rwss/docs/2001/15%20Armed%20Conflict.pdf.

a. **Response by International Community**

The international community mainly through United Nations (UN) missions has been successfully in ending more armed conflicts and reducing the number of deaths from organized violence. But as the overall GPI results show, peacefulness has declined in many parts of the world since 2008.

The UN has been seeking not only to find its role in addressing new technologies but also to integrate these technologies into its other areas of work. This integration is more advanced in some areas than in others. For example, the growing role of technology in sustainable development was highlighted in the outcomes of a number of major UN conferences in 2015. In other areas, such as peace and security, the UN is earlier in the process of integrating new technologies into its work.[30]

The UN has expanded the mandates of peacekeeping operations to increasingly provide multidimensional peacebuilding support in a variety of contexts, meaning that the UN no longer needs to wait for a comprehensive peace agreement to be in place before deploying peacekeepers.

The number of active peacekeepers has doubled in the past 25 years, from roughly 50,000 to nearly 100,000 deployed personnel. At the start of 2017, there were 21 active peace operations around the world. Of the 100,000 deployed personnel, about 85% of peacekeepers are military troops and 15% are police and experts or military observers. For the 12-year period 2002–2013, peacebuilding expenditures averaged US$13 per capita, per year, for conflict-affected countries. This is less than half of the needed level of peacebuilding, which IEP estimates at US$27 per capita. Based on IEP's model of the cost-effectiveness of peacebuilding, the total peace dividend that the international community would reap if it increased peacebuilding commitments over the next ten years could be as high as US$2.94 trillion (IEP 2017b). The doubling in number of deployed peacekeepers is an indication of goodwill of the international community willingness to address conflict situations. This is also where usage of ICT can be explored in monitoring situations in conflict prone areas.

b. **Response by African Union**

Conflicts in Africa are diverse and complex, and efforts at managing and resolving them are mixed. Aal (2015) has identified several responses to conflict in Africa namely;

(a) Increase elite incentives to negotiate an agreement (or consent to elections), rather than using force to settle the dispute,
(b) Limiting access to resources through transparency measures, sanctions or aid suspension. This may indeed change the equation, both for rebels and governments pursuing violent methods to promote their causes. Without access to easily convertible resources, funding war-related costs may prove prohibitive.
(c) In response to institutional weakness and fragility usually focuses on building up more representative and responsive governmental institutions. Toward this end, the European Union has a robust institutional-strengthening program for the

[30]Independent Commission on Multilateralism (ICM) (2016).

African Peace and Security Architecture "to enhance continental and regional capabilities for the prevention, management and resolution of conflict".

(d) Raising the cost of violence certainly lies behind a large part of international action to manage conflict in Africa, mainly through international military or security interventions.

According to Aal (2015), in mid-2014, the United Nations was involved in nine active peace operations in Africa—Mali, Darfur, Abyei, South Sudan, CÔte d'Ivoire, Liberia, the DRC, Western Sahara and the CAR. In October 2014, the European Union had military operations in Mali, the CAR and Somalia, and security-oriented civilian missions in Djibouti, Tanzania, the DRC, Niger, Mali and Libya. Some of the operations are joint, some coordinated and some are sole-actor, but with 20 or more peace and security missions occurring in Africa in 2013 and 2014, it is a crowded field.

Initiatives by African Union[31]

1. **Africa Peace and Security Architecture (APSA)**

It is a continental framework for the promotion of peace, security and stability in Africa. It is supported by the Protocol relating to the Establishment of the Peace and Security Council of the African Union, and the Common African Defence and Security Policy (CADSP). The Protocol was adopted by the AU assembly on 9 July 2002 in Durban, South Africa, and entered into force in December 2003. CADSP was adopted by the AU Assembly on 28 February 2004 in Sirte, Libya. It is under the overall leadership of the AU Peace and Security Council.

2. **African Standby Force (ASF)**

It is one of the pillars of the Peace and Security Council established under Article 13 of the Protocol Relating to the Establishment of the Peace and Security Council of the African Union. It is composed of five brigades from ECOWAS, SADC, ECCAS and Eastern and Northern geographical regions of Africa.

3. **Panels of Wise Africans (PanWise)**

It is a continental network that brings together panels or bodies of wise Africans under the AU Panel of the Wise umbrella to promote peace, security and stability on the continent.

Smart Applications to Attainment of Peace and Security in Africa

Information and Communication Technologies (ICTs) have greatly transformed societies, cultures and economies as well as created both new opportunities and threats for humankind (Sabadello 2010)[32]

Some of the way application can be applied in attaining peace and security in Africa are:

[31] AU (2015).

[32] Sabadello (2010).

a. **Crowdsourcing**

It is a widely known fact that, one of the major causes of conflict in Africa is political mistrust including sham elections. Use of crowdsourcing can enable reduce such suspicion and provide legitimacy to electoral process in Africa.

Crowdsourcing presents an opportunity to empower citizens and transform the state-society relationship. The term "crowdsourcing" was originally defined as the use of new technologies and social media to solicit contributions or share real-time information, generally in a business context.

According to Lehdonvirta and Bright (2015), crowdsourcing has the potential to augment more traditional routes for participation, such as elections and referenda. It can make government decision-making processes more inclusive and transparent and allow citizens to assess their outcomes, indirectly increasing their legitimacy.[33]

In Kenya For example, the **NGO** *Ushahidi* (Swahili word for witness) has developed crowdsourcing platforms that were originally designed as a website that was developed to map reports of violence in Kenya after the post-2007 election fallout. The original website relied on reports submitted via the web and mobile phone and presented this information on a Google Map. This website had 45,000 users in Kenya, and was the catalyst for subsequent platforms. Since then, the name "*Ushahidi*" has come to represent the people behind the "*Ushahidi* Platform". The *ushahidi* concept has also been in a variety of conflict settings including the Democratic Republic of Congo, Gaza, and Afghanistan. With its focus on user-generated information, *Ushahidi* is designed to be adaptable to SMS, mobile phone usage, and internet posts. Whilst, traditional information management systems are typically closed and controlled, *Ushahidi* is open and decentralized.[34]

b. **Networking**

Mobile phones and social media also present opportunities to empower citizens and transform their relationship with the state. Real-time photos and videos uploaded to social media can expose government corruption or abuse and increase government responsiveness to citizen concerns. These technologies have also revolutionized people's ability to organize and coordinate protest movements, a good example being the popular Arab uprisings in Tunisia, Morocco, Algeria, Libya and Egypt.

While new technologies can facilitate the rapid spread of ideas, this can have both positive and negative consequences. The easy manipulation of information and sources and the risk of viral dissemination without verification can propagate misinformation.

c. **Early Warning System**

ICTs provide opportunities to collect data about crime and conflict and reduce the gap between warning and response. For example, crisis mapping, social media mapping, and crowdsourcing tools can help generate data on conflict indicators.

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[33] Lehdonvirta and Bright (2015).

[34] Staffacher et al. (2011).

Regional organizations are also taking advantage of new communication tools to better protect their citizens. The Inter-Governmental Authority on Development (IGAD) in Eastern Africa has developed a Conflict Early Warning and Response Mechanism (CEWARN) in order to respond to and prevent conflict in their region (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda). In partnership with ICT4Peace, CEWARN has assessed how ICTs could be used in areas that generally have no access to communication technology, and started using high-frequency radios, satellite phones, and other technology to access areas that used to take days to travel to and review.8 Similar initiatives have also been developed by the Economic Community of Western African States (ECOWAS) within their ECOWAS Warning and Response Network.[35]

d. **Peace Operations**

Although new technologies have changed the way wars are fought, peace operations by various peacekeeping missions including UN have been slow to integrate these technologies in fulfilling their increasingly complex mandates (ICM 2016). Particularly useful for peace operations are technologies that facilitate monitoring and observation, including unarmed unmanned aerial vehicles (UUAVs), video monitoring systems, motion detectors, and satellite imagery.[36] These technologies can facilitate peace keeping operations by detecting and monitoring hostile movements virtually for protection of civilians.

e. **Peacebuilding**

New technologies offer new opportunities for managing conflict and building peace, particularly at the local level. ICTs can provide avenues for alternative discourse or community engagement that promote peace, and video games have been used to foster nonviolent attitudes and behaviors.

They use popular, commercial video games, whose themes revolve around the ideas of communication and collaboration within a virtual world. By exploiting their mass appeal, their programs aim to stimulate trust between children in Israel, Palestine, the Middle East and other parts of the world suffering from conflict.

f. **Social Media**

In Many Countries, use of Blogs, WhatsApp, Twitter and Facebook have become popular in sharing intelligence among civilians regardless of their age, socio-economic class, religion and racial affiliation. The social media has been used in spreading of peace messages during election in Kenya and in sharing of any imminent attack by outlawed gang's and also in reporting of police brutality during demonstrations.

g. **Geographic Information System**

Mapping technologies like Geographic Information Systems (GIS) and satellite imagery are also being used to engage with communities and map information that

[35] Search for Common Ground (SFCG) (Undated).

[36] Dorn (2011).

can help in forecasting trouble spots or see trends in the field. There is an increase in usage of Global Positioning Systems (GPS) and geographic information systems to map information on human rights abuses in order to, "strengthen advocacy campaigns, support legal cases, and enhance response coordination and prevention efforts."[37] The UN is using mapping in ongoing peacekeeping efforts, like in Sudan, to map where response teams are stationed. Similar initiatives are used by local community groups like Map Kiberia or Map Action to provide local information on community development issues or response efforts.

h. **Other Efforts such as ELVA, First Mile Go**

The rationale behind Elva is that the data (which may be predominantly collected over mobile phone text messages and web reports) is represented in a clear visual manner on maps and charts. With reference to "conflict transformation" approaches to peacebuilding, the platform represents how data has the potential to inform the need-focused distribution of resources by statutory and governmental bodies and agencies.

In Africa Elva has utilized these approaches in the following areas[38]:

Central African Republic: a platform that helps humanitarian actors map relevant incidents and needs of conflict-affected and displaced peoples;

Somalia: a platform that allows local organizations to carry out SMS polls on democratization issues amongst the general population;

Libya: support local organizations prevent conflict using a mobile phone based reporting platform.

First Mile Geo

First Mile Geo is a provider of Cloud Business Intelligence (BI) and Geospatial analytics. Its software enables users to collect, visualize, and monitor data, in any language, anywhere, on the fly, and through one unified interface. Data can be captured through whatever technology or third party platform deemed most appropriate (pen and paper, web surveys, SMS, mobile, tablet, etc.) and pushed into a unified system for map exploration, dashboards, and alerts across multiple languages. First Mile Geo was leveraged in Syria to collect, manage, and visualize time-series data from within Aleppo City, street block by street block during the conflict. It is yet to be used in Africa but has high potential.

i. **Use of Unmanned Aerial Vehicles (UAVs)**

The success of the UAVs and armed helicopters in the DRC is helping propel their deployment in other missions, especially in Mali and the Central African Republic. The Dutch contingent in Mali has used both UAVs and Apache helicopters with camera pods to great effect. Showing that UAVs are becoming "standard kit," the Swedish contingent in Mali deployed three types of its own UAVs, including mini-UAVs.[39]

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[37] AAAS Geospatial Technologies and Human Rights. http://shr.aaas.org/geotech/.

[38] Young and Young (2016).

[39] Dorn (2016).

11.7 African Cities as Areas Needy but Ready for Smart Solution to Attainment of Peace and Security

Cities all over the world are vibrant urban spaces giving hope of better future especially to the young professionals. As noted by various authors (IEP 2017b; Aal 2015[40]; Muraya 2014) with a rapid increase in African urban population, resulting to an extremely high density population with a large portion living in informal settlements, which creates a perfect breeding ground for insecurity as it becomes extremely difficult to monitor all clandestine antinational activities. This has resulted to unusual activities such as radicalization, violence and terrorism which consequently result to urban terrorism, cyber terrorism and related challenges to attainment of peace and security.

In most of African cities, it is now becoming a norm, that insecurity is not only growing, fast and out of government control but is also changing into a complex outcome of increasing interaction between historical injustices, growing income inequalities, a bulging and frustrated youth population, rising levels of education, access to information and communication technology and exposure to global influence in the back drop of poverty and unemployment, self-sabotage, and experimentation and curiosity (Muraya 2014).

To further compound this problem the weakening social contracts characterized by lose of trust by citizens on state institutions and on-going political transition is not making an already bad situation any better.

ICT Status Favoring African Cities

Africa is the fastest growing region in the World in terms of internet penetration, with a growth rate in internet users of 16.05% between 2013 and 2014 (more than twice as high as the global average growth of 7.85%). Internet use in Africa is mainly an urban phenomena for example in South Africa 24% of internet users are rural.[41]

Mobile-broadband subscriptions have grown more than 20% annually in the last five years and were expected to reach 4.3 billion globally by end 2017. Despite the high growth rates in developing countries and in LDCs, there are twice as many mobile-broadband subscriptions per 100 inhabitants in developed countries as in developing countries, and four times as many in developed countries as in LDCs (ITU 2017).

Only 15% of households in LDCs have Internet access at home. In these countries, many Internet users are accessing the Internet from work, schools and universities or from other shared public connections outside the home. Majority of those having access to internet are in the cities. International Internet bandwidth grew worldwide by 32% between 2015 and 2016. Africa experienced an increase of 72% during this period, the highest of all regions.[42]

[40] Aal (2015).

[41] Guerriero (2015).

[42] ITU (2017).

11.8 Conclusion

The chapter's introduction and conceptualization section points out clearly that ICT is a useful tool for facilitating attainment of peace and security in Africa as has been demonstrated in the literature and case studies, however use of ICT should not ignore the potential harm associated with the misuse of information communication technologies and the implications this has for international security.

As noted by Sommers (2001) surviving in cities is a hustle for many African youth with reference to Sect. 11.6 on African cities and smart application to peace and security attainment. Many are neither fully employed nor entirely unemployed. Much of what they do to make ends meet may be illegal. This may be particularly true for those affected by war. They are likely to engage in criminal work, which may range from simple thieving and vandalism to outright gang violence. Particularly compelling postwar examples of truly threatening urban gangs are the notorious Ninja that terrorize residents of Maputo, the capital of Mozambique.[43] This may require what IEP (2017b) term as need for investment in *youth development* policies which will require African governments to increase their budget funding for education and thereby improving the *High* Levels of Human Capital Pillar but go beyond this by absorbing them in various engaging employment programs. This will raise the Youth Development Index (YDI) which measures the status of 15–29 year-olds in according to five key Pillars: Education, Health and Well-being, Employment, Civic Participation and Political Participation. This is considered as key indicator in measuring Global Peace Index. This approach will be useful, since ITU (2017) facts and figures indicate that 70% of World's youth are online-referring to proportion of youth (15–24) years old using the internet. This means that solutions requiring adoption and usage of smart technology will be driven by youth, hence their importance in engaging them actively in programs aiming at attaining peace and security in Africa continent.

ICT has launched a revolution which can be both used and misused in creating or disturbing peaceful and secure environment due to its ability to transfer real time information to a mass of people rapidly.

In response to studies sole objective of mapping out Africa's peace and security landscape and digital platform, it is evident that ICTs have also been used in conflict situations to enable communication between citizens to warn each other and inform communities where violence is occurring. Existing social media like Twitter, Facebook, and blogging have been used to help share information about ongoing conflicts.

ICTs have given a new meaning to human rights, in particular the freedom of expression and information. They have allowed the creation of better communication and coordination mechanisms, the establishment of early warning systems as well as the development of other tools in the service of the humanitarian, human rights and peace communities.[44] This is clearly evident in African cities and urban areas

[43] Sommers (2001).

[44] United Nations ICT Task Force (2005).

where the youth and growing urban middle class have fully embraced social media in security alerts and exchanging of niceties.

The chapter recommends that as the continent citizens make use of ICTs, there is an urgent need to invest in peacebuilding in Africa as ICT will play a fundamental role in enhancing attainment of peace and security in Africa. IEP (2017a) estimates that the return on investment on peacebuilding funding can be up to 16 times the cost of the intervention, highlighting a major opportunity for future investment. This coupled with impressive statistics on internet penetration in urban areas in Africa, ICT has great potential of supporting peacebuilding in Africa cities.

In order to fully exploit the potential of smart technology in attainment of peace and security in African cities, ICT will have to be designed and developed in both the physical and the virtual worlds with 'Peacetech in mind'. Peace and security cannot be attained solely with traditional African government gun-power. It will require political goodwill and leadership, greater international cooperation and application of ICT in promotion of peace especially among the youth who seem to play major role as perpetrators and ambassadors nearly in all forms of known African continent conflicts.

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Chapter 12
Smart and Open Urban Governance in Africa

Merlin Chatwin and Godwin Arku

Abstract The broad notion of 'Smart Cities' in Africa is emerging amidst significant socio-political transitions in populations, economy, and technology. Local governments across the continent are being asked to contend with limited resources and an increase in demands for service and accountability. Advances in information communication and digital technology, if contextually appropriate, can be harnessed to support collaboration amongst governance stakeholders. However, for technology to be an asset it must be a facilitator of good governance rather than an end to itself. This chapter presents a conceptual framework for Smart and Open Urban Governance in Africa and explores themes of transparency, public participation, and accountability.

Keywords Urbanization · Smart cities · Local government · Governance system
Open government

12.1 Introduction

Countries across the continent of Africa are in the midst of a number of significant transitions, including; demographic, economic, environmental, socio-political, urban and technological. These transitions are felt most immediately within the continents rapidly urbanizing areas. Like in other geographic regions, national governments in Africa recognize that their major cities are a strategic point of entry to the global economy. Less known, are strategies for African countries to harness the potential of their cities through these transitions and leverage the global economy to raise living standards for all residents, even the most vulnerable. The unprecedented scale of African urban population growth over recent years raises concerns about the capacity of governments to effectively manage urban centres and the people within them. Improving livelihoods is the fundamental job of governments at all levels, however, history has demonstrated that governments, when acting alone, are often incapable

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of balancing global and local demands. Under-resourced institutions and insufficient laws governing the way cities are planned make informality the norm in all sectors. Large numbers of residents in urban areas throughout Africa lack access to formal employment and governmental provision of basic services. Contemporary modes of urban governance recognize the necessity of a wide variety of actors to overcome resource constraints. City governments have enormous potential to realize economic and social benefit from emerging information and communications technology (ICT) as well as digital technologies. The accessibility of ICT and digital technology provides local governments a way to enhance the collective ability of governance stakeholders to address challenges through global and local collaboration (Lindell 2008). However, technology in and of itself, will just be another smokescreen that gets in the way of true development unless it is seen as a means to an end, and not an end itself. A focus on technological infrastructure, and harnessing big data that needs to be analyzed, can distract from hearing the expertise and experience of the public.

A key question for this chapter is: Can a focus on 'Smart Cities' support local governments to create an enabling environment that mobilizes governance actors to increase the prosperity and liveability of cities? There is no 'right-way' forward for cities, and governance actors must adapt to the institutional, social, economic, and political context. This chapter starts with the premise that smart governance is predicated on openness and collaboration amongst all stakeholders, including members of the public who are typically underrepresented in decision-making. 'Smart' cities in Africa, those that achieve economic growth and increased liveability through policy reform, will be the ones that create an environment where the voices of stakeholders are heard, and governments harness their wisdom and lived experience through the use of contextually relevant 'smart' technology. Therefore, African governments at all levels must recognize that the first step towards success of their cities is contingent on a new spirit of openness and collaboration amongst governance stakeholders including; business, academic, civil society, and the public. The objective of the chapter is to argue that achieving *'Smart Cities'* in Africa requires *'Smart and Open Urban Governance'*.

The following chapter begins by situating the movement of 'smart' cities into the context of African urbanization (12.2). Rapid urbanization, often disconnected from broad economic growth, is challenging the ability of city governments to meet the needs of their residents leading to the perception of cities as sites of concern rather than prosperity. In contrast, cities throughout the continent are also playing a fundamental role in Africa's transformation by facilitating growth that is critical to the economic performance of their respective countries.

Section 12.2.1 presents the concept of 'good governance' as an overarching framework for exploring the potential of smart and open governance. Amid increasingly limited resources, city governments are facing pressure to become more transparent in their decision-making and respond to increasing public demands for involvement. Section 12.3 introduces the concept of smart and open governance as a response to the increasing pressure for efficient and good governance. This approach recognizes the need to mobilize the expertise of governance stakeholders and the public to create a system of governance rather than exclusively rely on the formal institution of local government (12.3.1). An emerging approach to smart and open governance is the adaptation of a business strategy called open innovation. Section 12.3.2 explores the core innovation processes and presents real-world examples of them in action.

Section 12.4 introduces the principle tenets of smart and open governance in urban Africa including; transparency (12.4.1), public participation (12.4.2), and accountability (12.4.3). While the concepts of openness, and the use of ICT and digital technologies to facilitate collaboration, are not new, their implementation in African cities is often unchartered territory. Section 12.4.4 explores the need for reflection, building a culture of monitoring and evaluation, to ensure that the approaches used are effective in the unique context of each city. This section concludes with a brief overview of participatory action research as an approach to evaluating the effectiveness of smart and open governance reforms.

12.2 Urbanization and Governance: The African Context

UN-Habitat (2016) estimates that the worlds urban population will nearly double by 2050 with sub-Saharan African receiving 672.5 million new urban dwellers, making urbanization and the governance of cities the central policy challenge of the twenty-first century. While there is limited consensus on Africa's demographic forecasts, the broad implication is that as the worlds second most populated major region, African cities face huge population growth over the years and decades to come (UN-Habitat 2014). To varying degrees, African cities already play a crucial role in the economic and social development of their respective countries, serving as centers for political organization, and economic activities, as well as containers of productive capacity, fixed assets, and resources (UN-Habitat 2018). The extent to which countries in Africa leverage the benefits of the rapid urbanization will largely depend on how successfully they develop their institutional capacity to manage and integrate into the global economy. In particular, urban management experts believe that rapid growth of African cities, without corresponding growth in institutional and management capacities, could lead to civil unrest and reduce the quality of life. This reduction especially impacts the poor, who are the most vulnerable because they are least able to purchase alternative services through the market (Stren 1991; Arku 2009).

The current challenges are not unique to African countries, as globally, local governments have been facing unprecedented struggles, in rapid urbanization, economic uncertainty, environmental degradation and threat to natural ecosystem, and security. Many of these challenges surpass the resources, capacities, capabilities, processes and reach of traditional institutions. Governments are responsible for ensuring that the public is protected from harm, and that markets are fair, that communities of all sizes can flourish, and the well-being of residents is ensured. In practice, though, issues of corruption, abuse of power, scarce resources, and inefficiency in the urban administration systems have combined to make cities problem-ridden and thereby make urban areas a challenging place for people to live and thrive. This has caused the perception of urban centers to be one of poverty and conflict rather than an integral component of sustainable development and livelihood improvements. Recently, this perception has begun to shift. Accompanying this shift is a growth in demands from the public and other stakeholders who want to be involved in the growth and design of their cities.

While there is an emerging understanding of the centrality of cities in supporting both economic growth and poverty eradication, urban governments are under increasing pressure to focus their resources in search of loans, international aid, and foreign investment. There is nothing wrong with pursuing policies that aim to create wealth and jobs and raise revenue for central governments. However, the experiences of most developing countries, especially those in Africa, show that a focus on economic growth does not necessarily translate into improved living standards for the populace, nor reduce income inequality. Indeed, in some instances it worsens the plight of marginalized groups. In the context of increasing complexity in economic and social challenges, along with ongoing reductions in budget, cities must address two battles: first, the need to become attractive for investment; and second, the necessity of addressing the increasing needs of the public. Recent publications suggest that sustainable economic growth only happens in concert with social development and political stability (UCLG 2015). In recent years 'good' governance has been acknowledged globally as critical to the development of equitable and inclusive societies that can address complex issues.

12.2.1 Good Governance

Good governance is essential in providing basic necessities of life and addressing poverty related issues, and promoting programs and policies that reduce inequality (Arku & Sadler 2017). Good governance has numerous key principles embedded in it, namely; participation, accountability, responsiveness to civil society, and efficiency of service delivery. Although these principles are not new, their role in the effective functioning of modern society is being increasingly acknowledged, as evident in their integration into the recently completed United Nations Millennium Development Goals (MDGs) (UN-DESA 2008). Further, in the current Sustainable Development Goals (SDGs) (United Nations 2016a), and New Urban Agenda then becomes (United Nations 2016b) the core elements of good governance are firmly recognized as essential to building effective, inclusive, and accountable institutions. Despite the explicit acknowledgment of the importance of good governance, there are lingering questions in how to achieve it within the context of African cities. Although it is commonly understood that good governance improves service delivery in areas such as health, education, and infrastructure, concerns remain around how cities can achieve these ideals.

Around the world, governments are under incredible pressure to make their ministries, departments, and agencies more efficient, more transparent, and more responsive to the demands of the public. Local governments in Africa are no exception in similarly experiencing this pressure. In essence, the pressure is to achieve good governance, with limited resources. At the local level, authorities are grappling with the need to rapidly develop new policies and regulations as technological innovation disrupts traditional governance, and societal and business transactions. The increasing demands of the public are forcing local governments to enhance their ability to effectively address collective problems through the adoption of innovative solutions in their management processes, tools, policies, and practices. Against this backdrop of societal changes and increasing public pressure, city governments in Africa embark on reforms to improve their efficiency and effectiveness in pursuit of rebuilding public trust and legitimacy in their administrations. To rebuild their legitimacy, African policy makers are increasingly called on to make evidence-based development decisions and justify them to the public. Increasingly high-quality data are essential for all levels of government to accurately plan, fund and evaluate development activities. However, this requires the rigorous collection of data as well as a coordinated system to analyze and disseminate it; the reality, though, is that the capacity for this work is often missing in local administrations throughout Africa. There is no proven formula for modernizing government to keep up with the pace of change in data and technology in the pursuit of efficiency and effectiveness. This, as stated in the NUA, is because urban challenges are unique and will continue to emerge in the foreseeable future, testing established systems and approaches (United Nations 2016b). Local governments must commit to continuously reviewing existing processes for challenges, and opportunities for improvement. This commitment requires a new organizational culture, built on an openness to collaborate that aims to achieve more innovative, entrepreneurial, competitive, liveable, and sustainable territories. In short, it requires a commitment to smart and open governance.

12.3 Smart and Open Governance in Africa

With the rapid advancement in digital technologies and the ever-growing amount of information and data, many cities around the world are pursuing ‘smart’ reforms to balance the needs of economic growth and social development. The smart city movement calls for modernization of all areas of responsibility of cities, including; mobility, environment, economic growth, poverty reduction, culture, health, tourism, and education, coupled with a sustainability of services for the public. The Smart Economy in Smart African conceptual model is based on the development of infrastructure, environmental sustainability, social inclusion, social development, disaster prevention, and peace and security for a sustainable, inclusive, resilient, and prosperous city (see Chapter 1.1). As Caragliu and Nijkamp (2009:50) suggest, “a city can be defined as ‘smart’ when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement.” The commonality of these definitions is the recognition that infrastructure-oriented strategies are fragmented and incomplete, emphasizing that technology is not enough. Perceptions of smart city development are often centered on technological infrastructure: an urban area that includes the internet of things (IoT), buildings managed by smart meters, cognitive analytics, machine learning algorithms managing transportation, and automated technologies managing infrastructure assets. This is based on the belief that investing in technologically based infrastructure will result in an output of enhanced efficiency and service provision leading to economic growth. However, as our definition suggests, to make the most of the intelligence of digital technologies, another ingredient is essential: human capital. Technology and infrastructure investments do not guarantee effective decisions or policy in cities, and it does not inherently improve the lives of people. For a region such as Africa, a more complete view of smart city development must combine context appropriate technology with all available resources, including the knowledge, creativity, and intellectual capacity of the public. Human and social capital development is critical to building a smart city where technology is leveraged to improve the relationship between residents and their government. This conceptualization of a smart city aligns with the NUA's participatory and people centered approach, where the public collaborates with local government to improve service delivery, design their community, and co-creates solutions to improve the quality of life of residents and economic competitiveness. Cities become smart with intentional investments in a culture of collaboration, high livability, global competitiveness, security, and safety, and economic and environmental sustainability.

12.3.1 Smart and Open Governance Systems

Thomas Paine (see Political Writings, 1989) states; "there exists a mass of sense lying in a dormant state…" (p. 170) that the government should bring forward to its fullest capacity. This idea holds true today, and as Noveck (2015: XVI) rightly suggests, governments still need to change the way they interact with people, stating a transformation is required that, "takes seriously the capacity, intelligence, and expertise of all people and forges institutions that know how to marshal and use that human capital." Achieving the benefits from smart city reforms requires a governance system that develops and implements policies that leverage technology, and actively involve and collaborate with stakeholders. 'Governance system' is an overarching term that encompasses the way stakeholders interact regarding budgeting, expenditure, participation, and service delivery. Smart local governance must be understood as an ecosystem of stakeholders including, but not limited to local, regional, and national government authorities, private business, both formal and informal, civil society, non-governmental organizations, academic institutions, traditional authorities, and residents. The NUA urges national, subnational, and local governments to, "revitalize, strengthen and create partnerships, enhancing coordination and cooperation…" (United Nations 2016b: 6). A governance ecosystem denotes the high level of interdependency that governments have with external stakeholders. Smart cities ensure that the stakeholders in the system are connected through appropriate digital technology to ensure the ubiquitous presence of ideas, people, and activities. Local governance systems are the closest level of government to the people and, it is argued, they can produce greater and more immediate impact on people's lives. Not only they are the closest to the residents, but they are frequently at the forefront of innovative reforms. The success of governance systems at the local level is largely determined by the effectiveness of their collaboration.

In many cities across Africa, stakeholders within the local governance systems have deficits in skills and/or resources that benefit from a polycentric form of governance that supports collaboration with a large cross-sectoral network (see: Araral 2013). This makes sense intuitively; institutional structures are often weak and local governments struggle with inadequate staffing, technical skills, and financial resources. They have limited access to the latest ideas, innovation, and technology. This can often result in a lack of motivation and incentives for local government staff to take initiative and propose new ideas. As such, external stakeholders involved in local governance systems are crucial to the strategy and implementation of smart city reforms, but they are also beneficiaries of its success. The first layer of collaboration to be addressed is that of internal ministries, departments, and agencies. Inter- and intra-governmental information and data sharing is an ongoing challenge that limits effective planning and resource allocation. In smart governance systems, local government is equipped to make evidence based decisions, collaborate on planning and implementation, and share the risk for infrastructure development and service delivery. Businesses, in smart governance ecosystems, receive increased investments due to economic stability and innovative environments. They operate in an environment that supports business development and product design with access to crucial public-sector data. A smart governance system promotes innovation in academia and provides researchers with the data and access they need to provide timely feedback on service design and implementation. The public benefits through city governments that act more swiftly in response to demand for new services or remediation of problems. They enjoy better community connectivity, increased opportunity to participate in decision-making, increased employment, and an overall better quality of life. At their best, smart local governance systems use technology and collaboration to solve issues for themselves and the people they represent. Stakeholders must come together to address their conflicting interests and any historical barriers to open and mutually beneficial collaboration. The success of smart cities depends on the right investment (from both public and private partners), policies, and robust community participation. Businesses, entrepreneurs, community groups, and individuals must come together to unlock the economic and social promise of smart cities—balancing different needs and keeping humanity at the centre of the equation.

12.3.2 Open Innovation

Attaining improved livelihoods and economic competitiveness through smart city investments requires a confluence between technology and openness in African cities.

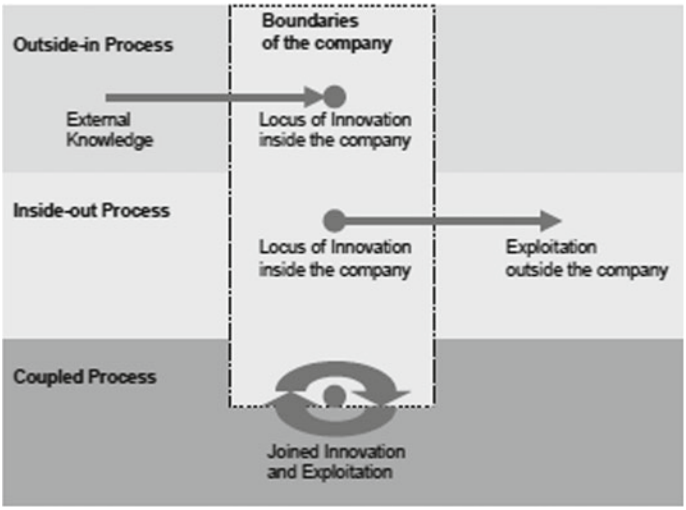

Fig. 12.1 Open Innovation. *Source* Gassman and Enkel (2004)

The promise of opening government means connecting to external stakeholders with diverse experience and skillsets, so government can be more effective and efficient. One emerging concept that supports local governance systems becoming 'smart' is called open innovation. It is an idea rooted in business strategy, utilizing technology and collaboration with external stakeholders to increase efficiency and innovation in policy development and service delivery. Simply, governments that implement the open innovation paradigm interact with external entities to increase their efficiency and effectiveness. In governance terms, open innovation offers the opportunity for stakeholders to co-create policy and services that reflect the knowledge of experts and lived experiences of the public (see: Chatwin & Arku 2017a).

Gassman and Enkel (2004) outline three core innovation processes that we can view through a public-sector lens (Fig. 12.1). The first process, *labelled outside-in*, enriches the information base of the decision-makers by integrating the knowledge of external governance stakeholders. A common example of the outside-in approach is the 'participatory budgeting' agenda, a practice in line with the commitments of the NUA that suggest cities benefit from broadening their platforms for inclusive and meaningful participation.

Pop out box 1: Participatory Budgeting

Participatory budgeting is most common practice of bringing the public into governance by enabling them to play a role in identifying, discussing and prioritizing local expenditures. It is an emerging practice in African urban management that can improve transparency in local government expenditures and stimulate the public's involvement in decision-making. It is increasingly being recognized across Africa as an innovative platform for strengthening the voice of the public, targeting resources to the poor, and supporting decentralization through social accountability.

In Elgeyo-Marakwet, a County Government in Kenya, public participation is required for more than 70% of the County's development budget. This provides a mandated platform for the public to access government information and provide their input into development programs at the community and regional level. Officials from Elgeyo-Marakwet suggest that the residents understand their community needs the best and engaging them in the budgeting and expenditure process can help ensure the development programs and their implementation are meeting their needs.

In Manhica Municipality (Mozambique) the administration set up ward development committees composed of locally based civil society organizations, including faith-based institutions, youth, and women's organizations. The local authority held public meetings for awareness-raising, needs identification and project formulation. The meetings are attended by local politicians and high-ranking public officials who interact to develop and evaluate community-led projects. The political support in Manhica has led to participatory budgeting being entrenched within the system.

Source Elgeyo Marakwet County Government (2016)
UN Habitat (2008)

In participatory budgeting, the locus of control remains with the government, but utilizes the expressed desires of the public. Participatory budgeting empowers community members to contribute their perspective about public spending and revenue, leading to informed, democratic, and fairer decisions. The second process, *labelled inside-out*, provides governmental knowledge and processes to external stakeholders for efficient service delivery. An exciting example of the inside-out process is the global 'civic tech(nology)' movement.

Pop out box 2: Civic Tech

Civic tech refers to a global movement where the public supports the government to do a better job either through voluntary, donor-funded, or crowdsourced initiatives. Civic tech can refer to one off projects, or groups of people that hold regular 'hackathons' to better understand and find solutions to civic challenges. As the name suggests, this support is frequently technology based and takes the form of custom built applications (apps), websites, and online or mobile tools. Civic tech works on the premise that information technology can enable public participation and engagement to improve government, empower residents, create opportunity, and solve public problems. Civic tech can be broadly categorized into two categories; open government and community action. Effective civic tech is a product of collaboration between a government that is willing to open its data and information, civil society, entrepreneurs, and the private sector.

The civic tech movement emerged in Kenya in 2005 with a group working to monitor the Kenyan parliament. The initial project called Mzalendo was designed to fill a gap in the tools available to automate the collection of information on parliamentary debates, records of Members of Parliament, and editorial resources on the processes of government in Kenya. Out of the heavily contested 2008 election in Kenya emerged another civic tech project called Ushahidi. This tool was designed as a way to collect and map eyewitness reports of violence in elections and has since grown to a global tool used in the Haitian earthquake in 2010 and in the recent storms throughout the United States and the Caribbean.

The civic tech movements are often seeded and supported by "Code for [Country]" groups around the world. Code for America and Code for Canada provide online and in-person resources to seed civic tech groups in the United States and Canada respectively. In 2012 Code for Africa was seeded in Kenya with the Code for Kenya citizen lab as its flagship project. This level of coordination and continental support indicates that civic tech movements across Africa will be a significant player supporting the use of government information and data to improve the lives of residents and hold their government more accountable. The widespread impact of the Go To Vote initiative, helping voters across Kenya, Malawi, Zimbabwe, and Ghana locate national registration and polling centres, indicates that the public are ready to lend their expertise in support of government reform. There are movements sprouting across Kenya, Tanzania, and Uganda focused on social accountability, monitoring public services, campaign fairness, and parliamentary monitoring, providing members of the public a platform to monitor and contribute to issues of local and national concern. Cities in Africa are ready for their own civic tech movement and any smart city initiative will only benefit from collaboration between interested and engaged members of the public, who are technologically proficient, and their government.

Source Mzalendo 2018
Code for Kenya 2018

Civic tech groups work on technology projects involving intentional collaboration between technologists, bureaucrats, entrepreneurs, and civil society to solve civic problems. The locus of control is predominantly within the civic tech community. They take government information, often released with the hope that others will work with it, and to create a deep understanding of the needs of the community and seek technology based solutions. The third, *coupled process*, links the outside-in and inside-out by creating strategic alliances with all governance stakeholders for policy and service design. The coupled approach is true collaboration as the locus of control is not held within the government or external to the government. The City of Paris, following the examples of cities in Mexico and Brazil, has launched an innovation lab.

Pop out box 3: Innovation Lab

Local governments around the world are searching for innovative solutions that enhance the design and delivery of public services. They are beginning to reach out to the private sector and the public, to become partners in solving key social challenges. Innovation labs provide a controlled space to foster collaboration between multiple partners from diverse sectors. The term 'innovation lab' is used to describe one-day intensive collaborations and more permanent structures that host ongoing collaboration between sectors. They have been a feature of collaborative business for the past decade or more and are beginning to gain traction in city government to foster creative solutions to civic problems and share responsibility for design and decision-making. City led innovation labs are intended to equip local governments to make user-centered public policies. They can be used as spaces to train civil servants and spread the culture of public innovation within local government administration.

While there exists a plethora of innovation labs in Africa that are seeded and controlled by supranational organizations (Africa Gender Innovation Lab 2018; Unicef Innovation Labs 2018), local government public service focused labs are still in a nascent stage across the continent. Local governments in African countries can benefit from lessons learned in cities like Mexico, Sao Paulo, Paris, Madrid, or Rio. While the context is surely different, the governance structures and approaches to innovation would be adaptable across the spectrum.

The ParticipaLAB in Madrid promotes itself as, "an interdisciplinary work space oriented to the study, development and practice of participation processes that can promote a direct, deliberative and distributed democracy" (2017). Stakeholders in the lab benefit from interactions with unexplored partners towards the aim of direct and participatory democracy. Mexico City's LabPLC promotes itself as an example for developing-world cities wrestling with urban problems. It has modeled itself after similar efforts in the US and the UK to be a place where creative people inside and external to the local government can innovate and test new ideas and technologies. LabPLC offers fellowships and hackathons to engage developers, academics, journalists and youth who want to create applications with city data. They have partnered with Code for America and have opened their doors to host international professionals interested in documenting and contributing to the work of lab.

Note to authors: City of Madrid (2016)
Arana (2014)

An innovation lab is dedicated to developing user-centered public policies through using a collaborative approach with external stakeholders. Innovation labs use design thinking methods; immersion, observation, investigations, interviews, prototyping, and experimentations to address the social and economic issues in the city. By including the public every step of the way, the lab serves as a tool for promoting accountability. The challenge to open innovation at the local governance level is often existing policy and legislation that governs interactions with stakeholders. Frequently, closed processes are legislated and decision-making is confidential. This is especially true in African cities where decentralization is incomplete and the national government mandates many local processes. Smart governance requires local government to examine the power relationships between governance stakeholders and identify limits to collaboration. The concept of open innovation is important to the participatory aspects of good governance because it opens the policy cycle, service design and implementation processes to outside stakeholders (Mergel & Desouza 2013). For this concept to successfully contribute to smart governance, local governments must commit to smart participation, smart transparency, and smart accountability.

Technology enabled open government reforms foster smart systems that provide feedback on the day to day issues and demand involvement in the political process. In this context, 'open' is reflective of a particular administration's willingness to redefine its relationship with stakeholders with the support of new technology and digital innovation. The theme of openness is most commonly expressed in the public sector as open access, open data, open knowledge, open platform, and open source. An interesting discussion within smart and open governance centers on the relationship necessary for the public to be willing to have government collect both passive and active data. While public data helps cities fix problems and provides powerful new insights into the functioning of urban services, it also shifts the relationship between city governments, businesses, and residents fundamentally. If residents are expected to provide feedback on potholes, street-light outages, or uncollected waste, they may also expect to be able to voice concerns about bigger issues, such as budget and investments, and seek more direct participation in the political process. This trend has important implications for local authorities as they pursue smart city strategies. They need to do more than invest in hardware and software and increase their capacity to use this equipment. They must also shift the culture of their governance system, moving away from an isolated top-down approach to one in which all stakeholders have the information and avenues to participate in shaping the city of the future. As African cities continue to experience rapid urbanization, there is an opportunity for various administrations to invest in emerging smart technologies to open their governments to collaboration with external stakeholders.

12.4 Principal Tenets of Smart and Open Urban Governance in Africa

There is a necessary confluence between 'smart' and 'open' government reforms for African cities to realize a return on their investment in improved livelihoods and economic investment. This section discusses the core tenets that are a part of both smart and open governance systems (for a more detailed examination of open government see: Chatwin & Arku 2017b).

12.4.1 Transparency

Transparency is a fundamental starting point for smart and open governance because the success of participation, collaboration and accountability depend on governments' proactive disclosure. Transparency refers to both the process; the way governments work, and information; the data government produces and collects. Transparency in informational terms can be referred to as 'vision' and transparency in participatory terms can be referred to as 'voice' (Meijer, Curtin, & Hillebrandt 2012). Local governments around the world produce and collect a broad range of different types of data to perform their tasks. The extraordinary quantity and centrality of data collected by governments make these data particularly significant as a resource for increased public transparency. Opening information into the public domain can benefit society by creating conditions for more inclusive service delivery and for more participatory democracy. It can stimulate the economy by allowing the possibility for open innovation with external parties to create new products and services using public data. The internet and associated digital advancements have significantly reduced the cost of data collection, management, and use, making transparency to external stakeholders feasible. Information transparency consists of freedom of information, active dissemination of information, access to data and usability of websites and portals. Discussions of information transparency generally focus on innovative uses of technology. Smart governance systems in African countries will need to address significant policy, technological and capacity challenges to properly manage emerging sources of data and information.

Open data initiatives are an approach frequently used by governments around the world to improve their information transparency. In this context, data is anything produced or commissioned by governments. Open data ensures that government information can be freely accessed, used, and re-used, by anyone. Relevant data sets included, but are not limited to, business information (including Industry Associations and Business Improvement Associations), public tender databases, geographic information, legal information, meteorological information, social data, and transportation data. African governments need to think carefully about whose interests are being served from the release of data sets. The data that is high value for the business community may not be a priority for residents interested in participation and accountability. All information released under transparency initiatives should be evaluated on its newness, respectability of source and frequency with which a problem is drawn to the government's attention by the public. While an overdependence on technology can reduce interaction between governance stakeholders, digital technology can be used to enhance engagement through timely (often automated) releases of information and access to decision-making processes. Access to policy cycles and decision-making processes ensures that the public understand the inner-workings of government. This ensures that the public understand how government data and information is produced and how to insert themselves into the formal and informal arenas. Transparency in government process is a precondition for public participation. It provides the public with a window into what their government is doing, so that they know whether or not their political leaders and technocrats are acting in the best interest of the populace. Providing vision and voice supports informed participation; residents can contribute to service design and decision-making based on knowledge and access to the governance arenas. Increased transparency provides the basis for public participation and collaboration in the creation of innovative, value-added services. However, for a government to really be considered open, there needs to be public use of the data.

12.4.2 Public Participation

The extent and level of public participation most beneficial to government decision-making and service design is arguable. However, representative democracy, the system upon which many countries have been built on, is being fiercely questioned due to corruption, abuse of power and inefficient use of public funds. There is steadily increasing pressure on local governments around the world to be open and provide residents more opportunities for meaningful participation. The necessity of public participation in service design and decision-making is a significant component of the current United Nations' Sustainable Development Goals (SDGs), specifically, No.16, which calls for building effective, accountable, and inclusive institutions at all levels. The NUA also centers on people-centered and participatory governments at the local level (UN Habitat 2016). Participation is an integral component of smart and open governance. Various forms of citizen participation must be prescribed and organized by laws and regulations, and monitored at central and local levels. The United Cities and Local Government (UCLG 2015:13) outlines the following methods: (1) consultation processes whose mechanisms are formalized and effective; (2) the possibility for citizens to submit petitions regarding areas of concern; (3) the ability to instigate citizen-led referendums; (4) an ongoing practice of participatory budgeting; and (5) invitations for the expression of public opinion through satisfaction surveys. The multiplicity of methods helps to balance the ideas that are not sustainable or relevant in the local context, but ensure that appropriate and expansive public participation is ongoing and inclusive of even the most marginalized groups. Civic participation is imperative for addressing exclusion and inequity in resource

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decision.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Fig. 12.2 IAP2. *Source* International Association for Public Participation (IAP2) (2005)

distribution. Reform efforts must recognize that participation must accommodate the diverse interests of the public and varying levels of political, economic, and social power. Smart governments will have to be prepared to attend the desires of their residents, with demands for a more direct and real contact with those who manage their city.

There are many different typologies for civic participation, typically outlining the level of public control on decision-making. They are often visualized as a ladder or a continuum from information dissemination (no public decision-making ability) to processes controlled by the public. The IAP2 framework (2005) (Fig. 12.2), widely seen as best practice, suggests that public participation must: ensure that contributions will influence the decisions, facilitate the involvement of those affected by decisions, provide participants with the information they need to meaningfully participate, and communicate how their input affected the outcome.

One of the principal barriers to meaningful participation in many African cities is insecure land tenure and poor civil registration systems. Often governments do not have a record of residents within their jurisdictions, especially those in informal housing and employment. In most African cities, the land governing system is complicated by a dual land tenure system (public and traditional/private). In most cases, operating these two systems without proper rationalization often results in frequent conflicts due to their differences in their underlying governing systems. Overall ineffective laws and administration mechanisms for land tenure creates situations where the public are in a consistent state of conflict with the local government. While this discussion merits further attention beyond the scope of this chapter, it is important to note that secure land tenure is fundamental to collaborative relationships between the public and government (see Mboup 2017). Enhanced use of technology in land development, planning, registration, while not a panacea, will go a long way in creating stronger relationships between government and the public.

There has been a significant increase in the use of technology for facilitating public participation. Technology has primarily been used for the lower end of the participation ladder, but it has the potential to provide more innovative ways of sharing information and collaboration. New digital feedback channels have the potential to shift the traditional relationship between municipal governments and its constituents. Audience response software can be used online or in-person to quickly poll and obtain input from participants, which can then be used to facilitate further discussions. E-participation methods such as email, chat, news and dialogue groups, as well as virtual communities are also useful when residents and stakeholders are spread over a large geographic area. At its best, technology is used in support of, not as a replacement for, other traditional forms of in-person participation opportunities. When considering the technology/approach to utilize in public participation, it is important to understand what approach aligns with the desired outcome. Typically, complex issues of high interest to the public should have intensive participation opportunities and processes that use a variety of interdependent tools and activities.

12.4.3 Accountability

Accountability is the public's ability to monitor and influence government processes, through being equipped with the necessary information and access to decision-making arenas. It is fostered through transparency and meaningful opportunities for participation. Unfortunately, in most African countries, administrative data is often fragmented and scattered across departments. To aid accountability, city governments aggregate data and share it with stakeholders. The benefits to this are two-fold: internal use of data is strengthened through making it available across departments, and external use of data to support accountability is fostered. Smart and open governance requires a focus on downward accountability, where the public and other stakeholders are empowered through information and process transparency and participation opportunities, to measure the level and quality of governance. The existing system of representative democracy has proven to be insufficient in holding governments to account, especially when voter turnout in local elections is often low. There has been a shift in modern values that has created urban residents who will ask for real-time data, to monitor and evaluate the performance of the city in open standards. Effective reforms must be responsive to this change and institute avenues for all members of the public to hold government to account and recognize, validate, and utilize formal and informal networks. As technology continues to improve and become more accessible, the public will become increasingly able to express their views on policy, programs, services, and investments. Civically active residents will question inefficiencies and inappropriate taxation or spending. City authorities that manage to navigate the new relationship with the public and build a level of trust will benefit from increasingly engaged constituents.

12.4.4 Reflective

Much of the road ahead in the development of smart cities in Africa, through smart and open governance systems, is uncharted territory. This necessitates that reflection and feedback be embedded into the design of practical projects providing for fast and systematic learning. Feedback offers invaluable perspectives on the reforms and allows people to maintain ownership of the process. When local governments are open to feedback it allows for course corrections before challenges become deeply entrenched as a way of doing business. Governments should embed the process of collecting feedback into smart and open reforms prior to launching them. Establishing clear and accessible avenues for feedback allows governments to gather rich insights from various stakeholders. Likely, the first-hand experience of the private sector will be different from that of civil society or academia. People who have historically been marginalized and are being recognized and included for the first time will likely have a different perspective than those who have always had positions of privilege. Collecting feedback is only a valuable exercise to the extent that it is analyzed and reflected upon by local government implementers. In fact, gathering feedback and not acting on it can have significantly negative consequences and damage the trust that the smart and open reforms are attempting to build.

How can the effectiveness of policy and service design be monitored and measured? Noveck (2015:144) suggests that "the first step toward implementing smarter governance… is to develop an agenda for research and experimentation…" Further, Noveck notes the need to test participatory approaches, "at the different stages of decision-making, including identifying problems, prioritizing the agenda, identifying solutions, choosing which solutions to implement, and assessing what works—to prove when and how it makes sense to use outside expertise" (2015:144–145). Presently, scholarly research is playing an important role in influencing and shaping the evolution of smart and open governance and an area where city governments can engage the support of the research institutions within their governance system. Concepts such as open innovation are a radical change, shifting from closed to open within a government, but they should not happen without evidence that open is working in the context. Agile experimentation can provide the necessary evidence to determine if reforms are working and where adjustment is required. Both practitioners and academia benefit from identifying what practices are essential components for the development and realization of smart and open governance. It is also important to gain an understanding of what limitations exist. An understanding of the facilitators and barriers to the development of smart cities in Africa can be shared, with cities at the beginning of their journey, saving fiscal and human resource investment. However, current research on smart and open reforms focuses almost exclusively on success stories and desirable outcomes. For cities to be truly reflective, they will need to also focus on the lessons learned from failure and challenging situations as well. Academic research can accelerate the learning process and implementation by systematically sharing the results of studies across all elements of smart governance. This can lead to sounder and more elaborated models of smart governance than when such initiatives are left to trial-and-error approaches in practice alone. Since quite a few smart governance initiatives are in nascent stages, research, including (participatory) action research, should accompany such initiatives and should be funded as an integral part of smart and open government projects.

Participatory action research, one of the preferred methods of government led research into change projects is, "a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human purposes, grounded in a participatory worldview" (Reason & Bradbury 2001:1).

Pop out box 4: Zambia case study

The town of Luanshya, Zambia, located 337 km away from the capital city of Lusaka researchers employed an action research approach to examine how actors decided upon and implemented an open dialogue platform at the local governance level. The objective of the project was, as stated, "to create an online space for Luanshya Municipal Council, citizens, public and private organizations, NGOs and anyone having an interest in the town to interact in meaningful and constructive ways for the benefit of the community as a whole" (Baka 2016:1). Action research is designed to lead to social action and is process of collecting data to understand the problems, collaboratively proposing and designing solutions, planning implementation strategies, and evaluation of the outcomes. In this particular iteration of action research interviews, focus groups, field notes, and online participant observation were the data collection methods. In participatory action research, the immersion of the researcher blurs the line between researchers and subjects. In Luanshya, the researcher was a part of a group that helped implement a dialogue platform as a strategy to support improved communication between the local government and its residents. In as sense, the researcher became a co-creator alongside the residents and the local government stakeholders. This project took place over a period of nine months where the stakeholder perceptions of openness were gathered to inform the design and co-creation of a technology intended to create an open space for dialogue. The design of open spaces does not guarantee an improvement in governance or democracy, however, building action research into the co-creation process ensures that residents have an active voice in designing the tools. These tools constitute a small step towards increased resident engagement in decision-making and service design (see: Baka 2016).

Source Baka (2016)

The distinguishing characteristics of action research are the focus on lived experience, collaboration, and working with people instead of merely studying them. It is a research methodology that aims at contributing to social intervention and improvement in the lives of people, especially those that are marginalized. It acknowledges that outside experts cannot address people's challenges and that stakeholders must be directly involved in formulating solutions to the problems they confront. The result of having stakeholders participate in the evaluation process is the development of mutual understanding of the interconnectedness of their situation, resulting in increased investment and ownership of putting the results into action. Action research is grounded in qualitative research and often utilizes in-depth interviews, focus groups and other familiar methods. Stringer (2007) suggests three stages of the methodology: look, think and asct. The 'look' stage is the literature review, document analysis and data collection portion of the methodology. The 'think' stage is the data analysis, commonly accomplished using thematic analysis. This stage attempts to analyze the perceptions of stakeholders and work toward a viable solution to addressing the challenges and directing people's energy and investment. The 'act' stage is the development of recommendations for change, proto-typing of interventions and revising of action plans.

12.5 Conclusion

This chapter began with a key question; Can a focus on 'Smart Cities' support local governments to create an enabling environment that mobilizes governance actors to increase the prosperity and liveability of cities? Exploring the broad context of African cities and their ongoing urbanization, highlights the necessity of multiple governance stakeholders to catalyze growth and improve the livelihoods of all residents. There is increasing pressure on governments to be efficient and responsive to the voices of the public. People around the world are starting new movements and creating public spaces where they are demanding real and open democracies. New technologies have facilitated the appearance of new highly collaborative environments that allow the immediate exchange of big amounts of information and facilitate the access and use of this information by its users. The public has embraced the use of these spaces and press their local government to use these channels for more direct and fluid interaction between all governance stakeholders. Equipped with a steady flow of constituent feedback and trust built on realizing the positive benefits of technology, communities will be rewarded with powerful new insights into the functioning of infrastructure and the demand for city services. Seeing the benefits that sharing their data can bring, people will begin to articulate more explicitly and regularly how they want their cities to develop.

The benefit of *'Smart and Open Urban Governance in Africa'* is therefore to create an enabling environment where all governance stakeholders can contribute to increased prosperity and liveability for all. City leaders, through appropriate ICT facilitated transparency and participation, can build a community of stakeholders who care deeply about their urban environment. However, there will be no smart cities without smart governance and there will be no smart cities without open, transparent, and collaborative systems of governance. Despite the inherent value that technology holds for good governance, it is imperative that African governments first understand and accept an overarching philosophy of openness. Focusing on technology, instead of transparency supported participation and accountability, provides a way for city governments to avoid the more difficult work of culture change.

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Chapter 13
Smart Social Development Key for Smart African Cities

Priscilla Idele and Gora Mboup

Abstract This chapter focuses on the Social Development dimensions of smart cities, composed of elements of health and education. Healthy workers are more productive, and bring greater income to families and higher levels of economic growth for nations, and, in turn, enhance smart economy. First the chapter focuses on health considering that a healthy population is critical to realizing any social and economic development. Then the chapter concentrates on Education, which is critical to meeting the challenges of smart city, as it connects people to new approaches, solutions and technologies that enable them to identify, clarify and tackle local and global problems. When education and health are combined, undoubtedly they contribute significantly to human development. In both these critical dimensions, African cities have made significant progress during these past twenty years, and continue to do so as we progress through the 21st century.

Keywords Smart city · Smart economy · Social development · Education · Health Youth · ICT

13.1 Introduction

A smart city is viewed as a sustainable, inclusive, resilient and prosperous city that promotes a people-centric approach based on three core components and seven dimensions. As presented in the first Chapter of this book, the three core components are Smart City Foundation, Smart ICT and Smart Institutions and Laws, which in turn are the pillars of the seven dimensions of a smart city: Infrastructure Development, Environmental Sustainability, Social Development, Social Inclusion, Disasters Exposure, Resilience, and Peace and Security. The three components together

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with the seven dimensions make a Smart Economy. This chapter focuses on one of the dimensions of a smart city, the Social Development which is composed of elements of education, health, social inclusion, social capital, population dynamics, and other variables. The first section of this chapter is on health considering that healthy population is critical to realizing any social and economic development.[1] Healthy workers are more productive, bringing greater income to families and higher levels of economic growth for nations. The second section of this chapter is on Education, which is critical to meeting the challenges of smart city, as it connects people to new approaches, solutions and technologies that enable them to identify, clarify and tackle local and global problems.

13.2 Smart Healthy Cities for Smart Social Development

A healthy population is critical to realizing any social and economic development. Healthy workers are more productive, bringing greater income to families and higher levels of economic growth for nations. African Urbanization is a driver of better health services and outcomes, but it also comes with Challenges and Externalities associated to emerging modern environment health hazards. Smart Healthy cities can, however, be achieved through smart urban planning and digitalization of health services and systems. This section is sub-divided in three sub-sections: (1) 13.2.1 African Urbanization as a driver of better health services and outcomes; (2) 13.2.2 Urbanization Challenges and Externalities: Health Inequalities and Emerging Modern Environment Health Hazards in African cities and; (3) 13.2.3 The road to inclusive, Smart Healthy cities through Urban Planning and ICTs.

13.2.1 African Urbanization as a Driver of Better Health Services and Outcomes

With the highest urban growth rates in the world (3.3% per year between 2000 and 2015), Africa will be predominantly urban by 2035. As presented in the second chapter of this book, four out of ten of African people live in cities and towns (42.5% in 2018). In terms of absolute number, in 2018 more than half a billion of African people live in urban areas (548 million), and it is projected that the African urban population will reach one billion in 2040.[2]

The level of urbanization is generally associated with numerous, positive societal outcomes, such as technological innovation, various forms of creativity, economic progress, higher standards of living, enhanced democratic accountability, and

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[1] African Union and ECA, COM2013 (2013).

[2] UN population Division, Department of Economic and Social Affairs, 2018. World Urbanization Prospects: The 2018 Revision. New York (USA).

women's empowerment. This makes cities places of opportunities where people tend to concentrate. Basic services make a significant contribution to the "urban advantage", and together with employment, feature high among the aspirations of those who move to cities in search of a better life. In the dreams of all those who move to urban areas, cities foster the healthy development of children and young people, providing easier access to education, health care and employment than is available in rural areas.[3]

Remarkable progress in health care in African cities

The Demographic and Health Surveys (DHS) held in African countries show a constant progress in access to health services in African cities during the past 25 years. In the 1990s, access to health services was very limited and infant and child mortality rates were consequently high. The steady improvement in health coverage was accelerated during the 15 years of the Millennium Development Goals (MDGs). There is no doubt that improvement in health is significantly contributing to the smartness of African cities. Children born in cities have more access to health services such as antenatal care (by their mothers), delivery care and immunization than those born in rural areas.

For instance, in Ethiopia, when we consider all four types of vaccinations, the percentage of children with all vaccinations is 48% in urban areas against 20% in rural areas according to the 2011 Ethiopian Demographic and Health Survey. The 2014 Kenya Demographic and Health Survey provides a coverage of 83% in urban areas against 77% in rural areas.[4] The 2013 Nigeria Demographic and Health Survey Nigeria showed huge disparities in immunization coverage from 43% in urban areas to 16% in rural areas.[5] Analysis of DHS conducted in 2012 in East Africa showed that in African cities coverage of child immunization is high both in non-slum and slum areas, a situation that shows that living in cities provide remarkably the opportunities of access to better health care. For instance, in Ethiopia the immunization coverage was estimated in 2011 at 73.5% in non-slum areas and 43.1% in slum areas against 20% in rural areas.[6]

Although health care access and delivery are skewed in favour of the rich in cities, all children in urban areas in the country are better off than their counterparts living in rural areas, with regard to health care access. In most African countries, rates of the measles vaccine and antenatal cares are higher in cities than in rural areas. This urban health advantage benefits all urban dwellers regardless of their migration status[7] as noted by Mboup (2012).[8] In Cameroon 88% of women rural migrants in urban areas have access to antenatal care compared to 71% for those living in rural areas. In Mali, while only 53% of rural women have access to antenatal care,

[3] UN-HABITAT (2010).

[4] Republic of Kenya et al. (2015).

[5] Republic of Nigeria et al. (2014).

[6] UN-Habitat, 2012. Global Urban Observatory Database 2012.

[7] Mboup (2011).

[8] See Footnote 7. For more details, UNECA et al. (2015).

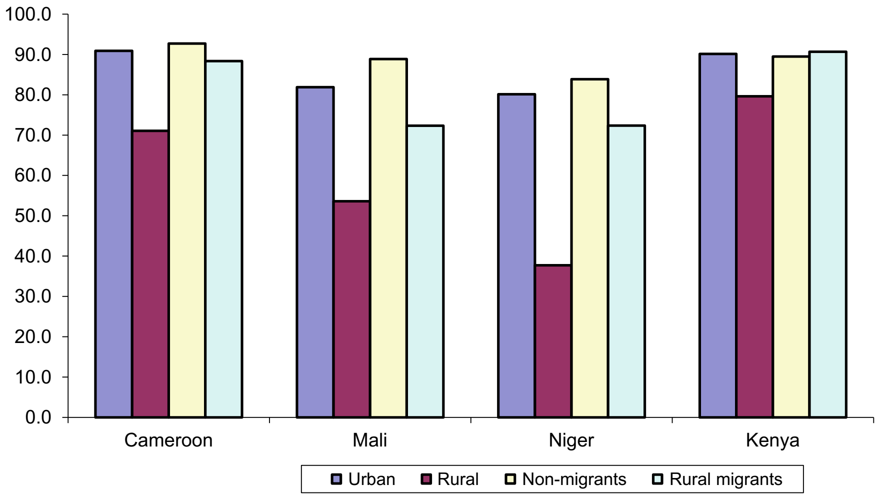

Fig. 13.1 Percentage of women aged 15–49 with a live birth in the last five years that received antenatal care visits (2 or more times) in selected African countries. *Source* Mboup (2012)

73% of those in urban areas have an access of antennal care. In Niger the coverage of antenatal care among rural migrants is twice the coverage for rural women. The effect of urbanization on access to health care services is undeniably positive regardless of the place of residence. Similar patterns are observed with the measles vaccine coverage (Figs. 13.1 and 13.2).[9]

Impressive progress in reducing child mortality

During the MDG period (1990–2015), the overall infant mortality in the African region decreased from 90 deaths per 1000 live births in 1990 to 54 deaths per 1000 live births in 2014, a decline of 40%.[10] This mortality decline is particularly pronounced in 18 African countries where the infant mortality in 2012 is less the half of its level in 1990. For instance in Egypt, Liberia, Malawi and Tunisia, the infant mortality was reduced by over 65%. In 26 countries the decline of the infant mortality is between 20 and 49.9%. However, in countries such as Lesotho, Swaziland and Zimbabwe, there was noticeable increase in under-five mortality rates. High infant mortality rates above 100 deaths per 1000 live births are still observed in African countries such as the Democratic Republic of the Congo, Sierra Leone, Somalia and the Central African Republic.

[9]See Footnote 7.

[10]See Footnote 8.

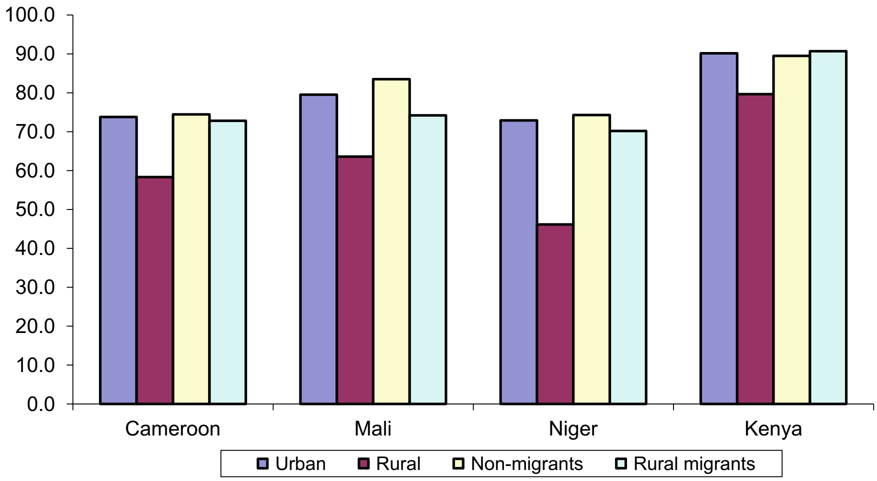

Fig. 13.2 Percentage of children 12–24 with measles vacccination in selected African countries. *Source* Mboup (2012)

Box 13.1 Significant Decline of Infant and Child Mortality Rates Make Living in Dakar Smart

In the context where access to health services has significantly improved, mortality has also significantly decreased, particularly among children under five years old. Infant and child mortality rates have been more than halved during the past 15 years. In particular, infant mortality has significantly decreased from 59 per 1000 in 2000 to 28 per 1000 in 2015, the child mortality from 35 per 1000 to 13 per 1000 during the same period. The under-five mortality rate, on the other hand, has decreased from 87 per 1000 to 41 per 1000. The decline of mortality rates has also been observed in other parts of Senegal, but to a lesser extent, making the figures of Dakar much better than the national figures. Life expectancy in Dakar is estimated at 69.6 years with an advantage of 2.5 years for female compared to male, 70.9 years and 68.4 years respectively. Overall, people living in Dakar live five years longer than those of others regions; the national life expectancy is estimated at 64.8 years. It is important to note that Senegal has experienced a remarkable improvement on health with the life expectancy of 10 years higher than the level 15 years ago. In 2000, the life expectancy was estimated at 56 years.

In Dakar, in the past fifteen years, there has been a significant decrease in malaria-related deaths from 40% in 2000 to less than 5% in 2015 contributing to the remarkable decline of mortality as observed in the same period. The prevalence of fever, among the symptoms of malaria, has also drastically decreased, estimated at over 40% to less than 20% in 2015 during the same period as indicated by DHS and MICS data. A hemoglobin level less than 8.0 g/dl is an indication of severe anemia. In African countries, the National Programme to fight against Malaria (NMCP) has included in its strategic planning the promotion of the use of Insecticide Treated Nets (ITNs) as a major axis of intervention for reducing morbidity and mortality due to malaria. To achieve this objective, the NMCP and its partners have implemented procurement and distribution activities "Impregnated mosquito nets Insecticide to Long Term Action". This distribution is performed during routine activities through health facilities and community-based organizations. Since 2000, with the spread of chloroquine resistance, most African countries adopted sulfadoxine—pyrimethamine combination plus amodiaquine for the treatment of uncomplicated malaria. Then in 2006 according to WHO recommendations for the management of confirmed cases of uncomplicated malaria, Senegal adopted a Therapeutic Artemisinin-based combination.[11]

Source: Mboup (2017).

13.2.2 *Urbanization Challenges and Externalities: Health Inequalities and Emerging Modern Environment Health Hazards in African Cities*

Despite the urban advantage, urbanization has also come with challenges that can be enormous such as finding a decent job and accessing basic services—adequate shelter, safe water, adequate sanitation, food, education and health services. In many African cities, living conditions in slum communities are worse than in rural areas. The poor are typically driven to the least developed areas of a city, often places that are poorly integrated to the urban fabric, where dilapidated environments lead to worse health outcomes and greater risks of premature deaths than in improved and well-maintained urban areas. This chapter argues that in cities where a higher degree of equality prevails—including lower income disparities, lower incidence of slums and only small numbers of slum dwellers with various shelter deprivations—the occurrence of ill health tends to be noticeably less frequent. Conversely, public health is generally poorer in more unequal cities that feature stark material differences in housing and basic service provision. Better housing conditions are therefore essential to ensuring a healthy population. For instance, in cities featuring large numbers of households with all four basic shelter deprivations, the prevalence of diseases such as diarrhoea rises twofold compared with the whole city, and about threefold or more when compared with the non-slum areas of the same city.[12] Moreover, child mortality rates remain highly associated with diarrhoeal diseases, malaria and acute respiratory

[11] Mboup (2017).

[12] UN-Habitat (2010).

infections related to overcrowding and air pollution; these in turn result from various environmental health hazards such as lack of sanitation and hygiene, lack of access to safe water, poor housing conditions, poor management of solid wastes, and many other hazardous conditions. Children in substandard environments are exposed to contaminated air, food, water and soil, and to conditions where parasite-carrying insects breed.

Beside health inequalities, modern environmental diseases appear to impede decline in morbidity and mortality rates. These modern environmental diseases are associated to change on urban life with the increase of motorized means that has enormous negative impacts on people's lives. Modern environmental health hazards include, but are not limited to, water pollution, urban air pollution from automobiles, radiation hazards, land degradation, climate change, and emerging and re-emerging infectious diseases.[13] The occurrence of several modern environmental health hazards and their sources has been noted in industrialized and urbanized African communities.[14,15] It is estimated that indoor air pollution is responsible for between 2.7 and 2.8 million deaths annually.[16] This makes it the second leading environmental health threat in the world, especially in women who cook and their children.[17,18] Women usually have the added responsibility of caring for children who are then also exposed to high levels of indoor air pollution on a daily basis.[19] Strong associations between bio-fuel exposure and increased incidences of chronic bronchitis in women and acute respiratory infections in children have been documented.[20] Indoor air pollution is a quiet and neglected killer, with lack of global awareness being one of the primary obstacles to the widespread implementation of existing, proven interventions.[21]

Due to lack of public transport, African cities are also haunted by motorized traffic dominated by buses at old age, leading to high emission of CO_2 and to what is called

[13] Corvalán et al. (1999).

[14] United Nations Environment Programme (UNEP) (2002). Nweke and Sanders III (2009).

[15] United Nations Industrial Development Organization (UNIDO) (2004).

[16] Bruce et al. (2000). Potential harm is the greatest for children under one year, since their lungs and immune system are not yet fully formed. Household use of biomass fuels has been found to significantly increase the risk of acute respiratory infections, which annually kill millions of children under age five. See also Smith et al. (2000).

[17] Smith et al. (2000), Bruce et al. (2002).

[18] Engel et al. (1998), Bruce et al. (2002).

[19] Potential harm is great for children under one year, since their lungs and immune system are not yet fully formed. Household use of biomass fuels has been found to significantly increase the risk of acute respiratory infections, which annually kill millions of children under age five. See Smith et al. (2000).

[20] Smith et al. (2000).

[21] Staton and Harding (2001). Staton et al. noted that the United Nations Environment Programme/World Health Organization Global Environment Monitoring System (GEMS) has confirmed that the worst overall air pollution conditions and the largest indoor pollutant concentrations and exposures are found in both rural and urban areas of the developing world. See also Global Environment Monitoring System. Assessment of Urban Air Quality. United Nations Environment Programme/World Health Organization, 1998. (Unpublished document cited in Chen et al. 1990).

modern environmental health hazards that may, in certain conditions, supersede traditional hazards. With the increased use of cars, a sedentary lifestyle is becoming more common among the urban middle and upper classes; contributing to increased obesity, in addition to increasing air pollution and greenhouse gas emissions.[22] Cardiovascular diseases have become a serious public health problem. Long neglected, given the magnitude of communicable diseases, they are now the second cause of death in health facilities in African cities after malaria. These are chronic diseases with expensive heavy burden of morbidity and mortality. Among the risk factors associated with cardiovascular diseases are hypertension, cholesterol and diabetes associated to smoking and obesity. Among the cardiovascular diseases, heart failure is also a major concern as being the first cause of hospitalization in hospital cardiology services. Another factor affecting health is the occurrences of disasters related to flooding, amplified by climate change. Climate change contributes to the increase of sea levels as recently noted in several African cities. The impacts of floods on people and communities are enormous ranging from economic, social and health issues to environmental aspects. Flooding affects the few existing social and community facilities such as schools, health centers, and markets. Floods are the most common natural disasters and the leading cause of fatalities in African cities and in the world generally.

13.2.2.1 The Road to Inclusive, Smart Healthy Cities Through Urban Planning and ICTs

Universal Health Care (UHC) is central to the Sustainable Development Goals (SDGs) adopted in 2015. The target 8 of Goal 3 on "Ensure healthy lives and promote well-being for all at all ages" is to "Achieve universal health coverage". This implies all people receive high-quality health services they need without suffering financial hardship.[23] Achieving UHC requires holistic approaches in policies, programmes and actions, including in urban planning, as well as, the use of information and communication technology (ICT) to digitize health services and systems.

13.2.2.2 Urban Planning for Inclusive, Smart Healthy Cities

Access to health services is influenced by the ways cities are planned, designed and managed. Adequate urban planning can help or hinder the development of opportunities for all. Planning an inclusive, healthy cities should include a sustainable, inclusive dimension that also benefits all citizens. While urban planning has the potential to promote inclusiveness of cities by ensuring the equitable distribution of city amenities, it has too often been used as an instrument of exclusion. Indeed, "master urban planning" has been often manipulated by elites to capture land and

[22] See Chap. 8 "Urban Accessibility and Mobility" and Chap. 9 "Air Quality in African Cities".
[23] WHO (2016).

infrastructure with millions of people living in unsuitable, insecure conditions, often characterized by a lack of basic services and serious health threats.[24] One solution is to focus more on the creation of inclusive healthy cities where urbanization is not only a positive force for economic development, but also one that has desirable social outcomes. In those cases, where urbanization has not been concomitant with significant improvements in quality of life, other divisive factors may be at play, such as extreme inequalities, conflict, inadequate or ineffective policies, which can block development or substantially set back progress. An inclusive healthy city shall address economic as well as social, political and cultural equality across all segments of society.[25] Cities must develop a vision that integrates everyone and put in place institutions that promote inclusiveness, accountability and efficiency.

The fight against child diseases should also go beyond the traditional environment of diseases which is the household, to the so-called modern environment of diseases—outdoor pollution, climate change, environmental degradation, etc. It must be at the city foundation level as well as the infrastructure development level. At the city foundation, it is required a better city planning combined with a good coverage of basic infrastructures. At the infrastructure development, this will go with the promotion of public transport and walkable streets in order to reduce emission of CO_2, and finally outdoor pollution. Streets that promote walkability and cycling as elements of an active lifestyle contribute to healthy living, as well as reduction in vehicle emissions. Many important quality-of-life benefits also arise when streets promote non-motorized transport. Increased outdoor activity and reduced air pollution translate into better public health in reducing heart diseases associated with obesity, high blood pressure, and diabetes which are now common diseases among the middle class and the richest families in cities.

ICT Revolution and Smart Health Services

Information and communications technologies (ICTs) can play a critical role in improving health care for individuals and communities. By providing new and more efficient ways of accessing, communicating, and storing information, ICTs can help to bridge the information divides that have emerged in the health sector in Africa, particularly between health professionals and the communities they serve and between the producers of health research and the practitioners who need it. Through the development of databases and other applications, ICTs also provide the capacity to improve health system efficiencies and prevent medical errors.

Universal Health Care calls for transformative actions with increased integration of ICTs in the health sector: transforming the analog health sector to an ehealth sector.[26] The WHO Report for the World Summit on the Information Society in

[24]UN-Habitat (2010), Mboup (2011, 2013).

[25]Sen (1999).

[26]At 58th session in May 2005, the World Health Assembly (WHA) adopted a resolution WHA 58.25 establishing eHealth strategy for WHO promoting the use ICTs in the health sector and

Tunis (2005) underscores the close link between health and ICT: "Today, ICT is fundamental for health systems to meet obligations to deliver care, pursue research, educate students, treat patients and monitor public health". The smartness of health care will depend on how well ICTs are integrated in health services and systems for efficiency of care delivery. Innovative care delivery comes along with ehealth for prevention as well as treatment care. Transformational change in care delivery will result from emerging, ubiquitous, participatory preventive and personalized smart models of care. Various possibilities in care delivery are associated with the use of mobile devices and the internet to address health care challenges. Introducing ehealth support self-management as well as "participatory healthcare".[27] ICT in the health system (ehealth) empower patients to take more responsibility of their own health.

With the ICT revolution, the impetus to strengthen health systems with better information has driven significant progress. There is increased use of ICTs in support of health services (ehealth) since 2000. As underscored by the World Health Organization (WHO), eHealth plays a vital role in promoting universal health coverage in a variety of ways including: (a) provision of services to remote populations and underserved communities through telehealth or mHealth; (b) training of the health workforce through the use of eLearning, and making education more widely accessible especially for those who are isolated; (c) efficiency of diagnosis and treatment by providing accurate and timely patient information through electronic health records and; (d) improvement of heath services' cost-efficiency. Further, WHO noted "eHealth is the cost-effective and secure use of ICT in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research."[28] ICT allows close communication between patients and health professionals. Patients are involved in diseases' prevention and treatment. Finally, it is found that ICT contributes to better health care quality for all citizens. It bridges the health divide.

The characteristic trend is, indeed, the change in health care paradigm which is based on the shift from medical services to disease prevention and health promotion. Studies show that premature health diseases, stroke and type 2 diabetes could be avoided by prevention and health promotion. ICT therefore should be applied in concordance with the new paradigm. ICT has an impact on many aspects of health care. The most important are: accessibility to health care by citizens, its economy, quality of care and education.

The ICT has an impact on accessibility to health care services. The main goal is to provide access to health services for citizens at any time and any place and especially for the patients from rural areas and small towns. The eHealth obvious advantage in remote or rural areas is the improved access to health services eliminating sometime

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services for all (citizens, patients, healthcare professionals, healthcare providers, as well as policy makers).

[27] http://www.oecd.org/sti/ieconomy/ict-and-the-health-sector.htm. ICTs and the Health Sector: Towards Smarter Health and Wellness Models. OECD, 2013.

[28] http://www.who.int/ehealth/en/. Global diffusion of eHealth: Making universal health coverage achievable. WHO (2016).

the need for a patient to travel to a distant hospital. As noted by Rudowski, ehealth has advantages at various levels: "For instance a physician in a remote rural hospital is initially unable to diagnose a patient with a complex array of symptoms. However, using his MEDLINE search training and the hospital's Internet connection, he can diagnose and successfully treat the patient for a tropical disease the patient picked up while traveling abroad. Another physician looks at her hospital's prescription trends using the newly created electronic health record system and finds that other physicians are not using the post-surgical antibiotic that is shown to be most effective according to the current international guidelines. She speaks to the administration about advocating a switch in antibiotics that will improve patient recovery outcomes and thereby save the hospital money. A neonatologist, who transmits CT-scans and other medical images by e-mail to his network of personal contacts around the world to help in diagnosing and treating premature newborns, estimates that teleconsultations have helped him to save numerous lives during the past year. A young woman, too embarrassed to ask her physician about reproductive health issues and the risks of sexually transmitted infections, anonymously contacts physicians at a woman's health clinic, where they've set up e-mail accounts for staff in order to support these types of physician-patient interactions".[29]

The use of mobile phones can particularly bridge the health divide as further noted by Bastawrous: "More people in Kenya, and in sub-Saharan Africa, have access to a mobile phone than clean running water. So we said, could we harness the power of mobile technology to deliver eye care in a new way? And so we developed Peek, a smartphone [system] that enables community health care workers and empowers them to deliver eye care everywhere."[30]

The wider use of ICT in healthcare is a basic condition for the development, implementation and further generation of innovative health care technologies. Though in most developed countries, the ICT is widely available in health systems, in many African cities, its penetration is still limited. Social capacity, knowledge and acceptance to use of eHealth technologies among citizens and medical professionals need to be strengthened throughout the African region. ICT also allow better planning, monitoring and management of health services and systems. For instance, an ehealth pilot programme focusing on chronic heart diseases has been launched to test a multi-lingual electronic health record. The relevant data will be self-recorded by the citizens with chronic diseases.[31]

[29]Rudowski (2005), WHO (2016).

[30]Bastawrous cited by WHO (2016). See also Bastawrous et al. (2015).

[31]WHO (2016).

13.2.3 Challenges Associated with the Integration of ICT in the Health Sector

The use of ICT to support health care faces many barriers such as the need for a trained workforce skilled in using eHealth solutions, the need for proper governance, funding, infrastructure, technical support, and sustainability. In the 21st century the delivery of health care and improvements of health systems must consider the contribution of ICT as an essential component, not an add-on. Indeed, eHealth is now an integral part of delivering improvements in health. However, the process of embedding eHealth everywhere still has a long way to go, both in terms of coverage and functionality from its foundations; legal frameworks; telehealth; the electronic health records; the use of elearning in health sciences; the mhealth; to social media and big data.

The ICT revolution is also associated with the generation of a wealth of data (big data) from multiple sources accessible to various stakeholders and citizens. This is particularly important in the health sector. However, key challenges of using big data lie on the management and analysis of data, particularly patient data that require confidentiality and to be stored securely and accurately. Transforming this wealth of data to meaningful health information is also another challenge.

Statistics from WHO's Global Observatory for ehealth show that the African region is lagging behind in introducing many components of health[32] despite various opportunities that ICT platforms offer. For instance, when comparing the use of eLearning within different WHO regions, the African region stands out with much lower rates of eLearning adoption for pre-service education. This demonstrates a considerable missed opportunity in terms of health sciences education, particularly given the abundance of available, free and relevant online educational resources.[33]

Assessment conducted by the European Space Agency (ESA) on regulatory aspects of satellite-enhanced telemedicine and e-health identifies a range of challenges with legal frameworks for eHealth in Africa on potential of telemedicine in Africa, regulation, governance, interoperability and sustainability. The study identified the following list of key regulatory issues relevant for eHealth in Sub-Saharan Africa: (a) access to and ownership of data; (b) security and access to clinical information systems by patients and care providers; (c) privacy and confidentiality; (d) informed consent for data use; (e) data ownership; (f) access rights to patient data; (g) integrity of data and; (h) patient safety.[34] In the African region, fewer than a third of countries reported legislation on data quality and transmission. Electronic access to health care is also another challenge with only two African countries having legislation that allows individuals to electronically access health-related data from their

[32]WHO (2015), Aranda-Jan et al. (2014).

[33]WHO (2015).

[34]WHO (2015). The European Space Agency (ESA) also supported the publication of four linked studies whose objective it was to explore the challenges and opportunities of a satellite-enhanced e-health and telemedicine infrastructure for sub-Saharan Africa.

Electronic Health Records (HER). Sharing data between health care professionals faces various challenges and barriers.[35]

Box 13.2 Improvement of Health Services to patients in Senegal using Lean Healthcare

Under the leadership of Mr. Abdoulaye Diouf SARR, Minister of Health and Social Action (MSAS) and with the technical support of the Office Organization and Methods (Bureau Organisation and Methode-BOM) of the General Secretariat of the Presidency of the Republic of Senegal, the program "Improvement of Health Services", in line with the Plan Senegal Emergent (PSE), is led by Dr. Mor DIAW, Director of Health Settlements of Senegal. The program "Improvement of Health Services" will be based on the Lean Healthcare of the Program of Improvement of the Performance of the Health System (PAPSS) developed by a group of companies AOB CONSULTING, LINOVATI, KAMITSOFT and the GLOBAL OBSERVATORY LINKING RESEARCH TO ACTION (GORA) Corp.

The PAPSS promotes the implementation of best practices in the organization of work, particularly the method of Lean Healthcare and the efficient and optimal use of its instruments in the field of information and communication technologies. The main objective of the Lean Healthcare is to move towards a more efficient, simplified, healthier, connected and efficient health system that better meets the needs of patients.

Several actions were carried out in Senegal and Canada with the participation of a dozen of Senegalese hospitals that will work collaboratively within the framework of this project. Pilot and/or showcase projects will be carried out in the short and medium term with ten (10) hospitals and about fifty medical and administrative services that will be selected on the basis of predefined criteria. In this context, a large delegation of leaders engaged in the health sector in Senegal attended a high level training on Lean management in the health sector, but above all participated in activities of reflection actions to address the problem related to the management of receptions and emergencies in the hospitals of Senegal.

Workshop of the Senegal Health Professionals on Lean Healthcare, Montreal (Quebec), Canada, June 2018

[35] WHO (2015).

Rank 1: From left to right: 1. Mme Diallo, directrice conduite du changement AOB; 2. Mme Ramata BA, directrice hôpital Roi Baudoin de Guédiawaye; 3. Pr Maguèye Gueye, PCME Hoggy; 4. Mme Khadidiatou Sarr KEBE, Directrice HOGGY, 5. Pr Phillipe Moreira, chef service gynécologie Dalal Jamm.

Rank 2: From left to right: 1. Pr Bara Ndiaye, PCPME hôpital Fann; 2. Dr Cheikh Tacko DIOP, directeur hôpital Fann; 3. M. Saliou Tall, directeur hôpital Kaolack, 4. Dr Mor Diaw, Directeur des établissements de santé (DES); 5. Dr Yves Bolduc, ministre de la santé du Québec de 2008–2012; 6. Dr Issa Tall DIOP, directrice hôpital pour enfants Albert Royer; 7. Dr Aida Thérèse Ndiaye, directrice hôpital de Tambacounda; 8. M. Stéphane Rousseau, expert en Lean LINOVATI.

Rank 3: From left to right: 1. Pr Malick Faye, PCME Albert Royer; 2. S. Cherif BARRY, AOB et administrateur du PAPSS pour Afrique Subsaharienne; 3. M. Camil Villeneuve- Expert Lean, Président Linovati, 4. M. Moussa Sam Daff, Directeur de l'hôpital Dalal Jamm; 5. M. Sidy DIOP, conseiller en organisation au BOM; 6. M. Amadou SOW, comptable à l'hôpital de Kaolack.

Improved heath processes and outcomes with a patient-centered approach

The main objective of this project is to re-structure the organizational processes of hospitals so that they can concentrate fully on what is important to the patient by eliminating as much as possible any non-essential activity that does not provide added value to the patients. The goal is to reduce the patient's time in the hospital and allow them to benefit as quickly as possible from quality care at a lower cost. Healthcare professionals, managers and all staff will be less busy, more motivated and quicker to bring out new ideas and solutions for continuous improvement.

This revision of the processes for the implementation of new ways of doing things will be de facto combined with the use of technological tools associated to this new management culture in order to improve the services of reception and emergencies and those who receive more of patients (UAA, laboratory, radiology, outpatient, etc.). Thanks to this use of ICTs, Senegal's health facilities will be able to move towards a *Smart Health System*.

Making hospitals efficient and smart

Senegal's ambition is to implement strategies for public health establishments to adapt to the demands of their environment. Hospitals must be efficient in order to offer quality services through the optimal use of their internal resources, which they will have to try to improve periodically and to protect adequately. To ensure success in this vast project of organizational and technological transformation, multi-stakeholder change management strategies will be implemented.

Showcase projects by October 2018 and September 2019

In order to experiment this new organizational method supported by technological tools, a steering committee has been set up and will carry out practical activities for one year, including reflections and modeling of the financial process with the implementation of an analytical accounting system integrating a Lean orientation. This committee is composed of several actors from the health sector and the government and aims to ensure the success of the program in the interest of the population, resulting in a significant reduction of the hospital's expenses and a production of relevant, real-time information that can assist in the development of public health policy.

Source: *Workshop of the Senegal Health Professionals on Lean Healthcare, Montreal (Quebec), Canada, June 2018 – Translated from the French original version by Cherif Barry, October 2018.*

13.3 Education as Key for Smart Social Development

Smart citizens make smart cities. They are sufficiently educated and digitally literate. Education is indeed critical to meeting the challenges of a smart city, as it connects people to new approaches, solutions and technologies that enable them to identify and solve local and national issues. The contribution of education to health and well-being and to better subsistence and livelihood is also indisputable. It is crucial to reducing poverty, improving health, and enabling people to play a full part in their communities and nations. It finally generates powerful poverty-reducing synergies and yields enormous intergenerational gains.[36]

13.3.1 Urbanization and Progress in Education and Literacy

Basic education is the foundation of any education system. Basic education is a human right, and most countries around the world today acknowledge the right to education in their constitution.[37] In countries where primary education is compulsory under law, governments deploy a nationwide education system with free primary school and social assistance towards indirect costs like transport and meals.[38] The international community assembled in Dakar in April 2000 to set an agenda, called the Dakar Framework for Action, for making progress in education to 2015.[39]

In this section, progress in education is assessed from analysing levels of education and literacy among young people age 15–19 years and 20–24 years old in 2015. These people were aged 0–5 years and 5–9 years in 2000 when the Millennium Development Goals (MDGs), including goals in basic education, and the Dakar Framework on Basic education were adopted. The progress in education is also assessed through the school attendance or enrolment among children and young people at school age. Any change on education must be reflected on these groups when comparing their

[36] World Bank (2015b).

[37] The Convention on the Rights of the Child in 1989 and the World Declaration on Education for All (EFA) in 1990 in Jomtien, Thailand, reaffirmed education as a human right and heralded a new environment of international cooperation.

[38] UN-Habitat (2010).

[39] The Dakar Framework comprised two key elements: 6 goals, and associated targets, to be achieved by 2015, and 12 strategies to which all stakeholders would contribute. UNESCO (2000).

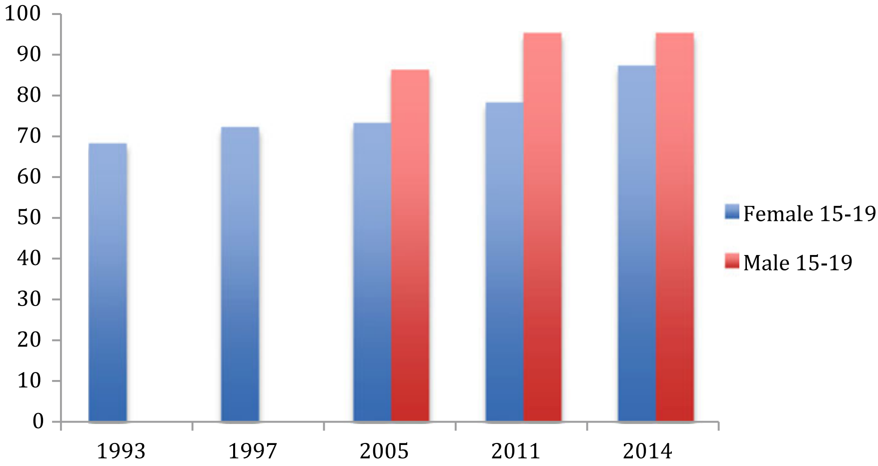

Fig. 13.3 Percentage of men and women aged 15–19 years old with at least a primary education level, Dakar (Senegal). *Source* Mboup (2017)

situation before and during the MDGs and the Dakar Framework. In addition to this technical consideration in terms of assessment, young people of 15–24 years old are those who are leading change of today and in the future along with the younger cohort.[40] Information on highest level of education of population aged 15 years an up, and on school attendance among children were collected in a series of Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS) conducted in selected African countries at different points in time.[41] This information is used to assess trends in education in African cities in the last 20 years.

In the last 20 years, considerable progress was made in education as witnessed by the increase in the percentage of young people 15–19 years and 20–24 years old with at least a primary level of education (Fig. 13.3). Basic education is almost universal in many African cities and makes African cities potentially smart. Education is, indeed, critical to meeting the challenges in the ICT era, as it also connects people to new approaches, solutions and technologies that require basic literacy. As illustrated in the situation of Dakar where the percentage of women and men 15–19 years with at least a primary education is estimated at 90 and 95% in 2015 respectively compared to 68% in 1993 and 72% in 1997.

It is important to note that in Dakar similarly the literacy rate has increased from 59% in 1993 to 80% in 2014 among the young women of 15–19 years and 84% in 2005 to 86% in 2015. However, these literacy rates are 10 points lower than proportion of people in the same age group with a primary education level, indicating

[40]Mboup (2017).

[41]The Demographic Health Surveys (DHS) are representative household surveys collecting information on education along with amenities and health variables. DHS is an international programme funded by USAID and implemented by Macro International since 1984.

that primary education does not necessarily provide literacy capabilities. In many African countries, measures have been taken to improve learning quality with the introduction of pedagogical resources, especially textbooks for the core subjects of reading and mathematics, with the provision of one textbook to every student in a classroom; this has increased literacy scores by 5–20%.[42] By 2030, it is expected that literacy will be universal in most African cities as access to education will also be generalised. This will impact all sectors of the smartness in many levels in terms of attitudes and behaviour.

In addition to analysing the education level, we have also assessed the net primary school attendance among children in African cities. Available data indicates that enrolment rates are in general much higher in cities than in rural areas. In most of the countries analysed here, more than 80% of the children of primary school age in urban areas attend school, while the proportion drops to less than 50% in rural areas. This pattern is most pronounced in Niger, where in 2006, 74.4% of children (7–12 years old) in Niamey attended a primary school, compared with 31.3% of children (7–12 years old) in rural areas.[43] Similar pattern is observed in Burkina Faso in 2003 with the children (7–12 years old) from rural areas lagging far behind than their urban counterparts, with 25% enrolment and 84% respectively.

High levels of enrolment rates in urban areas compared to rural areas confirm that African cities are places of opportunities for education. They ease school accessibility and provide the necessary incentives for parents to send their children, both boys and girls, to school. Evidence in some African countries suggests that when schools provide appropriate incentives, boys and girls will equally be enrolled to school.[44]

The treatment of early childhood care and education in the Dakar Framework had its roots in the rights-based approach of the Convention on the Rights of the Child. Since 2000, there has been an increasing focus on early childhood, in both poor and rich countries, informed by evidence of its fundamental consequences for future individual well-being, with further research emerging of the importance of the first 1000 days after conception.[45] Literacy skills are best developed in childhood through good quality education. They are sustained by continual practice in literate environments at work or in the community and through adult and continuing education. The quest for an education of good quality cuts across the Dakar Framework. The framework expresses concern over emerging evidence that a sizeable percentage of children were ‘acquiring only a fraction of the knowledge and skills they are expected to master.[46] However, the fact that primary school attendance rate is not 100% seems to indicate that effective attendance and access are not fully enforced in many African countries; the final decision is often left to parents who do not face

[42]Fehrler et al. (2009), based on 22 Sub-Saharan countries study, found that textbook investment are cost-effective, customizable and useful. They suggest that LSM, and textbooks in particular, are effective inputs to learning. See also Milligan et al. (2017).

[43]Republic of Niger (2007).

[44]See Footnote 38.

[45]UNESCO (2000).

[46]See Footnote 45.

penalties when they fail to enrol their children to a school.[47] Parental resistance to sending their children, particularly girls to school on the grounds of economic reasons or cultural norms can be overcome only if education is affordable, accessible, and, to some extent, flexible, including situating schools within walking distance of residential communities. However, mapping of the schools in urban areas has shown some geographical disparities where poor areas are less served with schools than rich areas.

Higher level of education for the development and use of ICTs

Though availability of ICT infrastructure is key to creating a digital city, it is equally important to have the human resources capable to use it and to further develop it. The primary education level alone may not provide the required capability to digitize a system, but it represents a good start towards an effective expansion of ICT infrastructure. Further education at the secondary level or higher may be required to develop and use sophisticated applications from mobile phones and computers. In several economic and social sectors of African cities, use of digital technology requires skills and competencies beyond literacy, and people must be equipped with ICT knowledge. Today, most African cities depend heavily on external technical assistance, but it has become clear that the digital African cities will be made by African people themselves.[48]

The increase in secondary education in African cities can be associated with two main aspects. First is the expansion of secondary education facilities in remote and poor areas taken by many African governments in the early 2000 allowing children to move from primary to secondary level within the same geographical area. Schooling in their neighbourhood has also mental and social advantages on children; it gives them the opportunity to grow along with their caretakers. Second is the extension of free and compulsory education to include lower secondary, which has been possible due to the political commitment of African countries as in the MDGs and in the Dakar Framework. This Framework was also influential in encouraging dialogue with traditional religious actors who had been resistant to what they viewed as Western forms of education. Increased dialogue helped generate support for legal reforms in early 2000 and facilitate the incorporation of religious schools in the formal education system, thus maximizing the enrolment of lower secondary school-aged children.[49]

Efforts are still needed to boost enrolment at secondary level where the figures are below 50% in most African cities. During the progress towards generalization of education, much has been done in favour of gender equity in education over the past 15 years, and narrowing of the gender gap.[50,51] In Africa, this progress was possible because national and local authorities clearly recognized the crucial importance of girls' education in development as well as the benefits derived from the "education

[47] See Footnote 45.

[48] See Footnote 40.

[49] Villalon and Bodian (2012).

[50] UNESCO Statistical Institute.

[51] Frolich and Michaelowa (2011), Fredriksen et al. (2015).

for all" agenda. Various policy frameworks, including the "women in development", "gender and development", post-structural and rights-based approaches, have jointly contributed to gender equality and quality education. The "women in development" approach generates clear policy directives on issues such as the hiring of more female teachers, tracking the number of girls and women in and out of school, overcoming barriers to girls' education, and reaping the benefits of schooling.[52] Improvements in girls' enrolment have resulted from eight interrelated strategies, some of which may provide some insights into ways to keep boys in school, as well: (1) elimination of user fees; (2) conditional cash transfers; (3) increased focus on gender inequality; (4) recognition of cultural and social constraints to girls' education; (5) improvement in the economic returns to girls' education; (6) promotion of post-primary education for girls; (7) making primary education more gender-sensitive; and (8) developing and disseminating gender-sensitive school and pedagogical models.[53]

13.3.2 Education Inequalities in African Cities

Averages may hide the situation of vulnerable groups; the situation on the ground shows different pictures with persistent social inequalities across settlements that influence and shape the education system. Though cities are hosts to more educational infrastructures than villages and provide young people with opportunities to continue their education and access gainful employment in the formal sector, they can also generate and intensify the kind of social exclusion that denies the benefits of the "urban advantage" to youth and other marginalized groups, particularly in conditions of unprecedented urban growth, increasing poverty and inequality, or inadequate policies.[54] In the same city, some youth are able to succeed and prosper while others drop out of school, fail to find productive employment and sink into poverty. This is the situation of education in most African cities where the differential between children in suburbs and those living in city cores remains high, particularly at higher levels of education. Social and cultural barriers continue to deny many urban slum dwellers the opportunity to reach secondary education. Statistics show that children from African suburbs are less likely to enrol in school; they are less likely to complete primary or attend secondary school than their counterparts living in privileged urban areas.[55] With the progressive privatization of the education system in many African cities, the education system also perpetuates and reproduces social inequalities. This is the stage where school enrolment rates are seen to diverge widely across settlements. In urban areas, access to education is often determined by ability to pay fees more than by the physical proximity of schools, or by curricula. School fees, costs of uniforms, materials, exams and other educational expenses have been

[52] UNESCO Statistical Institute.

[53] See Footnote 38.

[54] See Footnote 38.

[55] See Footnote 38.

shown to affect the chances of children from poor families, and girls in particular, going to school, as they add to the already high opportunity costs of letting them leave home to benefit from formal education. Hence, many children in suburbs do not attend secondary school and hence miss the opportunities that higher education offers, which is knowledge and skill development needed to enter the formal labour market.

Bridging the Education Divide Through ICT

Making ICT infrastructure economically, socially and environmentally sustainable for learning and knowledge sharing is the key in driving the African cities towards universal education. With the desire to digitize African cities, this trend can be boosted and the availability of an internet connection can be generalized way before the year 2030, and this will be in line with the increase in education and literacy observed in most African cities during these past 20 years.

Education has been for a long time obtained in a classroom with a teacher and students. Today, the ICT has transformed the learning environment and methods, and calls for a paradigm shift in assessing level of education and knowledge in a country or globally. Lots of things are happening outside the classroom and knowledge transfer is becoming possible in all corners of the world. ICT offers a unique, historical opportunity for most African countries where the educational resources in terms of school facilities and human resources have been unable to meet the growing demand in education from sustained increased numbers of children and young population to be enrolled in primary, secondary and higher education levels. With population growth rates of more than 2%,[56] the population of most African cities is still predominantly young with more than 50% below age 25 years old. However African cities have not been able to meet this pressing demand of pupils and students from primary to secondary school and college. Despite efforts for free primary education and lower secondary education in some countries, with the shortage of classrooms and teachers, disadvantaged children and young people have been left behind without education or just with some education in many African cities. In Many African cities, DHS data shows a high proportion of children and young people that had dropped out and had not been able to complete an entire level of education.[57] Despite the huge investments of African governments for these past years on educational infrastructures with the opening of more schools in remote areas and the decentralization of secondary schools and colleges, African countries still face shortage in infrastructures as well as in human resources. Exponential growth of private schools have been also noticed making school more accessible, but these are affordable in most cases to only rich families; those available for poor families are in most cases at a substandard performance in terms of infrastructure as well as in human resources. Bridging the gap in terms of social inequalities as well as in terms of supply-demand will call for a paradigm shift with the integration of the digital approach in learning. Investing in the ICT infrastructures will allow to reach the poor at lower costs and will also allow to fill the deficit supply to demand in lower cost and in a sustainable manner. African

[56] See Footnote 2.

[57] See Footnote 40.

cities are indeed, facing two educational problems; one is associated to quality of education and other is the shortage of infrastructure and human resources against the pressing demand of massive children and young people.

Digital technologies affect the whole skill formation process by changing both the teaching and the learning processes. It constitutes an effective way of improving the quality of education, particularly in developing countries where the ratio of teacher to students is exceptionally high.[58] Digitization of the education system with the provision of ICT infrastructure such as computer and internet connection will allow real time access and use of teaching materials and knowledge in general, making teaching more relevant and effective. Teachers can use online portals to connect with each other and to share lesson plans and best practices, while students can use ICT to access online libraries and to master new technologies.[59] For instance, in Senegal, the government with its development partners has launched programmes aiming to digitize the basic education system. For instance the FHI 360's Education Base project in Senegal has reached more 93,000 students and 4500 teachers nationwide in the use of ICT in middle school. This project won the Innovating Secondary Education Skills Enhancement Prize from the group Results for Development due to its effective use of ICT.[60] Senegal has also initiated other projects aiming to decentralize teacher preparation process; improve school policy, systems, and governance; strengthen students' basic skills in reading and math; and provide life and employability opportunities for middle school youth.[61,62] The African Network for Distance Education (Résafad) is also part of a partnership between the Ministry of Education and Microsoft Program Partners e-learning, particularly on access to ICT, and their use as a support for improved quality training and learning.

Several actors, such as families, school and training systems and other social and religious institutions, also play a key role on children education in building these skills in early age and throughout the life cycle. In the future, all these diverse institutions and groups will use digital technologies in the building of foundational skills. While there are concerns about the impact of digital technologies on cognitive capacities and socialization, especially among young children, increased development and use of these technologies are irreversible. Literacy and numeracy initiation of children often starts at home where they are exposed to mobile phones and other digital gadgets. In addition to that, online educational games for young children are introduced to children prior to starting school, hence boosting foundational skills.[63] Access to the internet, laptops, tablets, mobile phones, digital whiteboards,

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[58] World Bank (2015a).

[59] World Bank (2015a, b); Many of FHI 360's education projects use ICT as a tool to enhance the quality of teaching and learning, encourage community participation in education and increase school access.

[60] http://www.educationinnovations.org/program/education-de-base-edb-program.

[61] http://www.rti.org/page.cfm?obj=47AABCEA-0568-4553-9C15C11C07ECA651.

[62] https://www.changemakers.com/isese/entries/improving-quality-and-relevance-middle-school-senegal.

[63] Flannery et al. (2013) ScratchJr, is an application aimed at teaching algorithm thinking and coding principles to kids at young age (5–7 years) using a simple drag and drop interface.

and video-based instruction are increasingly common in primary and secondary education. Some African countries have also introduced programs like One Laptop per Child (OLPC).[64]

The digitalization of the education systems and methods will help to bridge the education divide—Many African countries in general have been unable to satisfy the educational demand, particularly at secondary and higher levels. In this regard, ICT revolution can play a significant role. For instance, the Massive Open Online Courses (MOOCs) is a recent development in distance learning, characterized by three key aspects: open enrolment, online assessment, and an interactive forum. They are at a large scale and mostly free, except fees for certification. Platforms such as Coursera.org, Udacity.com, and edX.org host these online courses, and are also used to assess participants' performances.[65] Training in advanced ICT skills can also be provided less systematically, and outside of the formal education system. Coding classes through free specialized online platforms Codecademy are available, and there are more than 24 million users who have completed over 100 million exercises through such coding classes. Two factors have contributed to the rapid rise of online courses such as MOOCs.[66] Firstly, digital technology has come of age, with widespread use of laptops, tablets and smartphones with growing broadband penetration in many countries. Secondly, the 'digital native' generation has now reached university age and is totally at ease with the all-pervasive use of digital social networks for personal communication.[67] The digital revolution is one new and disruptive way for universities to 'go global' beyond their single campuses to reach a global audience. Cloud computing and supercomputing as well as the handling of big data, have already transformed research.

Advanced development and use of ICT—The creation and transfer of scientific knowledge are critical to building and sustaining socio-economic welfare and integration in the global economy. In the long run, no region or nation can remain a simple 'user' of new knowledge but must also become a 'creator' of new knowledge. This also applies in the ICT sector where African countries must also develop digital products that culturally and socially take into account its identity. Many African countries are using more ICT infrastructure than developing it. Closing this gap will require investment on research and technology at higher education level in collaboration with the specialized ICT private sector.[68] It is, indeed, important to engage all actors to make full advantage of the ICT revolution. In the telecommunication sector,

[64] http://blog.laptop.org/tag/africa/#.W6JxK2Qzb-Y; https://pdfs.semanticscholar.org/5e26/8802991dd59c3d07a160d43277990a1d326b.pdf

[65] Ho et al. (2015).

[66] Escher et al. (2014).

[67] Mboup (2017). The number of world-class universities committed to this digital innovation is steadily growing, as is the number of students—one MOOCs provider, Coursera, has seen the number of students almost double from 7 million in April 2014 to 12 million today.

[68] Regarding investment in research and innovation in general, according to Bloom (2006), responsibility for this relative neglect of higher education lies partly at the door of the international development community, which in the past failed to encourage African governments to prioritize higher education.

examples are the mobile banking in Africa such as M-Pesa with the mobile provider Safaricom in Kenya and Orange Money in Countries using the Orange network such as Senegal. However there is need to support research in the ICT sector in order to move from simple users to developers then users. In this area, considering the limited public resource allocated to research in general, African cities must engage on public-private partnership on the ICT sector where the demand is growing. In general, most of the African countries are still lagging behind the African Union (AU)'s target of devoting 1% of GDP to Gross Domestic Expenditure on Research and Development (GERD); it is at a level of 0.6% with 41% of the funding from foreign sources. There is also little synergy in Research and Development, which suffers from a low budget and inadequate equipment, a low status for researchers and a lack of university–industry linkages. Research results are also insufficiently applied, owing to weak oversight and relatively low scientific output. Insufficient availability of funds for higher education calls for the use of ICT to bridge the gap with the introduction of the MOOC and similar platforms in the education system.

Box 13.3 Senegal Experience in Digital Education

ICT is indeed considered in national policies on research and innovation based on the vision of most African countries of becoming a middle-income country by 2035. This vision considers higher education and research as a catalyst to socio-economic development and thus a priority for reform. For instance in Senegal, the Ministry of Higher Education and Research launched in 2013 an action plan entitled "Priority Programme Reform and the Development Plan for Higher Education and Research" (PDESR) with a funding commitment of US$600 million over five years (2013–2017). In its first year of implementation, the PDESR created three new public universities: the University of Sine Saloum of Kaolack in central Senegal, specializing in agriculture, the Second University of Dakar, situated 30 km from the centre of Dakar, specializing in basic sciences, and the Virtual University of Senegal (VUS), enabling efficient and accessible Higher Education through a digital open space in each region of Senegal. Following the launch of the VUS in February 2014, over 2000 students had enrolled for the same academic year. A network of vocational training institutes and upgraded laboratories has also been developed with the introduction of high bandwidth to connect public universities with one another. Five Senegalese universities are interconnected with very high bandwidth that provides them the opportunity to share their teaching resources via videoconferencing and other distance learning techniques. This type of development in ICT has seen Senegal ranked 12th in Africa by the 2014 International Telecommunication Union (ITU) ICT Development Index. With around 90,000 educated students enrolled in tertiary institutions in Senegal, it trains a large number of students with excellent ICT skills.

Along the government programmes and policies on ICT, there are several other initiatives by private sectors, NGOs, Civil society, and academic that invest on the expansion of ICT and education to bridge the digital divide. Among them is the Senegalese Association of Educational Counselors (ASCP) who, with the support of Microsoft, held a capacity building workshop in 2009 "ICT for Education (ICD4Ed)".[69] The Senegal Global Distance Learning Centre of the World Bank's Global Development Learning Network (GDLN) is also contributing to the use of ICT for knowledge sharing.[70] Several research groups and think tanks have also undertaken studies and analyses on ICT related subjects: the Research and Try Programme Centre (Centre de Recherche et d'Essai Programme), the Scan ICT project, the Multimedia Community Centre Programme, the Senegal Observatory on Information Systems, the Networks and Info highways. "Observatoire sur les Systèmes d'Information, les Réseaux et les Inforoutes au Sénégal" (OSIRIS),[71] etc.

13.4 Conclusion

Children born in cities have more access to health services such as antenatal care for mothers, delivery care and immunization than those born in rural areas. Despite these urban advantages, urbanization has also come with challenges particularly for the urban poor exposed to high morbidity rates. In addition to that, modern environmental diseases, particularly associated to changes in urban life with the increase in motorized means of transport, appear to impede decline in morbidity and mortality rates. The fight against childhood diseases should also go beyond the traditional environment of diseases which is the household, to the so-called modern environment of diseases—outdoor pollution, climate change, environmental degradation, etc.

Universal Health Care also calls for transformative actions with increased integration of ICTs in the health sector: transforming the analogue health sector to an e-health sector. Transformational change in care delivery will result from emerging, ubiquitous, participatory preventive and personalized smart models of care. With the ICT revolution, the impetus to strengthen health systems with better information has driven significant progress. There is increased use of ICTs in support of health services (e-health) since 2000. The wider use of ICT in healthcare is a basic condition for the development, implementation and further generation of innovative health care technologies.

Though availability of ICT infrastructure is key to creating a digital city, it is equally important to have the human resources capable to use it and to further develop

[69] http://www.ernwaca.org/panaf/spip.php?article1143—Senegal—ICT in education: Serving quality training and learning.

[70] http://ela-newsportal.com/elearning-africa-interview-with-dr-mor-seck-director-senegal-dlc-senegal/.

[71] http://www.osiris.sn/.

it. The primary education level alone may not provide the required capability to digitize a system, but it represents a good start towards an effective expansion of ICT infrastructure. Further education at the secondary level or higher may be required to develop and use sophisticated applications from mobile phones and computers. Efforts are still needed to boost enrolment at secondary level where the figures are below 50% in most African cities. Averages may hide the situation of vulnerable groups; the situation on the ground shows different pictures with persistent social inequalities across settlements that influence and shape the education system.

ICT offers a unique, historical opportunity for most African countries where the educational resources in terms of school facilities and human resources have been unable to meet the growing demand in education from sustained increase of children and young population to be enrolled in primary, secondary and higher education. Digitization of the education system with the provision of ICT infrastructure such as computer and internet connection will allow real time access and use of teaching materials and knowledge in general, making teaching more relevant and effective. This digitalization of the education systems and methods will help to bridge the education divide.

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Chapter 14
Smart Urban Economy in Africa

Banji Oyelaran-Oyeyinka and Gora Mboup

Abstract Studies have shown that the association between the level of urbanization and GDP per capita is positive. Countries with higher GDP growth experienced faster urbanization, and rapid urbanization came hand-in hand with higher growth in industries and services. This is primarily because urbanization and structural transformation are two processes going hand in hand and mutually reinforcing each other. Urbanization is a powerful force for transformation as it enables agglomeration that facilitates industrial productions and economies of scale. This chapter aims at investigating the urban opportunities in traditional pattern of growth with the urbanization process in Africa. It then highlights the flip side of rapid urbanization and how national economies might miss out to gain from the urban advantage. It also examines the phenomenon of 'consumption cities' and absence of industrialization in urban centres. Finally, the chapter provides recommendation to seize the urban advantage in Africa in order to achieve liveable Smart Cities that undergo inclusive sustainable economic growth and development.

Keywords Smart economy · GDP · Land tenure · Security of tenure · Investment Capital · Economies of scale · Agglomeration · Urbanization

14.1 Introduction

Urbanization is one of the most significant global trends of the 21st Century. In 2008, for the first time in history, the global urban population outnumbered the rural

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population. More than 50% of the world's population now lives in urban centers. This figure was less than 20% only one century ago. Urban population is expected to further increase at an unprecedented rate, with 60% of the world population projected to live in urban areas by 2030. Most of this growth is expected to occur in developing nations which will contribute to 90% of the world urban population growth.

African cities have grown rapidly in the recent past. At the end of the 20th century, Africa's urban population was 35%, while today it stands at 41%, with more than 470 million inhabitants.[1] Although, Africa is currently the least urbanized continent, with only 41% of urban population, it is urbanizing the fastest. The growth from the past decade is expected to continue at an even increasing rate. In Africa, the urban population is projected to grow 1.8 times faster than the global urban population between 2015 and 2020. At this rate, in seven years' time, the urban population of Africa will be larger than the total population of Europe.[2] This implies that African urbanization is entering a critical phase where many cities will be doubling in size and playing a significant role in the national economy. For instance, Africa is currently home to three of the world's megacities, defined as cities hosting more than 10 million inhabitants, including Cairo, Lagos and Kinshasa. By 2030 three more are expected to emerge, as Dar es Salaam, Johannesburg, and Luanda are each projected to surpass the 10 million mark.[3]

Although urbanization brings about many challenges, it offers great potential for growth and development both at the local and national level. Past experiences have shown that economic growth and rising living standards have gone hand in hand with urbanization. Currently, cities are said to account for about 70% of global GDP.[4] In most countries, the contribution of their cities to their national GDP far exceeds their contribution to the total country's population. Economic activities in urban areas account for as much as 55% of the GDP in low-income countries, 73% in middle-income countries, and 85% in high-income economies.[5] This indicates that urban workers are more productive than their rural counterparts. According to projections, the productivity level of urban workers is going to increase further, with 80% of future global economic growth attributed to cities alone.[6]

Despite the disproportionate economic contribution of urban areas and their high level of productivity, urbanization is often ignored in development policy or not duly integrated in development strategies and plans. This neglect is especially prevalent in Africa where urbanization has been associated with growing urban poverty and unemployment. This has led numerous policy makers in Africa to formulate policies to halt rapid urbanization. However, studies have shown that the level of urbanization and GDP per capita is actually positive.[7] Countries with higher GDP growth expe-

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[1]UN Population Division, Department of Economic and Social Affairs (2018).

[2]See Footnote 1.

[3]United Nations Population Fund (UNFPA) (2014).

[4]World Bank (2009).

[5]UN-Habitat and DFID (2002).

[6]SIDA (2006).

[7]Fay and Opal (2000).

rienced faster urbanization, and rapid urbanization came hand-in hand with higher growth in industries and services. This is primarily because urbanization and structural transformation are two processes going hand in hand and mutually reinforcing each other. Urbanization is a powerful force for transformation as it enables agglomeration that facilitates industrial productions and economies of scale.

Consumption cities

African countries, and particularly resource-exporters countries, tend to see the emergence of "consumption cities" in which a large share of workers is employed in non-tradable services, including commerce, transportation or personal and government services.[8] These types of cities are different from what we refer to as "production cities" that have more workers in more productive sectors such as manufacturing and high value services according to traditional patterns. For example, it is estimated that Angola's urbanization rate was 15% before the discovery of oil in the 1960's, as opposed to 60% in 2010. Although oil accounts for over half of GDP, the sector only employs around 10,000 workers.[9] "Consumption cities" tend to have higher poverty rates and higher shares of population living in slums. On the contrary, "production cities" have a larger share of workers in industrial sectors like manufacturing or in tradable services like finance. For example, in cities of resource exporters countries such as Luanda, Lagos and Libreville, the portion of workers in manufacturing is lower compared to that of Johannesburg, Seoul, or Kuala Lumpur, although these cities have similar levels of urbanization.

While Africa has urbanized to the same level as Asia over the last decades, Asian labor productivity was 1.9 and 2.3 times higher in industry and services respectively.[10] This is explained by the fact that African cities lack opportunities in skill-intensive and productive activities such as manufacturing that constraint the usual labor movement from rural to urban areas. Consequently, new migrants constitute labor that is unemployed or underemployed. This absence of industrialization also translates into the phenomenon of urbanization without growth. While cities are the driving force for economic development in conventional model of growth, urbanization seems to occur in the absence of economic growth in most sub-Saharan African countries.[11]

Despite such challenges, particularly the limited industrialization in cities, the last decade in the rise of African cities has been associated with the region's growth and rejuvenation. Cities have been the epicenters of growth and structural transformation, which is crucial for the development of Africa. The same phenomenon persists that is urban growth without industrialization and the emergence of a "premature" service sector across African countries.[12] Africa's economic growth has been driven in large part by natural resource/commodity export as well as by the services sector including telecommunications.

[8] Oyelaran-Oyeyinka et al. (2016).

[9] Gollin et al. (2015).

[10] See Footnote 9.

[11] See Footnote 8.

[12] See Footnote 8.

This chapter aims at investigating the urban opportunities in traditional pattern of growth with the urbanization process in Africa starting with the economic rationale for the urban economy, Sects. 14.2 and 14.3. It then highlights the flip side of rapid urbanization and how national economies might miss out to gain from the urban advantage. It also examines the phenomenon of 'consumption cities' and absence of industrialization in urban centers. Finally, the chapter provides recommendation to seize the urban advantage in Africa in order to achieve livable Smart Cities that undergo inclusive sustainable economic growth and development.

14.2 Economic Rationale for the Urban Economy

Economic advancement has both depended on more people living in cities, and it has generated the resources to support continued urbanisation through essential infrastructure and services. More people living in cities has expanded the supply of labour and entrepreneurs, and stimulated mutual learning and creativity. The outcome of this virtuous circle has been rising national productivity, higher average incomes and greater all-round prosperity.

The economic rationale for urbanisation is underpinned by two basic concepts—the *division of labour* and *economies of scale*. The former was introduced by Adam Smith and explains the benefits for productivity arising from specialisation among producers. It accounted for the step change from simple craft processes to factory production that led to the industrial revolution. *Internal economies of scale* are the efficiencies arising from larger units of organised production. Larger firms can spread their fixed costs (rent, rates, R&D etc.) over a larger volume of output and buy their inputs at lower prices. Big efficiencies are also obtained by workers becoming more specialised and adept in particular tasks. *External economies of scale* (or *'agglomeration economies'*) are the benefits firms get from locating near to their customers and suppliers in order to reduce transport and communication costs. They also include proximity to a large labour pool, competitors within the same industry and firms in other industries. Alfred Marshall (1920) was the first economist to recognise the benefits for firms of having access to a reservoir of information and ideas, skills and shared inputs.

14.2.1 Urbanization Economies and Urban Agglomeration

These economic gains from spatial concentration can be summarised as three functions: Shared Assets, Shared Services and Information (Joint Action) and Shared Learning.

Shared Assets: first, cities enable firms to share and *match* their distinctive requirements for labour, premises and suppliers better than smaller towns because there is a bigger choice available. Better matching means greater flexibility, higher productivity and stronger growth. Agglomerations enable firms to 'mix and match' their various inputs, access scarce resources and alter their workforce more easily in response to changing business needs. This lowers costs and assists reorganisation and restructuring. Ease of staff recruitment and replacement are especially important in activities with a high labour turnover, such as business process outsourcing and the hospitality sector. Big cities benefit workers too in offering a wider selection of potential employers and lower risks of failure.

Shared Services and Information: Cities also give firms access to a bigger and better range of *shared services* and infrastructure. They have a better choice of education and training organisations to help with staff development, and a wider range of research and development organisations to assist with product design and improvement. Cities also have better external connectivity to national and global customers and suppliers through more frequent transport connections to a wider range of destinations, and higher capacity broadband for electronic communication. The matching and sharing functions may be most important for cities in developing economies and for second tier cities in advanced economies.

Shared Learning and Collaboration: firms benefit from the superior flows of information in cities, promoting more *learning* and innovation (Jacobs 1969, 1984; Porter 1998). Agglomeration is especially significant for technologically advanced activities that are differentiated from competitors by the continuing creation of higher quality goods and services. Proximity facilitates the communication of complex ideas between firms, research centres and investors (Cooke and Morgan 1998; Storper and Manville 2006; Scott 2006). Close contact enables formal and informal networks of experts to emerge, which promotes comparison, competition and collaboration. Brainstorming, mutual learning and exchanging tacit knowledge are more effective face-to-face than through remote electronic communication. Resources are used more productively and in new ways in this process of internally-generated growth.

Shared Public Goods: Economies of scale also apply to many public services and to consumption. It is cheaper and easier to provide public services such as health, water, power and communications in cities (United Nations 2007). The combined spending power of large populations also stimulates new consumer goods and amenities, such as leisure and recreation activities, which attract further rounds of job-creating investment, tourism and population growth (Glaeser and Gottlieb 2006). Cities contain the cultural vitality, social infrastructure and career choices to help regions and nations attract the skills and talent required to generate and exploit knowledge and build dynamic competitive advantage. Some consumer facilities are only viable in large cities, such as major entertainment venues, convention centres, museums, art galleries or specialised centres of education and health. Cities also offer greater choice of shopping, restaurants, hotels, sporting amenities and careers to attract people to visit, study, live and work. New migrants to cities may create new opportunities and new needs; offer new skills and new perspectives, and generate new requirements for institutional innovation.

14.2.2 'Agglomeration Diseconomies'

The benefits of agglomeration can be offset by rising congestion, pressure on natural resources, and higher labour and property costs in cities—*'agglomeration diseconomies'*. These inefficiencies grow with city size, especially if urbanisation is poorly managed, and if cities are deprived of essential public investment in infrastructure. The immediate effect may be to deter private investment, reduce urban productivity and hold back growth. Over time, there is likely to be a dispersal of lower value, land-intensive activities (such as routine production, distribution and warehousing) away from large cities. Meanwhile, the composition of the urban core might shift towards higher value industries and higher-skill functions that require central locations and can absorb the higher costs.

The process of urban economic growth can benefit surrounding towns through the outward spread of investment and jobs. The hinterland can also benefit from the large markets available in cities, and the logistics systems and shared infrastructure that connect cities to wider national and international markets. Rural areas can supply primary products, energy, water, leisure and recreational amenities for urban consumers. Rural workers can commute or migrate to urban labour markets, generating cash remittances for their place of origin. These points illustrate how rural and urban areas can perform complementary functions. Urban and rural development is not mutually exclusive, and it is wrong to think that urbanisation is necessarily harmful to rural areas. Urban-rural interactions should be encouraged because they help to promote trade and to distribute resources between groups of people in different places—effectively linking areas of 'need' and 'opportunity'.

These observations illustrate a broader point that there is no simple, inevitable or linear relationship between urbanisation and employment growth. Cities can follow different development paths and experience different rates of population and economic growth. The structure or composition of growth can also have very diverse consequences for the nature of employment generated. At one extreme, it may be high 'quality' growth associated with high-value output and productivity, and result in relatively few highly-paid jobs. Alternatively, it may be lower value production associated with larger amounts of lower-paid employment. Cities can also go through different phases of growth at different points in time. There is a large body of knowledge and evidence concerned with the variable development trajectories of cities. Key dimensions of variation include the age and size of the city, its economic structure, and its regional position or location.

14.3 Smart Economy and Economic Development

This book advances the notion that greater efforts are required to foster 'Smart Cities' and Smart Economies in Africa. One of the ways for cities to become 'smart' will be by the adoption of data and data analytics techniques. We examine a few of the ways to achieve this.

Urban Security

Predictive Analytics have been used in several cities across the world to help predict where crimes are likely to take place through historical data and geographical data. These have seen significant success in cities like London, Los Angeles and Chicago. Through data, it is often not even necessary to make arrests, having police officers appearing in certain areas at specific times has seen crime rates drop. Through data use like this, we could see significantly safer cities, with police who can stop crime without needing to put themselves at risk of harm.

Urban Planning Functions

Smart City techniques are useful for undertaking city planning functions, particularly analytics and data that handle large amounts of data. For now, they are deployed largely in web traffic and marketing, but increasingly these are used in the physical creation of buildings and spaces. The techniques can be used for delineating space from building zoning to public space and as well urban basic services using well known models to optimize time and important elements of the city's infrastructure. The use of these techniques with capacity to deal with long-range and multi-level complexities remove the tedium associated with the analog age and the modelling techniques map infrastructure outcomes with a high degree of accuracy.

Modelling Urban Basic Services

Increasingly Smart City techniques avail themselves of planning for urban basic services such as energy, transport, water, sanitation within networks of the urban fabric. In large part this is underpinned by data and analytics that ensures efficiency and productivity. Due to large memory in modern computers, Big Data allow technicians to input data from several nodal points to predict and model future usage such as numbers of commuters, volume of water and sewage used and so on. By the deployment of large amounts of available information and throughout water, energy, telecommunications and transport networks, it is possible to create effective and flexible systems that raise efficiency to very high levels. Data used this way also help monitor and evaluate systems and equipment reliability, improve safety and minimize accidents.

Effective Urban and Municipal Finance

Consistent with the earlier points made analysts are now using analytics and data 'Smart Cities' to model and create structures for effective municipal finance and also pinpoint where public money would most have the greatest impact. Through targeting optimum impact points, the entire infrastructure of the city can be improved and wastage can be minimized.

Mayors should be able to extract progressive tax commensurate with the evolution of new businesses that require public goods including industrial infrastructure necessary to sustain continued economic growth and innovation. Notably, basic amenities such as water and electricity are affected by the emergence of businesses and new residents. Through the use of modelling and predictive analytics, it becomes possible for city planners to see where these areas of growth are likely to be and how large this increase will be.

14.4 Urban Opportunities and Challenges

Throughout history, in rich as well as poor countries, urbanization has been closely associated with economic development. No nation has grown to middle income without urbanizing, or to high income without vibrant cities.[13] This is because economic and social development is intimately related to urban areas that have been indispensable to achieve productivity gains. As a result, the increase of urban population has not only generated the resources for infrastructure and services that are shared within cities, but has also significantly increased labor productivity. Therefore, continued urbanization represents a virtuous circle that enhances productivity increase and in turn higher national income. This rapid growth of cities calls for the intensification of smart city solutions to engender and foster city information gathering and knowledge building. This could be done by continuous development of scalable, sustainable, and inclusive system that promotes dynamic urbanization. The development of smart cities relies on Big Data that equally are dependent on improving all the latter stages of data processing and including all strata of the economic system such as various municipals and state agencies all of which currently generate a wide variety of heterogeneous data with little coordination.

A century of experience indicates that as developing countries move up the income ladder, labor increasingly moves from agricultural to industrial and service sectors. Workers leave their villages and their agrarian occupations to move into larger and denser settlements in which productivity is higher and where concentration and agglomeration matter. Unlike the rural sector, proximity plays an important role within urban spaces to access not only markets for goods and services, but also ideas and knowledge.[14] Due to scale economies, therefore, workers in cities are more productive compared to the same unit of labour in the rural sector, and they earn a higher income level. Consequently, urbanization theorists see cities as a space that represents an opportunity to earn higher income for excess labor from rural areas.[15] Due to higher levels of productivity, cities experience higher economic outcomes and employment opportunities, which translate into greater prosperity at both the local and national levels.

Agglomeration economies and external economies of scale are the main principles explaining why people in larger cities are more productive than those located in small towns or rural areas. It is fundamental to understand how agglomeration economics explains the higher productivity level of larger cities. According to the New

[13] Harvey (2009).

[14] See Footnote 13.

[15] Lewis (1954).

Economic Geography, firms particularly benefit from agglomeration economies as it enables them to be close to other firms. This in turn reduces their transaction costs and allows them to gain from network effects, such as shared information.[16] Being located in close proximity promotes positive externalities among economic agents such as the reduction of business costs, as well as improved interaction and knowledge spillovers.[17] Urban areas also provide giant market places, which facilitate trade and commerce, making the production of many goods and services more efficient.[18] In addition to this, the benefit of agglomeration economies include proximity to a large labor pool, suppliers, customers and competitors within the same industry, and firms in other industries.[19]

Due to the advantages of agglomeration economy, economic growth and rising living standards have gone hand in hand with urbanization. This is why there has been a puzzle regarding Africa's rapid urbanization and why it has not been accompanied by greater economic dynamism. Some scholars regard Africa as major exception to the urbanization-development nexus. Past studies found no relationship between urbanization and development in Africa. However, recent studies reveal that countries with higher GDP growth experienced faster urbanization and rapid urbanization come hand-in hand with higher growth in industries and services. A counterfactual of an Africa without urbanization is one with even slower economic growth, greater GDP per capita losses, and increases in poverty.[20]

In Africa, the rising number of urban dwellers creates large centers for consumption and represents considerable market opportunities favoring businesses. This enhances job creation and increases productivity due to the concentration of commercial and industrial activities, boosting growth and development. There is also proof that African cities improve human development and enhances living standards as they improved access to infrastructure. Education levels, health conditions and sanitation of urban dwellers are also better than their rural counterparts. Figures show that the higher the urban population share, the higher the life expectancy at birth and the higher school enrollments.[21]

14.4.1 Smart Economy Response to the Flip Side of Rapid Urbanization

Over the last two decades, Africa has been experiencing the fastest urbanization rate compared to other regions of the world. In 2015, the annual urban population growth rate was 4.1% in sub-Saharan Africa as opposed to 2.3% in East Asia and

[16] Ellisson et al. (2010); Turok and Mcgranahan (2013).

[17] Turok (2004).

[18] UN-Habitat (2012).

[19] Turok and Mcgranahan (2013).

[20] See Footnote 13.

[21] Arouri et al. (2013).

1.4% in Latin America.[22] This fast-paced growth of African cities is not limited to the number of population, but also extends to the size of cities. Many challenges arise from the rapidity of this process in African countries, which counteracts the benefits gained from urbanization. In order to tackle these challenges will require the application of the evolving as well as existing Big Data techniques in analytics for pushing the notion of smart cities which are still at incipient phases in the African region. Considerable capacity development would be required over time since most of the techniques require significant capabilities to attenuate the high processing time associated with conventional methods of data processing. The evolution of smart economies therefore points to the adoption of innovative and sophisticated instruments and that underpin the efficient processing of Big Data.

In theory, urbanization is caused by pull factors such as better access to jobs, basic services and social safety nets. However, African cities tend to be the results of push factors from rural conflicts and rural degradation.[23] While cities have the potential to spur growth and development, inadequate infrastructure and poor planning or management has posed enormous challenges to urban dwellers in Africa. For instance, it is estimated that Africa's enormous infrastructure deficit requires close to US$38 billion a year to service adequate growth and service delivery.[24] Most of this infrastructure investment is needed in cities despite municipal government's limited financial capacity. Much of all cities are under-resourced to fulfill their potential as drivers of national economic development, while the key drivers of productivity found in urban areas have been neglected by African governments.[25]

The rapid urbanization of Africa mostly arises from the influx of migrants from rural areas. The extensive rural-urban migration put significant strains on resources and infrastructure of African cities. Moreover, people move into cities to seek economic opportunities. However, the inflow of migrants has outpaced the creation of jobs in the formal economy. As a consequence, the informal economy has been the major source of employment for these newcomers. Urbanization in Africa is therefore associated with a significant increase of the informal sector. Over the past decades, informal work has accounted for more than 60% of urban employment in many African countries.[26] This has considerable repercussions as the informal sector is less productive and tends to reduce economic growth in developing countries. Furthermore, in terms of living standards, workers employed in the informal sectors are more likely to be worse-off in terms of salary and working conditions than those working in the formal economy.

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[22] World Bank (2015).

[23] See Footnote 18.

[24] Foster and Briceño-Garmendia (2009).

[25] See Footnote 9.

[26] International Labour Organization, 2018. https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page3.jspx?locale=en&MBI_ID=524&_adf.ctrl-state=kib4xktuj_68&_afrLoop=1129383011038991&_afrWindowMode=0&_afrWindowId=null#!%40%40%3F_afrWindowId%3Dnull%26locale%3Den%26_afrLoop%3D1129383011038991%26MBI_ID%3D524%26_afrWindowMode%3D0%26_adf.ctrl-state%3D3zuagt70k_4: Accessed on 27 September 2018.

In addition to rapid rural to urban migration, cities in Africa are poorly regulated and planned, which further encourages informality and illegality. The rapid proliferation of slums is the most visible sign of the challenges caused by urbanization and is explained by the cities lack of resources to meet basic needs such as housing. While slums are not specific to Africa, the continent has the highest share of urban slum dwellers. In 2014, more than a half of urban dwellers in sub-Saharan Africa lived in slums, as opposed to one fourth in East Asia and close to one third in South Asia.[27] In certain African cities, slum inhabitants make up a large proportion of the urban residents. For example in Nairobi, around a quarter of the population live in sprawling slums.[28] This poses multiple threats to the health and safety of the new migrants and those already residing in slums as the living and safety conditions tend to be worse in urban slums than in rural areas. This type of informal settlements is associated with the lack of water and sanitation and insecurity of tenure that especially affects the most vulnerable. In 2015, 60% of the urban population in sub-Saharan Africa did not have access to improved sanitation facilities.[29]

This is accentuated by urban primacy that characterized the urbanization process of Africa. In 2015, 28.4% of the urban population was living in each country's largest city, as opposed to 22.8% in Latin America and 11.7% in East Asia. This is a threat to the sustainable development of the continent as too much pressure on one single location is detrimental to achieve urban economic growth. Evidence shows that in the case where the largest city in a country grows too large compared to other cities, urban development does not favor economic growth.[30] Similarly, negative effects arise when a primate city is above its optimal size and that the excessive urban primacy experienced in Africa has a significant negative impact on economic growth.[31] The demographic pressure in African cities also leads to negative externalities such as congestion and pollution. All these challenges are exacerbated by climate and environmental change.

Little access to employment opportunities, insecure housing, violent environment, and limited access to health and education opportunities all result in urban poverty. This is accentuated by the high costs of living in cities that urban incomes, although higher than rural income, cannot compensate for. Housing costs but also the costs of informal service provision that people have to turn to are very high. In addition to urban poverty, urban inequalities are present in most cities of Africa. In fact, the region has the highest level of urban inequality in the world.[32] This is due to the fact that only a few benefits from the urban advantage, while the vast majority is left behind.

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[27] See Footnote 22.

[28] See Footnote 18.

[29] See Footnote 22.

[30] Duranton (2008).

[31] Overman and Venables (2005).

[32] UN Habitat (2010).

14.4.2 Seizing the Urban Advantage in Africa

Some African governments tend to consider urbanization as an uncontrollable pathology and have attempted to restrain this process. However, efforts to contain the flow of migrants have not been successful. Urbanization should rather be included in the policy formulation process as it is a cross-cutting subject impacting both social and economic development. The negative effects of urbanization are often over-emphasized, although cities represent the best hope for growth opportunities and drivers of economic development. While urban challenges are undeniable, cities are still loci of economic activities that generate economic output as well as employment. In addition, urbanization is associated with rising incomes and living standards. The central role of cities in national economies is more significant in developing countries than in developed countries. The largest cities in Africa account for 36% of GDP while only accounting for 16% of the total population as a result of higher labor productivity emanating from agglomeration economies.[33]

Attaining full urban efficiency is extremely difficult to achieve. However, when urbanization is properly managed and planned, African countries could reap the full benefits offered by their cities. The existence of urban inefficiencies only means that cities are less efficient than they could be. Well-designed urban policies could help in counteracting this inefficiency by unlocking the urban potential and generating important gains. Urbanization has to be guided through adequate policies designed and implemented at both the national and local levels in order to become a force for structural transformation and development. Not all types of urbanization lead to economic transformation and development. It is sustainable urbanization that contributes to the local and national economies. Sustainable urbanization refers to urban development that impact the economy, the society and the environment in a beneficial manner for the present generation without damaging the living standards and condition of future generations. Sustainable urbanization is enhanced by proper planning, financing and legal mechanisms.

Steered urbanization is essential to prevent some of the identified challenges, but most importantly, it helps countries to reap gains from urbanization.

First, this implies adequate urban governance as well as necessary funding. Local governments should not only receive new responsibilities but should also be given additional financial resources. Political decentralization can only work when accompanied by fiscal decentralization that is a pre-requisite for competent management of the urbanization process.

Second, it implies the provision of suitable and sufficient housing and basic infrastructure. Considerable investments in infrastructure are required to address the influx of people and associated challenges in terms of health, housing, public services, jobs and safety. Improving the quality of infrastructure is essential to provide a business friendly environment and to enhance the productivity of cities. This includes national networks for telecommunications, electricity and transport in addition to local services for public transport, water and sanitation. Improving the access to serviced

[33] Godfrey and Zhao (2014).

land for enterprises is also important for the same purpose. Local governments also need to reform local regulations that impede the operating conditions for enterprises. Legal reforms are indispensable to improve the investment climate of African cities, to enable business creation and expansion, and in turn to generate jobs. Regarding urban primacy, the phenomenon should be attenuated to release the pressure on prime cities. New urban hierarchies must be found while the importance of secondary cities and urban development corridors should be recognized.

All urban dwellers should be able to benefit from the urban advantage. Therefore, cities should be made livable and inclusive. Measure should be taken to prevent insecure tenure and dysfunctional land market that are affecting the poor. Furthermore, efforts should make the jobs in the informal economy more productive. Targeting informal employment and information settlements in policies would ensure to include the greater majority of urban residents and would be a further step towards urban equality.

Furthermore, the large number of youth population in urban areas constitutes a reservoir of labor for transformation and growth and should be seen as an economic asset. Africa is the youngest continent in the world with close to 70% of its population aged below 25. Large shares of these youth constitute the total labor force in Africa. This gives rise to a demographic dividend in African cities, which is promising to promote development.

14.5 Land: The Hidden Assets in African Cities—The Case of Dakar[34]

At the economic and financial aspect, there are various social and economic advantages associated to land including access to the financial and economic market as illustrated in de Soto publication (The Mistery of Capital 2000). De Soto argued that granting titles to the poor would liberate the plots they occupy and transform them into capital. This, in turn, could be used as collateral for loans to jumpstart their businesses, or improve their houses, among other gains that increase their quality of life. At the community level, the municipality can legally collect various taxes that can be used to improve basic infrastructures such as connection to water, sewerage facilities, energy sources and waste management facilities. This would also allow people to fully participate in the development of their communities at the policy as well as the implementation level instead of seeing proprieties as dead investments serving only for shelter.

Urban land is a vital economic asset, and asset transactions are viable only where purchasers can rely on enduring extra-legal documentation of ownership. A formal market offers purchasers legal protection with transactions adequately recorded in land administration book; it also generates public good with accurate valuation.[35]

[34] A Summary from Mboup (2017); De Soto (2000).

[35] Lall et al. (2017).

Transparent property rights to urban land are a precondition for formal land markets. When these systems pose barriers to urban land access, they impede the consolidation of plots and the evolution of land use. As noted by de Soto (2000), "any asset whose economic and social aspects are not fixed in a formal property system is extremely hard to move in the market…. Without such a system, any trade of an asset, say a piece of real estate, requires an enormous effort just to determine the basis of the transaction: does the seller own the real estate and have the right to transfer it? Can he pledge it? Will the new owner be accepted as such by those who enforce property right? What are the effective means to exclude other claimants?"

In Dakar, these questions enumerated by de Soto (2000) are difficult to answer. For most goods, there is no place where the answers are reliably fixed. That is why the sale or lease of a house may involve lengthy and complex procedures to ensure that propriety belongs to the seller. Land transactions are long, costly, and complicated in Dakar as in most African cities (World Bank 2015 cited by Lall et al. 2017). Such market constraints reduce the collateral value of structures, giving developers little incentive to invest in residential height. In such a condition transactions are made through informal arrangements (Collier 2016 cited by Lall et al. 2017).

14.5.1 Formal Land Tenure Provides Opportunities to Settlements and People

Large infrastructure projects require huge investments. However, like any large structures, they depreciate very slowly over decades or even centuries (Philibert 2007). The central government transfers on which Dakar as most African cities often rely will not suffice to finance all infrastructures required to take advantage of the economies of scale and agglomeration that Dakar can offer its large population of more than 3 million inhabitants with high density of over 15,000 inhabitants per square km. Therefore national and local authorities should explore various financing options for infrastructure development. The costs of developing housing, infrastructure, and industrial premises must be coordinated with land markets and land use regulations in order to fully take advantage of the economies of scale and agglomeration of the city of Dakar. This calls for the formalization of the land tenure, which, in turn, will increase the land values that can be used to contribute to the development of basic infrastructures such connection to water, sanitation, drainage, solid waste management and streets. For instance, in Dakar due to lack of municipal finances most municipal street networks are not paved. Municipalities with formal land system have the large proportion of paved streets compared to others without formal land system.[36] Secure tenure goes beyond the legal character; it attracts investments as illustrated by the level of provision of infrastructure in municipalities considered as legal settlements compared to others considered as informal settlements. These municipalities also enjoy health centers and school facilities. They also attract the

[36] ADM, 2001. Dakar Urban Audit Please give full reference.

financial market because they have a legal urban plan with a sufficiently documented cadaster system. This shows the community character of land tenure that goes beyond the household and embrace infrastructure in the municipality itself. In most irregular settlements, there are few or no paved streets, and the few streets they have do not have light. Lack of documented urban plans affects the financial as well as the land market. It is noted that capacity and resource constraints are the main reason infrastructure in most municipalities have been lagging behind. In absence of formal land system, a settlement is trapped into poverty. With this, there is no doubt that wealth is associated to formal land system. Let make secure tenure work for people and communities. Dakar is expected to reach 5 million inhabitants in 2035. This will propel new demand for infrastructure such as water, sanitation, sewerage, waste management and streets among others. To meet this demand, land transactions must be eased with transparent efficient land law, administration and governance with documented land and property rights; documented guidance of land valuation and prices and; coordinated land use and urban planning. Land tenure goes hand and hand with urban planning. Urban planning supported by accurate demarcation of public and private uses are of importance (Toulmin 2005). Without an accurate mapping, legal title dead cannot prevent land disputes as it often occurred in African cities. In Dakar, it may take several years before regularization, particularly when it is bought informally. Formal land Registration will ease transactions and boost economies of scale and agglomeration.

14.5.2 Tentative Estimation of Land Value of Dakar

Under its Disaster Risk Reduction (DRR) strategy as part of its Poverty Reduction Strategy (PRS) process (IMF 2007), land has been given a central place. Apart from habitat degradation, floods cause considerable economic losses on the various activities performed by people across various income and social connections. The impacts of floods on people and communities are enormous ranging from economic, social and health issues to environmental aspects. As shown previously, damages and losses associated to flooding are particularly high in Dakar as a coastal city. The DRR team combined hazard and population maps, *land price data*, and land cover information to derive the exposure of different variables in different locations. This allowed to assess the potential economic impact of natural hazards, taking into account direct and indirect damages. This has been done in conjunction with analysis of detailed geographic information systems (GIS) data, cadasters, and field verification to ascertain detailed risks faced by populations and built areas. Exposure and vulnerability of economic assets in the area were estimated with the spatial analysis of land price values. It is estimated that the Dakar Metropolitan Area represents a total land value of $44 billion. This figure represents is 8 times the city GDP. Considering the level of informality of 37%, we can assert that US$17.4 billion out of the US$44 billion of land value of Dakar is not convertible in the financial market to secure marketable financial transactions; it cannot also generate revenues for the development of infrastructures. In addition, due to poor urban planning and irregular land use, over \$2 billion or 5% is exposed to high natural hazard potentials. In the absence of functioning land market where prices are regulated and documented, these figures must been considered as rough estimations of the exposure of economic assets to natural hazard such as flooding.[37] Information from the PROGEP corroborates the economic damages and losses associated to flooding in Dakar. At the household levels, an estimated 30,000 houses were affected in the Dakar region, most of which are now uninhabitable and often abandoned,[38] and nearly 360,000 people representing 44% of the population of Pikine were affected. The impact of flooding related disasters remains a significant challenge to sustainable development of the city of Dakar.[39] These various estimates point out the importance of adequate planning and land use regulation to mitigate the city's economic vulnerability against risks such as flooding. Dakar has launched the Initiative for Sustainable Cities such aim to integrate vulnerability to urban planning and management.[40]

Considering the weak financial revenues of the city Dakar, a land value of 44US\$ must be seen as an opportunity to tap on it. It represents nearly 500 times the annual revenue of the metropolitan area estimated at US\$94.8 million. Though there is a steady increase of the budget of Dakar from FCFA 2 billion to over FCFA 28 billion in 2006, the city is still in the incapacity to satisfy the increased demand in most basic services such as water, sanitation, solid waste management, health and education. The budget of the city finances mainly operational against investment expenditures (59% against 41%).[41] The budgets mainly include local taxes and levies (around 90%) for all the departments. Subsidies from central government remain minimal, less than 2%. But this situation is more due to the nature of taxes levied in each entity rather than to performance of local authorities.[42]

It is also noted that due its rapid growth, land prices are high in the city of Dakar but benefits less to the infrastructural development of the city. It does not create revenues for the cities as illustrated in the city income-expenditures sheet. In cities of developed countries, land-based financing has significantly contributed to urban investment. Taxes on land use will reduce the high level of inactive land in Dakar. Considering that they are paying taxes on the land, landowners will either develop their land in its most profitable use or they will rent/sell it. Improved valuation of

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[37] Hyoung Gun Wang Economist, Spatial team FEU, SDN Marisela Montoliu-Munoz Head, Spatial team FEU, SDN The Geoville Group Ndèye Fatou D. Gueye Consultant, FUE, SDN, 2009. Preparing to Manage Natural Hazards and Climate Change Risks in Dakar, Senegal. A Spatial and Institutional Approach. Pilot Study Report. See also World Bank & Republic of Senegal, 2013. Economic and Spatial Study of the Vulnerability and Adaptation to Climate Change of Coastal Areas in Senegal.

[38] Republic of Senegal, AWF, EAA, Donor Roundtable aimed at financing the emergency phase of the Ten-Year Flood Program, Programs for Integrated Water Resources Management and Access to Drinking Water and Sanitation, December 2012.

[39] The World Conference on Disaster Reduction, held in Kobe, in Japan's Hyogo Prefecture, from 18 to 22 January, 2005.

[40] Senegal, Project document "Sustainable Cities Initiative", GEF-6 Sustainable Cities Programme.

[41] CDS, IAGU, 2008 cited by Wang et al. (2009).

[42] See Footnote 42.

land and properties closer to their market value, deepening the tax base; Improved enforcement of land and property taxes on a larger number of owners, broadening the tax base and; monetization of underused public land.[43] This will require functioning institutions in a transparent manner with inclusive, documented property rights using standardized and objective methods of land valuation. Good land governance and administration where corruption does not have a place will make trusted institutions and will encourage landowners to register their properties considering the high returns for them and for their community.

Due to limited revenues of the city of Dakar, it is high time to tap to the potential capital of land through the regularization of land tenure. In Dakar, it is not only the poor that lack title deed but also an important number of middle class and upper class families or settlements. In his book, de Soto advocates for the secure property rights to the poor. But in the case of Senegal lack of property rights affects the poor as well as the rich. While there is argument against de Soto theory, in Dakar regularization of land tenure will work for many middle and upper income households that have not been able to use their property as collateral due to lack of legal ownership document.

Another important group land regularization will benefit is the Senegalese from the diaspora who usually send money to their family and build houses in Senegal. Most of these houses are built in irregular settlements. Among the Senegalese of the diaspora, certain have a high desire to return home, but they have not save enough to do so, and they cannot use their houses as collateral and start a business in Senegal. No choice, even those they are here cannot get a title dead, what about those that just come to visit their family for a month or less. These are not the poor as described in the de Soto book, they have already the value of savings as underlined by the money they sent to their family in a monthly basis. The money received from the diaspora is estimated at \$1.9 billion (FCFA 971.4) by the Senegalese Ministry of Finances, much higher than the foreign aid Senegal received during the same year. It represented 12.1% of the national GDP. The Ministry of Finances considered that the diaspora are the first donors of Senegal.[44] However, the money of the diaspora is not invested in the market, it is invested in residential houses and household subsistence. Without legal recognition, these houses cannot be transformed neither into capital nor transacted through the economies of scale and agglomeration that the city of Dakar potentially offers.

These Senegalese from the diaspora as most Senegalese have houses but not titles; crops but not deeds. They also face multiple difficulties to incorporate businesses if they wish to return. Even the poor are not poor as we can imagine, but their problems are more complex than the category of the middle and upper income families. Senegalese possess wealth beyond our imagination. They are not poor, but their wealth is not legally recognized by their government, which finally turns to the Western nation

[43]See Footnote 36.

[44]Ministry of Finance of Senegal (2017).

seeking for aid. What a paradox! Why have the government of Senegal failed to tap into the potential wealth of its people?[45]

Following the same illustration of de Soto (2000), “A country, where nobody can identify who owns what, addresses cannot easily be verified, people cannot be made to pay their debts, resources cannot immediately be turned into money, ownership cannot be divided into shares, descriptions of assets are not standardized and cannot easily be compared, and the rules that govern property vary from neighborhood to neighborhood or even from street to street, cannot sufficiently create prosperity.[46] The majority of the residents of Dakar belong to that category. Finally the informal becomes the de facto formal. Institutions and laws are fundamental to create trusted communities and ease transactions and attract investors”. This is the key difference between Senegal, and in general African countries, and developed countries. With the ICT revolution, we have all access to the same technology and high tech goods, the only difference lies on the enforcement of the rule of laws to make all actors accountable. When the diaspora return to Senegal, they are not missing the comfort they left in Europe or America, they have all in Senegal and even more, with large houses, high tech TV, cars, etc., “What they are really leaving behind is the world of legally enforceable transactions on property rights”.[47]

Land economic return lag in poor settlements

Though having a title dead does not necessary lead to secure a bank loan, it may not be sufficient in itself to animate the dead capital interred in land and property, particularly in countries where banks lend only to workers with high wages and a stable job, as it seems happen in some countries covered in de Soto study. However, families with title dead may be likely to invest either to improve the quality of their homes or to increase their size. It is also important to note that land tenure goes hand and hand with urban planning (Toulmin 2005). Without an accurate mapping, legal title dead cannot prevent land disputes as it often occurred in African cities. In Dakar, it may take several years before regularization, particularly when it is bought informally.

The conditions of the houses in poor settlements which are the face of slums lacking most basic infrastructures such as connection to water, sanitation, sewerage system and solid waste management. In addition to that they are not built with durable materials, they do not respect building code and they are likely to locate in hazardous locations. Lack of secure tenure is only one of the pieces of puzzle. In such a condition, providing title dead will not directly lead to the bankability of the property before the formal private financial market, and the public financial market may not guarantee a scheme of loans for houses with high liability costs. Here providing title deed without creating adequate framework may lead to speculation

[45]As noted by de Soto (2000). The Mistery of Capital. Black Swan "houses without documents are “dead capital” and lack the process to represent their property and create capital.

[46]De Soto (2000).

[47]see also de Soto (2000).

where wealthier households may convince poor household to sold their property as it happened elsewhere such as Cambodia.

The way forward

Learning from the experience in other countries, Senegal can develop a good framework for land regularization in all neighborhoods, starting first with mapping the neighborhood. This process adds value to the land itself as title dead does. This is not just mapping for demarcation of plot but for also assessing the conditions on which houses are built, particularly the exposure to disaster, for them and their neighborhood. This survey may be followed with carefully identification of owners of plot, as it is already done in the PROGEP. At the end of this exercise Dakar will have an organized property right system in rich neighborhood as well as in poor neighborhood. The latter will enjoy secure tenure without being exposed to fear against eviction while the former will directly enjoy secure tenure with all social and financial advantages attached to. The economic return may take longer, but at least we have created a property right system transferable from generation to generation.

14.6 Conclusion

How do we use Smart City techniques to create Smart Economies in Africa? How do we use this to enhance city employment, industrialization and raise living standards? In brief there are well tested mechanisms among which are:

- Smart Cities techniques can enhance the convergence between investment and technology policies for job creation;
- Promote Collective and community based programmes particularly for informal economies;
- Development of enterprise clusters and urban agglomerations through direct policy interventions emphasizing decent jobs;
- Promote investment in local high employment elastic sectors such as construction and housing;
- Foster convergence of urban planning and Investment in infrastructure to attract investment in cities.

One of the keys to sustainability is monitoring and having effective controls in place to quickly make changes in order to keep output at a certain level. Data is the most decisive factor for achieving this, it allows for governments and companies to see how their outputs are having a positive or negative result on the city as a whole. This monitoring also creates the opportunity to see which technologies work best in reducing the negative fallouts of urbanization such as pollution, congestion and advancing innovations to prevent environmental damage.

The emerging African Smart Cities should foster sustainable urbanization, industrialization and economic growth in ways that are closely interrelated and mutually reinforcing. This is to bring African cities back to the conventional growth path and to ensure the development of production cities, rather than consumption cities.

Sustainable urbanization, safe and resilient human settlements increases sustainable growth pathways, reduces inequality, increases productivity and economic opportunities; therefore, the role of sustainable urbanization and highly productive cities to national development cannot be over-emphasized. The analysis of the linkages between urbanization and economic development suggests that the association between both factors is positive in all countries. The degree of urbanization also varies between countries from 18.59% in Ethiopia to 63.79% in South Africa in 2013.

Evolving towards Smart Cities should lead to rise in productivity in high productive sectors such as industry and manufacturing that has been the major reasons for the slow urbanization process and the stagnation of economic development. The process should result in higher income and better quality of life. Urbanization can breed misery if it is not sustainable as it creates slums, rising congestion, pollution, pressure on natural resources, higher labour and property costs, higher levels of crime and insecurity often in the form of negative externalities or agglomeration diseconomies which could prevent private investment, reduce urban productivity and hold back growth; but sustainable urbanization and formation of cities can also be harnessed to boost productivity (which increases as workers migrate from agricultural work into urban jobs), demand, and investment. If properly harnessed, urbanization and strategic positioning of cities will boost production.

A strategy to promote efficient urbanization should target density level, land market efficiency, connectivity, potentials for industrialization and interventions arising from pollution, congestion and concentration of people in vulnerable areas. Efficient governance institutions and effective political leadership are critical to address the interrelated challenges of urbanization and maximize its potentials; the capacity to produce sustainable solutions must also be harnessed. Urban governance is an essential component to effectively manage cities; the national, local, and regional governments plays a strategic role in guiding economic, social, and environmental policy decisions to sustain the quality of urban areas. It is also essential that policies and decision making are cantered on the local conditions and viewed in the current economic and social contexts. Overall, economic transformation which is often known to be associated with the migration of labor out of rural agricultural sector into the urban industrial sector, has not been strongly experienced in the African context during most of the first five decades of their independence. Driven by urbanization and decades of neglect of agriculture, most countries in the region have seen rapid labor migration out of a stagnating agriculture sector into an informal services sector-with even lower productivity levels. The contribution to overall economic productivity has therefore been negative but Smart City techniques can assist to reverse this.

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Chapter 15
Information and Communication Technologies in Africa: Levels, Trends and Perspectives

Komlan Franck Godefroy Beda

Abstract The ICTs revolution has caused profound upheavals in various aspects around the world including Africa. Whatever form they take, ICT-induced changes may have significant implications not only in the sector itself but also in all development sectors. The changes in the ICT sector in Africa are part of an international dynamic resulting from the combination of liberalization policies, incredible technological advances and strong consumer demand. This chapter presents the levels, trends and perspectives of Information and Communication Technologies in the African region. This chapter proceeds first with a literature review on regulatory policies in order to understand their ripple effects. After presenting a general history of ICTs, it analyses the evolving factors of internet connection in Sub-Saharan Africa. It also presents the internet perspectives and regulation in Africa including technologies trends as well as key technologies. It also assesses and proposes types of technologies for internet connection in Africa. It concludes with perspectives for sustainable trends of ICT in Africa.

Keywords ICT · Information · Communication · Internet · Mobile phones
Computers · Connection · Africa

15.1 Introduction

The information and communication technologies (ICTs) revolution has impacted various aspects of our lives. Starting from the United States of America in the 1960s, ICTS reached the rest of the Western world in the years 1970–1980. Much later (towards the end of the 20th century), like many other developing countries, the

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The orginal version is written in French. This is a translation of that version. In case you need more clarification, please refer to the author to access the original version.

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ICT revolution reached the African countries. In general, the expansion of ICT is primarily regulatory, technological, social and security. However, there are specificities depending on each region, country and communities. Whatever form they take, ICT-induced changes may have significant implications not only for the sector itself but also for the whole development process.

The changes in the ICT sector in Africa are part of an international dynamic resulting from the combination of liberalization policies, incredible technological advances and strong consumer demand. As it happens elsewhere in the world, ICT revolution in Africa is real and is linked to three factors that will be analyzed here:

- Regulation of the ICT sector,
- State legislation
- Investment in the ICT sector

If state regulations have, throughout the history of ICT, been sheltered from serious challenges for strategic issues (concern for national security), they were from the seventies, the object of several criticisms urging African states to deregulate. Thus, WAEMU and ECOWAS Member States have to transpose these Community provisions into their national legislation. Thus, a bill was examined to repeal and replace Law No. 2001-15 of 27 December 2001 on the Telecommunications Code, amended by Law 2006-02 of 4 January 2006, to set the framework. Legal framework governing the landscape of the sector of telecommunications and information and communication technologies in phase with the WAEMU/ECOWAS community law.

In the context of legislation, African countries, have set up a legal framework for information and communication technologies. For instance in Senegal five laws have been passed: (1) the Information Society Act, (2) the Electronic Transactions Act, (3) the Cybercrime Act, (4) the Personal Data Act and (5) the Cryptology Act.[1] This proves that the African legal arsenal is not quite silent about the use of ICTs.

We will first proceed with a literature review on regulatory policies in order to understand their ripple effects on the ICT revolution. Before analysing the ICT revolution in terms of levels, trends and perspectives, we will present first a brief history of the evolution of ICT in the world and particularly in Africa. Subsequently, we will conduct research studies supplemented by the analysis of the ICT environment and its impact on various economic and social sectors.

15.2 Brief History on ICT

ICTs were anchored from the Internet which was also introduced in 1969 under the leadership of the US Department of Defense (DOD). Called ARPANET, it was supposed to ensure the exchange of electronic information between the American nerve centers in the context of the cold war.

[1] www.cpd.sn/.

In 1984, with the loss of its military character, the Internet will reach businesses and then civilians to transfer to ICTs. The fall of the Berlin Wall 1989 facilitated the popularization of this new technology across the planet.

15.2.1 Evolution of ICT over the Last 15 Years

ICT refers to computer, audiovisual, multimedia, Internet and telecommunications technologies that allow users to communicate, access information sources, store, manipulate, produce and transmit information in all forms: text, music, sound, image, video and interactive graphic interface (GUI).

The rapid expansion and adoption of information and communication technologies (ICT) by the African population has been translated into increased demand for ICT services. Not everyone uses them in the same way or to the same degree; not everyone has access to or access to some of the digital services. The ICT adoption evolution will vary according to the expectations of users.

15.2.2 Evolving Factors

Since the mid-1990s (in early 1992), the computer reached the the sub-Saharan African region, just less than 30 years compared to developed regions. At the beginning, the computer was expensive and inaccessible to the general public. Since the computer was the only means to access internet in the early 90s, the Internet and ICT in general were little known insub-Saharan Africa until the end of 1990s. It is only in the millennium, that the access of African households to internet has increased. In Response the increased and progressive demand of ICTs from companies, African authorities took strong measures with the creation of the services dedicated to the ICT within the state structures of Telecommunication. These decisions have led to effective reforms that had accelerated the the expansion of ICTs in Africa. The Table 15.1 illustrates how in Senegal the legal and regulatory environment has contributed to the rapid evolution of ICT in the country.

It is clear that already from 1996 strong decisions to generalize the development and the use of ICTs were taken by African governments. From 1960 to towards the years 1981, the classical telecommunication was on the Telex and the telegram and telephony. From 1988 most African countries were moving from circuit switching to message switching and packet switching where:

- Circuit switching consists in successively connecting the various intermediate nodes in order to propagate the data of the sending node to the receiving node. In this type of scenario, the communication line can be linked to a pipe dedicated to communication.

Table 15.1 ICT environment in Senegal since 1960

Evolution du secteur des TIC depuis 1960	
1960	Création de l'*Office des pastes et télécommunications* (OPT) chargé de la gestion des télécommunications nationales Gestion des communications internationales par *France Càbles et Radio* (FCR)
1972	Adoption de loi n°72–39 du 26 mai 1972 relative aux télécommunications
1981	Création de *TéléSénégal*, société d'économie mixte associant I'Etat et FCR, chargée de la gestion des télécommunications internationales
1985	Séparation des activités postales et des activités de télécommunications Création de I'*Office des postes et de la Caisse d'épargne* (OPCE) Création de la *Société nationale des télécommunications du Sénégal* (Sonatel) désormais responsable des télécommunications nationales et internationales
1987	Création de la *Délégation à I'lnformatique (DINFO)*
1988	Mise en service du réseau de transmission de données par paquets SENPAC
1996	Adoption d'un nouveau code des télécommunications autorisant la privatisation de la Sonatel et la libéralisation du marché des télécommunications Connexion à Internet et installation d'un réseau de téléphonie mobile par la Sonatel
1997	Privatisation de la Sonatel avec cession de 33.33% des parts du capital à FCR
1998	Lancement du Réseau numérique à intégration de service (RNIS) et du réseau IP national
1999	Démarrage des activités de Sentel, second opérateur de téléphonie mobile
2001	Création de la *Direction de I'lnformatique de I'Etat* (DIE) Adoption d'un nouveau code des télécommunications
2002	Mise en place de I'*Agence de régulation des télécommunications (ART)*
2003	Mise en service de I'ADSL
2004	Fin du monopole de la Sonatel sur la téléphonie fixe et internationale Création de I'*Agence de i'lnformatique de I'Etat* (ADIE)
2005	Publication d'une lettre de politique sectorielle du secteur des télécommunications
2006	Transformation de I'ART en *Agence de régulations des télécommunications et des postes* (ARTP)
2007	Attribution d'une licence globale de télécommunications à Sudatel

Source http://www.cepodsn.org/cepod/pub/tmp/Rapport%20final.pdf

- Message switching involves transmitting the message sequentially from one node to another. Each node waits to receive the entire message before transmitting it to the next.
- Packet switching consists of segmenting information into data packets, transmitted independently by the intermediate nodes and reassembled at the recipient level. It is this last mode of communication adopted towards the 1996 which will allow the most African countries including Senegal to open a way towards Internet. Already thanks to the packet switching the ISDN and local IP networks were adopted allowing quickly the adoption of internet. The Internet connection reached the

sub-Saharan African region in the early 1990s (Kenya in 1993, Uganda, Nigeria in 1995, and Togo in 1996). In most of these countries, Internet connectivity was done through an analog phone line.[2]

15.2.3 Ways of Connection to the Internet

Today, there are two types of connection to the Internet namely the wired connection and the wireless connection or radio.

15.2.3.1 Wired Internet Connection not Switched

The unswitched Internet connection includes the leased line (dedicated line) and the ***ADSL*** (Asymmetric Digital Subscriber Line).

The leased line is a cable lease made by a Wireline Operator to a company to connect to the Internet. This type of connection is expensive and generally offered to businesses.

ADSL is provided in most sub-Saharan African countries. However, its expansion is hampered by the weakness of the subscriber base in many countries.

15.2.3.2 Wireless Internet Connection (or Radio)

Wireless (or radio) Internet connections are made from four technologies: (a) the radio local loop (BLR), (b) GSM (Mobile Special Group), (c) CDMA (Code Division Multiple Access) and (d) WiMax (Worldwide Interoperability for Microwave Access).

Box 15.1 Way of Connection to the Internet

Radio local loop

The local radio loop is used to serve localities or areas without wireline telephone lines. It is often used by Internet Service Providers (ISPs) that connect their customers. This is the case, for example, of CAFE INFORMATIQUE in Togo, of CONNECTEO in Burkina Faso. In general, these ISPs are licensed and obtain a frequency from the National Regulatory Authority (NRA).

Internet connection with GSM

GSM also provides an Internet connection from General Packet Radio Service (GPRS) technologies, EDGE (Enhanced Data Rates for Global Evolution)

[2] Source: ETUDE SUR LA CONNECTIVITÉ INTERNATIONALE D'INTERNET EN AFRIQUE SUBSAHARIENNE Mars 2013 *UIT.*

and 3G. The service is provided from a Personal Computer Memory Card International Association (PCMCIA) modem or a Universal Serial Bus (USB) key. The future of the broadband Internet connection will be mainly with 3G GSM as it is the largest network in sub-Saharan Africa. 3G is already in operation in some countries like Nigeria, Ghana and Kenya. Studies are underway for its possible allocation in Niger, the DRC or Benin.

Internet connection with CDMA

The CDMA technology has been adopted by many incumbent operators to catch up with the delay in the construction of the wired network and to reduce the many wireline applications, not yet satisfied by the provision of a fixed wireless line. The option of the Internet connection of this technology has been used with varying degrees of success by some Operators to provide Internet access to users. Two types of Internet connection are offered by this technology. A low speed connection up to 256 kbit/s and EVDO (Evolution Data Optimized) offering speeds up to 2 Mbit/s and beyond depending on the version.

Internet connection with WiMax

WiMax appeared in the sub-Saharan region in the mid-2000s. Dozens of such networks exist in sub-Saharan Africa. The future of this type of connection in the sub-Saharan region will depend on the evolution of this technology worldwide.

Source: Groupe d'étude 3 pour l'Afrique (SG3RG-AFR) en mai 2012 et pour l'Amérique latine et les Caraïbes (SG3RG-LAC) en mars 2012.

15.2.4 Internet Connection in Sub-saharan Africa

In general, a subscription to an Internet connection (fixed or mobile) is shared by several people. In addition, many people have access to the Internet through their professional occupation or in educational institutions especially at the university level. Moreover, the first source of Internet connection in several countries are cybercafés at least until 2012.

15.2.4.1 Number of Users Per Hundred Inhabitants in Sub-saharan Africa

The penetration rate of the Internet in sub-Saharan Africa is still very low. The Fig. 15.1 shows the number of users per hundred inhabitants for forty-five sub-Saharan African countries.

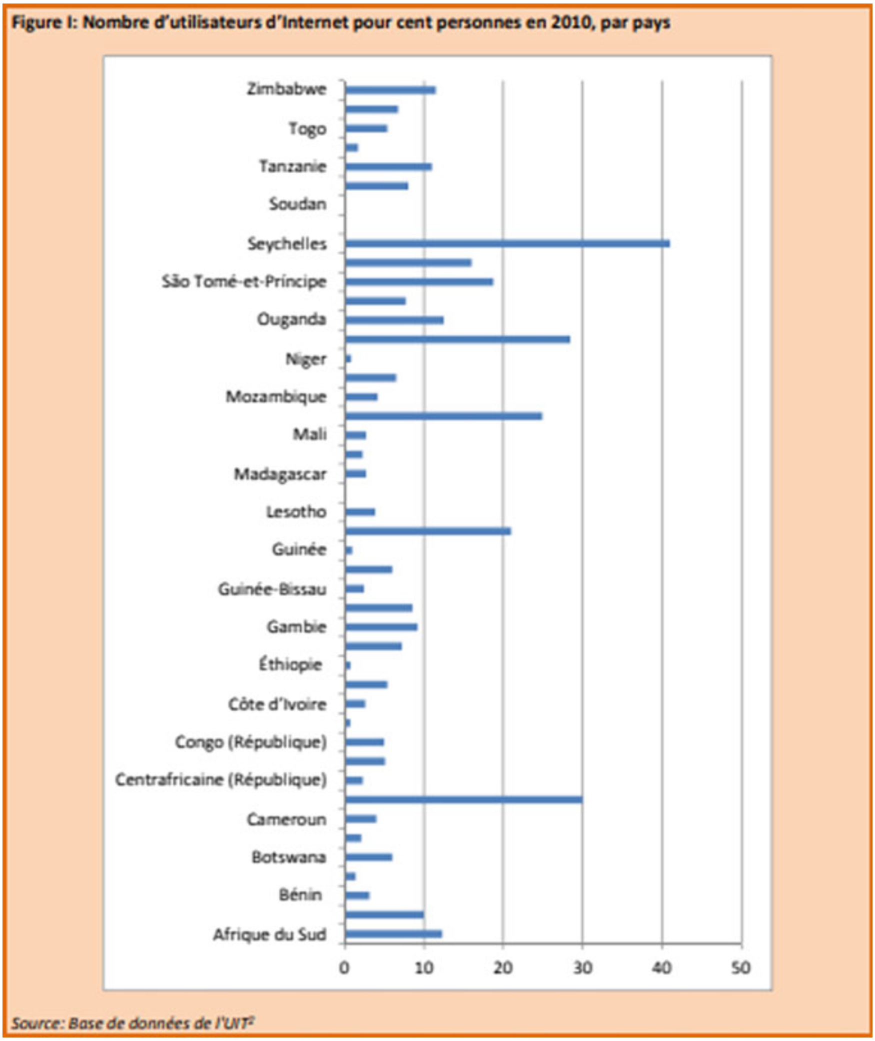


Fig. 15.1 Percentage internet users in 2010 in 45 sub-saharan African Countries. *Source* UIT database, 2010 (Base de donnée de l'UIT 2010)

15.2.5 Basic ICT Services

The basic Internet services is summarized in the Fig. 15.2:

- Email (E-Mail)
- Collaborative work
- The TV service

Fig. 15.2 Basic ICT services. *Source* http://www.servicenet.in/enterprise-communication/

- Telephony
- The video conference

1. **E-mail**

E-Mail commonly called electronic mail on the Internet. An email message reaches anywhere in the world in seconds or minutes. In addition, the recipient does not have to be present to receive the message.

The messaging basically rests on the protocols1:

Simple Mail Transfer Protocol (SMTP), Post Office Protocol (POP), and Internet Message Access Protocol (IMAP). There is another one, the Messaging Application Programming Interface (MAPI), but it is only used when using Microsoft Exchange2.

The largest mail providers in the world are Yahoo, Outlook, Gmail, AOl

YAHOO! MAIL
Outlook
Gmail
Microsoft Outlook Aol Mail.

At the opposite of the paid mail via the post office which can take days and require the presence of recipient, mail via e-mail reach instantly one recipient or multiple recipients without a cost once the internet is available. Now the transfer of documents such as contracts, job application, invitations are exchanged safely with no limit and time constraint.

2. **Conferences**

A conference is a simultaneous conversation between several people on a subject of interest. There are two types of conferences: Audio and Video.

Fig. 15.3 Videoconference session. *Source* http://www.congoactuel.com/electricite-labanque-mondiale-plaide-pour-desinvestissements-dans-lenergie-renouvelable/

Fig. 15.4 Example of instant messaging tools. *Source* https://fastsms.co.uk/blog/fastsms-email-tosms-brochure.html

Today, thanks to the popularization of the Internet, we can organize an oral discussion with or without video between a group of people. This practice has become recurrent in Africa, particularly in the public administration, companies and universities. The video conference introduced by the Internet will significantly inter-regional and global communication and cooperation. It will also ease social communication and exhange between friends and families.

Today in most African countries (example of Senegal, Ivory Coast, Ghana, Nigeria, Uganda, Rwanda, South Africa, etc.), the Visio is a reality. Meetings, trainings, and interviews are progressively conducted via video conference (Fig. 15.3).

3. **Instant messaging**

Instant messaging, a form of real-time dialogue, allows the immediate exchange of text messages and files between several people via computers or smartphones connected to the same network as illustrated in the Fig. 15.4

Instant Messaging (IM) allow communication in general and interpersonal relationship in particular. Now with this service friends and members of the same family can create discussion groups and exchange. In African countries this service has taken precedence over most Internet services. In practice, employee of a company in mission can exchange via IM with a team in the headquarter as well as from other places.

Apart from the aforementioned services, ICT offers:

- **Audiovisual services**
  They allow access to audiovisual content on TV through Internet connection, provide access to consumers to a very wide range of content, with increased diversity.
- **Telemedicine**
  Telemedicine, in the context of an aging population, may contribute to the optimization of home care for patients or in areas where the medical resource is insufficient. ICTs can provide favorable conditions for the development of these services (including the use of video services as a substitute for the displacement of medical staff).
- **Distributed computing**
  Distributed computing is part of the recent trend of hosting applications and computing resources on a cloud ("Cloud Computing"), and provides cheaper, more reliable and more scalable services than existing services.
- **Telecommuting**
  Telework, which is still not widespread in Africa compared to many other developed countries, has many advantages, such as improved working conditions for employees and a better balance between personal and professional life. The development of ICT has favored the development of telework since these infrastructures allow all this to be added teletraining or distance learning.
- **Online games**
  Online games, based on multi-player functionality or running on a network-hosted compute engine, provide a gaming experience without the need for specific hardware. The ICT brings a new comfort in the use of these games.
- **Home automation—Smart home**
  Home automation for control and centralized and possibly remote interaction with the home environment, especially through the networking of the various electrical appliances in the house, will benefit from the reliability and the ability to manage simultaneity thanks to the use of ICT.
  In the longer term, ICTs will also enable the sharing of computing resources between a closed user group, which enables the provision and receipt of on-demand computing resources from its community.
  Thus, if the current state, ICT does not allow the aforementioned services it will not be surprising to witness in the short and medium term the emergence of specific services that will bring greater comfort and a much more fluid user experience to the data revolution and artificial intelligence.

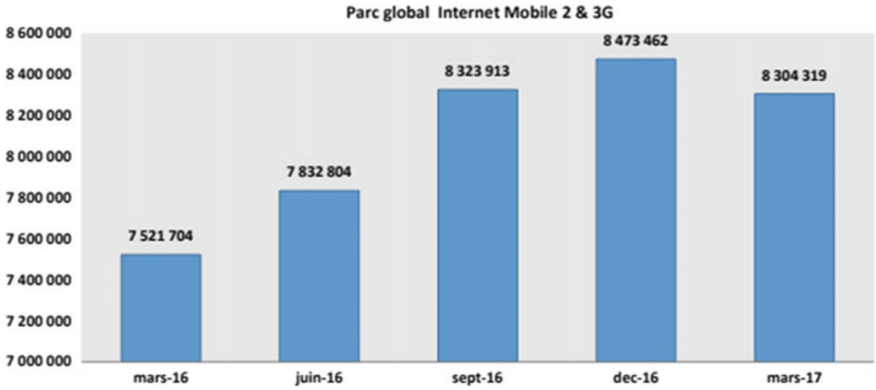


Fig. 15.5 Parc global internet mobile 2 and 3G au Senegal 2016–2017. *Source* ARTP Senegal, 2017. https://www.artpsenegal.net/sites/default/files/docs_actualites/rapport_observatoire_t1_2017_vf.pdf (ARTP: Sénégal)

15.2.6 Internet Evolution Perspectives

1. **Outlook for evolutions**

The exponential increase in the price/performance ratio leads to a situation of abundance of processing, storage and, to a lesser extent, communication resources. This trend is expressed in particular through the production of serial ICT equipment by industrial powers such as China, South Korea and Japan. This trend is marked by miniaturization, mobility and digital convergence.

2. **Miniaturization and mobility**

Miniaturization translates into the development of mobile devices and the insertion of chips into a number of objects of everyday life, in places and, increasingly, in bodies. Mass production and cheaper mobile devices such as smartphones,

Walkmans, game consoles, personal organizers, GPS navigators, etc. are progressively used for several services. One can even declare that there are more chips in Africa than Africans.

Nevertheless Internet penetration of homes in Africa has been possible thanks to the Smartphone.

In Africa, the number of Internet users has nothing to do with the number of subscribers, as some studies suggest, so that mobile access is not restricted to the subscription to an offer or to the buying a phone because a subscriber can share his connection with the whole house. In Senegal, for example, out of a population of around 16 million, the mobile Internet off-key network stood at 8,304,319 users in March 2017, with a mobile penetration rate of 103.25%. The phenomenon of multi SIM (users with multiple subscriptions) makes the penetration rate exceeds 100%. This does not mean that the Internet is accessible to everyone (Fig. 15.5).

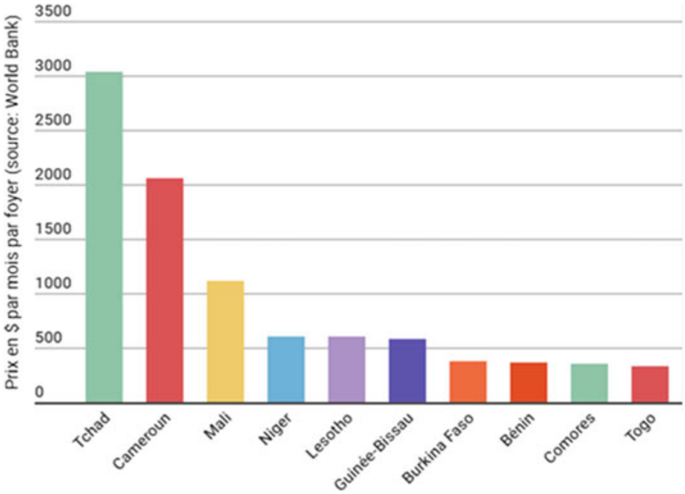


Fig. 15.6 Countries with the most expensive ICTS. *Source* Word Bank

Sub-Saharan African countries most often face barriers that make it extremely difficult to use the Internet on a large scale with significant impact. Without mentioning the insufficient level of literacy, the most obvious obstacles are the lack of telecommunication infrastructures and the lack of electrical energy. Sub-Saharan African countries are not directly connected to each other and the bandwidth offered in the countries is insufficient and therefore too expensive (see Fig. 15.6) with the exception of the coastal countries (Nigeria, Ghana, Gabon, Senegal, etc.) where the costs are still bearable thanks to the SAT3 submarine cable program feeding the countries of the African coast.

3. **Digitization and "digital convergence"**

The ICT revolution has led to the progressive digitization of all our exchanges: texts, sounds, and animated images. Today, the majority of texts and photos are not printed in paper and a large part of the music is produced through digital instruments. Movie theaters are used for other purposes with the adoption of portable movie video. Generalized digitization is primarily at the origin of "convergence", which is basically a generalized mixture of borders between cultural enterprises or the media, telecom operators and companies in the computer and electronic sectors: everyone is likely to do a bit of the business of others, sell listening devices or music, produce movies, etc.

This situation extends from the nature of the contents to that of the individuals: the difference between visio communication between two people and the viewing of a film does not appear physically at first sight; that between amateur production and professional production even less, etc.

The second consequence of digitization is the dematerialization of contents, which no longer have to be fixed on a physical medium to circulate and be used. This results in both a much greater ease of dissemination and a facilitation of the copy that pulls the unit value of the contents towards zero. Today the public administration of African countries for the most part advocates the dematerialization of processes to facilitate the daily lives of citizens.

Third consequence, the establishment of links between different comments, information, works, references, etc. and that from the semantic web. This is the principle of hypertext, popularized since the emergence of the web, in 1994. Thus, it will be noted by tags that this is the title of a regulation that this is the title of a document, it is author, date of creation, revision, etc. Especially effective on text or structured databases, this device now extends to sound (speech recognition) and visual (face recognition) documents.

4. **Technology Trends in Africa**

In this part of the chapter we will present the key technologies of ICT in general and specify the trend in Africa. These technologies include:

5. **Wireless network technologies**

Talking about wireless technology is about mobile networks that have grown in Africa and remains the only real accessible way for most Africans to connect to the Internet.

A mobile network consists of base stations that provide coverage of a given geographical area and manage communication with terminal equipment. The lifespan of a mobile system generation is about twenty years. The GSM networks, launched in 1993, are fully mature and are progressively replaced within five to ten years by 3G or 4G networks. 3G networks are still improving and will remain in service for another ten to fifteen years. The LTE networks (Long term evolution) were launched in 2011–2012 and, now we have the penetration of the 4G evolution since 2015. The latter will increase mobile speeds to around 100 Mbps peak per downstream user. This rate will reach 1 Gbps maximum in nomadic situation. Mobile WiMAX technology, which provides LTE-like features, does not have the same development and suffers from a very limited ecosystem.

In addition to the continuous improvement of spectral efficiency and therefore of data rates, the evolution of mobile networks is moving from a circuit-mode architecture to an IP packet architecture, which in particular allows for further integration with fixed networks. An equally notable development is that of software radio, in which the physical functions related to the transmission process (modulation, filtering, etc.) are carried out by digital computers, allowing a great evolution of the hardware. The development of chipsets for mobile terminals and communicating objects is characterized by increased power, extensive integration and the support of several standards.

Wireless networking technologies are applied in the markets and application domains of mobility and allow applications of voice, short messages (SMS) and data transmission. The addition of geolocation functions and payment and leisure services (video, television, games, etc.) increases the attractiveness of mobile terminals. It also allows M2M (machine-to-machine) communications, whether it is the transmission of small amounts of information (e.g. meter readings), or a higher bit rate for video (e.g. remote monitoring). In some cases, mobile technologies can serve as a substitute when no fixed network is available. With the evolution of 3G and 4G and the arrival of the LTE standard.

Mobile networks can offer Internet access services in white areas. The coverage of these areas will nevertheless be subject to possible regulatory constraints and support from local authorities as previously for GSM. Deployment of next-generation LTE networks is conditional on spectrum allocation in the 2.6 GHz and 800 MHz bands. This technology will initially be available in major African cities to bring capacity while 3G networks begin to experience saturation phenomena. The African mobile services market represents a windfall for telecom operators and authorities.
Mobile radio network technologies provide services to people with mobility issues. They also help meet growing societal needs, such as: extending the area of use of terminals internationally through the standardization of mobile technology and international roaming:

- Make possible a number of home medical care and thus limit the movement of patients;
- Facilitate access to educational content concerning training;
- Reduce the travel of professionals thanks to the easy use of video telephony.

It is a diffusing and future technology that is constantly improving in terms of technology and whose cost of use drops significantly thanks to its worldwide distribution. Finally, power consumption constraints are increasingly taken into account with a reduction in the size and consumption of base stations.

6. Mobile evolution

The Mobile has experienced a meteoric evolution this last year.

Box 15.2 Generations of Mobile Communication

The first-generation (1G) analogue systems for mobile communications have brought two major improvements over the first radiotelephone services: the invention of the microprocessor and the digitization of the control link between the mobile phone and the cellular site.

Second generation (2G) digital cellular systems were first developed in the late 1980s and were initially deployed in the early 1990s. These systems digitized not only the control link but also the voice signal. They provided better quality and greater capacity at a lower cost for consumers. The regional/global exploitation of these systems has, however, been hampered by the existence of several incompatible standards and the fact that different frequency bands and channel arrangements were used in different parts of the world. The 1992 World Administrative Radio Conference of the ITU (WARC-92) made a historic decision to identify in the Radio Regulations internationally approved frequency bands for the operation of future public land mobile systems. Telecommunications—now called International Mobile Telecommunications Systems (IMT).

After more than a decade of hard work and effort, the ITU Radiocommunication Sector (ITU-R) has, in close collaboration with regional and national standardization organizations, finalized the technical standards for the radio interfaces of third generation (3G) under the IMT-2000 brand. ITU's global standard for IMT-2000 cellular communications was unanimously approved by the ITU Radiocommunication Assembly 2000 (AR-2000), which paved the way for innovative services and applications (e.g. example multimedia entertainment, info recreation and location services).

In January 2012, the ITU Radiocommunication Assembly (AR12) approved specifications for fourth generation mobile technologies in Geneva: 4G

IMT-Advanced. IMT-Advanced systems incorporate new capabilities beyond those of IMT-2000 and provide access to a wide range of telecommunication services supported by mobile networks and fixed networks, which are increasingly grounded on packet transmission.

In early 2012, the ITU launched a program on "International Mobile Telecommunications (IMT) to 2020 and Beyond", which sets the framework for research, development and commercialization in the world on these systems. In September 2015, ITU-R finalized its "Vision" of IMT-2020 in the 5G mobile broadband connected society. ITU-R will finalize IMT-2020 technical standards in 2020. 5G is a means of developing broadband mobile communications, but also extending the application of this technology to use cases involving ultra-reliable low latency and massive machine type communications. In addition, the 2019 World Radiocommunication Conference (WRC-19) will address the need to identify additional frequency bands to support the future growth of IMT systems.

Source: ITU New MAGAZINE 2017_ITUNews02-en.pdf.

7. **Virtualization and cloud computing**

Virtualization itself is not a young technology; it is the technical step towards the concept of cloud computing. "Cloud computing" is a major concept of computing. It is an elastic storage and execution environment for IT resources involving multiple actors, connected via the Internet. This environment delivers a measurable service, on demand, with variable granularity and which implies levels of quality of services. For some parts of the information system, we gradually move to a computer on demand, shared and automated. This optimization of the use of machines also allows IT to be greener. Critical technology is the multi-tenant. There are three main levels of cloud computing interactions:

- Infrastructure as a Service (IaaS), which provides computing capacity for storage or for more computing power;

- Platform as a Service (PaaS), which provides a platform for design, development and testing tools;
- Software as a Service (SaaS), which provides application services such as CRM or messaging.

There are also three types of cloud computing:

- Audience: shared capabilities at a third-party operator (Amazon, Google, Salesforce, OBS, Microsoft, etc.);
- Private: Cloud architecture built in-house (eBay),
- Hybrid: which mixes public and private. The applications of "public" cloud computing potentially concern all sectors, for their common applications and infrastructures: CRM, HR, office automation, storage, development and testing. This is particularly promising for SMEs.

With regard to private cloud architecture, medium and large companies will be setting it up, for all types of applications. Subsequently, these companies will also be able to use public offerings for very general needs such as messaging, or for very specific needs such as intensive computing or occasional needs for computing power.

8. Content scanning technologies

Content digitization is a process of constructing a discrete representation of an object of the real world (video film, image, audio, printing characters, buildings, etc.) in the form of a computer file and therefore digital. A conversion is then possible in different digital formats. In addition, the development of digitization also uses other technologies such as indexing techniques to classify these contents and facilitate their access. Scanning of content typically involves a scanner, optical character recognition (OCR) tools, quantization, sampling and compression technologies, storage elements, and so on.

In addition, the digitization of content benefits from numerous innovations such as the process of scanning closed books (without having to open them), printed or handwritten documents, bound or in bundles, without having to separate them, by means of a system. imaging of a three-dimensional object by terahertz waves (1 THz = 1012 Hz).

It addresses in particular old content, many contents are now directly created in digital form, but also addresses objects dedicated to be made in physical form. In the case of content created directly in digital form, conversions may be necessary depending on the distribution network and/or the reading terminal of the content. The main drivers of growth lie on:

- The rise of the Internet and the explosion of demand from users who want to access services from a distance, and around the world;
- Access to information faster and sometimes cheaper (lower distribution costs);
- Standardization of digital media;
- Compression with the ability to store hundreds of musical titles, literary, etc. in a very small object;

- The level of maturity of the technologies used (technical and economic interest);
- The digitization of broadcast networks (TV and Internet).

- **Applications**
  This technology is used primarily in the following industries through various applications:
  - The culture industry, particularly in the context of the digitization of artistic works, as well as for remote access to libraries. This has a direct impact in the education and training sector;
  - Urban planning and tourism with the 3D representation of monuments and some buildings;
  - Consumer electronics for the consumption of digitized content (e-books, digital music players, computers, etc.). But it can also be implemented in all industries and administrations with significant heritage funds (marital status, etc.).

The main objective of this type of technology is to safeguard, disseminate and promote heritage (especially national) but also all content in the broad sense. It also allows users to store their personal content. The integration of technology into processes is not automatic. It requires a generalization of compatible players (audio, video, text files, etc.).

9. **Intensive calculation**

- **Description**

Since the invention of the computer, we have constantly wanted to increase its performance, especially to meet the needs of the most demanding sectors such as nuclear or military. The increase in computing capacity in accordance with Moore's Law (doubling every two years) and the decrease in the relative cost of computing power have provided the opportunity for companies to equip themselves with hardware that is powerful enough to use simulation software particularly greedy operations. High Performance Computing (HPC) is the process of using highly advanced computer systems to perform tasks or solve complex problems. This computing differs from conventional computing which is more transaction-oriented than raw computing power. Intensive computing is based on two types of architectures:

- **Mainframes**
  - Grid computing, which is the most efficient architecture at the moment. There are three types of calculation:
  - The vector calculation, which was reserved for the mainframes but which was updated by the chips from the world of video games;
  - Parallel computing;
  - The fusion of these two approaches. The intensive computing is based on "super computers", highly optimized machines, integrated at all levels (components, buses, memories, input-output, etc.…) and often designed for specific tasks.

Africa for the moment is on the sidelines of this technology which is a military preserve.

10. **Systems of system engineering (SoSE)**

Description: A system of systems (SoSE) is a set of autonomous systems interconnected and coordinated to satisfy a capacity and/or achieve a set of predetermined effects that none of the constituent systems can provide alone. Another definition may be the integration of multiple systems to achieve the desired behavior of the entire system. SoSE is a set of development processes, tools and methods for designing, redesigning and deploying systems of systems. We speak of a complex system when it becomes very difficult to predict the behavior of the system by calculation. These methods, which are heavily used at the military and space level, are increasingly applied and applicable in the civilian field (transport, health, telecommunication networks, space exploration, etc.).

15.3 Human-Machine Interfaces (HMI)

Human-machine interfaces use a very diverse set of technologies that use software and algorithms in combination with a wide variety of equipment. Thus, HMI technologies fall under several technological axes:

- Hardware interfaces: joysticks, keyboards, mice, touch screens, remote controls, joysticks (specific or used in the video game like, cameras, microphones, display means (screens, display headsets, holographic display, etc.), tablets seizure, biometric or biomedical sensors, etc.;
- The design of the interfaces: ergonomics, design, cognitive psychology, adaptation to context from hypotheses, etc.;

More conventional user interfaces of the keyboard, mouse or joystick type can nevertheless be used. Speech can also be used, both to control and to communicate from the machine to the user.

There is an important offer of tools to help HMI development. It is part of global offers from major IT players such as Microsoft, Borland, IBM, Google or Adobe. Beyond this market, there is an important service offer. There is also specialized software for modeling, simulation and generation of interfaces dedicated to different types of equipment. HMIs are central to many application sectors: consumer electronics, industrial environments, automotive, defense, aeronautics, education, training, cooperative work, etc.

It is a technology with very high diffusing potential. The stakes are multiple:

HMIs facilitate or even enable the development of innovative products, tools or services in all sectors. The use of virtual reality makes it possible to design GUIs more intuitively.

11. **3D technologies**

3D technologies include two large sets of distinct technologies:

- 3D video is to offer users a stereoscopic visual immersion. By the projection of 3D images and the wearing of specific glasses (except in the case where stereoscopic screens), the user is immersed in the image;
- Virtual reality, a scientific and technical domain aiming to simulate, in a completely virtual world, the behavior of 3D entities, which interact in real time with each other and with one or more users in pseudo-natural immersion. With the arrival of 3D, the audio-visual technical chain must adapt. The main outstanding point remains the image format chosen in the absence of industry standards. In addition, to appreciate 3D, the end consumer must equip a new screen (TV-monitor) compatible. The major issues of virtual reality are both related to the creation of the virtual world and the interfacing between the subject and the virtual world:

It is necessary to model and process a virtual world evolving in real time. But the models can be simply descriptive, with deterministic behavior, or autonomous, which induces generally very important computing times;

- In the case of virtual reality, 3D technologies are generally proprietary and weakly interoperable;
- 3D on the web still faces the technical and economic complexity of creating 3D content in a real-time environment.

The video game industry has democratized virtual reality among the general public. The success of 3D animation films, as well as the upcoming release of 3D video game consoles such as the Nintendo 3DS, allows the general public to gradually become familiar with 3D relief. But beyond the world of leisure, 3D and virtual reality, in their simplest forms as the most sophisticated, are gradually becoming tools of work among others in companies:

- Modeling, virtual prototyping, digital model (industry, architecture, urban planning);
- Simulation of production processes, to visualize activities, constraints and risks;
- Professional training through serious games;
- Training by simulator (driving vehicles, aeronautics, medicine);
- telepresence and video telephony;
- Scientific visualization (visualization of the central nervous system in 3D for example). After sound, image and video, the Web is also enriched with total or partial representations (objects) in real-time 3D. Degree of diffusion in the absolute.

15.4 The Concept of Communicating Objects

Description: The concept of communicating objects essentially involves communication technologies, such as RFID (Radio Frequency Identification), including NFC

(Near Field Communications), so-called short-range communications (Bluetooth, ZigBee, UWB, etc.).) and mobile technologies (cellular but also satellite). For the moment, this very young technology (launch phase) is growing strongly.

The main drivers of growth lie in:

- Successful feedback (consumer satisfaction via savings);
- Regulation in different vertical markets favoring automation or encouraging more monitoring;
- The maturity level of the technologies used (inexpensive technologies). Nevertheless, there are still many blocking points:
- Initial investment and high installation costs;
- Technical improvements needed for roaming (or international roaming) for e.g. M2M or interference on RFID;
- A highly fragmented value chain with a myriad of players (often SMEs or even small businesses), which can lead to a more complex identification of suppliers and therefore to a more difficult technical integration;
- Pure technical performance around data security (at the access level), quality of service (end-to-end), standardization (favors massification).

  – Automotive/transport (telematics, fleet management, logistics, etc.);
  – Energy (meter reading, smart grid, etc.);
  – Security (remote surveillance, alerts, etc.);
  – Industry (logistics, traceability, etc.);
  – Retail trade (mobile payment, logistics, payment terminals, etc.);
  – Consumer electronics (radar warnings, e-books, connected GPS navigators, etc.);
  – Health (e-health).

The main goal of this type of technology is to reduce operational costs through automation, reduced travel and reduced errors. Business users are therefore hoping for a quick return on investment (ROI). Nevertheless, in the longer term, some of them intend to generate additional significant revenues thanks to this technology by proposing new services (customer service, preventive maintenance, billing by use, etc.). The integration of technology into processes is not automatic. It most often requires an education-training to master the capabilities of M2M or RFID and enjoy. Some adaptation time is sometimes necessary for the implementation of the technology (problems during installation, higher error rates than expected). This has an impact on the processes internally but also on the information system itself. It has to integrate new data (thus generating new costs) and sees the establishment of new business models with an impact on customer service. In addition, the cost reduction brought about by the introduction of technology is also a reduction of costs in terms of human resources.

13. **Optical broadband networks**

- Description: fiber-based networks have grown significantly since the mid-2000s, especially in northern European countries and Asia. They are rightly considered to be more sustainable and efficient than copper-based networks. Current developments focus more on the technologies implemented than on the architectures themselves. Indeed, several technologies coexist:

- Point-to-point Ethernet: an end-to-end fiber between the connection center and the subscriber;
- Point-to-Multipoint Ethernet (commonly referred to as Active Optical Network): technology using a switch to demultiplex incoming fiber from the central office;
- PON (Passive Optical Network): the most deployed technology in the world today, based on an optical coupler, so-called passive equipment.
  Current standards make it possible to reach very high theoretical rates, exceeding Gbps. In fact, in Africa, offers are not extended at the moment.
- In the future, technological developments will provide speeds beyond 10 Gbps. Nevertheless, the main obstacle to the deployment of optical networks remains the cost of deployment, because they require very expensive civil works. The technologies and architectures implemented are therefore chosen according to the technical interest but also the cost they represent for the area concerned (urban vs. rural in particular).
- Applications: optical networks are used to improve Internet connections and therefore apply to all sectors of activity for which the Internet becomes an inevitable mode of communication. While no application currently justifies multi-Gbps speeds, the deployment of Optical Networks makes it possible to anticipate future needs, particularly those related to the development of services related to health or online education. In parallel, some sectors in particular already require high bit rates and symmetry, such as online gaming, video telephony and television (HDTV, video on demand, TV3D). Today, the very broadband players rely heavily on these types of services to develop their new fiber optic infrastructure in the short and medium term. Optical deployments, however, are not yet widespread and, except in the most advanced countries like Japan.

14. **Portal, collaboration and unified communications**

Description Portal, collaboration, and unified communications are solutions that enable employees, partners, and suppliers to interact and share with each other, optimize, and retain their knowledge; and this while significantly reducing the marketing, operational complexity and, in general, the costs. The portals and collaboration tools segment includes browsers, semantics, document management, groupware software, exchange and collaboration platforms, workflow, intranet and extranet, portals, search engines and applications. Rich Internet platforms. Unified Communications includes IP telephony (call management), instant messaging, video conferencing, calendar management, presence management, email, fax, voice mail, telepresence, customized communications. The development of IP communications (integrating voice and data) has made it possible to offer convergent services. Advanced unified communications solutions, such as VoIP or Unified Messaging, enable small businesses to remain competitive and responsive to large corporations while improving their professional image. These technologies make it possible to connect IT to its users, but above all to optimize this relationship. It is the software counter of the HMI. This segment is very dynamic as information sharing and knowledge management become crucial in private companies. Applications All sectors are likely to implement collaboration, portal and unified communications solutions. The market is divided into two parts: high added value solutions and unmarked solutions. The main applications with high added value are:

- The relationship with customers, whether in call centers or in agencies, where the actor must have at his disposal the maximum of information in the most economical way possible;
- Engineering and R&D, one of the most demanding sectors of these productivity tools, especially at a time when innovation is more and more collaborative;
- Market finance. The unmarked applications will, for their part, spread over the entire market where they will replace, complete and unify the old approaches. In the medium term, the majority of access to computers will come from collaborative portals, especially with the advent of cloud computing. The segment will remain very dynamic as information sharing and knowledge management are crucial in our societies. It will also help to cope with the shortage of certain skills, which is partly due to demographic changes in Africa.

15.4.1 Connection Offer in Africa

The supply of connections in sub-Saharan Africa is mainly based on GSM and CDMA.

This is explained by the rate of acquisition of smartphones by Africans.

Through Figs. 15.7 and 15.8 we note that Africa is not so far from others despite all that can be said about our penetration rate and use of the Internet.

On the other hand we note through the Fig. 15.9 that Africa has adopted most faster the mobile Internet than the fixed Internet (ADSL-LS …).

15.5 Legislation and Regulation in the ICT Sector in Africa

African countries have generally taken on the stakes that ICT poses for them and their people. They will be very quickly in the regulation and the drafting of the laws for the sanitation and the protection of the sector. For example on May 03, 2017, the President of the National Assembly of Niger, Ousseini Tinni,[3] invited Africans not to miss the rendezvous of digital, and to make up their huge backlog in other regions of the world. He launched in Niamey, Niger, at the opening ceremony of the Forum on

[3]Source: http://www.ecowas.int/vers-lharmonisation-des-cadres-politique-et-reglementaire-des-tic-dans-lespace-cedeao/?lang=fr.

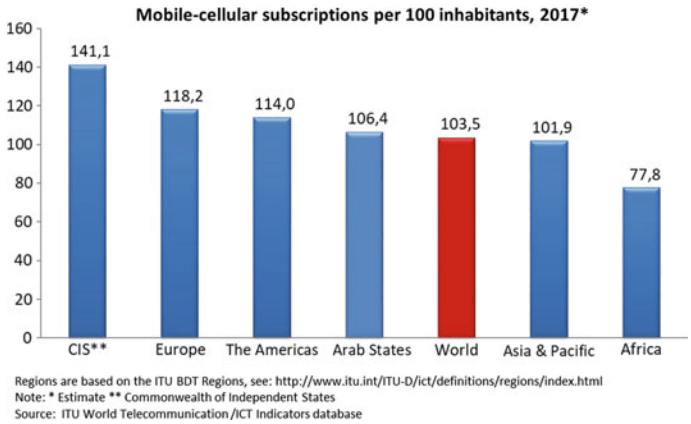


Fig. 15.7 Mobile-cellular subscriptions per 100 inhabitants, 2017. *Source* IUT word telecommunication/ITC indicators database. www.iut.int/IUT-D/ict/definitions/regions/index.html

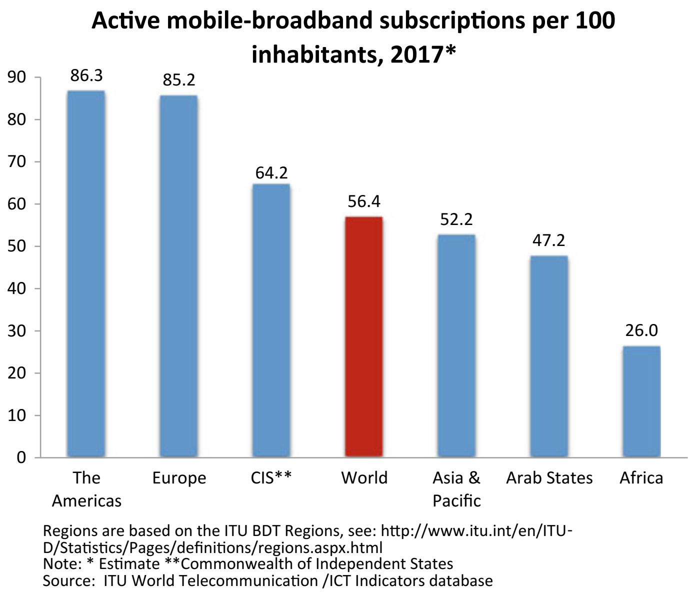


Fig. 15.8 Active mobile-broadband subscriptions per 100 inhabitants, 2017. *Source* IUT word telecommunication/ITC indicators database. www.iut.int/IUT-D/ict/definitions/regions/index.html

the Harmonization of Political and Legal Frameworks for Information and Communication Technologies (ICT) in the Economic Community of States of West Africa (ECOWAS) an appeal to all African countries. He urged ECOWAS member states to resolve what he called the "digital divide" with which they entered the ICT era, and to work together to reduce all the costs of the various factors related to it. He called

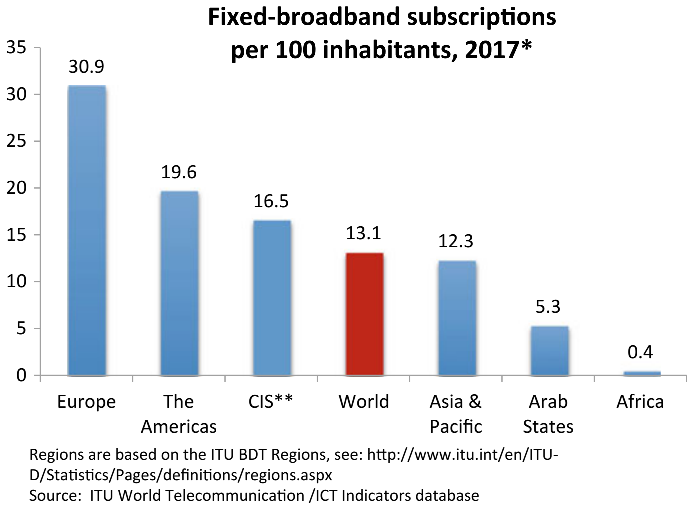


Fig. 15.9 Fixed-broadband subscriptions per 100 inhabitants, 2017. *Source* IUT word telecommunication/ITC indicators database. www.iut.int/IUT-D/ict/definitions/regions/index.html

on West African parliamentarians to mobilize in order to transpose the outstanding community texts, and to proactively take forward legislation to accompany all digital innovations. For him, the Niamey meeting will allow greater appropriation of community texts by West African MPs, and thus facilitate the effective participation of ECOWAS member states in the implementation of the single ICT market in West Africa.

African policymakers and regulators are increasingly applying the kind of growth-friendly practices that will make these dreams a reality. This article focuses on the change in ICT policy and regulation in Africa.

Ernest Ndukwe, Executive Vice-President of the Nigerian Communications Commission (NCC), tirelessly defends the market principle and credits regulatory reform with his country's two-year record in the telecommunications sector. The Nigerian regulator distinguished itself in a recent statement on the NCC website stating, "To prosper, Africa must embark on the liberalization of its markets." He emphasized how the African model of telecommunications policy and regulation has evolved in recent years.

Traditionally, the African model of intervention focused only on telecommunications. The most common was that Ministry of Telecommunications Services supervised a state-owned monopolistic operator that was funded by the state to extend the basic telecommunications network. Much of the revenue obtained from the national operator of the telecommunication network was deposited in the coffers of the State instead of being devoted to the development of the sector. This model resulted in a slow deployment of the network, the absence of competition, the inability of governments to attract investors, losses incurred on the local segment, virtually no private sector participation and a huge demand repressed by the innumerable unregulated users. These few telephone subscribers were largely fixed-line users living in major cities. It is on the basis of this model that the Maitland Commission recommended to developing countries nearly 20 years ago to strive to achieve, in terms of teledensity, the meager objective of a main line for 100 inhabitants.

The new policy and regulatory environment in Africa is fundamentally different. First, the focus is not just on telecommunications. The concern of most African countries is to improve access to the Internet and to participate in the information society. Their policies now focus on ICT development. The role of the state in a number of countries is essentially to develop policies and regulate the sector in order to promote competition and defend the interests of the consumer. As for large service providers, they are no longer state-owned fixed line operators but private mobile phone companies. There are 121 mobile operators operating in Africa at the moment. In 43 African countries, there are now more cellular subscribers than fixed-line subscribers.

What remains to be done? Africa can build on its early successes in the cellular sector to implement a series of policies to promote access to ICTs. Countries with three or more cellular operators generally experience higher growth in subscribers and lower end-user rates than their counterparts with more limited competition. However, today most African countries continue to be characterized by duopolies that prevail in the mobile phone market; some even retain monopoly mobile operators. According to a market survey conducted by the ITU, out of 55 African countries with mobile operators, 15 still have a monopoly situation. Stronger competition in the mobile phone sector would help attract subscribers and investors. In addition, business strategies designed by mobile operators for the African market are key to the miracle of mobile telephony in Africa.

Similarly, regional roaming agreements will result in more affordable cross-border communications prices. Prepaid cards and the use of the mobile phone to ensure public access will allow more Africans to communicate. There are various aspects to public access, whether it is the informal resale of mobile phone services in the streets of Lagos, the sale of services in Mauritania by nomads to other homeless people, or postal service employees. They carry mobile phones and sell up-to-the-minute communications at the same time as they deliver the mail.

Local participation in ICT development is also fundamental. In Niger, rural communities operate their own telephone booths and telecentres. In addition, village associations are working to develop content in local languages on development issues, including wastewater treatment, health and hygiene.

This collective awareness has produced very interesting results, for example in Mauritius in terms of general policy and regulation, the country is striving to become an island open to e-business, to focus its economy on information and to transform into a regional information communication center. This country has already made tremendous progress in policy and regulation but goes even further by preparing a

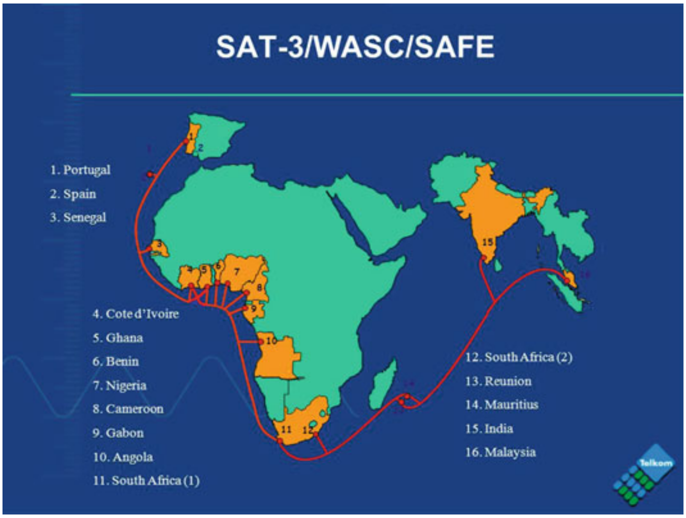


Fig. 15.10 SAT-3/AWSC/SAFE. *Source* Adapté de SAT-3/WASC/SAFE

convergence law that includes information technology, the media, broadcasting and telecommunications.[4]

It is moving to 80% of mobile cellular density by 2005.

Expand broadband connectivity to all business centers by 2016.

Providing at least 70% of households with broadband connectivity by 2018.

This shared vision is reflected in the realization of the common ICT connectivity project, as indicated in the Fig. 15.10.

Botswana has long been known to be a pioneer in regulation, one of the first countries in Africa to have established a regulatory body to which it has also granted autonomy that has led to market growth and attracted investment.[5]

Africa is pioneering a number of important policies governing the Internet. Egypt is one of those pioneers who, to encourage the use of the Internet, allows, thanks to a subsidy, to subscribe free of charge to Internet service providers. Egypt has also undertaken, as part of a new initiative, to provide home users with low-cost home computers through a loan program that allows subscribers to repay the cost of the computer in their monthly phone bill.[6]

Uganda has partnered with the ITU to test packet-based wireless IP technology to extend the services offered by the ITU/UNESCO/IDRC multipurpose community telecentre to rural and remote areas. This project, funded by the ITU TELECOM Surplus Fund, is being implemented in collaboration with the Uganda Communications

[4] see "The ICT Sector in Mauritius: An Overview", which can be found on the website of the body responsible for information and communication at: http://www.icta.mu/.

[5] see "Effective regulation, case study: Botswana 2001" available on the web page: www.itu.int/ITU-D/treg/.

[6] see article: Building the Egyptian Information Society.

Commission (UCC). At present, it is working both to implement its rural communication policy and to test the VoIP protocol (it is considering making changes to its VoIP regulations). In Senegal, SONATEL offers special rates to Senegalese schools and universities to enable students to use the Internet at low prices. ITU supports many of these regulatory initiatives in Africa.

15.6 Investment in the ICT Sector

Africa is becoming aware of the importance of ICTs in its evolution and it is the investment in the essential projects that will make it possible to move towards the ICT economy and thus allow the citizen to benefit from the economy. Digital.

To succeed in this challenge, the states have understood the involvement of the private sector which pushes them to review their respective legislation to allow the success of the sector. Each African state is called to develop a ICT strategic plan as noted in the Smart Program initiated in 2013 and endorsed by African Head of States.[7]

Target project presented in the strategic plan of the majority of African countries are[8]:

- Optical fiber networks
- Mobile broadband networks
- Satellite
- Data Centers
- Cyber security
- Smart cities
- Internet of Things (IoT)
- Big Data Analysis
- e-Applications
- e-Education
- eHealth
- e-Tourism
- e-Agriculture
- e-Commerce
- eGovernment
- Content development and applications
- From design to fitting devices
- Consumer electronics
- Investment in innovations/local products
- Capacity development Etc.

[7] http://smartafrica.org/resources/africa-ict-policies-and-strategies/.

[8] Source: http://smartafrica.org/IMG/pdf/smart_africa_vision_strategique.pdf.

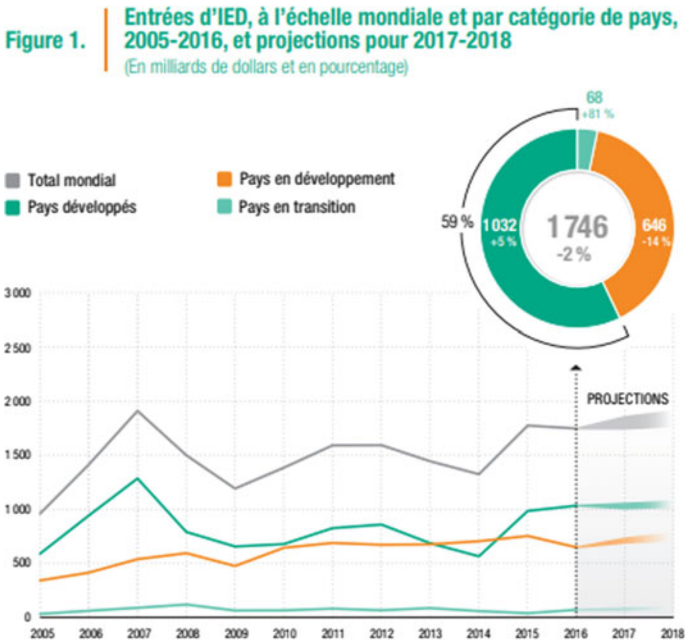


Fig. 15.11 Entry of IED worldwide and category of countries, 2005–2016 and projecttions for the period 2017–2018

According to Siyabonga Cwele, the Minister of Telecommunication of South Africa

The South African government has invested 78 billions of rands (US$5.9 billions) in the ICT secto during the last three years.

The Senegalese government is also investing in the ICT sector over 15.3 million of euros, supplemented by 76.6 million euros from the African Development Bank (ADB). The technological and digital park of Diamnadio in Senegal will be able to rely on the establishment of the "City of knowledge", a 12 ha area that will include information systems (sharing and sharing center, cloud computing center' , Physical and digital archive center, IT resource center), a technical services area (remote monitoring and control center), a governance and evaluation area (MESR, national agency for quality assurance in the higher education), and a research and scientific and technical culture area (advanced technologies pooling platform, incubator, fablab, planetarium, media library).[9]

Figure 15.11 gives us an idea of the state of investment in Africa and the world.

Multinational enterprises from developing countries are more and more present in the African continent, but those of developed countries remain the most important investors. Overseas investment by African multinationals has slightly increased (by 1% to US$18 billion), mainly due to the growth of Angolan investments (up 35%

[9]Source: http://www.osiris.sn/Numerique-au-Senegal-Etat-des.html.

to US$11 billion), which offset the sharp decline in flows from South Africa (down 41% to $3 billion).

Whatever the difficulties Africa is not on the sidelines of ICT and investment projects are under way.

15.7 ICT in the Making of Smart Economy in Africa

One thing is certain: Africa is aware of the the opportunities ICTs offer and challenges they represent: lawmakers, regulators and policymakers are doing everything possible to support this sector and to promote the smart economy. To do this, Africa is initiating typical startup ecosystems. The objective is to develop a highly dependent on the existing ecosystem in order to articulate it around core dimensions and adjacent and transversal dimensions. These dynamics vary in intensity and nature according to four groups of major countries:

- The leading countries of English-speaking Africa, like Kenya, regional hub of innovation
- the emerging countries of North Africa, including Morocco, which has a relatively developed ICT sector
- new players in West Africa such as Côte d'Ivoire and Senegal, who are experiencing rapid development of their ecosystems
- and the rest of the continent, like Mali, whose startup scene remains embryonic, facing structural obstacles.

A brief diagnosis allows us to understand that Africa has taken the lead and is doing everything possible to promote the smart economy.

Diagnostic from Roland Berger in Kenya, Morocco, Cote d'Ivoire Mali is presented below

In Kenya the government has embarked on an ambitious drive to make the country a regional leader in several digital sectors, the Vision 2030. In addition, the emergence of national success stories, like M-Pesa has set a new trend for young Kenyans and lifted the barrier of the weak banking market. Thus, nearly 1500 startups are active in Kenya, created by local youth, Kenyans of the diaspora or foreigners attracted by the opportunities offered in the country. A dynamism of creation that was particularly favoured by the existence of a rich ecosystem and covering a large part of the need. Nevertheless, some shortcomings remain, particularly in terms of seed funding, the qualification of support structures and the structuring of the ecosystem

- In Morocco, the country has an ambitious ICT strategic plan and has experienced strong growth in internet penetration. However, Morocco remains below comparable or less developed countries in terms of start-up creation, particularly because of the lack of enthusiasm among "high technical profiles". In addition, the national

digital innovation ecosystem is immature and has significant gaps on several levels. The operational support offer for startups is particularly weak, limited to two social incubators and an accelerator. Funding options also remain very limited; apart from competitions and a loan offer of honor subject to strong competition, only a venture capital fund is active in Morocco (a new seed capital fund was launched in January 2017). The Moroccan Government, however, intends to boost innovation through the development of a strategic vision dedicated to startups
- Like Kenya and Morocco, Côte d'Ivoire has also launched a National Master Plan to support the development of ICTs and has taken many steps to simplify business creation and encourage the emergence of ICT companies. An environment that has encouraged many young Ivorians to cope with unemployment through entrepreneurship start-up, but promising projects remain rare, due to the lack of business qualification of the founders. Despite the number of actors and initiatives deployed, some of which are supported by large multinationals, carriers of ideas face significant gaps in offers of support and funding. A particularly pronounced lack of funding for seed and growth, maturity of the offer of support and level of involvement of large companies and the State. Nevertheless, some structuring projects should support the future development of the ecosystem, as in incubators of international level preparing their establishment in Abidjan
- Malian start-ups face structural obstacles; very limited access to the internet and a scarcity of competent profile. Entrepreneurship is therefore struggling to develop despite some public support initiatives. In addition, despite the appearance of some events and support structures dedicated to startups, the ecosystem remains embryonic. Start-up entrepreneurship in Mali therefore requires fundamental prerequisites, upstream of the development of ecosystem.

15.7.1 Transformation of the Container Facing the Challenges of the Smart Economy

The African continent is experiencing a phase of major economic and social transformation (Figs. 15.12 and 15.13).

The Anglo-Saxon countries present a particular dynamism. The continent shows a significant growth in the supply of co-working spaces, despite their unsustainable business model.

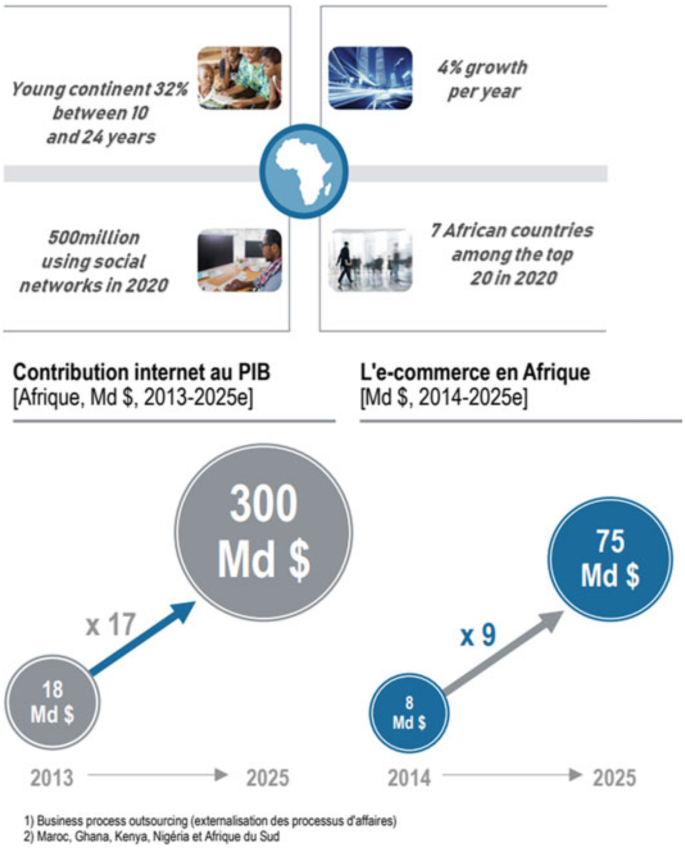
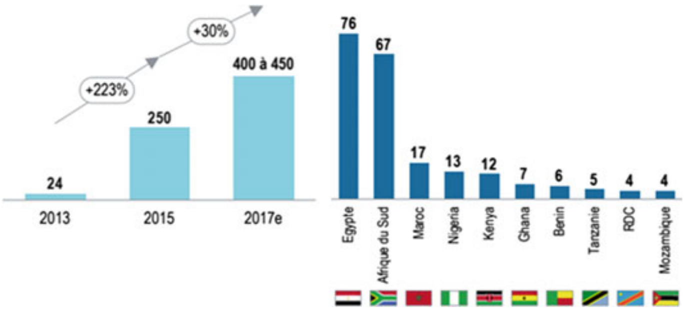


Fig. 15.12 Diagnostic of African continent. *Source* UN, World Bank, Roland Berger



Source: UNDATA, Roland Berger co-working spaces

There is also the presence of incubators that play a key role in the ICT economy by allowing young project. Incubator supply is crucial for the qualification of an

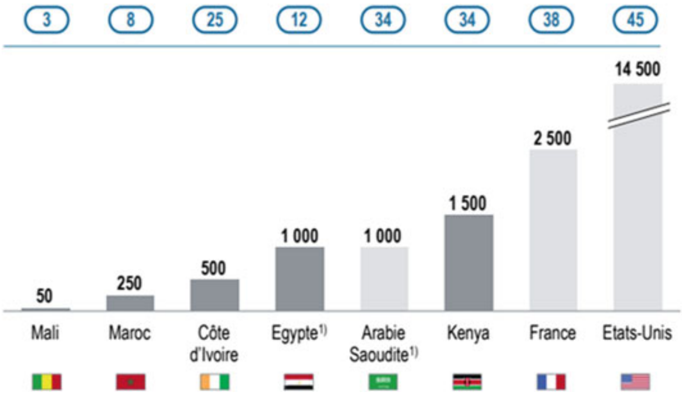
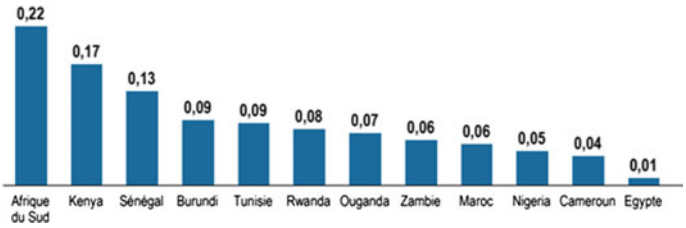


Fig. 15.13 Comparison of startup number per million inhabitants between countries

idea or a technology having understood this aspect the African country encourages projects and the installation of incubators.



Source: UNDATA, Roland Berger Incubator per million inhabitants

Komlan Franck Godefroy Beda Director of ESITEC "School of Computer Science and Technology" member of Supdeco Group. Married and father of four, I am what I am. I was born on November 21, 1967 in vogan TOGO. I want to be free in my thoughts and inscribe my actions in the integrity, the transparency and the defense of my freedom and my vision. My activities consist of supervising students and teachers and setting up the appropriate IT tools available to all Group staff. After the F2 baccalaureate with honors at the Technical High School of Adidogomé I benefited to join the State University of Electrical Engineering Saint Petersburg in Russia where I did a preparatory year before being accepted into the prestigious department Calculators where are all the famous Russian scientists. I then specialized in Computer Science or I had 1996 my Master of Science with honors. I was then accepted into the Cybernetics laboratory to finish in 2001 with a thesis in

Computer Mathematics option Artificial Intelligence. Returning to the country first in Togo I worked at WANG one of the first computer companies and was a consultant to the National Gendarmerie. Towards the end of 2002 I decided to move to Ivory Coast for personal reasons. I was first Technical Director of AIGL then Inspector of Private Higher Education of Côte d'Ivoire until 2004. I worked from 2004 to 2006 with Singapore companies in the deployment of turnkey IT solutions as Director of Corids Technology based in Ivory Coast at II Abidjan Plateau. Arrived in Senegal for personal reasons I led the computerization project of the Ministry of SMEs/SMIs in 2007 I attended the majority of training institutions (HECI- UHB- ISI-SUPMANAGEMENT—University of Sahel- CTI ESCI …). In March 2012, I joined Sup de Co as Program Officer and for two years I have been the Director of ESITEC.

Conclusion

Gora Mboup

Though African societies were predominantly rural during the pre-colonial era, pre-colonial African urban settlements exhibited economic, comparative opportunities, as well as political and social advantages long before the arrival of European colonisers. Pre-colonial African cities were, indeed, featured not only in terms of their size but also particularly by their degree of heterogeneity as being the place where people from different localities agglomerated for different social, economic and political purposes. The African urbanization is historically rich and dated back thousands of years in ancient Egypt, the Western Sudan, Nigeria, Ethiopia, the East African City States, and Southern Africa, etc. The early African urban development, associated with agriculture and the Neolithic revolution, led to high population densities that propelled economies of scale and agglomerations and new forms of specialization as well as political and administrative organizations.

Walled cities were also common in Africa's pre-colonial era as a means of protection from hostile neighbouring communities. Wall systems also played a role in the control of merchants and goods for purposes of taxes, tolls and the reduction of smuggling. However, most of these pre-colonial African urban centres rarely appeared on official national population estimates that mostly included only large urban agglomerations; they were either destroyed or downgraded along the European colonialism. Without being part of the UNESCO heritage sites, these early African urban centres would be forgotten and/or remain unaccounted for.

Africa's urban centres also recognized the benefits of inter-communal cooperation for their economic development as well as political strength long before the arrival of European settlers. In the 16th century, African communities were also conscious of the need of inter-urban cooperation for disaster prevention. They were particularly conscious of the need of a drainage system in order to prevent flooding and other natural disasters. During the pre-colonial period several African urban settlements were also based on decentralized administration and governance, as it was observed in the Lebou Group in Dakar (Senegal) in the 15th and the 16th

G. Mboup and B. Oyelaran-Oyeyinka (eds.), *Smart Economy in Smart African Cities*, Advances in 21st Century Human Settlements,
https://doi.org/10.1007/978-981-13-3471-9

centuries, in Ife, Benin City of Nigeria on the 15th century and in Abomey of the Republic of Benin in the early 18th century. Pre-colonial African towns and cities were also historically organized along streets and roads with the main purposes of mobility, commerce and social interactions. Streets radiated from the nucleus of the city, which was usually the seat of political power or place of worship, such as a mosque, a temple or a cathedral, or some other structure(s) of political, commercial or cultural significance, such as a royal palace.

However, there is noticeable transformation of the African urban space consistent with the European colonial conception of cities, particularly in terms of urban planning. The European colonisers brought forth a new form of monocentric settlement system. The centre of such colonial cities hosted large administrative and commercial buildings as well as the European residences, while the indigenous people were relocated to areas that lacked most basic services (such as piped water, sewerage systems, education facilities and health centres) as well as administrative and commercial businesses. Being the only places where indigenous groups were allowed to settle, these colonial settlements became densely populated, and since they were neither properly planned nor were there adequate basic service provisions, disease outbreaks became the norm. The indigenous communities as well as migrants were, indeed, excluded from the comparative urban advantage a city can offer. Today, these areas remain haunted by this early spatial and social segregation.

The urban monocentrism as well as the colonial urban divide has been pursued in most African capital cities after independence without taking into account ground realities. In these cities, residential areas were also designed along economic class lines. This has led to social and economic fragmentations that have disadvantaged lower income groups in accessing basic services, such as public transport, and prevent social interaction and integration. Today, the urban monocentrism is a source of traffic congestion and an obstacle to city smartness.

Independence of African countries marked a significant turning point in African urbanization with massive migration from rural areas seeking jobs, particularly to capital cities. Along the African urbanization, cities form and grow in many different parts of the continent for various different reasons, such as rural-to-urban migration, economic opportunities, politics, natural disasters and social conflicts. The African population is estimated at 1.3 billion in 2018 in an area of about 30.2 million square kilometres. Africa is the world's third largest continent as well as the world's second most populous continent after Asia. African cities are also densely populated—Three out of four African cities have a population density of more than 5000 persons per km^2. However, there is no specific model associated to the variation of densities in Africa. There are cities where densities increase when moving from the city centre to the outskirts. There are also cities where density decreases first then increase. Lack of specific model of densities in African cities is associated with the lack of functioning master urban plan. Most African households settle first in unplanned settlements either at the outskirts or anywhere in the cities where there is space for settlements and then undertake legal steps for land regularization.

Though African cities are of high density, we should not overlook the fact that leapfrog and inclusion are emerging trends in some African countries where cities are expanding in a discontinuous, scattered and low-density form that is not sustainable. A defining feature of these cities is an outward expansion far beyond formal administrative boundaries, largely propelled by land speculation. A large number of cities feature very land-consuming suburban sprawling patterns that often extend even to farther peripheries. However, every time rural land is converted for urban uses, there is an opportunity cost to be considered. There is an environmental cost including land degradation, loss of biodiversity and climate change as well as a huge economic loss for the farmers who depend on agriculture outcomes in economic and financial terms. Another urban development is the emergence of urban corridors, which present a type of spatial organization with specific economic and transportation objectives. In African countries, governments are also encouraging growth, convergence and spatial spread of geographically linked metropolitan areas and other agglomerations. Though their economic output may be enormous, their management requires considerable investment on infrastructure, particularly to ease mobility and communication in order to constitute a large economic output, combining large markets, skilled labour and innovation.

Today, while ageing is a crucial problem particularly in developed countries, African population is particularly young and progressively educated: 70% of African people living in urban areas are below 35 years old, and most of them constitute the generation of the “millennial” born and grow along with the development and use of ICTs. Educated, young people constitute a comparative advantage as a demographic dividend as well as economic opportunities. Rapidly increasing urbanization levels from the 20th to the 21st century in Africa have also been accompanied by spectacular growth in city sizes. By 2030, there will be an increased number of cities with a size of more than 5 million. The increased number of large cities in Africa constitutes economic and social opportunities.

Dense African cities coupled with youthful population provide opportunities for economies of scale and agglomeration, but they will also call for large investments in infrastructures to respond to the increased demand, for instance, for water, sanitation, solid management, energy, mobility, streets and public spaces. This will also require efficient institutions for the management of social demand and equity such as on education and health as well as protection of people against violence and insecurity. However, the African urbanization has been characterized by proliferation of unplanned settlements that lack most basic services exposing household to disaster prone areas such as flooding. This kind of urbanization creates slums, congestion, pollution, pressure on natural resources, higher labour and property costs, higher levels of crime and insecurity which could prevent private investment, reduce urban productivity and hold back economic growth.

This book puts forward a shift of the paradigm to re-conceptualize the future of African cities towards sustainability, resilience, inclusion and prosperity in the context of an information-driven global and local development. It proposes a planning of African cities in digital revolution era that can make cities smart, green, ecological, livable and healthy. In the last decade, internet connection has grown exponentially and Africa as other developing countries have adopted new technologies albeit to varying degrees following the rapid pace of technological innovations. Greater internet access has led to an explosion in the production and consumption of information in the continent. With the increased development of ICTs, African towns and villages will be digitally connected for their commercial, financial, administrative, and social activities. The emergence of these digitally served towns and villages will foster economic development without damaging the environment; there will be less consumption of land for private proprieties, and few cars than before in the road making streets friendly and healthy for walking and cycling. In the long term, this will reduce emissions of CO_2, promote the creation of low carbon settlements, reduce land degradation and promote biodiversity.

The nexus of ICTs with dense urban agglomeration is associated with advantages such as efficient diffusion of ideas, innovation, economies of scale and agglomeration economies. Today, African cities must be planned and managed consistent with these emerging parameters and conditions that are pointers of a new form of urbanization; the era of digital urbanization where digitally connected towns and villages offer social, economic and political advantages traditionally only found in big cities with high densities. The African digital urbanization will affect all urban sectors in ways that will turn current urban challenges in Africa to opportunities, bring African cities back to the conventional growth path and to ensure the development of production cities, rather than consumption cities. Sustainable urbanization, safe and resilient human settlements increases sustainable growth pathways, reduces inequality, increases productivity and economic opportunities; therefore, the role of sustainable urbanization and highly productive cities to national development cannot be over-emphasized. A strategy to promote efficient urbanization will target density level, land market efficiency, connectivity, potentials for industrialization and interventions arising from pollution, congestion and concentration of people in vulnerable areas.

As African countries increasingly adopt digital technologies, there is an expected rise in efficiency and productivity through automation and data-driven management. Recognizing the crucial role ICT can play in sustainable development, African Heads of States went further and created a holistic programme "Smart Africa" in 2013. The programme aims to foster Africa's development through ICT by 2025. African Head of States are committed to put in place the right policy and regulatory environment that will encourage partnerships, entrepreneurship, job creation and knowledge sharing. They recognize that ICTs have the ability to level the global playing field, unlock human capital and harness its full potential. ICT indeed reduces costs of transactions and eases economies of scale and agglomeration. It eases the development of low carbon cities, reduces the demand for infrastructures such as transport, and allows better management of water, sanitation, and solid waste and energy. It makes more efficient the planning of cities, makes land administration and governance efficient, prevents settlements in disaster prone areas, and promotes social development and inclusion, peace and security.

However, ICT is a means not an end in the city smartness process. Making ICT works in the umbrella of a transformative Africa as it is anchored in the Africa

Agenda 2063 requires adequate human capital as well as faithful enforcement of institutional laws and accountability at all levels: individual, community and the highest level of government. This will start with people participation, accountability, good governance and transparency. Good governance, accountability and participation are "bedrocks" for the overall development of African countries. Better tools for communicating with citizens and providing information also allow greater participation of citizens in public programme planning, management and monitoring. The most important benefit of the use of ICT may be in better integrating marginalized or disadvantaged groups into society. This calls for smart governance, smart city foundation, smart environmental development, smart infrastructure development, smart social development and inclusion, smart peace and security and smart disaster prevention and resilience.

Smart Urban Planning—New urban planning instruments are becoming available with the worldwide spread of ICTs. They make it possible to adopt innovative e-planning approaches, strengthen communication between urban stakeholders, and make communication available at various stages of the planning process. Local governments can engage their citizens with real-time information to gain support for policy initiatives, identify unforeseen concerns, and recognize potential conflicts. However, ICTs will not be equal to this challenge on their own. They must be accompanied by more extensive approaches that meet the key conditions of tackling the challenges of urban planning in African cities. ICT will not turn unplanned to planned cities, but it can ease the re-structuration of unplanned settlements through digital mapping. Even though a great variety of web-based examples of e-planning currently exists, the socio-cultural and political context that conditions and shapes the appropriation of ICT and its eventual benefits in city planning and management remain central.

Smart Security of tenure—In most African cities, land tenure is neither well governed nor well administered. Poor land governance is surrounded by poor land administration characterized by a poor determination, recording and dissemination of information about tenure. In addition to being exposed to eviction, without legal proof of ownership, African households cannot enjoy the economic and financial opportunity associated with investment and saving using their property as collateral. At the community level, the municipality cannot also legally collect various taxes that can be used to improve basic infrastructures. Providing security of tenure depends on a range of policies related to institutions and laws put in place to protect people against unlawful eviction, to ensure equitable distribution to basic services to all communities, and to put in place transparent and accountable processes of land regulation, key for secure land tenure. Promotion of secure land tenure in African cities will boost investment in property development, increase municipal tax collection and in turn promote economic growth. ICT can help to promote principles of good land administration and governance. Land tenure experts and stakeholders must use ICT opportunities for the regularization of land along with e-planning.

Smart Urban accessibility and mobility—Besides the low level of land allocated to streets, the street networks in most African cities are generally substandard: they lack service lanes, pavements and are poorly maintained, with limited street lighting. The street planning and design had not anticipated the polycentric form of cites and the rapid increase in the use of private cars. African cities are not benefitting from the multiple advantages associated with sufficient, connected streets such as: safeguarding environmental sustainability; promoting economic development; enhancing social development and social inclusion; safeguarding peace and security; and preventing disasters and building resilience. Inefficient urban mobility system has also impeded multiple advantages from large urban agglomerations such economies scale and agglomeration. In most sub-Saharan African cities, people have limited mobility choices in getting to work: either they ride minibuses, or they walk. Despite various efforts taken by national and local authorities to boost formal public transport, it constitutes a very low share in African cities, less than 5% in the total public transport. Low share of formal means in the public transport sector is the result from poor infrastructures conditions as well as from the weak capacity of city authorities to plan and manage the transport sector. The efficiency challenge of public companies results in large part from various network supply and demand constraints: lack of institutional coordination between the city council and the transport companies; structural deficit associated with the gap between affordable fares and the operating costs leading to operating deficit; and poor operational and commercial performances associated to public service obligations without the corresponding resources. We have, however, witnessed few examples of emerging trends and conditions with respect to the introduction of BRT in Africa. This must be assessed and the good practices emulated and replicated within the continent.

Smart Energy—Access to safe and sustainable energy is critical for sustainable development. Energy has a direct impact to social welfare, economic growth and environmental sustainability. Achieving the UN SDGs 2030, African Agenda 2063 and national development plans in Africa will require improved access to energy, increased share of renewable energy in the energy mix and energy efficiency. Smart energy infrastructure can help the reduction of the emission of CO_2 by increasing the share of renewable energy mix and energy efficiency. Africa is rich in energy sources but poor in energy supply. Adequate energy infrastructure remains a barrier for many African countries even though there has been significant progress in improving energy sectors governance. Changing the way energy is generated, transmitted, distributed and used will have an impact on the future of Africa. Due to lack of long term planning, aging infrastructure and insufficient infrastructure, Africa is struggling to meet the energy demand. Energy efficiency is key to ensuring a safe, reliable, affordable and sustainable energy system for the future. Renewable energy will provide Africa with an opportunity to improve access to energy and hence help reduce poverty, promote economic growth and reduce greenhouse emissions. A number of African countries have policies and strategies that are aimed at increasing renewable energy share and energy efficiencies. The availability of renewable energy resources provides Africa with an opportunity to not only expand access to electricity but also to use sustainable, clean and safe energy sources. Public-Private partnerships in energy infrastructure development can also contribute towards development and maintenance of sustainable energy infrastructure.

The success of smart energy solution is highly dependent on availability of reliable and affordable ICT infrastructure. ICT plays an important role towards implementing energy efficiency innovations. Smart ICT can contribute to a more economical use of energy and can help users manage their energy consumption and improve the communication with the energy providers. Smart grid allows the use of digital communication between the utility and its customers and the sensing between transmission lines. Smart grid provides a number of benefits including improved efficiency, quicker restoration of electricity after power outages, reduced operational and maintenance costs, improved security, increased integration of large scale renewable systems. Internet of Things (IoT) technologies are advancing development of smart buildings. These technologies use sensors to control heating, lighting, physical security, sanitation and other systems through building automation system. Smart commercial and industrial buildings and homes can improve energy efficiency, save costs and reduce greenhouse emissions. A number of countries in Africa are investing and promoting sustainable building starting with the government offices. Africa's energy challenges also require accurate and timely geospatial information at various scales from regional to local scale. Remote sensing technologies provide dynamic data to help address energy challenges and data required to model energy demand. Information on spatial distribution of human settlements and urban growth patterns can be vital during planning of energy infrastructure. Sharing lessons learnt and collaboration within Africa and other countries in other regions will also help fast track access and energy efficiency.

Smart Climate Change—Urban growth in Africa, by fueling increased energy consumption and higher GHG emissions, creates greater exposure to climate vulnerability and risks. It provides opportunities as well as challenges for climate actions. Measures taken to respond to climate change could also have unintended positive and negative impacts. The positive impacts, often referred to as co-benefits, need to be enhanced and in fact could be used for further promoting ambitious climate actions, whilst efforts need to be taken to minimize the unintended adverse social, economic and environmental impacts especially on the most vulnerable communities and sectors. In this regards, for transformation to low-carbon climate resilient smart cities, the United Nations Framework Convention on Climate Change encourages public-private partnership, technology transfer, capacity building, stakeholder engagement and development of measuring, reporting and verification frameworks. Notwithstanding the numerous opportunities that prevail under the Convention and its related instruments, African countries have generally least benefited from these opportunities. It is therefore not surprising that local or municipal authorities in Africa have also not been able to avail themselves of the provisions of support in the form of finance, technology, capacity building, development of measurement verification and reporting systems, recognition for implemented actions, etc. There is a need of more focused attention and targeted capacity building for local authorities within Africa during the period of implementation of Paris Agreement for them to actively engage and contribute to the global effort to address climate change and assist their constituencies to better able to adapt to the impacts thereof.

Whether it is the material for construction and production, food and water, human resources inflow from surrounding or energy and information flow from wider region or across the globe, to out flow of waste, trade and other material including pollutants out of the city limits, the cities are constantly interacting with their surrounding and growing. Indeed, co-benefits of climate action by cities may not necessary be limited to city limits that are politically determined for governance, but will be impacting a wider surrounding area. While even within cities where these transactions between various parties can be complicated, some of these savings may be hence relevant to national government budgets and in Africa the flow of funding between local governments where actions are implemented and national governments where benefits may be experienced has been always a challenge. For the African cities to fully benefit from the opportunities presented under the Convention for climate actions at city levels with co-benefits, there is an urgent need for capacity development focusing on institutional, systemic and human resource development and coupled with targeted education and awareness creation for all stakeholders, better regulatory systems, policies integrating that ensures national and local government interactions, more effective allocation of public finance, establishing and improving efficiency to deliver cross-departmental co-benefits, better institutional arrangements and improved information management systems.

Smart Biodiversity—The African rapid urbanization is likely to present challenges and opportunity for biodiversity conservation. Because of the continent's strategic importance for safeguarding the global commons, it is essential that efforts to promote smart and sustainable growth in cities accommodate biodiversity priorities and contribute solutions to emerging threats from urbanization. Evidence from across the continent suggests that there are diverse opportunities for African cities to plan and pursue smart and sustainable growth that integrates biodiversity conservation. With availability and access to data and innovative tools for planning, there is considerable potential for cities to tackle threats to biodiversity while at the same time harnessing ecosystem services as part of their smart, sustainable and resilient growth strategies. The challenge is for city and municipal leaders to create an appropriate institutional and governance framework that will foster collaborative engagement by city planners and biodiversity experts. Such a framework could also take advantage of a potentially new generation of urban residents that is both passionate about nature and technologically savvy, to promote their participation and stewardship of biodiversity in the cityscape. The growing availability and application of ICT across the continent presents an invaluable opportunity for cities to establish the necessary foundation for implementation and monitoring of biodiversity conservation outcomes in smart city programs.

Smart Waste Management—The absence of adequate waste management is a major obstacle to sustainable development in almost all African cities due to various factors that include: high population growth, rapid urbanization, increasing economic activity, increasing need for consumer goods, and more importantly the lack of sustainable waste management strategies both at national and local levels, including lack of adequate policies. The combination of these factors creates significant amounts of waste whose management represents a major challenge for sustainable development of African cities. Barriers to sustainable waste management include lack of adequate policy and strategic choices in waste management; limited capacity at national and local levels; legal and regulatory, technical, financial, educational and social barriers. Due to limited financial resources, municipalities are often forced to focus on the urgent needs that are the cost associated with collection. In these circumstances, the sustainable management of waste cannot be envisaged. The private sector, including Small Medium Enterprises (SMEs), is facing huge challenges in obtaining financing, given that these activities are always considered a financial risk, while many operators are in the informal sector. However in many cities, waste can be an important source of income for a significant part of the population and of raw materials for many sectors of the economy.

Sustainable solutions in waste management will require an integrated approach through a comprehensive urban planning system, use of ICT, a strong and innovative financial mechanism, appropriate mechanisms for community participation and private sector involvement coupled with a comprehensive education programmes on waste production and management. Moreover, promoting environmentally sound management of waste through waste minimization, recycling, recovery and reuse as well as waste to energy programs is an important niche of jobs creation which is critical in the context of African cities. Planning effective and sustainable investments in municipal solid waste management systems requires indeed an understanding of the needs and preferences of a wide range of stakeholders in service delivery, cots and corresponding environmental and social impacts.

Smart Air Quality—The rapid urbanization and motorization in Africa combined with poor urban planning are worsening air pollution. Several cities in Africa are facing mobility crisis, use of old cars, poor quality of fuel, unorganized public transport. Air pollution is the single largest environmental risk to health globally. It increases the risk of stroke, cardiopathy, lung cancer and acute respiratory diseases, especially asthma and causes more than 3,000,000 deaths annually around the world according to the World Health Organization (WHO). Besides outdoor air pollution, African population are exposed to indoor air population associated to domestic smoke (based on biomass and charcoal). In many African countries, this anthropogenic outdoor and indoor air pollution is worsened by natural sources such as dust from Sahara. However, there are lacks of data for a better estimation and understanding of air pollution and studies linking this to health. Over 90% of African cities do not meet the guidelines for particulate matter (PM10 and PM2.5) concentrations. Effective air quality management has become an environmental emergency for Africa considering the rapid urbanization of the continent. Continuous monitoring of air quality should be encouraged in the continent, particularly in large cities. This will enable to alert people about pollution peak in order to reduce the short-terms effects on their health. In the longer term, this provides reference data useful in the development of policies and programs in the fields of transport, industry, public health, etc.

Smart Disaster Prevention and Resilience—African cities are exposed to numerous types of disasters (both natural and humanly induced). These types of disasters include flooding, landslide, drought, desertification, erosion, windstorms, ethno-religious conflicts, resource-based conflicts, fire disasters, and accident-related disasters. Out of the numerous smart ways of preventing disaster is the early warning systems that tend to give early warnings to residents about an imminent disaster. Also the use of satellites and the mainstreaming of ICT into risk prevention and resilience in the management of disasters represent additional tools for disaster management. Most African cities need to step up their smart strategies and initiatives especially with the use of ICT to address the issues of disaster prevention and resilience. Greater adoption of ICT, public education and awareness and engagement constitute imperatives for more effective disaster resilience and prevention in most African cities. Adoption of Bottom-Up-Approach especially by actively involving CSOs is required, including: Effective community participation; Effective media management to prevent misinformation; and real time monitoring and management of disasters. Greater attention should be paid to public education and awareness of disaster risk reduction, including: identification of zones which are prone to floods, forest fires, landslides etc.; location of emergency shelter, health facilities etc.; awareness regarding use of safe routes; information on conservation of ecological resources e.g. wetlands, forests etc.; availability and type of Early Warning Systems; possible channels of communication, etc.

Smart Peace and Security in Africa It is widely accepted that the major threat or great disturbance to peace and security is conflict. Conflicts in Africa may be said to have been caused by a multiplicity of factors such as: arbitrary borders created by the colonial powers, heterogeneous ethnic composition of African states, inept political leadership, corruption, negative effect of external debt burden and poverty. Despite its wealth in natural and human resources, African is lagging behind due to endless civil wars, border conflicts, weak structures of democratic governance, economic mismanagement and harsh climatic conditions resulting to draughts and other natural incidents amongst others.

ICT can be a useful tool for facilitating attainment of peace and security in Africa as has been demonstrated in the literature and case studies discussed in this book. However use of ICT should not ignore the potential harm associated with the misuse of ICTs and the implications this has for international security. The ICT revolution can be both used and misused in creating or disturbing the peaceful and secure environment due to its ability to transfer real time information to a mass of people rapidly. It is evident that ICTs have also been used in conflict situations to enable communication between citizens in environments beset with violent conflicts. Existing social media like Twitter, Facebook, and blogging have been used to help share information about on-going conflicts. There is an urgent need to invest in peace building in Africa as ICT will play a fundamental role in enhancing attainment of peace and security in the region. The attainment of peace and security in African cities will have to be designed and developed in both the physical and the virtual worlds. This approach will require considerable change in mind-set particularly at the government level. It will require political goodwill and leadership, greater international cooperation and application of ICT in promotion of peace especially among the youth who seem to play major role nearly in all forms of known African continent conflicts.

Smart and Open Governance—There is increasing pressure on African governments to be efficient and responsive to the voices of the public. There will be no smart cities without smart governance with open, transparent, and collaborative stakeholders. ICTs ease the evolution of new highly collaborative environments that allow the immediate exchange and use of large amounts of information by people and all governance stakeholders. Equipped with a steady flow of constituent feedback and trust built on realizing the positive benefits of technology, communities will be rewarded with powerful new insights into the functioning of infrastructure and the demand for city services. Seeing the benefits that sharing their data can bring, people will begin to articulate more explicitly and regularly how they want their cities to develop. City leaders, through appropriate transparency and participation, can build a community of stakeholders who care deeply about their urban environment.

Smart Health—There has been a relatively sustained rate of progress in access to health services in Africa during the past 25 years. In the 1990s, access to health services was very limited and infant and child mortality rates were consequently high. With a steady improvement in health coverage, enhanced with the Millennium Development Goals (MDGs), the improvement was accelerated during the 15 years of the MDGs despite the incidence and prevalence of HIV and AIDS in some parts of Africa. However, modern environmental diseases appear to impede decline in morbidity and mortality rates. These modern environmental diseases are associated to changes in urban life with the increased motorized means of mobility that has enormous negative impacts on people's lives. With the increased use of cars, a sedentary lifestyle is becoming more common among the urban middle and upper classes; contributing increased obesity, in addition to increasing air pollution and greenhouse gas emissions. Universal Health Care calls for transformative actions with increased integration of ICTs in the health sector: transforming the analogue health sector to an e-health sector. Transformational change in care delivery will result from emerging, ubiquitous, participatory preventive and personalized smart models of care. With the ICT revolution, the impetus to strengthen health systems with better information has driven significant progress. There is increased use of ICTs in support of health services (e-health) since 2000. The wider use of ICT in healthcare is a basic condition for the development, implementation and further generation of innovative health care technologies.

Smart Education—Education is critical to meeting the challenges of smart city, as it connects people to new approaches, solutions and technologies that enable them to identify, clarify and tackle local and global problems. It is crucial to reducing poverty, improving health, and enabling people to play a full part in their communities and nations. The primary education level alone may not provide the required capability to digitize a system, but it represents a good start towards an effective expansion of ICT infrastructure. In the last 20 years, considerable progress had been made in education as witnessed by the increase in the percentage of young people with at least a primary level of education. Though primary education level and its correlate literacy level are important for the use of ICT, further education at the secondary level or higher may be required to develop and use sophisticated applications from mobile phones and computers. Higher education can allow people not only to use the ICT infrastructure but also to develop sophisticated applications for complex problems and situations with the ICT infrastructure.

Bridging the education divide through ICT—Leaving no one behind in the journey towards a smart city—Making ICT infrastructure economically, socially and environmentally sustainable for learning and knowledge sharing is the key in driving African cities towards smartness. Education has been for a long time obtained in a classroom with a teacher and students. Today, the ICT has transformed the learning environment and methods and calls for a paradigm shift in assessing level of education and knowledge in a country or globally. Bridging the gap by reducing social inequalities as well as bridging supply-demand gap calls for a paradigm shift with the integration of the digital approach in learning. Investing in ICT infrastructure fosters engagement with the poor at lower transaction costs.

Evolving towards Smart Cities will lead Smart Economy with the rise of productivity in high productive sectors such as industry and manufacturing that has been the major reasons for the slow/stagnation of economic development in most African countries. Sustainable urbanization and formation of cities can also be harnessed to boost productivity (which increases as workers migrate from agricultural work into urban jobs), demand, and investment. If properly harnessed, urbanization and strategic positioning of cities will boost production. A strategy to promote efficient urbanization should target density level, land market efficiency, connectivity, potentials for industrialization and interventions arising from pollution, congestion and concentration of people in vulnerable areas. Efficient governance institutions and effective political leadership are critical to address the interrelated challenges of urbanization and maximize its potentials; the capacity to produce sustainable solutions must also be harnessed. Urban governance is an essential component to effectively manage cities; the national, local, and regional governments plays a strategic role in guiding economic, social, and environmental policy decisions to sustain the quality of urban areas.