# Greening African Cities: Urbanization, Structural Transformation and Sustainable Resource Use

**Draft 1**

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## 1. Introduction

The challenges facing Africa's growing cities represent an unprecedented opportunity to affect a transition that could chart a more sustainable developmental trajectory for well over a billion of the seven billion people expected to be living in cities by 2050. Instead of a developmental laggard, this would transform Africa into a region that demonstrates in practice what it could mean to implement the Sustainable Development Goals (SDGs). Unencumbered by many of the large-scale resource-hungry fixed infrastructure systems of the developed world, the continent's cities will need to develop in a manner that frees their inhabitants from poverty, maximizes their adaptive capacities for catalysing economic growth, and minimises their respective environmental impacts. This chapter discusses how African cities can be spaces where challenges meet opportunities and where innovative transitions could take place if an appropriate set of assumptions about the nature of urban development replaces conventional paradigms.

Unlike other world regions that have urbanized over the past three centuries, the African region will be urbanizing in a climate- and resource-constrained world – what the scientific community refer to now as the Anthropocene (Crutzen 2002), or what should more accurately be called the urban Anthropocene (Swilling 2016b). In response, during the course of 2015 the SDGs were adopted by the UN and COP 21 approved a global climate deal in Paris in December 2015.

No other region has had to face the challenge of urbanization by paying attention to the resource requirements, carbon emissions and biodiversity impacts of urban development. Whether Africans know it or not, we face this challenge at a time when we have at our disposal all the potential made possible by the technologies of the Information Age: we must, therefore, find out how to use these technologies to harness urbanization as the driving force of structural transformation in a climate- and resource-constrained world. Ignoring this challenge will mean that the African Union Vision 2063 will not be realized. More significantly, not tackling this challenge will mean ignoring the aspirations of Africa's youth majority, many of whom are now concentrated in Africa's cities which is where the third wave of African uprisings is taking place (Branch & Mampilly 2015). In August 2016, 272 activists from the movements driving these uprisings met in Arusha, Tanzania, and issued the Kilimanjaro Declaration – one of the six 'declarations' were as follows:

- "Africa is a rich continent. That wealth belongs to all our People, not to a narrow political and economic elite. We need to fight for economic development that is just and embraces social inclusion and environmental care. We have a right to the 'better life' our governments have promised."

To address this challenge, this report will proceed as follows:

- a summary overview of global resource consumption and the resulting need to decouple rates of resource use from economic growth will contextualize the analysis of African urbanization from a sustainable resource use perspective;

- this will be followed by a discussion across three sections of the linkage between structural transformation and urbanization in Africa starting with an overview of African urban realities (Section 3), the dynamics of structural transformation (Section 4) and then the relationship between urbanization and structural transformation (Section 5), arguing that if the spatial context of structural transformation is ignored cities will become binding constraints on future growth and development;
- to connect urbanization, resource flows and structural transformation, it will be necessary to use the urban metabolism approach to greening urban development (Section 6);
- four future African urban development pathways will then be sketched, namely the makeshift, mesmerizing, mindless and malleable urbanism pathways with the last proposed as the preferable way to green African urban settlements (Section 7);
- the penultimate section then reviews the emergence of National Urban Policies (NUPs) and how they need to be refocussed (Section 8).

The core argument of this chapter is that African cities as currently constituted are – to use the language of institutional economics – 'binding constraints' on future economic growth and development, irrespective of whether growth is green or not. However, for *sustainable* structural transformation – or green growth to use more mainstream discourse - to be a viable future developmental trajectory, it will be necessary to recognize that growth and development takes place within specific spatial contexts. How these spaces are configured will profoundly influence the outcome of the structural transformation programme that has been prioritised by multi-lateral institutions like the African Union (AU) and the United Nations Economic Commission for Africa (UNECA) and most African Governments. If cities are ignored, structural transformation has little chance of success. Fortunately, an increasing number of African Governments have either adopted National Urban Policies (NUPs), or have initiated policy processes to this end. However, it will be necessary to ensure that these NUPs not only focus on socio-economic imperatives, but also address the challenges of decarbonisation, ecosystem restoration and resource efficiency. This is the essence of a sustainable city agenda in the African context. It is argued that African cities face a unique opportunity: they can invest in urban infrastructures that replicate the ecosystem degrading, high carbon and resource inefficient urban systems that have been introduced in most other parts of the developed and developing world, or in anticipation of where the world is heading since the adoption of the SDGs in 2015 African cities can invest in urban infrastructures that result in low carbon, ecosystem restoring and resource efficient cities. To this end it is recommended that NUPs incorporate a focus on resource efficiency that can guide the design, construction and operation of urban infrastructures. These infrastructures must ensure that African cities develop in ways that are resource efficient. This will provide the spatial context for green industrialization and sustainable structural transformation – the twin policy goals advocated by the 2016 Annual Report of UNECA (United Nations Economic Commission for Africa 2016).

This chapter is a contribution to the discussion about the First Ten Year Implementation Plan (2014-2023) of the African Union's Agenda 2063, adopted at the AU Summit in June 2015, especially its objective of increasing urban investments under Aspiration 1: A Prosperous Africa based on inclusive Growth and Sustainable Development; and it also is supportive of the implementation of SDG 11 to "Make cities and human settlements inclusive, safe, resilient and sustainable" and the Kilimanjaro Declaration.

Cities have traditionally been designed on the assumption that there is an unlimited supply of resources and unlimited land and air spaces for dumping wastes. The result is global warming from carbon emissions, global resource depletion and degradation of the biodiversity upon which all life – including human life – depends. As a result, a sustainable city can be defined as a city that restores biodiversity, reduces carbon emissions to a minimum of 2 tons of $CO_2$ per capita, and massively improves resource efficiency (i.e. the total quantity of resources required by the city to grow and develop) so that on average city dwellers consume approximately 6-8 tons per capita (Swilling & Hajer Forthcoming). The latter – resource efficiency – actually holds the key to the other two: by requiring less to do more, wasting nothing and using more renewables, cities become less carbon intensive and less destructive with respect to biodiversity. The innovations and underlying knowledge infrastructures/networks required to make this all happen become the driving force of the current policy focus on 'green industrialization' (United Nations Economic Commission for Africa 2016).

## 2. Global Context

There is growing acceptance across a wide range of audiences that 'modern society' is currently facing historically unprecedented challenges. The advent of the 'anthropocene' comes with an all-pervasive sense that macro-structural pressures like climate change, resource depletion and ecosystem breakdown threaten the conditions of existence of human life as we know it (Crutzen 2002). This has reinforced the crisis of the global capitalist system: the onset of the global economic crisis in 2007/8 has resulted in a realisation that we may have come to the end of the post-WWII long-term development cycle (Gore 2010; Swilling 2013b), and there is little understanding of what will come next. Some argue that we may have reached a metabolic turning point that marks the end-game of the industrial era (Fischer-Kowalski 2011; German Advisory Council on Global Change 2011; Haberl *et al* 2011) that may, in turn, catalyse more fundamental economic transformations. The result of these converging industrial and metabolic crises is an interregnum Edgar Morin has usefully called a 'polycrisis' (Morin 1999:73).

Following long-wave theory (Foxon 2011; Freeman & Louca 2001; Köhler 2012; Swilling 2013b), it can be argued that we should anticipate the third 'great transformation' comparable in its historical significance to the first two 'great transformations': the neo-lithic revolution some 13000 years ago and the industrial revolution some 250 years ago that gave birth to the essentials of the capitalist system (Fischer-Kowalski & Haberl 2007; German Advisory Council on Global Change 2011). Both can be defined as great transformations because they both resulted in fundamental shifts in the metabolic foundations of society: for the neo-lithic transformation this entailed a shift to permanently occupied land, cultivated soils, harvested biomass, animal power, clay, rocks and the basic implements of pre-industrial agriculture; and then 250 years ago a shift to fossil fuels, metals, construction minerals and massive increases in biomass use and water use with the onset of the industrial revolution (Fischer-Kowalski & Haberl 2007). For the German Advisory Council on Global Change, the third great transformation must be about radical decarbonisation and resource efficiency to "provide wealth, stability and democracy within the planetary boundaries" (2011:81). If state interventions redirect the productivity improvements made possible by the information revolution into human development (following Castells & Himanen 2014), this may in turn make possible what some are referring to as a transition to a post-capitalist mode of production (Mason 2015). However, all those who use long-wave theory recognize that these transitions are by no means linear and therefore cannot be easily predicted: they are highly complex processes that manifest differently across geographical scales and historical time. Key events can coalesce unexpectedly with accumulated macro-level structural shifts and the dynamics of conjunctural re-alignments to open up hitherto unlikely future trajectories.

The environmental science of pollution, climate science and ecosystem science have traditionally been the three underlying bodies of science that have supported the claims of the environmental movement. In recent years material flow analysis has emerged as the fourth body of science, with roots in industrial ecology, resource economics and political economy (Fischer-Kowalski 1998; Fischer-Kowalski 1999). Major historical re-interpretations of agricultural and industrial economic transitions have now been written that are clearly extremely useful for anticipating the dynamics of future transitions (Fischer-Kowalski & Haberl 2007; Giampietro *et al* 2012; Smil 2014). The focus has shifted from the negative environmental impacts of the outputs of industrial processes to the material inputs into a global economy that depends on a finite set of material resources. UNEP established the International Resource Panel (IRP) in 2007 to promote this approach to global change (Fischer-Kowalski & Swilling 2011; Swilling 2016a), including a Working Group on Cities to apply this perspective to an understanding of urban transitions (Swilling *et al* 2013).

According to the IRP, domestic extraction of non-metallic materials, metal ores, fossil fuels and biomass increased from just over 20 b tons in 1970 to 70 b tons by 2010. This translated into an increase in average per capita resource use of just over 6 tons in 1970 to 10 tons by 2050.

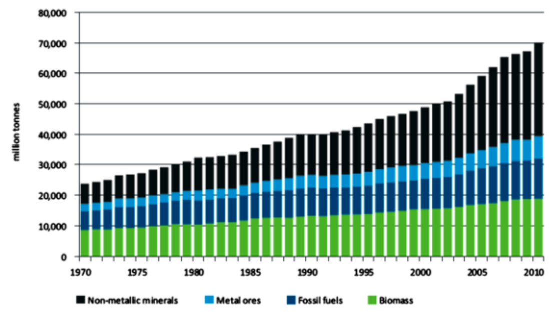



Figure 7. Global material extraction (DE) by four material categories, 1970–2010, million tonnes

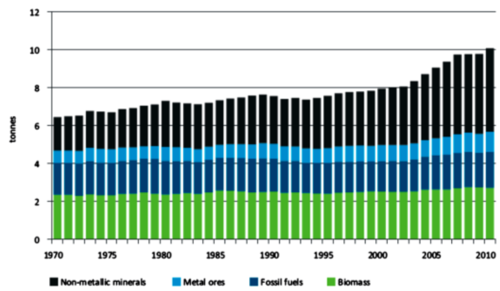



Figure 8. Per capita global material extraction (DE) by four material categories, 1970–2010, tonnes

(Source: Schandl *et al* 2016:32-33)

Between 1900 and 2005 total material extraction increased over this period by a factor of 8, while GDP increased by a factor of 23 for the same period (Fischer-Kowalski & Swilling 2011).

Rising global resource use during the course of the c.20th (including the metabolic shift that took place from mid-century onwards as non-renewables grew and dependence on renewable biomass declined in relative terms) corresponded with declining real resource prices – a trend that came to an end in 2000-2002. Since 2000-2002, the macro trend in real resource prices has been upwards (notwithstanding dips along the way), and since 2014 has dipped down again.

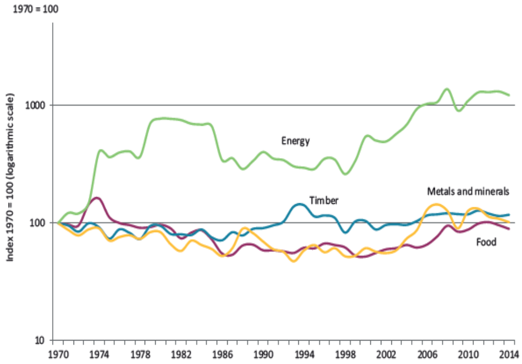



Figure 4. Trends in global resource prices, 1970–2010, indexed

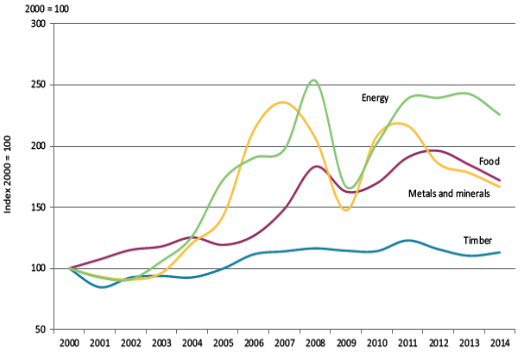



Figure 5. Trends in global resource prices, 2000–2014, indexed

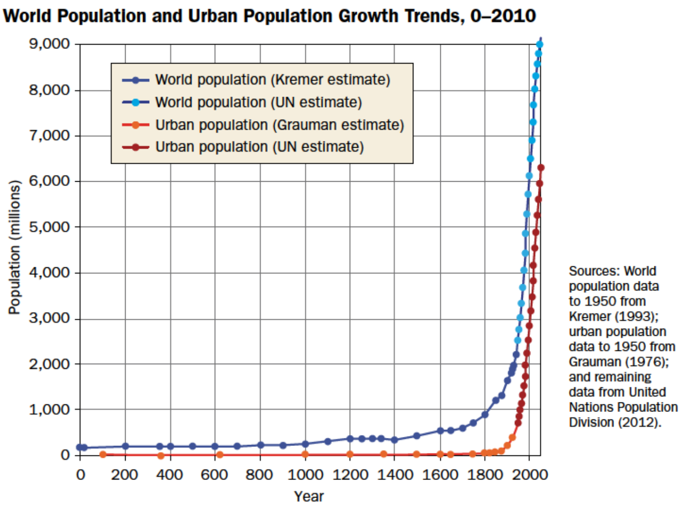
(Source: Schandl *et al* 2016:27-28)

As far as the IRP is concerned, a transition to a more sustainable global economy will depend on absolute resource reduction in the developed world, and relative decoupling of economic growth rates from rates of resource use in the developing world. If this is not achieved, the result may well be an increase in total resource use from 70 bt in 2010 to 140 bt by 2050 if all 9.5 billion living on the planet by then consume the equivalent of the average European (i.e. 16 tons per annum per capita, which is half what the average American consumes). However, if the convergence point is 8 t/cap, the total material requirement would be 70 bt by 2050 on a planet of 9.5 billion people (Fischer-Kowalski & Swilling 2011). The IRP suggests that the material equivalent of living in ways that will result in the emission of 2 tons of $CO_2$ per annum per capita by 2050 on a planet of 9.5 billion people (as recommended by the IPCC) may well be 60 bt or 6 t/cap for everyone. Although the latter is the logical consequence of the science of the IPCC that all countries approved, it implies a 'great transformation' equal in significance to the metabolic transformations that resulted in the Neo-Lithic and Industrial Revolutions. After all, per capita resource consumption in low density industrialised countries (e.g. North America, Australia) is 25-35 tons. Given the inherent resource intensity of the growth imperatives of actually existing capitalism, such a 'great transformation' might well require information intensive post-capitalist modes of economic development that are not dependent are maintaining positive economic growth rates. This outcome is probably only conceivable if maximum use of information in open source environments is facilitated by appropriate regulatory regimes (Mason 2015).

Now that the majority of people live in urban settlements, it follows that such a 'great transformation' could well be the emergent outcome of a multiplicity of urban transitions instigated and managed by city-level coalitions of change agents. This is suggested by another IRP report entitled *City-Level Decoupling: Governance of Urban Infrastructure Transitions* (Swilling *et al* 2013). Deploying the methods of urban metabolism (see below), this report highlighted the fact that cities are where the bulk of the world's resources and energy are consumed. It is urban infrastructures that conduct the flows of these resources through cities. It follows, therefore, that reconfiguring urban infrastructures holds the key to more resource efficient urbanisms within a wider economic system that can be configured in two alternative or even related ways: where financial markets are re-embedded within the 'real capitalist economy' with a strong human development focus (Castells & Himanen 2014), and/or where new postcapitalist modes of economic development emerge from open cyberspaces that enable new sharing inclusive economies. This is the strategic-cum-conceptual context for investigating the dynamics of structural transformation and urbanization in Africa, especially in light of the emergence of the new African discourse of 'green industrialisation'.

## 3. African urban realities

The 2014 revision of the *WUP* report (UNPD, 2015c) shows that population growth and urbanisation will result in 2.4 billion people being added to the current global urban population by the middle of the century. The global level of urbanisation is expected to rise from 54 percent (in 2015) to 60 percent by 2030 and to 66 percent by 2050 (UNPD, 2015c). Nearly 37 percent of the projected urban population growth to 2050 is expected to come from only three countries: China, India and Nigeria – who are estimated to contribute 404 million, 292 million and 212 million urban dwellers respectively (UNPD, 2015c). Africa's urban population is expected to grow from 400 million in 2010 to 1.2 billion in 20150 (Parnell & Pieterse 2014). This forms a major part of the second urbanization wave that began in 1950 and will largely be a global South phenomenon. By contrast, the first wave took place between 1750 and 1950 and resulted in the urbanization of only 400 million people, mainly in the global North. This means that by 2015 the global process of urbanisation that began in earnest in 1800 (see figure below) had only resulted in the creation of just over 50% of the urban fabric that is expected to exist by 2050 (which includes the 1 billion living slums). This defines the context for SDG number II.




(Source: Angel 2012)

Furthermore, according to the ground breaking UN Habitat report *Challenge of Slums* (United Nations Centre for Human Settlements 2003), of the more or less 3 billion who were living in cities by 2010, 1 billion lived in slums. In other words, 210 years of urbanisation had created a decent quality of life for only two thirds of all urban dwellers. Resolving this problem must, therefore, be seen as integral to a just urban transition by 2050.

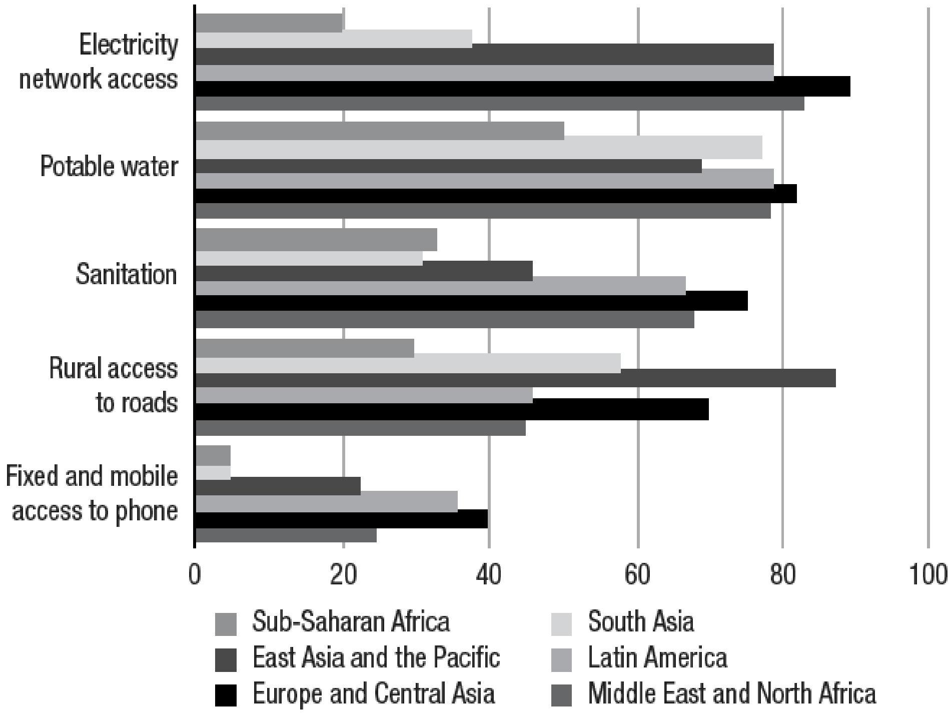
It follows, therefore, that the projected near doubling of the urban population expected to be living in urban settlements by 2050 is still expected to happen over the four decades to 2050. The significant proportion of the additional urban population of nearly 3 billion people will end up in developing country urban settlements, in particular Asian and African cities. If we include the 1 billion people who live in slums, then it follows that material infrastructures of one kind or another will need to be assembled for an additional 5 billion new urban dwellers by 2050.

This raises an obvious and vitally important question from a resource use perspective: what will the resource requirements of future urbanisation be if business-as-usual socio-technical systems are deployed to assemble built environments? What are the resource implications of more sustainable socio-technical systems? To contextualise the significance of these questions, consider one remarkable fact: in the three years 2011-2013 China used more cement than the USA used during the course of the entire c.20$^{th}$. Using business-as-usual technologies to build African cities could result in a demand for cement over the four decades to 2050 that is double what China consumed between 2002 and 2012 – a decade when it was the number one consumer of cement, using during certain years on average nearly half of global cement production. To address these questions, a three year IRP project has concluded that urbanization on a business-as-usual basis will result in an increase in urban land cover from 1 million km2 in 2010, to 2.5 million km2 by 2050, most likely destroying in the process some of the world's most productive farmland that has emerged around most urban settlements. Furthermore, urban resource consumption could increase from 40 billion tons in 2010 to 85 billion tons by 2050. However, a combination of mass transit systems (to bring an end to the private car), renewable energy, green buildings and radical densification using already-proven technologies in combination with advanced information systems could cut resource consumption by 30-50% (Swilling & Hajer Forthcoming).

African states can potentially make strategic choices now about the kinds of socio-technical regimes that need to be built that could result in a very different mode of urbanism to the unsustainable urbanisms that have emerged in other world regions during a period when resource and climate constraints were not yet significant structural dynamics. In other words, maybe the African case is suggestive of the possibility to imagine in advance how to relatively dematerialize future urbanization trajectories.

Africa is now 40% urbanised and is projected to be 50% urbanised by 2030. The *urban* population is expected to increase from 427 million in 2015 (African Development Bank *et al* 2016:147) to nearly 1,2 billion by 2050 (UN Habitat 2008). Africa is forecast to have 560 million urbanites by 2020, which means it will be the region with the highest number of urban dwellers after Asia (2,3 billion). Urban land cover is expected to grow the fastest in Africa from 50 000 km2 in 2000 to 450 000 km2, which is a function of decreasing average densities of -2% per annum (African Development Bank *et al* 2016:174-5). Small urban settlements are projected to grow the fastest between 2010 and 2030 making up for 51% of all future urban growth, followed by intermediate cities (16%) and large cities (33%) (African Development Bank *et al* 2016:148-9).

Significantly, although half of all slumdwellers are in Asian cities, it is only in sub-Saharan Africa that one finds cities where the majority of the population live in slums. No less than 62% of all urban dwellers in sub-Saharan Africa live in slums, compared to Asia where it varies from 43% (Southern Asia) to 24% (Western Asia), and in Latin America and the Caribbean where slums make up 27% of the urban population (UN Habitat 2008). The large majority of cities in Sub-Saharan Africa are, therefore, slum cities. Given the fact that urbanisation rates in Africa are the highest in the world at 3.3% (UN Habitat 2008), the slum cities of Sub-Saharan Africa will be with us for the foreseeable decades. As figure ? reveals, service levels compared to other world regions are the lowest.




(Ajulu & Motsamai 2008:3)

Africa is becoming a continent of slum cities and, in so doing, it is transforming entirely what we mean when we use the word 'city' to describe quite a unique set of urban dynamics and modalities (Pieterse 2008; Simone 2004; Simone 2001; Swilling *et al* 2003). Indeed, for many analysts and policy-makers, African cities don't deserve to be called cities at all – a position that is only tenable if you assume that the 'Western City' is the only legitimate template for defining the city. Maybe it is time to realise that the iconic image of the 'Western City' that emerged from the specificities of the first urbanisation wave (1750-1950) has become little more than a mirage from an African perspective. Maybe it is time to find non-western reference points for rethinking our deepest assumptions about the purpose, meaning and impact of the city (Malik 2001; Swilling *et al* 2003). This will mean recognising that industrialisation, modernisation, and (from the late 1980s onwards) high-tech informationalism – the traditional economic drivers of urbanisation – have not been the primary driving forces of African urbanisation and the emergent urbanisms we see across the diverse cities of the continent.

But this is starting to change in light of rapid economic growth of many African economies since the late 1990s and the resultant focus on 'structural transformation'. The key question becomes: are traditional urban socio-technical regimes appropriate for an African information-based industrialization pathway within a resource- and climate-constrained world?

A key driver of both economic growth and the demand for urban development is the rapidly expanding African middle class that is well-connected via cellphones and the internet. Although a small part of a continent with over a billion people, it is a class that comprises of a rapidly expanding number of increasingly better educated younger people, with enormous potential for rapid improvements in productivity through education, health and functional urban systems. It has emerged from adversity and its strengths are adaptability, flexibility and high levels of ICT-based interconnectivity. It is primarily urban-based, largely service-sector employed and the annual growth of its consumption expenditure is over 3% (McKinsey Global Institute 2010). It is, however, an extremely fragile middle class and the term incorrectly suggests that it is similar in character to western middle classes. This fragility is largely due to the way the decrease in agricultural labour has been coupled to an expansion of the service sector labour force rather than the more traditional expansions of the industrial labour force during a period of structural transformation. This is because urbanisation and industrialisation tracked each other until the mid-1970s after which the manufacturing sector effectively collapsed while urbanization continued. The commodity boom from the late 1990s onwards started to stimulate diversification, but only in specific clusters with only limited re-investment in industrialization. The potential of a development paradigm that connects investments in human development made possible by productivity improvements generated by informationalism (Castells & Himanen 2014) has yet to be recognised.

African urban planning (to the extent that it exists) tends to merge a colonial cognitive model with an idealised conception of urban modernity and conventional socio-technical regimes to deliver the false promise that African cities can replicate what has been achieved elsewhere (Parnell & Pieterse 2014). For those interested in sustainability transitions this is a new kind of challenge: the challenge here is not about the path dependency of existing ‘sunk in concrete’ socio-technical systems, but rather it is about replacing this unrealised idealised false promise with an alternative vision of what is possible that could potentially be a more appropriate response to changing global pressures and thus more equitable, inclusive and ecologically sustainable (Parnell & Pieterse 2014). For in this hodge-podge of extra-ordinary urban initiatives lies the evolutionary potential of Africa’s urban present that is characterised by continuous hybridization in response to extremely complex dynamics that change at sonic speeds (Jaglin 2014). Futures in this context are rarely constructed according to approved masterplans, but are emergent outcomes shaped by conditions that defy the neat categories of formal urban planning analysis.

To achieve a more sustainable future for African cities it will be necessary to address two key challenges: what the African discourse refers to as ‘structural transformation’ to overcome the so-called ‘resource curse’, and spatial transformation to foster the emergence of a unique mode of African urbanism. These are not unrelated: the human and institutional capabilities that many in Africa regard as essential preconditions for structural transformation do not emerge in a spatial and informational vacuum, and yet discussion of these capabilities hardly ever refers to these preconditions. At the same time, the discussion about an appropriate mode of African urbanism needs to interface more coherently with the dominant discussion of structural transformation.

## 4. Towards Sustainable Structural Transformation

The front page of an edition of *The Economist* magazine in 2000 depicted Africa as the ‘the hopeless continent’. Just over a decade later Africa was depicted in its 3 December 2011 edition as ‘the hopeful continent’ and has since waxed lyrical about ‘Africa Rising’. For 8 out of the 10 years to 2011 economic growth rates in sub-Saharan Africa were higher than in East Asia, and 6 of the 10 fastest growing economies by 2015 were African. This kind of upbeat hype about African growth was also reflected in a spate of reports by leading consulting companies (Ernst & Young 2011; McKinsey Global Institute 2010; Monitor 2009) and financial institutions (International Monetary Fund 2011; World Bank 2011) that provided extensive data to back up their optimism.

However, at an African Union summit of Ministers of Finance and Economics in Abuja, 27-31 March 2014, there were repeated warnings that this economic boom is too dependent on the extraction and export of primary resources.[1] Primary resources still make up 86% of exports into non-African markets (United Nations Economic Commission for Africa & African Union 2014:17). There seemed to be complete consensus at this Summit that unless Africa implements what was repeatedly referred to as 'structural transformation', the economic fortunes of African economies will be determined by the notoriously unstable global commodity markets. Furthermore, extractive industries are seen to benefit only a narrow band of employees and shareholders with limited backward and forward linkages within the domestic economies.

The challenge, therefore, is to ensure that resource rents from the extractive sector are re-invested in the diversification of African economies to ensure sustained long-term economic growth. It is this process of change that is referred to in African discussions as 'structural transformation'. However, as Paul Collier has argued, the more dependent an economy becomes on the exploitation of natural endowments, the less incentive it has to diversify (Collier 2010). This, in essence, is what the 'resource curse' is all about. Key consequences are state failure and resource wars resulting from entrenched corporate and elite practices that prevent the re-investment of resource rents (Swilling 2013a) – this being the primary focus of the civil society movements that produced the Kilimanjaro Declaration.

According to UNCTAD total domestic material extraction in Africa increased by 87% between 1980 and 2008, from 2.8 bt to 5.3 bt, with fossil fuels and minerals extraction increasing faster than the other sectors (United Nations Conference on Trade and Development 2012). UNCTAD's data shows that Africa is a net exporter of non-renewable resources (fossil fuels and minerals) and a net importer of biomass (renewables).  Africa exported 500 Mt of unrefined fossil fuels and imported 100 Mt of refined fuels in 2008. And contrary to the popular image that Africa is the producer of mainly agricultural exports, only 14.5Mt of largely unprocessed agricultural materials were exported, while 95.8 Mt of mainly processes biomass was imported (mainly cereals followed by vegetable fats and oils, timber and sugar crops). Compared to the rest of the world, resource productivity (i.e. purchasing power parity in US$/per ton of resources) in Africa by 2008 was the lowest by a factor of 4 compared to Europe and by factor of 0.5 compared to Latin America and Asia. This improved by 33% over the period 1980-2008, but off such a low base that Africa remained with the lowest resource productivity levels in 2008.  This is what led UNCTAD to call for

> "a strategy of sustainable structural transformation (SST). This is a development strategy which promotes structural transformation but which adopts deliberate, concerted and proactive measures to improve resource efficiency and mitigate environmental impacts of the growth process. In short, they should promote sustainable structural transformation, which will be defined here as structural transformation accompanied by the relative decoupling of resource use and environmental impact from the economic growth process." (United Nations Conference on Trade and Development 2012:26)

Energy provision is an excellent candidate for this kind of decoupling. Given that the installed electricity capacity of Africa is equal to that which exists in France (only 80 million people), and given that many African economies are growing at 5-7% per annum (with a population of over a billion),

[1] Personal observations by Mark Swilling, who attended the AU Summit.

for this rate of growth to persist Africa has to embark on a massive electrification programme. If this is done using fossil fuel-based technologies, all the global climate targets agreed in Paris in late 2015 will be breached (Africa Progress Panel 2015). The world, in short, has an interest in African economies investing in renewable energy. Fortunately, this is technically and economically feasible. The International Renewable Energy Agency has developed a detailed feasibility assessment for what they call the Africa Clean Energy Corridor that stretches from the radiation-rich south west, to the hydro reserves of the Congo River, to the geo-thermal potential of the Rift Valley and the windswept expanses of North Africa (International Renewable Energy Agency 2014). This feasible alternative capable of meeting 50% of Africa's energy needs would contribute substantially to what UNCTAD has in mind, including reducing the cost of electrification over the 20 year life cycle.

The United Nations Economic Commission for Africa, which has traditionally ignored the need to consider sustainability issues and urban space, completely changed its tune in its 2016 Report which built on the UNCTAD Report's call for SST and recognised the significance of the adoption of the SDGs and the Paris Agreement on climate in 2015.

The starting point for UNECA is the argument it has mounted for many years now: "high rates of growth over the past decade have not translated into the structural transformation of the economy required. Manufacturing, also, has not made the expected contribution to aggregate output, trade or gross domestic product" (United Nations Economic Commission for Africa 2016:53). Indeed, manufacturing now contributes less in percentage terms to GDP than it did 30 years ago! In its previous three reports UNECA has emphasized building state capabilities for fostering industrial policies influenced by the 'entrepreneurial state' approach (Mazzucato 2011), with a focus on commodities, trade and dynamic interventionist policy management. In its 2016 report, UNECA goes beyond this economistic focus and follows IRP thinking recognising that "decoupling of growth from resource use" (United Nations Economic Commission for Africa 2016:59) provides a major opportunity for African economies to "be among the leaders in designing the new global low-carbon economy" (Ibid:55). A three-pronged rationale for this conclusion is provided: decoupling will spur "structural transformation" (echoeing the UNCTAD report), "increase knowledge intensity in production", and "sustain global competitiveness" in a world committed to decarbonisation (Ibid:55). Significantly, by industrialization UNECA does not simply mean manufacturing – instead it can be defined as "promoting higher-productivity growth" across the whole economic system by making sure that governments develop "capabilities to enable their enterprises to compete in global value chains, promote technical and economic innovation, develop new sectors (such as green industries), and diffuse new technologies (renewables, for example)." (Ibid:63) UNECA concludes that African governments "need to understand how they can launch and sustain a holistic process of economic transformation, which greens the entire system, and drive the economy in a different manner from business as usual." (Ibid: 65) Three strategies for achieving this are described: "transitioning out of brown industries; greening existing industries by increasing resource productivity, cutting pollution, and managing chemicals more safely; and creating new green enterprise, such as producing green capital goods, generating renewable energy and providing environmental advisory services." (Ibid: 69) Significantly, the UNECA report repeatedly emphasizes that greening includes but is not limited to decarbonisation – it is, rather, primarily about resource productivity. This is why both are seen as sources of growth driven by innovation, a way of improving trade balances, fostering regional integration through cooperation to support innovation, stimulating resource efficiency, catalysing knowledge intensity, reducing pollution, and restoring ecosystems. Understood in this way, “green industrialization can contribute to faster, more equitable and more sustainable patterns of growth”. This is a long-term commitment, and “[s]trategic vision and leadership at the highest level are thus critical to inclusive green industrialization”. (Ibid: 70-71)

However, structural transformation – whether it is sustainable or not - will depend on how functional African cities can become as they emerge as the economic centres of accelerated economic growth and development. This is the argument in the UN Habitat State of African Cities 2014 Report which was subtitled “re-imagining sustainable urban transitions” (UN Habitat 2014).

## 5. Connecting African Urbanization and Sustainable Structural Transformation

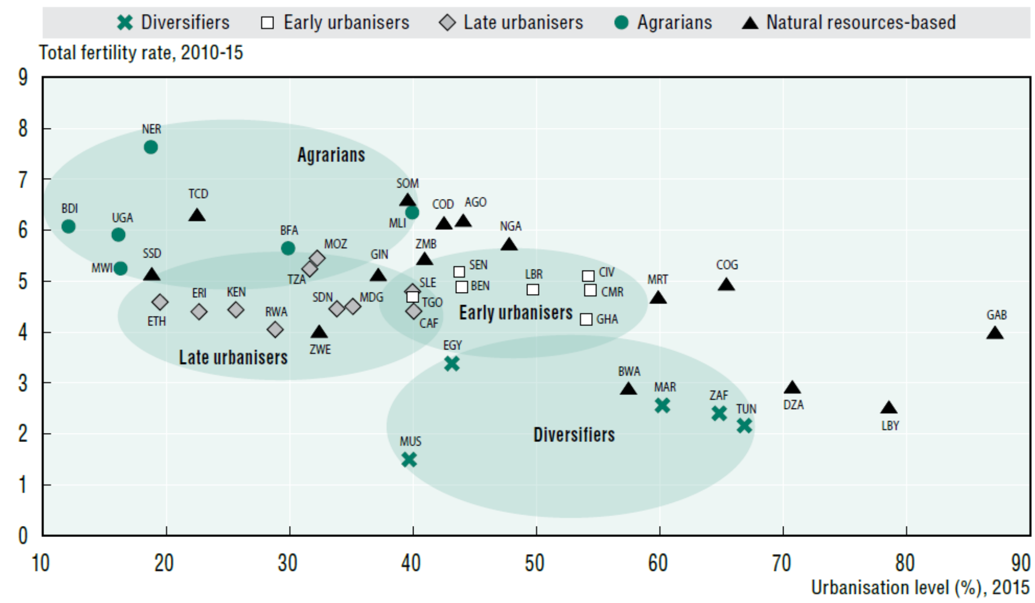
Significantly, the UNECA report not only recognises the need to green industrialization; it also recognizes (to a limited extent, but for the first time) that the ‘where’ of industrialization also matters: “Greening Africa’s industrialization needs to be tied to the region’s urban transition.” (United Nations Economic Commission for Africa 2016:32) It would seem that this realization is driven by the results of a modelling exercise that compared economic outcomes on a ‘Business-As-Usual’ scenario with a ‘Green Agenda’ scenario. The key variables used were energy, population growth and urbanization (with investments in green infrastructure having beneficial impacts on urban fertility levels over time). It was recognised that “[c]ities—key engines of economic growth, job creation and innovation and major contributors to global warming and environmental problems—are at the heart of the transition to a green global economy.” (Ibid: 161) Echoing the UN Habitat Report (cited above) and the IRP Report on Cities, UNECA argues that:

> “[i]n Africa, city governments are key to designing the hardware of city infrastructure, the building standards for private investors and the broader software of urban systems. Africa’s municipal authorities have growing knowledge of what they can achieve by rethinking how they design buildings; public spaces; and energy, water, transport and waste systems. … As the continent shifts to having 55 per cent of its people in urban areas by 2050 (Chapter 5), city planning will need to meet this challenge through greening its public and ecological infrastructure with ambitious energy and water use reduction targets, best-practice urban planning, and innovative technologies. Jobs, enhanced skills and social inclusion are major co-benefits of this process.” (Ibid: 93)

The empirical evidence seems to support this argument. The OECD Report clustered Africa’s 54 countries according to three factors: urbanization levels, fertility transition and structural transformation (as reflected in reduced role of the agricultural sector and reduced dependence on natural resource extraction) (African Development Bank *et al* 2016155-7). The result is 5 clusters as reflected in Figure ??? below. The first cluster are the “diversifiers” comprising Egypt, Mauritius, Morocco, South Africa and Tunisia. With urbanization levels of 40-67%, fertility levels of 3 or less per woman, and agriculture contributing less than 16% of GDP, these countries have an annual GNI/cap of $10 000 or more and a HDI above 0.6. The second cluster are the “early urbanizers” comprising seven countries mainly in West Africa including Cote d’Ivoire, Ghana and Senegal. With urbanization levels of 35-50%, fertility levels of about 5 children per woman, a growing urban informal sector because the urban labour force relative to the rural labour force is growing without a significant increase in the size of the manufacturing sector (which is 2-14% of GDP), the GNI/cap is at $1000-4000 and HDI is 0.4-0.57. The third cluster is “later urbanisers” comprising eight countries mainly in

East Africa including Ethiopia, Kenya and Tanzania. Although less than a third of the population lives in urban areas and fertility is at 6 children per woman, the urban and fertility transitions in these countries have begun, and structural transformation is proceeding apace as developmental states actively promote industrialization in economies where manufacturing is still low (4-12% of GDP). GNI/cap in these countries is $1000-3500 and HDI values are at 0.38-0.54. The fourth cluster are the "agrarians" comprising nine countries (often landlocked) including Niger, Chad and Malawi. With urbanization levels at around 30%, fertility at 6 children per woman and a predominantly agricultural economy with a large informal urban sector, GNI/cap does not exceed $1900 and HDI values are at 0.4 – 0.34. The fifth cluster includes the natural resource-based countries comprising 13 countries that have generated significant surpluses from resource extraction some of which have been re-invested in urbanization (especially in the capital cities). Urbanization levels in these countries are quite high at 40-78%, fertility rates remain quite high but within a wide range (4-7 children per woman) and agriculture's contribution to GDP is low (3-21%). GNI/cap is also wide ranging from $500-20 000, and HDI values are highly variable across this cluster of countries.

Figure 6.11. **Urbanisation levels and total fertility rate by typology of African countries**




*Note:* Natural resources-based countries are not clustered in the figure because they are more scattered across the board. The history and ability of states to invest resource rents can have implications for their development.
*Source:* UN DESA (2015, 2014).
StatLink http://dx.doi.org/10.1787/888933350624

(Source: African Development Bank *et al* 2016:157)

The implication of this new clustering of African countries according to urbanization and fertility levels is that it reveals a fairly strong correlation between diversification and urbanization. The urbanization patterns in the resource-based countries cannot be clustered suggesting that where choices are made to reinvest resource rents in urban development, this could enhance urbanization rates. What this analysis does not make clear is the precise relationship between diversification and urbanization: does the former determine the latter, or vice a versa? To answer this we need to address the discussion about agglomeration effects.

Although the absence of coherent urban development policies in Africa reflects the fact that geography has yet to be recognised as significant in mainstream African economic thinking (Parnell & Pieterse 2014); by contrast there is now a widely held assumption in global mainstream thinking that functional spaces really do positively affect economic growth (Monitor 2009; World Bank 2009). From this perspective, urbanization in Africa is presented as a panacea, with cities providing the platforms for economic growth and development. This evidence reflected in Figure ??? above seems to corroborate this general assumption. However, as Turok (2014) demonstrates, the empirical evidence that urbanization has positive effects on economic development is by no means conclusive. The mounting evidence from the African context suggests that what matters is not just agglomeration per se (which is happening as economies diversify as the evidence presented above suggests), but in particular the quality and efficiency of the urban environments that urbanization makes possible within particular contexts (Turok 2014). This, in turn, is dependent on the evolution of a set of developmental institutions mandated to govern cities in ways that engage and include the urban poor in programmes that are designed for particular contexts with each characterised by unique economic dynamics (Parnell & Pieterse 2014). However, following Buckley & Kallergis (2014), the combined effect of Africa's unique urbanization patterns and historically weak (and in many cases non-existent) urban governance institutions means that African cities are currently in reality 'binding constraints' on - rather than potential enablers of – SST/green industrialization as envisaged by the UNCTAD and UNECA Reports cited above.

The UN Habitat State of the African Cities Report 2014 addresses this more qualitative challenge when it highlights the need for structural transformation of resource intensive, extractive and agricultural economies in Africa, and the role that African cities and their growth trajectories can play in this respect. It emphasizes both the role of cities in Africa as (1) binding constraints on growth, as well as (2) the existing and emerging potentials within African cities to contribute to sustainable, macro-economic structural transformation. It argues that recognising both the constraints and potentials within a 'sustainability' perspective sheds light on the key factors that could bring about more sustainable urban growth trajectories on the continent, and proposes that a 're-imagining' of sustainable urban transitions in Africa is necessary (UN Habitat 2014). To this end, economic diversification requires the careful consideration of all the technology and urban infrastructure options that are available, as well as emerging and new economic activity areas and niches that are less resource intensive, before commitments are made; so that countries can avoid locking themselves into investment patterns that exacerbate resource depletion and ecological degradation (UN Habitat 2014:20). In upgrading and expanding African cities, there is an opportunity to "leapfrog" ahead of their more established counterparts by implementing sustainable and resource-efficient urban designs, infrastructures, technologies and services from the start (UN Habitat 2014:47). In many cases, low-tech interventions that are cheap and easy to maintain may be more appropriate for diversifying local economies than imported high-tech solutions (UN Habitat 2014:20).

It follows, therefore, that the African urban transition must recognize that the dysfunctional geographies and governance dynamics of cities are in fact 'binding constraints' on structural transformation, while at the same time they also hold the key to sustainability transitions. A theory of urban transition that is appropriate to the African context must, therefore, conceive of a set of urban regimes that respond to these twin landscape imperatives of a spatially conscious structural transformation that also recognizes the significance of sustainable resource use over the long-term. For this it will be necessary to incorporate an understanding of urban metabolism.

## 6. Urban Metabolism as the Key to Greening Cities

What is Urban Metabolism?

Cities have traditionally been designed on the assumption that there is an unlimited supply of resources and unlimited land and air spaces for dumping wastes. The result is global warming from carbon emissions, global resource depletion and degradation of the biodiversity upon which all life – including human life – depends. As a result, a green/sustainable city can be defined as a city that restores biodiversity, reduces carbon emissions to a minimum of 2 tons of $CO_2$ per capita, and massively improves resource efficiency (i.e. the total quantity of resources required by the city per unit of economic output and per capita to grow and develop) so that average resource consumption per capita levels out at 6-8 tons. Resource efficiency – or what can also be called 'urban productivity' – actually holds the key to decarbonisation and ecosystem restoration: by requiring less to do more and wasting nothing while increasing the use of renewables, cities become less carbon intensive and less destructive with respect to biodiversity. But for resource efficiency, we need to know how to calculate the quantity of resources required by a city. This is where material flow analysis and its application to cities – urban metabolism – comes in.

The systematic application of Material Flow Analysis (MFA) to the city-region has started to generate some sophisticated frameworks for grasping the complex empirical dynamics of resource flows through (mainly developed world) cities (for recent examples see Barles 2009; Barles 2010; Costa *et al* 2004; Fernandez 2007; Kennedy *et al* 2007; Weisz & Steinberger 2010) but with suggestions for application to developing country cities (Robinson *et al* 2013). A number of cases have been published that demonstrate the robustness of what has now come to be called the Urban Metabolism (UM) methodology (Barles 2009; Brunner *et al* 1994; Burstrom, Brandt, Frostell and Mohlander 1998; Daxbeck *et al* 1997; Faist Emmenegger & Frischknecht 2003; Hammer *et al* 2006).

The difference between countries and cities is that the latter are open systems that will always require sources (of resources) and sinks (for wastes) that are located outside their borders. For example, a substantial proportion of the wastes generated by the city are eventually exported out of the city either into the wider region, or beyond. Also, Domestic Material Consumption (DMC) of resources in a city is equal to Domestic Material Input (DMI) minus what is exported out of the system. (DMI comprises both locally extracted and imported materials.)

The advantage of these methods is that they make it possible to identify and distinguish between the differentiated direct and indirect flows that get sourced from within and beyond the city, then get conducted through the city with some ending up as net addition to stocks (NAS), and then moving into or beyond the city as wastes, goods and services. It is, of course, urban infrastructures which primarily conduct these flows. For example, the DMI/capita for a city where mobility is dominated by the private car in what are usually sprawled out urban forms will be much greater than the DMI/capita in cities that have an excellent public transport system embedded within a high density urban form. The same applies to density: the more dense the city (i.e. the higher the number of people per hectare), the more resource efficient the city will be (i.e. tons of resources per capita will be lower).

The most significant outcome of the application of UM is that it facilitates the re-embedding of urban systems within the wider nexus of ecological services (e.g. water supplies, soils, air quality, landfill space) and natural resource extraction (such as, for example, fossil fuels or building materials that can be drawn from multiple sources). This is what one could call the 'recoupling' of urban systems with the natural systems that support them – a precondition for considering real actually existing sustainability interventions. This effectively recognises that decoupling urban growth from rising use of constrained and non-renewable resources will depend on a conceptual 'recoupling' of 'urban systems' to more abundant and renewable resource sources.

Resource Profile of African Cities

What follows below is the first ever presentation of the most extensive data research done to date to compile the first resource profile of African Cities (Currie 2015)[2]. The resource profile of 120 African cities was derived using various data sources. The number of cities sampled from each region is somewhat proportional to the total populations and urban populations in each region. Of the 120 cities included in Annexure A, 56 are capital cities, 44 are the single prime city in their country, 43 are coastal cities, 38 of which are described as international ports by World Port Source (www.worldportsource.com), and five are island cities. The aggregate material and energy intensities for the sampled cities are ranked in this Annexure.

To draw out the strategic patterns from the list in Annexure A, it is necessary to cluster African cities by the key resource indicators used in UM. Cities were clustered by levels of fossil fuel use, electricity, construction material, biomass and water consumption, and carbon emissions. Table ?? shows the resource profiles for the 10 clusters of cities, organised by speculated progression along the socio-metabolic transition, with median total material consumption displayed. Groups 1 to 3 are deemed resource poor, groups 4 to 7 are in transition and groups 8 to 10 are resource sufficient (on average, ignoring inequality i.e. does not mean everyone has sufficient in these cities). The red lines demonstrate the median or most typical level of consumption by members of each group. The pink area shows the range of consumption levels, which demonstrates the robustness of the range of cities included in each group. In other words, large ranges suggest that the cities may be less similar in resource profile, such as in Group 10, than those with low ranges, such as group 3 or 9.

The groups can be described as follows:

Group 1. These cities show low consumption of all materials except biomass and water. This suggests limited industry and low incomes in these cities. The range for construction materials and fossil fuels suggests that these cities are growing fast.

Group 2. This group of cities shows the same resource profile as group 1 but with low water consumption.

[2] . All the data referred to in this section is derived from this Masters thesis. The detailed methodologies and data sources used can be found in the Masters thesis that can be downloaded at http://scholar.sun.ac.za/

Group 3. This group is made up of exclusively Nigerian cities, still primarily biomass dependent, yet with medium fossil fuel consumption and medium construction materials to suggest a faster growing economy. The sheer size of these cities' populations shows low per capita magnitude, despite these cities being some of the most resource intense cities on the continent.

Group 4. These cities show medium consumption of biomass, water and electricity, and low to medium consumption of construction materials and fossil fuels, with medium-low carbon emissions. This suggests these cities re making use of electricity, most likely from hydroelectric generation.

Group 5. This group shows medium all-round energy consumption and medium consumption of construction materials, with medium-high biomass consumption and medium-low water consumption

Group 6. Like group 5, these cities show medium energy consumption, medium-high biomass consumption, yet with medium-low construction materials and medium high water consumption.

Group 7. This group shows medium consumption of biomass, electricity, fossil fuels and medium-low consumption of water and construction materials.

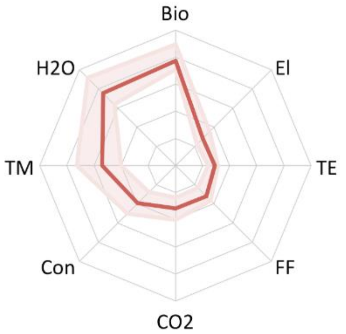
Group 8. This group is almost the same shape as the national resource group 8, and includes cities from the same countries, with the addition of Senegalese cities. It shows medium-low to medium consumption of biomass, medium to medium-high electricity consumption, medium fossil fuel, medium to medium-high construction material, and medium-high water consumption.

Group 9. This group is made up of South African cities, which show medium to medium-high biomass consumption, high electricity consumption, medium to medium-high fossil fuel consumption, medium-high carbon emissions, due to coal produced electricity and abundant private transport in less dense cities, medium to medium-high construction materials and medium to medium-high water consumption.

Group 10. This group is made up of outliers who, between them all, account for the largest consumption of all resources. Swazi cities show the highest consumption of water and biomass, Victoria, in Seychelles, consumes the most energy, and Malabo, in Equatorial Guinea, consumes the most construction materials.

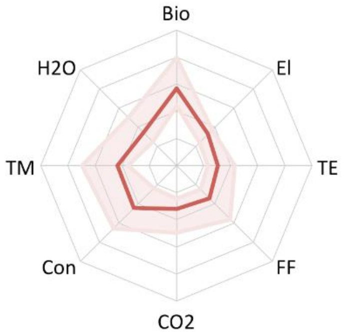
Table ??: Typology of African cities, produced using hierarchical clustering of resource indicators per capita

**Group 1 - 4.9 ton per cap**



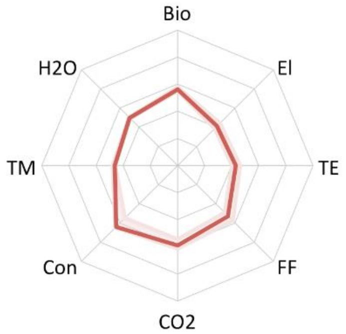

GB-Bissau, GU-Conakry, MAD-Antananarivo, MAD-Mahajanga, MALI-Bamako, MALI-Gao, NI-Maradi, NI-Niamey, SL-Freetown, SO-Hargeisa, SO-Mogadishu

**Group 2 - 3.5 ton per cap**



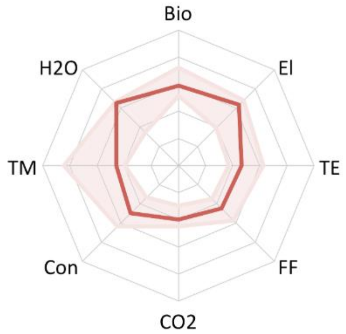

BF-Bobo Dioulasso, BF-Ouagadougou, BU-Bujumbura, BU-Gitega, CAR-Bangui, CH-Moundou, CH-N'Djamena, CO-Moroni, DRC-Bandundu, DRC-Kinshasa, DRC-Lubumbashi, ETH-Addis Ababa, ETH-Mek'ele, GAM-Banjui, LI-Monrovia, RW-Gisenyi, RW-Kigali, TO-Lome, TO-Sokode

**Group 3 - 3.9 ton per cap**



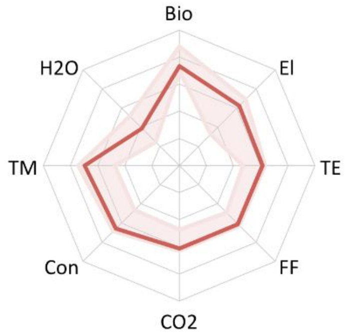

NG-Abuja, NG-Benin City, NG-Ibadan, NG-Ilorin, NG-Kaduna, NG-Kano, NG-Lagos, NG-Ogbomosho, NG-Port Harcourt, NG-Zaria

**Group 4 - 3.8 ton per cap**




CDI-Abidjan, CDI-Yamoussoukro, ER-Asmara, MAL-Blantyre, MAL-Lilongwe, MZ-Maputo, MZ-Nampula, TZ-Dar es Salaam, TZ-Dodoma, TZ-Mwanza, TZ-Zanzibar, ZA-Kitwe, ZA-Lusaka, ZA-Ndola

**Group 5 - 6.2 ton per cap**




BE-Cotonou , BE-Porto Novo, CA-Douala, CA-Yaounde, DJ-Djibouti, GH-Accra, GH-Kumasi, GH-Sekondi-Takoradi, KE-Kisumu, KE-Mombasa, KE-Nairobi, LE-Maseru, SS-Juba, SU-Khartoum, SU-Nyala, UG-Kampala

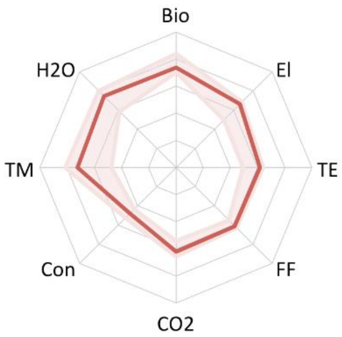
**Group 6 - 7.9 ton per cap**

**Group 7 - 3.8 ton per cap**

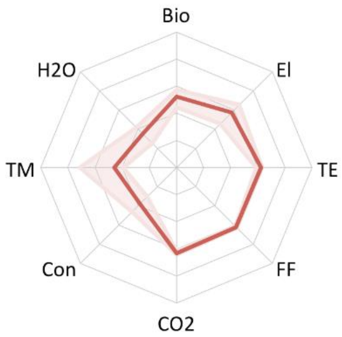
**Group 8 - 9.7 ton per cap**

**Group 9 - 11.6 ton per cap**

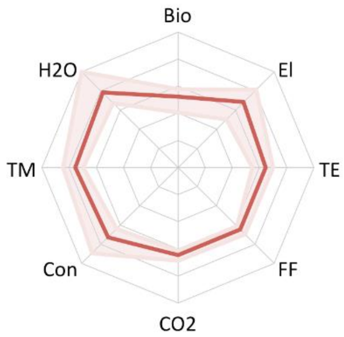
**Group 10 - 23.2 ton per cap**



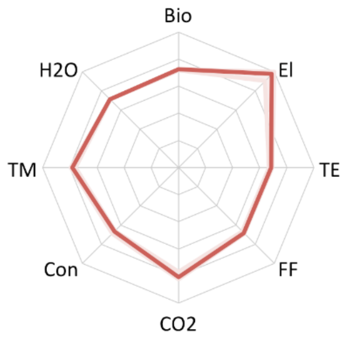

GAB-Libreville, GAB-Port-Gentil, MN-Nouadhibou, MN-Nouakchott, ZI-Bulawayo, ZI-Gweru, ZI-Harare



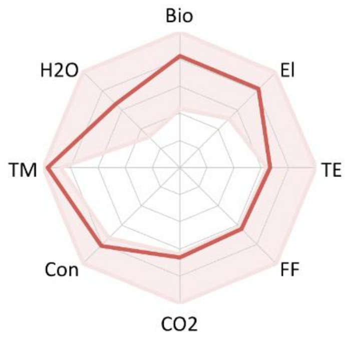

AN-Huambo, AN-Luanda, CV-Praia, RC-Brazzaville, RC-Pointe-Noire, ST-Sao Tome




AL-Algiers, AL-Constantine, AL-Oran, EG-Alexandria, EG-Asyut, EG-Cairo, EG-Fayum, EG-Port Said, LY-Benghazi, LY-Tripoli, MC-Casablanca, MC-Fes, MC-Kenitra, MC-Marrakesh, MC-Rabat, MC-Tangier, SE-Dakar, SE-Thies, TU-Sfax, TU-Sousse, TU-Tunis




SA-Cape Town, SA-eThekwini, SA-Johannesburg, SA-Mangaung, SA-Nelson Mandela Bay, SA-Stellenbosch, SA-Tshwane

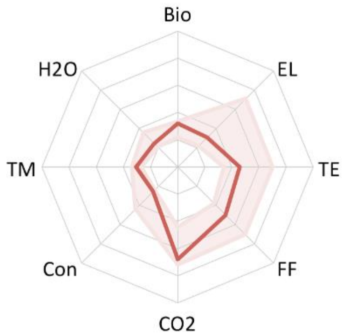



BO-Francistown, BO-Gaborone, EQG-Malabo, MS-Port Louis, NA-Walvis Bay, NA-Windhoek, SW-Manzini, SW-Mbabane, SY-Victoria

Unsurprisingly, resource and energy consumption correlates with the level of economic development as measured by GDP. Table ??? demonstrates how resource use (in tons) and energy use (in MWh) per unit of GDP output (1 US Dollar in value) tends to increase as the overall GDP of the city goes up. However, it would be incorrect to assume that GDP growth is the ONLY determinant of resource use growth – climate zone (which determines heating and cooling requirements) and density (which determines how efficiently resources are used) also play a key role. However, GDP growth is the most important overall driver.

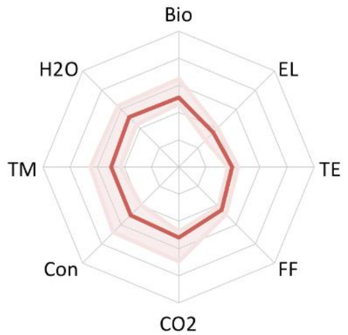
**Table ??: Typology of resource consumption by per-unit-GDP measure**

**Group 1 - 89 t/USD - 29 MWh/USD**



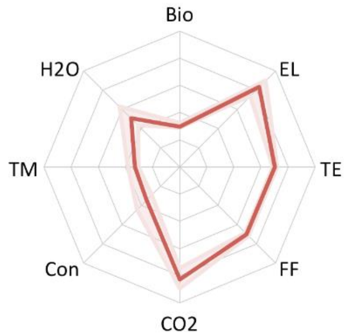

AN-Huambo, AN-Luanda, CV-Praia, EQG-Malabo, GAB-Libreville, GAB-Port-Gentil, RC-Brazzaville, RC-Pointe-Noire

**Group 2 - 226 t/USD - 43 MWh/USD**



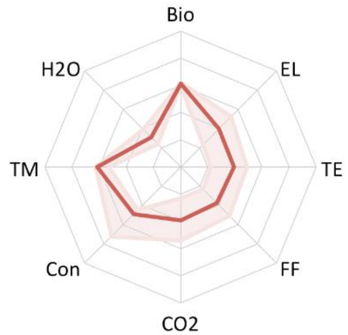

ER-Asmara, NG-Abuja, NG-Benin City, NG-Ibadan, NG-Ilorin, NG-Kaduna, NG-Kano, NG-Lagos, NG-Ogbomosho, NG-Port Harcourt, NG-Zaria, SL-Freetown

**Group 3 - 166 t/USD - 27 MWh/USD**



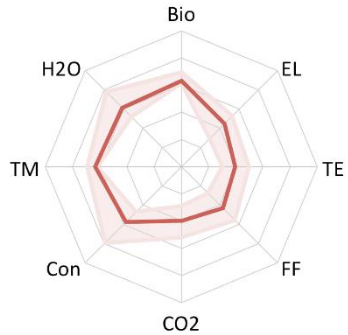

LY-Benghazi, LY-Tripoli, SA-Cape Town, SA-eThekwini, SA-Johannesburg, SA-Mangaung, SA-Nelson Mandela Bay, SA-Stellenbosch, SA-Tshwane

**Group 4 - 134 t/USD - 37 MWh/USD**




CH-Moundou, CH-N'Djamena, DRC-Bandundu, DRC-Kinshasa, DRC-Lubumbashi, RW-Gisenyi, RW-Kigali, SU-Khartoum, UG-Kampala

**Group 5 - 239 t/USD - 27 MWh/USD**




BF-Bobo Dioulasso, BF-Ouagadougou, BU-Bujumbura, BU-Gitega, CAR-Bangui, ETH-Addis Ababa, ETH-Mek'ele, GU-Conakry, MAD-Antananarivo, MAD-Mahajanga, MALI-Bamako, MALI-Gao, NI-Maradi, NI-Niamey, TZ-Dar es Salaam

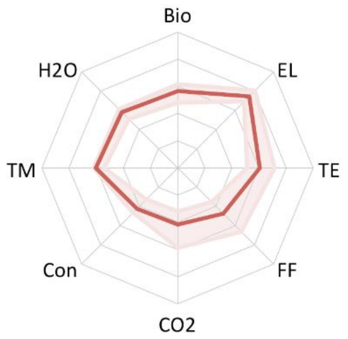
**Group 6 - 455 t/USD - 27 MWh/USD**

**Group 7 - 340 t/USD - 34 MWh/USD**

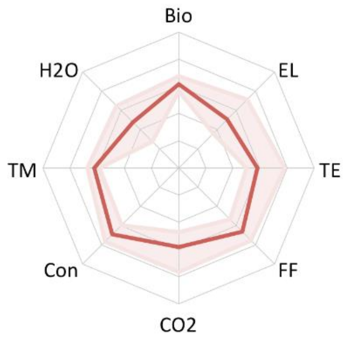
**Group 8 - 349 t/USD - 35 MWh/USD**

**Group 9 - 480 t/USD - 43 MWh/USD**

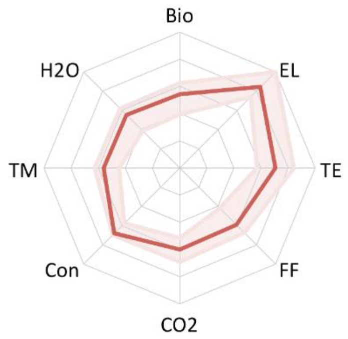
**Group 10 - 266 t/USD - 38 MWh/USD**



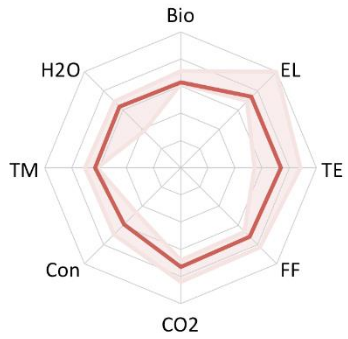

CA-Douala, CA-Yaounde, CDI-Abidjan, CDI-Yamoussoukro, ZA-Kitwe, ZA-Lusaka, ZA-Ndola



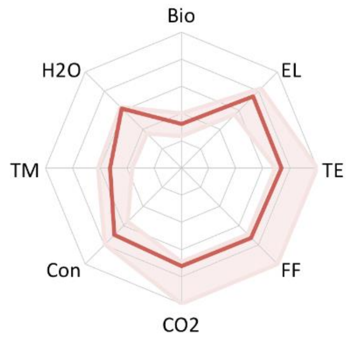

BE-Cotonou , BE-Porto Novo, CO-Moroni, GB-Bissau, GH-Accra, GH-Kumasi, GH-Sekondi-Takoradi, KE-Kisumu, KE-Mombasa, KE-Nairobi, SE-Dakar, SE-Thies, SS-Juba, SU-Nyala, TZ-Dodoma, TZ-Mwanza, TZ-Zanzibar



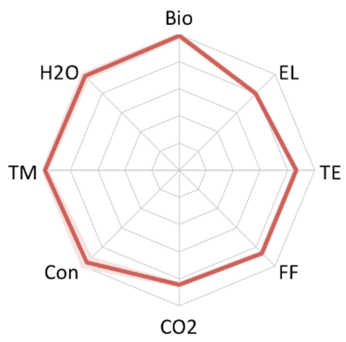

BO-Francistown, BO-Gaborone, LE-Maseru, MAL-Blantyre, MAL-Lilongwe, MZ-Maputo, MZ-Nampula, NA-Walvis Bay, NA-Windhoek, SW-Manzini, SW-Mbabane




DJ-Djibouti, GAM-Banjui, LI-Monrovia, MN-Nouadhibou, MN-Nouakchott, ST-Sao Tome , TO-Lome, TO-Sokode, ZI-Bulawayo, ZI-Gweru, ZI-Harare




AL-Algiers, AL-Constantine, AL-Oran, EG-Alexandria, EG-Asyut, EG-Cairo, EG-Fayum, EG-Port Said, MC-Casablanca, MC-Fes, MC-Kenitra, MC-Marrakesh, MC-Rabat, MC-Tangier, MS-Port Louis, SY-Victoria, TU-Sfax, TU-Sousse, TU-Tunis




SO-Hargeisa, SO-Mogadishu, Group 11 - 4081 t/USD – 64 MWh

It is, of course, possible to cluster African cities by similarity of population, population density, cooling degree days, heating degree days and per capita GDP. Based on lessons from the global resource typology of cities (Saldivar-Sali, 2010; Fernández et al., 2013), as well as arguments from Krausmann et al. (2008), Barles (2009), Satterthwaite (2009) and Weisz and Steinberger (2010), these variables give strong indications as to the likely level of resource consumption. Table ?? shows the 10 resultant groupings of cities along with brief descriptions.

Table ??: Typology of African cities by similarity of predictor variables

| Group | Members | Description of Attributes |
|---|---|---|
| Group 1 | BO-Francistown, BO-Gaborone, LE-Maseru, NA-Walvis Bay, SA-Stellenbosch, SW-Manzini, SW-Mbabane, TU-Sousse, ZI-Gweru | This group contains very small- to small-sized cities of low density, with low population growth. The cities are in quite variable temperatures and show medium to very high incomes |
| Group 2 | CH-Moundou, CO-Moroni, CV-Praia, EQG-Malabo, GAB-Port-Gentil, MS-Port Louis, ST-Sao Tome , SY-Victoria | This group contains very small to small cities of low density, with low population growth. The cities are in constantly hot temperatures and show medium to very high incomes |
| Group 3 | BU-Gitega, DRC-Bandundu, KE-Kisumu, MAD-Mahajanga, MALI-Gao, MN-Nouadhibou, SE-Thies, TO-Sokode, TZ-Dodoma, ZI-Bulawayo | This group contains small cities of low density, with low population growth. The cities are in somewhat variable temperatures and show low incomes |
| Group 4 | BF-Bobo Dioulasso, BF-Ouagadougou, GAM-Banjui, GB-Bissau, MAL-Blantyre, MAL-Lilongwe, MZ-Maputo, SS-Juba, SU-Khartoum, ZI-Harare | This group contains medium cities of low density, with medium population growth. The cities are in somewhat variable temperatures and show low incomes |
| Group 5 | AL-Algiers, AL-Constantine, AL-Oran, DJ-Djibouti, DRC-Lubumbashi, EG-Alexandria, EG-Asyut, EG-Cairo, EG-Fayum, EG-Port Said, ER-Asmara, ETH-Addis Ababa, ETH-Mek'ele, KE-Nairobi, MAD-Antananarivo, MC-Casablanca, MC-Fes, MC-Marrakesh, MC-Tangier, SU-Nyala, ZA-Lusaka | This group contains mostly medium to large cities of medium to high density, with medium population growth. The cities are in quite variable temperatures and show low to medium incomes |
| Group 6 | AN-Luanda, CAR-Bangui, CH-N'Djamena, LY-Tripoli, MN-Nouakchott, MZ-Nampula, NG-Benin City, NG-Ibadan, NG-Ilorin, NG-Kaduna, NG-Ogbomosho, NI-Niamey, RC-Brazzaville, RC-Pointe-Noire, RW-Kigali, TZ-Zanzibar | This group contains mostly medium or large cities of medium density, with medium population growth. The cities are in somewhat variable temperatures and show low incomes |
| Group 7 | AN-Huambo, BU-Bujumbura, CA-Yaounde, MALI-Bamako, NG-Abuja, TZ-Dar es Salaam, TZ-Mwanza | This group contains medium to large cities of medium density, with high population growth. The cities are in somewhat variable temperatures and show low incomes |
| Group 8 | BE-Cotonou , GAB-Libreville, GH-Accra, GH-Kumasi, GH-Sekondi-Takoradi, LI-Monrovia, TO-Lome, UG-Kampala | This group contains medium to large cities of low density, with medium to high population growth. The cities are in constantly hot temperatures and show low to medium incomes |

| | | |
|---|---|---|
| Group 9 | LY-Benghazi, MC-Kenitra, MC-Rabat, NA-Windhoek, SA-Cape Town, SA-eThekwini, SA-Johannesburg, SA-Mangaung, SA-Nelson Mandela Bay, SA-Tshwane, TU-Sfax, TU-Tunis, ZA-Kitwe, ZA-Ndola | This group contains medium to large cities of low density, with medium population growth. The cities are in quite variable temperatures and show medium to very high incomes |
| Group 10 | BE-Porto Novo, CA-Douala, CDI-Abidjan, CDI-Yamoussoukro, DRC-Kinshasa, GU-Conakry, KE-Mombasa, NG-Kano, NG-Lagos, NG-Port Harcourt, NG-Zaria, NI-Maradi, RW-Gisenyi, SE-Dakar, SL-Freetown, SO-Hargeisa, SO-Mogadishu | This group contains medium to very large cities of high density, with medium population growth. The cities are in somewhat variable temperatures and show low incomes |

Based on the typical predictor variables elucidated in the literature, the following resource profiles are expected from each group.

Group 1: With medium to very high incomes and low density, it is expected that such cities will show high fossil fuel consumption in the form of transportation, and a large proportion of electricity as energy carrier. Low population growth suggests that there will be less reliance on construction materials for building new stock. Due to climate, this group of cities is likely to spend energy on both heating and cooling.

Group 2: This group is similar to group 1, except that its climate indicators suggest it will spend more energy in cooling.

Group 3: Low incomes in small cities suggest higher reliance on biomass as the primary resource. As they are smaller cities, they may not reap large benefits of scale, so may show higher per capita consumption of materials than their larger counterparts. Variable temperatures suggest expenditure of energy on both heating and cooling.

Group 4: These cities should show a similar profile to group 3 but at slightly larger magnitude, due to larger city sizes and increased population growth.

Group 5: These cities show low to medium incomes, suggesting that fossil energy may be becoming competitive with biomass. Their mid to high density suggests that energy will be spent more on industry than transport, and very variable temperatures suggest a large proportion used for thermal regulation. Medium population growth and medium income suggests more need for construction materials for formal building developments.

Group 6: Like group 5, these cities will expend more energy on industry than transit, yet the low incomes suggest that industry is still agricultural or extractive, and yet to fully diversify. Biomass will still be the predominant resource consumed, though medium growth rates suggest the occurrence of more construction to accommodate new people, whether formally or informally.

Group 7: These cities will show the same profile as group 6, but with higher growth, they should show higher consumption of construction materials. Low incomes may mean that more informal construction is taking place.

Group 8: Low to medium incomes suggests a transition from biomass reliance to fossil fuel industry, and low density suggests large proportions of fossil fuels used in transit. However, this may be reduced by less widespread reliance on private transport. In Benin and Burkina Faso, for example, motorbikes are the predominating vehicles and minibus taxis are common in all these cities. As income increases, occurrence of more private vehicles will push up fossil fuel consumption and carbon emissions. High population growth suggests high construction needs, though this will be more pronounced in the higher income cities. Consistent heat suggests more energy expended on cooling, though this is also tied to income.

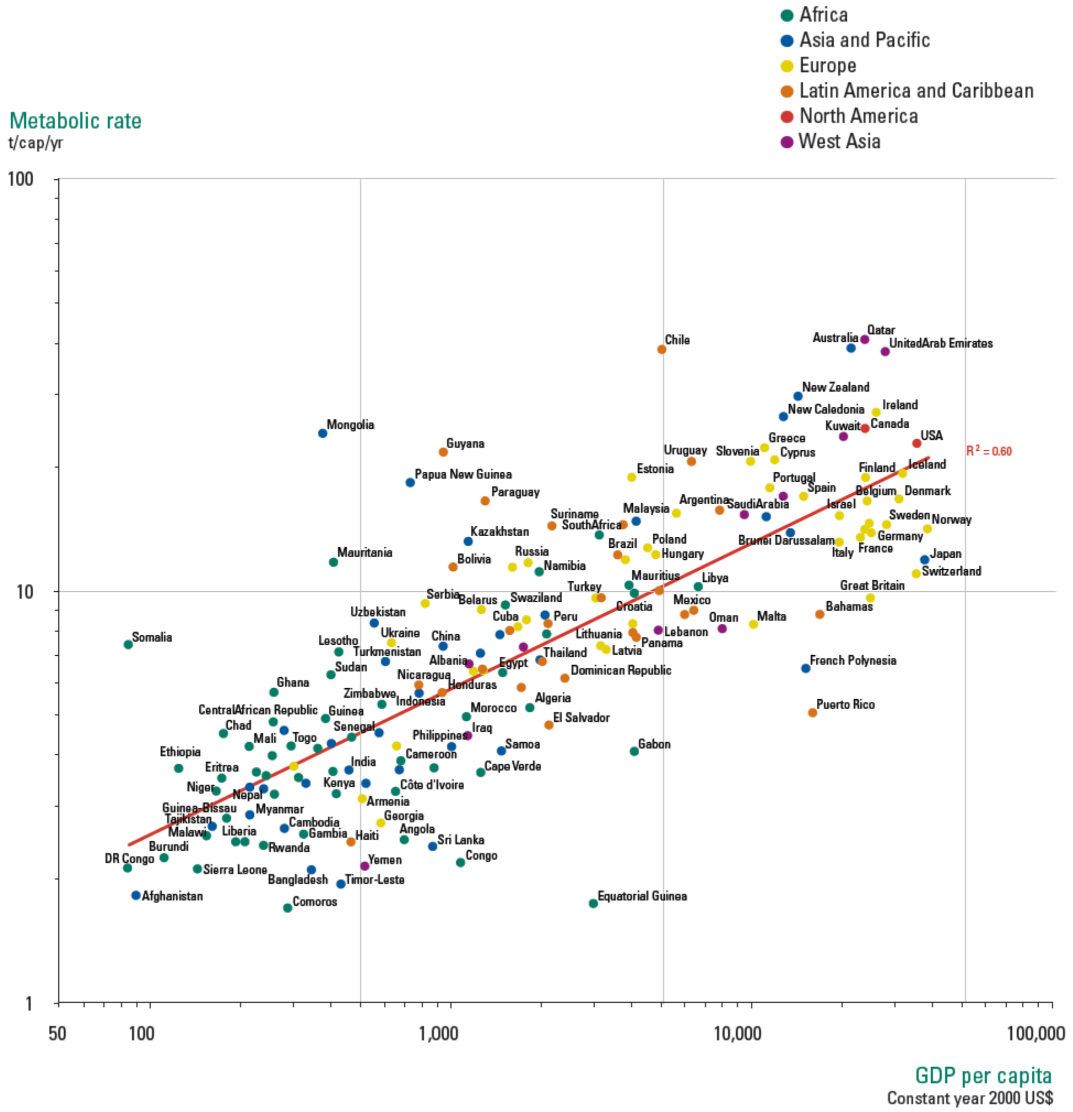
Group 9: Like group 8, these cities will expend more energy on transit, though higher incomes suggest more private transportation, so higher fossil fuel consumption. This group will likely use more construction materials too, despite only medium growth. This is because higher incomes indicate more formal types of construction. Variable temperatures and high income suggest large amounts of electricity spent on thermal regulation.

Group 10: These cities show larger high-density cities, which suggest that benefits of economic agglomeration will reduce per capita material consumption and low income means that less energy will likely be expended on transportation. These cities will show high biomass consumption and, despite high construction needs due to medium population growth, low to medium formal construction material consumption is expected. Consistent heat suggests that some energy is expended on cooling.

Towards sustainable urban metabolisms

This analysis raises an obvious question: what is a sustainable urban metabolism? According to the International Resource Panel, the metabolism per capita ranges from approximately 35 tons per capita in low density developed industrial economies like North America and Australia, through to 16 tons per capita in high density developed industrial economies as is common in Europe, through to industrialising developing economies like South Africa and Brazil at 12 tons per capita, while China is at 8, and India and Ethiopia are at 5 tons per capita (see Figure ???). These averages mask the fact that consumption in cities is higher (often double) than average consumption for the country. Nevertheless, it was possible for the IRP to propose that a sustainable level of consumption is around 8 tons per capita (Fischer-Kowalski & Swilling 2011).

**Figure 2.6.** The global interrelation between resource use and income (175 countries in the year 2000)



Using the clusters described in Table ?? (Typology of African cities, produced using hierarchical clustering of resource indicators per capita), this means that cities in Groups 1 – 8 can increase their resource consumption per capita to about where Group 9 cities are located, while most Group 10 cities will need to cut average consumption down. If conventional urban infrastructures and land uses are promoted (private cars, low density, fossil fuel-based energy, limited waste recycling etc), then urban development will not be resource efficient and low carbon and African cities will end up looking like Western cities (i.e. between 16 and 30 tons per capita).

Using the UM approach, this section has depicted African cities in terms of their resource and energy consumption. A clear pattern is that resource and energy consumption increases with economic growth. However, climate zone (which determines energy requirements for heating and cooling depending on affordability) and density (which affects tons of materials per capita) are also determining factors (but due to space constraints this data could not be presented here). What this analysis does not reveal is that resource consumption depends on infrastructure provision. Infrastructures conduct the resource flows through urban systems that are required by households, businesses, community and public services. Infrastructure backlogs will obviously limit resource consumption and, more importantly, hamper economic growth. It follows, therefore, that as African economies develop further and as more resources become available for investments in urban infrastructure, the key challenge will be to specify an appropriate set of infrastructures within an appropriate urban form (i.e. density). South Africa's urban infrastructures are relatively well developed, but as recognised in South Africa's Integrated Urban Development Framework they were not designed to sustainably use resources and South African cities have been allowed to sprawl outwards in extremely inefficient ways. It is for this reason that South Africa is not a good model for how to build a sustainable Africa city. This will be a surprising conclusion for many African decision-makers who often refer to South Africa's urban infrastructure as a model worth replicating. This would be a grave mistake in a world transitioning to low-carbon resource efficient economies.

## 7. African Urban Pathways

A productive way to anticipate the future of African urbanism is to construct what could be called *urbanisation pathways* to facilitate ways of thinking through present-day interventions. This is done here by deploying four made-up signifiers that serve as a bridge between urban trends analysis and propositional thinking. The hope is that these signifiers provoke new ways of thinking and seeing to reveal the emergence of organic innovation, often as a result of attending to necessity. It is possible to evoke the dilemmas and possibilities of African urban futures around four M words: makeshift, mesmerizing, mindless and malleable urbanisms.

*Makeshift urbanism* denotes what is increasingly understood or theorised as "everyday urbanism". This includes the routine practices, social relations, social bonds and anxieties that constitute daily survival, sociality and aspiration by urban majorities. In particular, it invokes the urban majorities lives are completely overrun by informality—i.e. where one lives; how food gets put on the table; how essential services are tapped and maintained; and how one gets from A to B without paying an arm and a leg. The sociologist, Asef Bayat presciently refers to these practices and dispositions as the "encroachment of the ordinary" (Bayat 2000). Since these practices accompany the lives and aspirations of the majority of the population, it arguably constitutes the primary form of city-building in Africa and as such demands most of our intellectual and aesthetic attention, not least because it has been overlooked for so long. From the perspective of the analysis thus far, what matters is how the social energies that drive makeshift urbanism are mobilized and harnessed to help catalyse the kinds of urban metabolic configurations that will reinforce green industrialisation.

On the other end of the spectrum is a growing phenomenon that can be described as *mesmerizing urbanism*. This conveys the decontextualized, elite-oriented investments in enclave living, sometimes with impeccable green building credentials and increasingly adorned with smart city armatures. As African cities become more and more attractive landing pads for speculative international capital, there is a growing appetite for these "next generation" real estate developments in evidence from Kinshasa, to Lagos, Dar es Salaam, Johannesburg, Luanda, among an ever-growing list. Even though these glamour projects are getting a lot of media and scholarly attention, they still represent a small fraction of the total built environment investment across African cities. However, their power lies in colonising the imagination of urban leaders and national policy makers. There is a desperate need to peel back the layers of seductive gloss to reveal the true urban cost of these fantastical schemes, while using their symbolic importance as an entry point to tell different stories about other possible futures. This requires the energies of speculative design and art to do their work of deconstruction, satire and re-description. It is important to elide the temptation to simply critique these made-up schemes for the folly that they are on the surface. Instead, what they demand is a creative engagement that plays along in order to make room for much more interesting and resonant possibilities that can, over time, divert the wasteful investments of mesmerizing urbanism towards more interesting ways of building, movement and living together. In particular, one can anticipate that a lot of the mesmerising schemes will experiment with smart city and green building technologies and be forced to confront the tough landscapes of African cities and climate. The inevitable failures that will result will hold important clues about how best to be creative about the limitations of cookie-cutter urbanism.

A growing trend is what could be called *mindless urbanism*. This involves the reproduction of a type of mall-based suburban sprawl (often via security estates) that has been perfected and normalized in the South African context (heavily influenced by American styles of suburban sprawl). Aimed at the lower and sometimes the upper ends of the expanding middle class market, mindless urbanism is replicated by property developers and their tightly connected banking partners who provide the working capital and housing mortgages. It is mindless because it is an uncreative replication of a tried and tested mode of doing urban development that has dominated South Africa in particular over the last three decades or so, now translated by many South African property developers into the African context. It is not mezmerising because it does not pretend to be new – indeed, it does not pretend to be anything other than just 'the norm'. Its blandness is what allows it to be seen as 'normal'. The driver of mindless urbanism is purely financial: both the property developers and their bankers need scale to ensure that the replication of a large number of similar units makes up for the fact that profit margins per unit are now much lower than they used to be until the 1990s. For this kind of urbanism to work, the middle class spend needs to be redirected away from traditional street-based markets into malls dominated by retail chains backed/funded by financial institutions who, in turn, prefer to fund large mall developments rather than developing the expertise needed to make funding decisions for small-scale projects embedded within complex urban tenure arrangements that cannot be easily securitized. A consequence of both mezmerising and mindless urbanism is that decision-makers are increasingly favouring speculative projects and are thus allocating all available resources for urban infrastructures and public facilities that reinforce these two forms of urban life, leaving nothing or very little for addressing the imperatives of the makeshift city. However, instead of progressive urbanists running for the hills, this confluence of thought, investment and imagination should be redefined as an opportunity for thoughtful, critical and playful engagement.

The final naming concept is *malleable urbanism*. This denotes the aesthetic and political practice to obsessively search for an alternative paradigm or horizon line for African cities, which can only arise from a deliberate articulation of makeshift, mesmerizing and mindless urbanisms with the intent of subverting the latter two categories in the interests of the first, producing a creative hybrid: malleable urbanism. These co-existing and overlapping urbanisms that constitute the unruly African city demands an agonistic rubbing together in order to generate enough frisson to give birth to newly imagined alternatives. The discourses of urban management, governance and urban order will never deliver us to this space of agonistic creativity. It demands an artful and design-based invocation of new possibilities. Most importantly, it empowers one to think differently, and more propositionally, about the emergent conditions in African cities.

Conceptually it is useful to distinguish between two vital scales of spatial organisation and resonance that co-constitute the African city and along which the four Ms need to be understood: 1) the intimacy of the local neighbourhood comprised of streets, public infrastructure, houses, businesses and common areas; and 2) city-regional systems that cohere environmental catchments and economic agglomeration. The green African city has to emerge at both scales, and most importantly, creatively articulate these scales of city making to be a genuine force of social-cultural transformation.

It is self-evident in the developing world that viable cities require a growing economy that provides expanding opportunities for work, access to wellbeing and the possibility of productive investment. However, economic expansion is fundamentally dependent on infrastructure systems to ensure that goods, services and people can circulate in order to enact their intentions and perform exchange and value creation. In the absence of such infrastructures, economic life becomes predominantly compensatory, inefficient and lacks the prospect of productivity growth—the elixir of prosperity. Infrastructure, especially renewable energy, and optimal connectivity via information communication technologies and physical transport systems are the non-negotiable foundation stones for a green African city.

However, with the exception of North African countries and South Africa, most urban areas across the continent confront a completely different reality: the majority of citizens live informally (in makeshift slum conditions) due the absence of sufficient affordable infrastructures. Most of these families cannot escape these conditions because they are trapped in erratic informal employment that yield extremely low incomes and poor health, making most Africans the wounded, working poor; in other words, predominantly informal economies make informal living the only viable prospect for most Africans. A particularly pernicious outcome of this scenario is that these conditions reinforce a tiny tax base that is completely dwarfed by the scale of the public investment challenge. The inevitable result is a fraught political economy of urban governance and management that is dominated by powerful elite minorities who ensure that the limited public resource envelop is redirected to economic infrastructure investments that simply reproduce the status quo (mesmerising and mindless urbanisms) and at the expense of the needs of the urban majority and informal businesses. As one can predict, this essentially produces a self-fulfilling dynamic whereby growing urban needs continue to outstrip supply, reinforcing the imperatives of urban elites to capture as much of the public purse for their own interests, creating islands of connectivity and prosperity in a sea of disconnected communities and businesses.

Yet, despite this rigged game, hundreds of millions of Africans get on with their lives, keeping multiple investments in play mediated through complex, overlapping (and opposing) social networks and attachments (Simone 2004). In this practice of making a living and community in the city, households and various forms of collectivity continuously work the edges of the possible to ensure some modicum of access to the bare essentials of a dignified life: food, affordable micro loans, trading strategic information in exchange for air time, a supportive hand to repair a damaged roof or brittle wall, and so on. The fundamental knowledge and political challenge is to pay respectful attention to what people are doing as they build their cities through the sheer acts of survival and hustling. By analysing these practices through the lenses of radical localisation and regional innovation networks, we can begin to discern the ingredients of the green African city.

Through this analytical approach, we can now further specify the meaning of radical localisation as neighbourhood level projects or initiatives that seek to establish closed-loop economic activities at the micro scale that simultaneously provide for environmental, material, social and economic needs, especially in very poor areas. By definition these initiatives are culturally specific but also reflect a logic that can easily be adapted by another community and made their own through experimentation that can lead to continuous refinements. Regional innovation networks point to the backbone of the green city: city-regions (or smaller scale town-centred agglomerations) committed to low-carbon, resource-efficient and inclusive growth paths working in concert to consolidate intra-African trade and solidarity. Key environmentally sensitive infrastructure systems in the domains of energy, water management, mobility, and ICT can accelerate city-based regionalism. The elegance of these mutually reinforcing scales is that it obviates the need for rigid blue-prints but at the same time underscores the value of strategic roadmaps – such as National Urban Policies (see below) - that provide an orientation for how different experiments and innovations can best be articulated and horizontally distributed (Evans *et al* 2016). Moreover, they point to the beginning of a new urban sensibility and disposition that will only grow in visibility and relevance.

## 8. National Urban Policies

The argument thus far is that African structural transformation programmes have hitherto tended to ignore the developmental role of towns and cities. However, as reflected in the various reports referred to thus far by UNECA, UNCTAD and UN Habitat, this is starting to change. It has been argued that the design, construction and operation of *malleable* resource efficient cities to cater for both the expanding urban populations and businesses in functionally coherent and productive spatial contexts must become a conceptual and policy focus. To this end, urban metabolic analysis needs to be deployed to understand the resource-use patterns in African cities, with special reference to the design of resource efficient urban infrastructures that are technologically and economically appropriate for a carbon- and resource constrained world where global policy-making is guided by the SDGs. By formalising the physical locations of these households and businesses, new tax bases will be created to sustainably finance urban development over the medium- to long-term future. The economic functionality, ecological sustainability and liveability of these urban spaces will then reinforce commitments to tax payments and collection. To achieve this goal a new generation of National Urban Policies (NUPs) that includes green city guidelines and indicators will be required. Without NUPs, the macro-economic goals of green industrialisation will not be achieved.

The evidence suggests that a growing number of African Governments have either adopted or are in the process of formulating NUPs (Turok 2015). Turok refers to the survey by UCLGA and Cities Alliance (Table ???) and concludes positively that 17 (or 1 in 3) African Governments have approved a "clear NUP" while 5 others are in the process of formulating some sort of NUP (Turok 2015:351-2). He then reviews the comprehensive NUPs that have been adopted in Ethiopia, Morocco, Ghana, South Africa and Uganda. Turok's definition of a NUP is worth citing:

> "The simplest definition is a government statement of what it intends to do within cities and towns to make them function better – economically, socially, ecologically and institutionally – and to help them accommodate future population growth more efficiently and equitably. It is bound to be broad in scope, offers a vision of a better urban future and encourages coordination across different departments and spheres of government in order to ensure that public and private investment decisions are complementary, carefully sequenced and connected in space." (Turok 2015: 355)

**Table** The existence of national urban policies.

| Type of urban strategy in place | Number of countries | Country names | |
|---|---|---|---|
| A clear national urban strategy exists, along with the financial and technical capacities to implement it | 4 | Morocco<br>Senegal | South Africa<br>Swaziland |
| A clear national urban strategy exists, but without the capacities to implement it | 13 | Algeria<br>Benin<br>Burkina Faso<br>Cote d'Ivoire<br>Egypt<br>Ethiopia<br>Gabon | Ghana<br>Malawi<br>Mali<br>Niger<br>Rwanda<br>Uganda |
| National reflection on urbanisation is underway, but an urban strategy has not yet been defined | 5 | Cameroon<br>Guinea–Conakry<br>Kenya | Nigeria<br>Tunisia |
| There is no national urban strategy | 28 | Angola<br>Botswana<br>Burundi<br>Central African Republic<br>Chad<br>Comoros<br>Congo Brazzaville<br>Democratic Republic of Congo<br>Djibouti<br>Equatorial Guinea<br>Eritrea<br>Guinea-Bissau<br>Lesotho<br>Liberia | Madagascar<br>Mauritania<br>Mozambique<br>Namibia<br>Sao Tome and Principe<br>Seychelles<br>Sierra Leone<br>Somalia<br>Sudan<br>Tanzania<br>The Gambia<br>Togo<br>Zambia<br>Zimbabwe |

(Source:Turok 2015: 352)

Turok concludes his analysis of the rising number of NUPs on the continent by arguing that the significance of NUPs is less about addressing the traditional challenges of urban poverty and social unrest and more about cities as opportunities for generating investment, jobs and tax revenues (Turok 2015:365). Both, however, will require – using his description above of NUPs - "public and private investments …. connected in space", but with greater emphasis on the latter. However, given the preceding arguments, what matters in a carbon- and resource-constrained world at a time when policies are guided by the SDGs is how resource efficient the outcome will be. Unless land-use decisions are aimed at achieving densification and urban infrastructure investments are aimed at fostering transit-oriented development, densification, energy efficiency and renewable energy, NUPs could end up reinforcing the application of outdated low density urban development approaches that tend to reinforce inequalities (mesmerising and mindless urbanism). South Africa's NUP – the Integrated Urban Development Framework (IUDF) – has an explicit commitment to resource efficient urbanism for precisely this reason. This has opened up new spaces for innovation in South Africa, attracting major new public and private investments in TOD, green buildings and renewable energy. The Addis metro is another similar example. In short, NUPs must incorporate a commitment to resource efficient urbanism.

## 9. Conclusions and Recommendations

This chapter has argued that the combining of makeshift urbanism for the urban poor, mezmerising urbanism for a few rich enclaves and mindless urbanism to capture the middle in neighbourhoods disconnected from the urban economic mainstream that characterizes African cities results in these cities becoming binding constraints on green industrialization and structural transformation. For *sustainable* structural transformation – green growth - to be a viable future developmental trajectory, it will be necessary to recognize that growth and development takes place within specific spatial contexts that can be shaped in ways that reinforce a more inclusive malleable urbanism. How these spaces are configured will profoundly influence the outcome of the structural transformation programme. If cities are ignored, structural transformation has little chance of success. Fortunately, an increasing number of African Governments have either adopted National Urban Policies (NUPs), or have initiated policy processes to this end. If these NUPs help to counteract mesmerising and mindless modes of urban development in favour of resource efficient malleable urbanism, then they are definitely a step in the right direction. However, it will be necessary to ensure that these NUPs not only focus on socio-economic imperatives, but also address the challenges of decarbonisation, ecosystem restoration and resource efficiency. This is the essence of any green city agenda.

It was argued that African cities face a unique opportunity: they can invest in urban infrastructures that replicate the high carbon and resource inefficient urban systems that also degrade ecosystems that have been implemented in most other parts of the developed and developing world; or, as suggested by the UNECA, UNCTAD and UN Habitat Reports, in anticipation of where the world is heading since the adoption of the SDGs in 2015, African cities can invest in urban infrastructures that result in low carbon, ecosystem restoring and resource efficient malleable cities. To this end it is recommended that NUPs incorporate a focus on resource efficiency that can guide the design, construction and operation of urban infrastructures. These infrastructures must ensure that African cities develop in ways that are resource efficient. This will provide the spatial context for green industrialization and sustainable structural transformation. The most immediate and direct action is to ensure that every NUP commits to building cities that derive at least 50% of their energy supplies from renewable energy sources.

To substantiate the argument, the urban metabolism approach was presented and applied for the first time to a wide sample of African cities. Urban metabolism is necessary because it generates the data needed to influence the two key drivers of the green city agenda in Africa, namely urban infrastructures and urban densities. If city visions and plans are informed by a commitment to foster rapid economic growth within high density cities that are serviced by resource efficient infrastructures, that will help African cities to leap-frog into the c.21st without having to pass through and eventually dismantle the high carbon, wasteful and unequal phases of c.19$^{th}$ and c.20$^{th}$ socio-technical systems. It was proposed that an average of 8 tons per capita would be a viable target for most African cities. GDP per capita, climate zone and density will be the key factors that will need to be addressed when it comes to designing infrastructures and densities.

**ANNEXURE A**

**Ranking of city by aggregate resource impact**

| City Name | Total Energy Consumption (ktoe) | City Name | Per Capita Total Material Consumption (kt) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| BU-Gitega | 2.17 | BU-Gitega | 161.75 |
| CH-Moundou | 3.74 | CO-Moroni | 161.93 |
| MALI-Gao | 4.38 | ST-Sao Tome | 233.64 |
| DRC-Bandundu | 8.21 | TO-Sokode | 314.03 |
| CO-Moroni | 11.26 | DRC-Bandundu | 317.01 |
| TO-Sokode | 12.12 | CV-Praia | 531.01 |
| RW-Gisenyi | 12.55 | RW-Gisenyi | 535.61 |
| NI-Maradi | 15.14 | SY-Victoria | 612.22 |
| MAD-Mahajanga | 15.64 | MAD-Mahajanga | 732.80 |
| ST-Sao Tome | 23.44 | ZI-Gweru | 737.36 |
| LI-Monrovia | 26.72 | MALI-Gao | 816.07 |
| MN-Nouadhibou | 28.33 | CH-Moundou | 835.73 |
| GB-Bissau | 29.61 | LE-Maseru | 1,019.18 |
| CH-N'Djamena | 29.72 | GAB-Port-Gentil | 1,021.80 |
| BU-Bujumbura | 30.59 | TZ-Dodoma | 1,038.35 |
| TZ-Dodoma | 30.99 | NG-Ogbomosho | 1,224.94 |
| CAR-Bangui | 34.55 | BE-Porto Novo | 1,248.88 |
| ETH-Mek'ele | 35.17 | GAM-Banjui | 1,285.70 |
| BF-Bobo Dioulasso | 42.11 | NI-Maradi | 1,433.01 |
| CV-Praia | 42.40 | SW-Manzini | 1,438.37 |
| SL-Freetown | 47.02 | MN-Nouadhibou | 1,467.96 |
| NG-Ogbomosho | 49.95 | NA-Walvis Bay | 1,483.96 |
| ZI-Gweru | 55.32 | DJ-Djibouti | 1,485.11 |
| SO-Hargeisa | 59.23 | ETH-Mek'ele | 1,509.97 |
| GAM-Banjui | 59.27 | GB-Bissau | 1,593.83 |
| GH-Sekondi-Takoradi | 63.74 | SE-Thies | 1,610.66 |
| NI-Niamey | 63.90 | BO-Francistown | 1,669.68 |
| GAB-Port-Gentil | 66.65 | KE-Kisumu | 1,703.48 |
| SE-Thies | 78.84 | BU-Bujumbura | 1,770.14 |
| BE-Porto Novo | 79.38 | MZ-Nampula | 1,794.75 |
| MALI-Bamako | 81.96 | SA-Stellenbosch | 1,855.35 |
| LE-Maseru | 86.17 | SW-Mbabane | 1,868.06 |
| KE-Kisumu | 88.99 | GH-Sekondi-Takoradi | 1,926.38 |
| BO-Francistown | 89.99 | TU-Sousse | 1,947.45 |
| NA-Walvis Bay | 91.85 | RC-Pointe-Noire | 2,301.30 |
| SW-Manzini | 96.81 | LI-Monrovia | 2,372.77 |
| TZ-Zanzibar | 98.75 | EQG-Malabo | 2,423.15 |
| ER-Asmara | 99.91 | CDI-Yamoussoukro | 2,714.56 |
| RW-Kigali | 110.11 | BF-Bobo Dioulasso | 2,720.08 |
| TZ-Mwanza | 111.44 | TO-Lome | 2,859.24 |
| TO-Lome | 124.33 | MAL-Blantyre | 2,886.89 |
| DRC-Lubumbashi | 124.76 | TU-Sfax | 2,928.01 |
| SW-Mbabane | 128.29 | TZ-Zanzibar | 3,036.77 |
| BF-Ouagadougou | 136.96 | SL-Freetown | 3,036.89 |
| NG-Ilorin | 145.34 | CAR-Bangui | 3,118.30 |

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|---|---|---|---|
| GU-Conakry | 152.99 | ZI-Bulawayo | 3,129.76 |
| SO-Mogadishu | 172.67 | NG-Ilorin | 3,220.87 |
| NG-Zaria | 173.39 | MAL-Lilongwe | 3,316.83 |
| TU-Sousse | 174.44 | TZ-Mwanza | 3,397.25 |
| SU-Nyala | 174.87 | MS-Port Louis | 3,406.98 |
| SS-Juba | 177.53 | MZ-Maputo | 3,595.88 |
| MAL-Blantyre | 183.55 | BE-Cotonou | 3,638.10 |
| MAD-Antananarivo | 187.31 | ER-Asmara | 3,693.12 |
| CDI-Yamoussoukro | 189.76 | NG-Zaria | 3,780.30 |
| MAL-Lilongwe | 213.54 | BO-Gaborone | 3,941.75 |
| BO-Gaborone | 216.51 | DRC-Lubumbashi | 3,949.48 |
| SY-Victoria | 235.70 | RW-Kigali | 3,957.81 |
| ZA-Ndola | 236.99 | RC-Brazzaville | 4,459.34 |
| SA-Stellenbosch | 243.83 | SU-Nyala | 4,657.16 |
| NG-Benin City | 251.51 | SS-Juba | 4,722.87 |
| BE-Cotonou | 254.90 | EG-Fayyum | 4,931.00 |
| ZI-Bulawayo | 258.20 | NG-Benin City | 5,299.21 |
| ZA-Kitwe | 265.25 | NI-Niamey | 5,557.58 |
| MN-Nouakchott | 265.99 | CH-N'Djamena | 5,567.74 |
| MZ-Nampula | 270.91 | SO-Hargeisa | 5,697.39 |
| TU-Sfax | 275.37 | KE-Mombasa | 5,773.60 |
| DJ-Djibouti | 277.94 | NG-Kaduna | 5,924.01 |
| NG-Kaduna | 284.31 | EG-Asyut | 5,993.08 |
| KE-Mombasa | 343.12 | MC-Rabat | 6,039.87 |
| NG-Port Harcourt | 358.76 | LY-Benghazi | 6,388.19 |
| UG-Kampala | 395.49 | AL-Constantine | 6,510.75 |
| NG-Abuja | 411.49 | ZA-Ndola | 6,725.42 |
| MS-Port Louis | 436.66 | AL-Oran | 6,899.33 |
| MC-Rabat | 447.69 | ZI-Harare | 7,162.92 |
| ETH-Addis Ababa | 450.01 | NG-Port Harcourt | 7,319.61 |
| CA-Yaounde | 522.22 | MAD-Antananarivo | 7,411.17 |
| GAB-Libreville | 524.40 | ZA-Kitwe | 7,509.34 |
| CA-Douala | 529.45 | GAB-Libreville | 7,637.54 |
| EG-Fayyum | 534.71 | AN-Huambo | 7,720.70 |
| NA-Windhoek | 541.29 | NA-Windhoek | 7,915.30 |
| RC-Pointe-Noire | 558.09 | MC-Tangier | 8,049.25 |
| MZ-Maputo | 575.94 | NG-Abuja | 8,292.80 |
| NG-Ibadan | 576.18 | BF-Ouagadougou | 8,301.33 |
| EQG-Malabo | 607.68 | TU-Tunis | 8,435.88 |
| MC-Tangier | 617.40 | EG-Port Said | 8,569.33 |
| ZI-Harare | 621.69 | SA-Mangaung | 9,036.73 |
| LY-Benghazi | 622.30 | CA-Yaounde | 9,374.75 |
| AN-Huambo | 624.55 | CA-Douala | 9,495.00 |
| GH-Kumasi | 662.04 | MC-Fes | 9,867.98 |
| NG-Kano | 665.67 | UG-Kampala | 9,940.32 |

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|---|---|---|---|
| EG-Asyut | 668.57 | MC-Marrakesh | 10,944.57 |
| GH-Accra | 674.37 | NG-Ibadan | 11,269.00 |
| MC-Fes | 775.31 | MC-Kenitra | 11,560.69 |
| TZ-Dar es Salaam | 782.09 | GU-Conakry | 11,626.74 |
| DRC-Kinshasa | 795.36 | LY-Tripoli | 12,164.61 |
| TU-Tunis | 812.05 | MN-Nouakchott | 12,823.00 |
| MC-Marrakesh | 863.74 | NG-Kano | 12,854.53 |
| MC-Kenitra | 913.46 | MALI-Bamako | 12,935.28 |
| SE-Dakar | 979.15 | SA-Nelson Mandela Bay | 14,016.45 |
| EG-Port Said | 1,006.50 | CDI-Abidjan | 14,654.09 |
| ZA-Lusaka | 1,008.78 | SO-Mogadishu | 15,620.93 |
| RC-Brazzaville | 1,125.31 | ETH-Addis Ababa | 16,024.28 |
| CDI-Abidjan | 1,142.58 | GH-Kumasi | 16,666.85 |
| AL-Constantine | 1,181.28 | GH-Accra | 16,954.35 |
| LY-Tripoli | 1,201.91 | SE-Dakar | 18,947.00 |
| AL-Oran | 1,261.10 | KE-Nairobi | 19,118.01 |
| KE-Nairobi | 1,2,,,,80.64 | TZ-Dar es Salaam | 20,856.45 |
| SA-Mangaung | 1,306.08 | DRC-Kinshasa | 23,653.99 |
| SU-Khartoum | 1,922.00 | AL-Algiers | 23,817.92 |
| SA-Nelson Mandela Bay | 2,075.14 | ZA-Lusaka | 27,802.50 |
| MC-Casablanca | 2,310.80 | MC-Casablanca | 28,666.87 |
| NG-Lagos | 2,407.80 | SA-Tshwane | 36,128.74 |
| AN-Luanda | 3,652.54 | NG-Lagos | 41,636.53 |
| AL-Algiers | 5,075.11 | SA-eThekwini | 42,710.61 |
| SA-Tshwane | 5,616.22 | SU-Khartoum | 43,252.64 |
| SA-eThekwini | 6,693.97 | AN-Luanda | 43,468.79 |
| SA-Cape Town | 7,315.15 | SA-Cape Town | 46,483.30 |
| EG-Alexandria | 8,845.47 | EG-Alexandria | 59,418.36 |
| SA-Johannesburg | 15,650.58 | SA-Johannesburg | 96,137.85 |
| EG-Cairo | 40,239.17 | EG-Cairo | 261,629.40 |

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