DEVELOPMENT OF AN INTEGRATED MODEL FOR URBAN SUSTAINABLE RESILIENCE THROUGH SMART CITY PROJECTS IN THE SOUTHERN AFRICAN CONTEXT

by

Antonio Blanco-Montero

214585810

October 2021

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Doctoral Programme in the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, South Africa.

Supervisor: Professor Cristina Trois

Co-supervisor: Doctor Vittorio Tramontin

Co-supervisor: Doctor Claudia Loggia

As the candidate's Supervisor I agree to the submission of this thesis.

Signed

Durban, October 2021

DECLARATION 1 - PLAGIARISM

I, Antonio Blanco-Montero declare that

I. The research reported in this thesis, except where otherwise indicated, is my original research.
II. This thesis has not been submitted for any degree or examination at any other university.
III. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.
IV. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:
    a) Their words have been re-written but the general information attributed to them has been referenced;
    b) Where their exact words have been used, their writing has been placed inside quotation marks, and referenced.
V. This thesis does not contain text, graphics or tables copied and pasted from the Internet, unless specifically acknowledged, and the source detailed in the thesis and in the References sections.

Signed

Durban, October 2021

Supervisor: Professor Cristina Trois
Co-supervisor: Doctor Vittorio Tramontin
Co-supervisor: Doctor Claudia Loggia

Acknowledgement

This journey started after 14 years of professional practice. I missed the challenging atmosphere of the university; staying close to forward thinking and avant-garde. I had just arrived in South Africa when luck struck and I met a beautiful group of people, most of them being Italians, Mexican, French and a few interesting South Africans, who also became my friends. Among those cheerful individuals were Prof. Cristina Trois and Dr. Claudia Loggia. I remember the day Prof. Trois convinced me to join her research team. It was a Friday afternoon in springtime, enjoying a Spritz and talking about how badly I would like to do some research about African cities. At that moment, she was the brains behind the Hub of the African City of the Future. She saw potential in bringing a professional from the built environment into the research team, "to look at the big picture", she said. At that time, I had no idea that the "big picture" was that big. With her constant support and guidance, I have managed to put together this thesis after 6 years. We went from part-time to full-time, through pandemics, retrenchments, heartbreaks, movings… We have gone through a life that I can now recall. No matter what, her high spirit has always been a beacon for me not to get lost and give up.

The adaptation from being an experienced professional to getting back to the classroom as a student would not have been possible without the help of Prof. Vittorio Tramontin. His remarkable work ethic and commitment with the craft of teaching have already been recognized within the UKZN. His sound advice put my work on track, especially at the beginning.

In such a long journey, there are many unexpected situations to deal with: different country, culture, race, age. To find a travel partner is the most unexpected one. Khayakazi has shown me, even without realizing, that true values go beyond race, age and culture. She is a humble achiever whose only presence reminds me that making possible the impossible is just the starting point.

I had to make some compromises in order to achieve this goal. The most expensive has been to be 9,000 Km away from my family. Their supportive spirit and understanding of what I wanted to achieve fueled my drive in the process. This circumstance has allowed me to look at

them from the outside and learn how blessed I have been. I think of my father, vigilant of his children not to derail in their studies; and my mother, unselfishly supporting three kids while still in college. The constant communication and good advices from my siblings have made the distance a bit easier to bear.

Someone once said, sometimes, your life is in the hands of the clerk. I must have been lucky and therefore I am grateful to have had Ms. Aussie Luthuli and Ms. Winile Shozi to help whenever I needed them.

Finally, I would like to pay a tribute to my uncle Mariano Blanco Vega, who passed away due to COVID-19 complications. He was an engineer, the first college graduate in the family and inspiration for all of us following his footsteps; an example of hard work, honesty and coherence.

Abstract

The construct Smart City has gone through a few phases in the last decades. Today there is still no consensus on an accurate definition of Smart City, even though a few concepts are now accepted by most stakeholders, establishing frameworks heading to enhance the quality of life of citizens, sustainable development and economic competitiveness, and, most importantly, the optimal balance between these. Starting from the framework of the Smart City model as conceptualized by the developed world, this research attempts to critically analyse the challenges and barriers to a transition and upgrade of such a model for implementation in developing countries, particularly in the Southern Africa.

The mid-term future trends in the region create a huge expectation and concern internationally. Factors like the considerable demographic increase in the post-colonial Africa, the massive migration from the rural areas to cities and the shift from the manufacturing world pole in the East to the African continent predict a remarkable dynamic and vibrant scene in the near future. Stressing the ability of the region to respond to these challenges is starting to gain the attention of scholars and organizations internationally. However, it is important to say that most of the research studies point to both, the solution of dramatic situations related to poverty and underdevelopment, and secondly, the market prospect studies that research the economic potential of the region to foreign capital. Moreover, regarding urban systems, most African governments have scarce and unreliable data.

Therefore, looking from a local perspective, it is fair to explore ways Africa and Africans are able to cope with the challenges to come. Not only to make the place attractive to outsider eyes but to increase the quality of life and opportunities for local people through self-management.

Africa has undergone through a long history of catastrophes in recent times, with horrendous impact on the population. Yet, a proved resilience makes room for hope in a better future, away from a patronizing management by external forces. Part of this research stresses the feasibility of tailor made solutions to cope with future challenges from a local perspective in the era of globalization. International agencies tend to rate performance in multiple fields based on worldwide standards. Taking into account the use of a series of indicators as a tool to

rationalize (evaluate) the performance of any particular field of human action; the measurement of those indicators can vary from region to region.

In such resilient environment as described above, the aim of this research is to identify sustainable ways for long-term implementation of up to date technologies in Southern African cities for an effective leapfrog that would bring Southern Africa up to nowadays standards without losing local references.

A deep dive into the literature about current technologies and the African city represents the starting point of the methodological approach in order to understand localities and real challenges. The research looked at worldwide urban trends and aims to extract those parameters that are meaningful to Africa today.

In order to validate the findings of the research, a case study focussed on specific urban challenges has been identified: the Umgeni River estuary in eThekwini municipality is representative of the confluence of multiple urban dynamics: environmental concerns, lack of municipal services, climate change vulnerability, ocean pollution, poverty, regional business, mining, commercial activities, informal settlements and formal planning. The waste sector in particular, typically undermined in the Global South, has been identified as a potential common thread across the aforementioned urban dynamics. The application to the case study of the lessons learnt through the study of the smart city and urban sustainable resilience highlights the readiness of the Southern Africa city and unlocks a discussion about sustainable urban growth.

The results indicate a dual scenario, concerning yet optimistic: there are great disparities between the aspirations from city managers and policy makers, and the conflicted reality at ground level. The pressure due the competitive agenda to render Southern African cities appealing in order to gain foreign economic attention could fade as local communities improve their life condition and strength local markets: “Africa by Africans for Africans”. Two important factors can make this shift possible: one is the presence of strong academic institution with great number of strong collaborations with organizations of great reputation. The case study proves a great interest to assist with solutions to African matters by the international community, but probably not in the way city managers expect. The second one is the

advantage that can be taken from the “already made” infrastructure fabric, re-programming the initially “colonial-conceived extractive economic vision” towards social gain.

Keywords— Urban Resileince; Urban Sustainability; Smart Cities; Sustainable Development; Developing Countries; Waste Management; Southern Africa

Abbreviations and acronyms

AI: Artificial intelligence

ACCCRN: Asian Cities Climate Change Resilience Network

AUC: African Union Commission

BRT: Bus rapid transport

CBD : Central business district

CCI: Cultural and creative industries

CFTA: Continental Free Trade Area

CID: City improvement districts

CSIR: South African Council for Scientific and Industrial Research

CSO: Combined Sewer Overflow

DAPP: Durbanites Against Plastic Pollution

DGC: Durban Green Corridors

DSW: Durban Solid Waste

DUCT: Dusi uMngeni Conservation Trust

ECI: European Common Indicators

EPI: Environmental Performance Index

FDI: Foreign direct investment

GDP: Gross domestic product

GHG: Greenhouse gas

GIS: Geographic information system

GPS: Global Positioning System

HDPE : High Density Polyethylene

HUGSI: Husqvarna Urban Green Space Index

ICT: Information and communication technologies

ICT4D : Information and Communications Technologies for Development

IEA: International Energy Agency

IOC: Intergovernmental Oceanographic Commission's

IODE: International Oceanographic Data and Information Exchange

IoT: Internet of things

ISP: Internet service provider

ITU: International Telecommunications Union

KZN: KwaZulu-Natal

LDPE: Low Density Polyethylene

MONARES: Monitoring Urban Climate Change Resilience and Adaptation

MRF: Materials recovery facility

NGO: Nongovernmental organizations

NUA: New urban agenda

OCDE: Organisation for Economic Co-operation and Development

ODA : Official development assistance

PE: Polyethylene

PET: Polyethylene terephthalate

PETE: Polyethylene terephthalate

PIDA: Programme for Infrastructure Development in Africa

PP: Polypropylene

PS: Polystyrene

PVC: Polyvinyl chloride

RDI: Research Development and Innovation

REPLICATE: Renaissance of Places with Innovative Citizenship and Technology

RSA: Republic of South Africa

SADC : Southern African Development Community

SAHRC: South African Human Rights Commission

SARChI: South African Research Chairs Initiative

SCP : Smart City Project

SDF: Spatial Development Framework

SDGs: Sustainable development goals

SEA: Strategic environmental assessment

SMMEs: Small, micro and medium-sized enterprises

SOC : State Owned Company

SSA: Sub-Saharan Africa

STAR: Sustainability Tools for Assessing and Rating

STEM degree: science, technology, engineering and mathematics college degree

STI: Science, technology and innovation

TLP: The Litterboom Project

TOC: The ocean cleanup

TTCI: Travel and Tourism Competitiveness Index

UAV: Unmanned Aerial Vehicles

UNESCO: United Nations Educational, Scientific and Cultural Organization

WHO: World Health Organization

WIO region : Western Indian Ocean region

Glossary

Agglomeration economies

The great density of economic activity in regions or urban areas.

Apartheid

Economic and political discrimination based on race diferences, officialised by the government of the Republic of South Africa against ethnic groups other than European.

City

An inhabited place by a group of people who are mainly engaged in industrial and commercial activities.

Climate change

A change in climate patterns associated mostly to the levels of CO_2 in the atmosphere, increased by the extensive use of fossil fuels.

Decentralization

The relocation of power out of major centres to other regions and cities.

Digital divide

Unbalanced distribution information and communications technologies (ICT) among groups with different geographical, geopolitical, social or any other distinctive criteria.

Digitalization

The process of converting something to digital form, in which the information is organized into bits and can be processed by a computer.

Forth industrial revolution (4IR)

4IR (or Industry 4.0) is the shift from current industrial and manufacturing practices to new production processes due to the impact of ICT on automation, using modern smart technology.

Frontier technologies

New technologies with higher impact based on the use of ICT. Examples of frontier technologies are: 3D printing, the Internet of things (IoT), nanotechnology, artificial intelligence (AI), big data, 3D printing, robotics, gene editing and drones among others.

Gated community

A form of real estate development enclosed within a perimeter barrier (typically wall or fence) and controlled access by security services.

Gentrification

A process by which the traditionally low-income residents of a given area in the city found themselves forced to move out of the area due to an increase of the cost of living caused by the arrival and settle of new residents of higher income classes.

Globalization

It is a worldwide cultural, political, technological, economic and social process consisting of increasing interdependence and communication between the countries of the world, blending their markets through political and social transformations.

Habitat III

The UN Conferences on Housing (Habitat) are occurring in the bi-decennial cycle (1976, 1996 and 2016). The third edition, Habitat III, the United Nations Conference on Housing and Sustainable Urban Development, took place in Quito, Ecuador, from 17 – 20 October 2016. with the purpose of strengthening the international commitments on the implementation of the UN "New Urban Agenda".

Human capital

Schultz (2003) defined Human capital as "the stock of habits, knowledge, social and personal attributes (including creativity) embodied in the ability to perform labour so as to produce economic value".

Indicator

"A quantitative, qualitative or descriptive measure" (ISO, 2008).

Inequality (Income)

The term specifically refers to an uneven distribution of wealth between population groups. It is not necessarily correlated with social inequality. Economic measurements focus on wealth, income, and consumption.

Inequality (Social)

Social inequality refers to an uneven distribution of resources, typically through state policies and norms, that engender specific socially defined categories of persons, such as race, genre, sexual orientation or religious believes.

Informal settlement

Huchzermeyer, Karam and Maina (2018) define informal settlement as "residential areas where 1) inhabitants have no security of tenure vis-à-vis the land or dwellings they inhabit, with modalities ranging from squatting to informal rental housing, 2) the neighbourhoods usually lack, or are cut off from, basic services and city infrastructure and 3) the housing may not comply with current planning and building regulations, and is often situated in geographically and environmentally hazardous areas. In addition, informal settlements can be a form of real estate speculation for all income levels of urban residents, affluent and poor. Slums are the most deprived and excluded form of informal settlements characterized by poverty and large agglomerations of dilapidated housing often located in the most hazardous urban land. In addition to tenure insecurity, slum dwellers lack formal supply of basic infrastructure and services, public space and green areas, and are constantly exposed to eviction, disease and violence".

Information and communication technologies (ICT)

It is a group of technologies in the realm of communications (telephone lines and wireless signals) integrated through digitalization (computers) and applied by a specialized industry including software designers and electronics.

Information and Communications Technologies for Development (ICT4D)

It is an initiative intended to reduce the gap in digital divide and supporting economic growth by ensuring even access to ICT.

Infrastructure

It is a human realization designed and directed by professionals in engineering and regional and town planning, which serve as support for the development of other activities, necessary in the structural organization of cities and companies.

Innovation

It is a process of introducing new ideas aiming to modifying existing elements in a context, in order to improve them, though the implementation of totally new elements it is also possible.

Internet of Things (IoT)

It is a system of interconnected computers and machines, either mechanical or digital, with the ability to communicate without human-to-computer or human-to-human interaction.

Leapfrogging

Davison *et al.* (2013) defined leapfrogging as “the implementation of a new and up-to-date technology in an application area in which at least the previous version of that technology has not been deployed”.

New Urban Agenda (NUA)

The New Urban Agenda is an implementation document that encourages Members States of the UN and other strategic stakeholders to conduct sustainable urban development.

Pedestrianization

A group of strategic plans and actions to convert traffic roads into walkable areas, excluding motor vehicles.

Polycentricism

The development of a number of centres within a region to contribute to regional specialization.

Prosumer

The word prosumer is a portmanteau of the words 'provider' and 'consumer'. The term refers to someone who actively consumes and also produces.

Small, micro and medium-sized enterprises (SMMEs)

The World Bank (Bridges.org, 2002) classifies "micro enterprises as those with ten or fewer employees and assets and annual sales each of US$100,000 or less. Small enterprises are those with 11–50 employees and assets and sales each between US$100,000 and US$ 3 million while medium-sized ones are those with 51–300 employees and annual sales and assets each of US$3–15 million".

STEM degrees

These are college programs in science, technology, engineering and mathematics.

Strategic facilities

Strategic facilities are universities, financial centre, international airports and freight harbours which reinforce the competitiveness and support value chains of a region or city.

Sustainable Development Goals (SDG's)

These are 17 goals adopted by Member States of the United Nations in 2015, included in the 2030 Agenda for Sustainable Development. They are a global request to protect the planet, improve the lives and prospects of people, and end poverty worldwide (UN, 2015b).

Triple helix collaboration / innovation

When government, industry and academia play their specific roles with common aims in the pursuit of innovation.

Umgeni River

The spelling of Umgeni River can vary depending of the source, being the English spelling Umgeni and the Zulu spelling uMngeni or Mgeni. For the sake of language coherency, the English spelling is used in this document.

Urban area

Human settlement with political jurisdiction boundaries, large amount of developed land, a highly dense populated and infrastructure of built environment (i.e., paved streets, electric lighting and sewerage). Most inhabitants of urban areas have non-agricultural jobs.

Urban planning

It is a political and technical process regarding the design, development, and management of land that focus on the location of human activities within it, including air, water, and the network infrastructure such as communications and transportation and on the economic functions, physical form and social impacts of the urban context.

Urbanization

Pieterse, Parnell and Haysom (2018) define urbanization as "complex socio-economic process that transforms the built environment, converting formerly rural into urban settlements, while also shifting the spatial distribution of a population from rural to urban areas. It includes changes in dominant occupations, lifestyle, culture and behaviour, and thus alters the demographic and social structure of both urban and rural areas. A major consequence of urbanization is a rise in the number, land area and population size of urban settlements and in the number and share of urban residents compared to rural dwellers".

Table of content

List of tables

List of figures

1 INTRODUCTION

1.1 Motivation

The construct Smart City has gone through a few phases in the last decades. Today there is still no agreement on an accurate definition of Smart City (Albino, Berardi and Dangelico, 2015), even though a few concepts are now accepted by most stakeholders, establishing frameworks heading to improve the quality of life of citizens, sustainable development and economic competitiveness, and, most importantly, the optimal balance between these. Starting from the framework of the Smart City model as conceptualized by the developed world, this research attempts to critically analyse the challenges and barriers to a transition and upgrade of such a model for implementation in developing countries, particularly in the Southern Africa.

The mid-term future trends in the region create a huge expectation and concern internationally. Factors like the considerable demographic increase in the post-colonial Africa, the massive migration from the rural areas to cities (UNDESA, 2018) along with the shift from the manufacturing world pole in the East to the African continent (Hai, 2016) predict a remarkable dynamic and vibrant scene in the near future. Stressing the ability of the region to respond to these challenges is starting to gain the attention of scholars and organizations internationally (Pieterse, 2019).However, it is important to say that most of the research studies point to both, the solution of dramatic situations related to poverty and underdevelopment, and secondly, the market prospect studies that research the economic potential of the region to foreign capital (Pieterse, 2019). Moreover, most African governments do not have sufficient and adequate data on urban systems (Pieterse, 2019).

Therefore, and looking from a local perspective, it is fair to explore ways Africa and Africans are able to cope with the challenges to come. Not only to make the place attractive to foreign eyes but to increase the quality of life and opportunities for local people through self-management.

Africa has undergone through a long history of catastrophes in recent times, with horrendous impact on the people: hunger, slavery, natural disasters, HIV pandemic, Ebola outbreak, post-colonial constant armed conflicts, refugees and economic migration (UNDRR, 2008). Yet, a proved resilience makes room for hope in a better future, away from a patronizing management by external actors. Part of this research stresses the possibility for tailor made solutions to cope with future challenges from a local perspective in the era of globalization. International agencies tend to rate performance in multiple fields based on standards applied worldwide. Taking into account the use of a series of indicators as a tool to rationalize (rather than evaluate) the performance of any particular field of human action; the measurement of those indicators can vary from region to region. What is important in Norway might not be necessary in Namibia. The identification of the essentials at a local level will be crucial for the outcomes of this research. In addition to this, from an urban perspective, it is important to differentiate Northern Africa from Sub-Saharan Africa (SSA). The former is historically strongly interconnected with Southern Europe (Britannica enciylopedia, 2021), and the overlapping of ethno-cultural layers, with levels of self-governance along thousands of years, has occurred until present times. On the contrary, the urban development of the later is essentially related to colonialism starting in the 15th century, with the foundation of new cities without a prior historical background and unrelated to the local traditions and culture (Silva, 2015) Urban planning in SSA. For the purpose of this study, the initial approach to the African context is limited to the region of Southern Africa. Data and samples from Sub-Saharan countries have also been taken into consideration when appropriate.

The fundamental aim of this research is to identify sustainable ways for long-term implementation of up to date technologies in Southern African cities for an effective leapfrog that would bring Southern Africa up to nowadays standards without losing local references.

In order to validate the findings of the research, a case study focussed on specific urban challenges has been identified: the Umgeni River estuary in eThekwini municipality is representative of the confluence of multiple urban dynamics: environmental concerns, lack of municipal services, climate change vulnerability, ocean pollution, poverty, regional business, mining, commercial activities, informal settlements and formal planning. The waste sector in particular, typically undermined in the Global South, has been identified as a potential common thread across the aforementioned urban dynamics. The application to the case study of the lessons learnt through the study of the smart city and urban sustainable resilience highlights the readiness of the Southern Africa city and unlocks a discussion about sustainable urban growth.

1.2 Background and research gaps

1.2.1 The Southern African city: specific features

In a globalized, the use of the same language can lead to misunderstandings, taking for granted a set of concepts automatically associated to words. It is acceptable worldwide to understand the word city as a defined territory with a highly densify concentration of people, present of second and tertiary sector, absence of primary sector and common services and infrastructures managed by a reduced group of people in comparison with the entire population of the city. Nevertheless, the way each and every element is present or absent in the city, the relationship between them and the performance of each of them define complete different scenarios across not only different regions of the world but also even within the same country in some cases.

Southern Africa has suffered for centuries of imported-imposed foreign technologies, not only foreign due to origin but most important, due to conceptualization. This research must look at the local features of the Southern African city in order to avoid, once more, another foreign approach with little impact.

In fact, the features that define and differentiate the Southern African cities are rather overwhelming, not likely to be found in the Global North but very present in developing countries.

Notwithstanding high growth rates of urban population, the colonial city model in which one large city, dominant nationwide and typically the capital has the economic activity, population, and political power. This one city is several times bigger than the next largest city and receives most of attention and resources in comparison to other urban centres and towns throughout the country (Güneralp *et al.*, 2018). Unplanned and unregulated growth characterizes the urban expansion in Africa, exacerbated by neo liberalism, the legacy of colonialism and structural adjustment with the result of fragile urban planning institutions (Parnell and Pieterse, 2014), which have an impact on land administration as well (Mamdani, 1996). It also increases costs of administering electricity, waste management, water and transport services through centralized systems as well as goods such as food (UN, 2014). Urban services in the region are constrained by greater infrastructure deficits. These cities are not ready for such increase of the population (UN, 2014).

The shift of the residents profile in the Central Business Districts (CBDs), with different lifestyles and lower income, together with a shortage of public investment, led to a progressive decay of the Southern African urban centres after independence and the end of apartheid (Amirtahmasebi *et al.*, 2016). Moreover, nowadays, the socio-economic class-based segregation is added to the racially segregated urban context inherited from colonial and apartheid planning (Hart, 2004; Huchzermeyer, 2004).

The deepest mean of the city is ultimately the achievement of a well planned piece of territory, in order to harmoniously organize all resident actors and their interaction. The business niche for the Smart City industry lays on the optimization and improvement of such interaction. Informality is considered a failure and needs to be eradicated. Nevertheless, the overwhelming socio-economic scale of urban informality in Southern Africa leads to consider informality a feature rather than an anomaly to be fixed. Moreover, the formal sector pressures governments to criminalize the informal sector rather than engaging and negotiate a transition from informal to formal (Skinner and Watson, 2019).

Informality has a big impact in the use of land and reflects the mismatch of the present with the spatial models of the colonial era, based on a British land use by zoning, traditional mono-functional with a car-dominated traffic mobility, aiming to meet the ideal image of a modern British city. Urban farming and homes as workspace has been historically banned in the colonial planning (Skinner and Watson, 2019). On the contrary, the majority of urban Africans live in slums, which comes with additional challenges in the form of administrative exclusion, health and environmental hazards, together with under covered forms of power: the control over the land empowers informal leaders and therefore, control the residents who settle. Informality is the result of government failures to provide alternatives to city economies, workforce and fundamental structural inequalities (UN, 2014).

Consumer behaviour changes from one region to another. From quality perception to payment methods, local trends can differ enormously within the region. This situation challenges standardized strategies for successful foreign direct investment projects. Updated databases become essential for an effective supply chain.

Growth in Southern Africa has failed to improve income levels and living standards. Instead, urban communities have become extremely fragmented, greatly unequal and consequently, potentially a socio-political hazard due to rapid growth in GDP (UN, 2014).

The majority of Africans live on very humble budgets and spend more than 50% of their resources on food (Banerjee *et al.*, 2008). Accessibility and effective utilization are concept substantially dependant on urban planning. Spatial location, access to clean water, sanitation, storage, refrigeration and healthcare (Battersby, 2014) 'Cities, planning and urban food poverty in Africa' are parameters which are not taken for granted in the Southern African cities.

One distinguishing characteristic of Africa is that the most of the labour force is trapped in vulnerable employment (Pieterse, Parnell and Haysom, 2018). The transition from a primary economy, to a secondary such as manufacturing and industrialisation did not take place in most African countries. Yet, workers who from primary sectors with informal employment, do not evolve into manufacturing and industrial jobs in the formal sector and stay trapped in occupations of a service nature in vulnerable condition, characterised by irregular and very low wages (Pieterse, 2019).

Local governments are often most accustom to issues related to vulnerabilities and risks (Bulkeley, 2010), and many also oversee duty on managing services and infrastructure that are fundamental for quality living standards (Anguelovski, Chu and Carmin, 2014). Mainstreaming adaptation into different development agendas is a practical challenge for many cities in the developing countries due to staffing capacity, supportive cultural values, financial deficits, information and local leadership (Anguelovski, Chu and Carmin, 2014). Financial instability at municipal level affects planning and management policies of cities (UN, 2014). Staff expenditure of municipalities consumes significant proportions of municipal funds. The lack of capacity also constrains how municipal planners, engineers and service delivery professionals are able to foresee gradually more severe climate impacts (Anguelovski, Chu and Carmin, 2014).

Southern African cities are prone to disasters associated to climate change. The region is warming (SADC, 2010) and this is probable to result in bigger drought in the future (NCAR, 2005). Growth of Southern African cities will come under increased pressure to meet rising water demands of industrial expansion and urban growth. For instance, cities relaying on aquifers for fresh water consumption are already under pressure. While climate change impacts will manifest differently at local scales, it increase social inequalities with the poor taking the worst part (UN, 2014).

Africa is home of regions with exceptional biodiversity (Mittermeier *et al.*, 2011). The rapid urbanization without efficient planning is putting under pressure natural habitats adjacent to urban areas. Lack of involvement of ecological experts in policy decisions and the lack of capacity are two of the main impediments in the region regarding ecological governance (Güneralp *et al.*, 2018). Moreover, in the region, pressing development priorities and human rights typically clash with environmental considerations instead of consider then a base for planning. (Roberts, 2012).

The forecast for 2025 is that the African population will increase up to one fifth of the world, half of will live in cities (UNDESA, 2019). High levels of rural urban migrations are a consequence of rural poverty. The best expectations foresee an increase of people emerging from poverty and thus conforming a middle class at the same time. However, the direct consequence is the increase of urban poverty, overtaking for the first time rural figures (Ruhiiga, 2014).

Urbanization arguably refers to the rising portion of the population living in urban areas. Asia and Africa remain mainly rural (UNDESA, 2018). In the revision of the World Urbanization Prospects by the Department of Economic and Social Affairs Population of the United Nation in 2018, the estimation for 2030 is that most countries in the region will reach the levels of the world average except for Zimbabwe.

The echoes of the colonial era still sound clear in the urban arena. The foundation of cities was not based on a spontaneous way of spatial organization by locals but rather, coastal base port for extractive economic activities in contrast with the inland areas, which remained rural until the Industrial Revolution happening in the European powers. In the postcolonial era, the control of economic resources has been transferred to companies based in the coloniser regions. Little wealth remains in the African countries, unable to invest in new economic sectors, research and development (Pieterse, 2019).

The current trend on urban regeneration happens at the same time of an "increased interest for the qualities of place". Initially, urban regeneration focused on the physical effects of urban decay. It evolved towards soft-oriented strategies linked to urban management to encourage place competitiveness and attractiveness, and moving in the direction of a "sustainability" agenda (Burzynski, 2012). Public–private partnership as a model of urban renewal based on 'urban entrepreneurialism', in a neoliberal policy context (Didier, Peyroux and Morange, 2012), aims to increases substantially the economic potential of now attractive areas. The improvement of the environmental quality of districts makes them more desirable and therefore more expensive. The result is social displacement (Wachsmuth, Aldana Cohen and Angelo, 2016). Public space, amenities, public transport, pedestrianization, ICT connectivity and green energy infrastructures have taken over the planning agenda (African Union, 2015; De Vries and Kotze, 2016). This clashes with the proliferation of gated communities, considered by mid and high income residents as a safer place to stay within a high crime rate environment, and represents a barrier to planning towards greater integration and accessibility (Burzynski, 2012).

The concept of "competitiveness" is attracting much attention of academics and policy makers as globalization and the transition to green economy is urging cities to compete with each other (Porter, 1995; Martin and Sunley, 2003). The official narrative from local governments tends to highlight the benefits of the city in order to attract investment and financial power. The rather ambitious goals tackle absolutely every mainstream topic on discussion at the moment (Department of Transport and Public Works, 2011): competiveness, sustainability, smartness, resilience, social cohesion, quality of life and SDGs Goal 11 as a summary. It is therefore acknowledged from the academia the important role that the existence of competition on the local market, together with human capital and innovation play in establishing competitive advantage (Porter, 1990).

Speeding up structural transformation in order to control the rapid urban transition is basic to confront challenges derived from poverty and inequality in Africa. This transformation must look at the promotion of economic diversification, especially focus on job creation through industrialization, improvement of access to basic services and policies addressing poverty and inequality (UNECA, 2017). The biggest impediment on Africa's developmental potential lays on its limited infrastructure, which need for strategic development is acknowledged by African leaders and included in recent investment patterns (Pieterse, 2019).

The Agenda 2063 is "Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. It is the continent's strategic framework that aims to deliver on its goal for inclusive and sustainable development and is a concrete manifestation of the pan-African drive for unity, self-determination, freedom, progress and collective prosperity pursued under Pan-Africanism and African Renaissance" (African Union, 2015).

It is finally obvious that economic, social and environmental agendas must be merged into a combined inclusive and sustainable growth agenda rather than being addressed independently. Failing to consider the environmental milestones will affect productivity (World Economic Forum, 2019). Additionally, countries with solid human capital, more advanced infrastructure and superior innovation power are more probable to transition to a more sustainable energy strategy (World Economic Forum, 2019).

With close to 4 million inhabitants and 225.91 km^2, Durban represents a paradigm of the African city described in this section. It was recently founded by European settlers, 1835, to strength the control of the strategic Port of Natal. The city evolved based on the urban trends of British planning, with an inflexible zoning system (De Vries and Kotze, 2016). Moreover, the idea of a modern city in the early 20th century steered the urban planning to a strongly car oriented scenario (Skinner and Watson, 2019). This planning criteria together with the later apartheid segregation laws, derived in a highly disconnected city and therefore important structural problems have arrived to date (Beavon, 1992).

High levels of poverty and inequality, public services backlogs and lack of inclusivity are features of the urban landscape of Durban. Despite the political interest in aiming for sustainability and adhere to the NUA, the strategic project fail in tackling local problems. There is a clear bias towards international competitiveness (eThekwini Municipality, 2020a) and therefore, endemic structural challenges remain in a secondary agenda. Durban is at the same time a coastal city that is prone to natural disaster due to climate change (Hansen, 2019; Nsibande, 2019).

1.2.2 Ubiquitous smartness

The Smart City model seems to be an unavoidable approach for the organization of urban areas worldwide. It is here to stay and no stakeholder involved in the structure of the city dares to openly deny the present capacity and future potential of smart solutions for a successful urban management. Nevertheless, the concept of smartness applied to the city has gone through different stages, from the optimistic vision of a computer assisted and therefore enhanced management of an interconnected network of urban events, moving to a phase of intense branding and commercialization of the concept, to finally awaken suspicion of under covered intentions of the private sector aligned to power, and the space that such computerization allows to the citizen within this framework of smartness. This path of constant revisions and mutations of the concept has resulted in a certain level of diversity on approaches that however, can be classified using a few measurement scales. For instance, based on how technology fits in a particular context, smart projects can be classified as *Technology push,* which refers to the delivery of technology regardless actual needs; “if it is available, they will use it”, with a strong commercial character, or on the contrary *demand pull,* where technology is delivered based on proven needs to be attended. Another scale that classifies smart initiatives refers to what extent technology is woven into the city. The two poles of the scale are defined by *soft infrastructure oriented strategies*, where human capital is put in the centre, with the goal of increasing human interaction, versus *hard infrastructure oriented strategies,* where citizens seem to hold a more peripheral position and the main aim is computerized efficiency.

Notwithstanding the multiple, sometimes antagonist, positions on the understanding of applied smartness, there seems to be an agreement that considers **digitalization** as a key factor of disruption of the traditional idea of the city as a socio-technical system structured in two main components: infrastructures and services (Finger, 2017). Digitalization allows a bi-directional flow, due to a decentralized new structure where the citizen is not only fed but also produces data, either in a passive or active way, turning consumers into prosumers (Finger, 2017). Therefore, it is important to conceptualize this digital hinge which blends infrastructures and services, which operates at two levels: data generation and data processing.

The use of computational technology automatically introduce the idea of measurement of performance of the smart components and hence the city as a system. This rating exercise appears crucial for the design of strategies by policy-makers and city managers. Different methods of measurement have been developed using rating systems based on quantitative indicators (Craglia *et al.*, 2004) organized in categories. There is no general consensus on rating criteria and these are generally bias towards the particular field of interest of the institution carrying the study, from both, public institutions and private sector companies (Neirotti *et al.*, 2014). The most common trend is considering a group of dimensions of a Smart City (Figure 3 by Cohen, 2012). The Ranking of European medium-sized cities (Fertner *et al.*, 2007) is a good example of systematically advanced and well-documented rankings conducted by academics or research institutes in the field of economics. Therefore, a level of transparency and independence is to be assumed. The authors indentify six relevant key-fields of the city: *economy, people, governance, mobility, environment* and *living*; and define Smart City as "a City well performing in six characteristics, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens" (Fertner *et al.*, 2007).

1.2.3 Approaching the 6 Key-Fields of the Smart City from the Southern African perspective

The study of the Smart City from an African perspective seems to be scarce. In 2016 Purnomo et al analysed a systematic literature review, identifying the hundred more relevant papers since 2004. No paper from Africa was on the list (Purnomo, Meyliana and Prabowo, 2016).

The initial two-ways approach of this research starts from a well established and internationally accepted concept of Smart City and overlap it to the Southern African existing reality. Afterwards, analysing the clash and defining a tailor-made smart solution for such context. Therefore, both the smart framework and the Southern African context will be subjected to adaptation in order to merge in a functional system.

If digitalization and the use of ICT are key drivers in the implementation of smart solutions, a look to the existing capacity is to be taken. Whilst developing countries represent 80% of the world population, their total global spending on informatics accounts for just 2% (Hanna, 1991). Only 0.01% of Africans outside South Africa enjoy Internet connectivity (Amoako, 1998a).

Less than an average 10% of the world population has access to internet and online content is mostly produced by the Global North (Graham, 2014). Inequality is definitely reflected on the access to the internet and the use of ICT. The uneven development of the internet throughout the world over time is known as Digital Divide. Moreover, the spatial distribution of ICT access is largely located in urban areas, with age, income, race, education and gender important determinants (Langa, Conradie and Roberts, 2006). informal phone shops on sidewalks and container telecentres are the normal in the region (Donner, 2008).

The Fourth Industrial Revolution (4IR) is defined as a confluence of the new technologies, which are developing at exponential velocity. Considered the current lack of industrialization in Africa, the most important impact of the technologies of the 4IR is expected to be a leapfrog to bypass some of the challenges on developing the industry sector (Deloitte & Touche, 2014). The transition to a circular economy can help to mitigate the need of imports, as the concept of waste becomes obsolete due to the ability of the Internet of Things in tracking material and energy flows (Harvey, 2017). The African city is therefore seemed as a blank canvas for development of the new urban typology despite the thread of magnifying inequalities due to the disruption of the job market by new technologies(Meads and Africa, 2019).

Generally, African governments do not handle reliable data (Pieterse, 2019). The institutions in charge of collecting and storing basic data are often underfunded and understaffed, affecting the availability and reliability of data (Güneralp *et al.*, 2018). Insignificant amount of statistical data is collected and filtered at city level, especially for productivity estimates and workforce census due to the blurry character of income sources in the informal economy (Bryceson, 2010). Additionally, the availability of data in informal settlements and slums is close to null despite the efforts of members of the civil society and academia in recent years (Georgiadou *et al.*, 2020). This gap represents an additional burden for almost two thirds of the African population which live in slums (UNDESA, 2010).

As initial approach, a discussion on at what extent the current status of Southern Africa whether complies or lacks of smart capabilities can be articulated by using the 6 key-fields of the city: *people, economy, environment, governance, mobility,* and *living* (Fertner *et al.*, 2007). This section is a summary of the analysis further developed in the literature review.

a) Economy

Africa is home to six of the world’s twelve fastest growing economies from 2014 to 2017 (Knowledge@Wharton, 2017). The strategy put in place by successful companies is based on a careful selection of the market they are entering. The forecast for consumption spending by

2025 concentrates the 60% of the spending in the 20 biggest cities (Agyenim-boateng, Benson-Armer and Russo, 2015).

The economies of the Southern African Development Community (SADC) depend enormously on natural resources although the region is characterized by a general desire to exploit science, technology and innovation (STI) to sustainable development. There is however, a large difference in R&D strength to attract FDI to help developing the private sector. A winning horse strategy for most of the investors exacerbates inequality in the region, with South Africa attracting about 45% of the FDI injected to the SADC (UNESCO, 2015c). Only 2% students graduate with a STEM degree (World Economic Forum, 2017a).

In Africa, only 2% of employers have ten or more employees. The prevalent lack of social protection together with very low household incomes, force individuals to accept any sort of job in order to survive. Informal employment is essentially the norm. This is the explains the comparatively low rate of unemployment in SSA (ILO, 2020).

The reasons for individuals to starting new business are varied but can be classified in two groups. On one hand, the desire to innovate, the aim for independence and financial soundness, continuation of family business and motivation to help others are considered pull factors. On the other hand, economic necessity, unemployment, scarce education usually push individuals to venture on self-employment. In Africa, this second group are known as 'necessity' entrepreneurs. These businesses are typically informal and revenues cover basic needs. Employees lack the stability and security of an employment contract (Abdychev *et al.*, 2018; Skinner and Watson, 2019).

Patent filings exceeded 3.3 million and trademark filing activity totalled 14.3 million around the world in 2018. The African region represents 0.5% and 1.7% respectively. Although Africa experienced a growth of 2.5% in total filings between 2008 and 2018, in terms of intellectual property, the region has an insignificant role worldwide, except for South Africa which is the highest ranked African office, in 24th place (OMPI, 2019).

Worldwide, the lowest share on employment in secondary sector is in SSA. Job creation is generally associated to low productivity: agriculture and traditional services. Cities in SSA are congested but not economically dense, reflecting deficient planning and the impact on labour and goods efficient transport, putting pressure on formal employment wages (Lall, Henderson and Venables, 2017).

SSA is the least integrated region within itself and internationally. Physical distances and socioeconomic differences represent obstacles to trade in SSA that seem to have a bigger impact than in other regions (Abdychev *et al.*, 2018). However, considerable efforts have been made over the past fifteen years to improve their investment environment and attract FDI. As a result the economic rate of the region had considerably improved from the mid-90's. The African Union decided to implement a Continental Free Trade Area (CFTA), which has created high expectations about the outcomes of such agreement in terms of jobs and wealth creation, and promoting equality, aligned to the Sustainable Development Goals and the African Union's Agenda 2063 (Gathii *et al.*, 2017).

b) People

By the end of the 21st century, 40% of the global population will be African. The total population of SSA amounted to over 1.09 billion inhabitants (UNDESA, 2019).

Of all regions, SSA accounts the highest rates of education exclusion. Almost two thirds of youth between the ages of about 15 and 17 are not in school (UNESCO, 2021b), although most children in the region lack of opportunities to start primary school. In terms of high education, South Africa has exceptionally the highest number of researchers and the highest output in terms of publications and patents, with nearly 35% of their publications regarding physics, chemistry, mathematics and engineering. In relation to international collaboration, South African and Mauritian scientists are the most prolific again (UNESCO, 2015c).

The understanding of lifelong learning has rooted differences to the Western and the Southern African perspective (Preece, 2013). For the former, lifelong learning implies an individual economistic visions for growth (Preece, 2013) whereas for the latter the concept has a more collective, interconnected and holistic way (Aitchison, 2004). Nevertheless, the reality is that strategic plans and initiatives continue not to be persistent and fail due to other financial priorities.

The borders of African nations were determined foreign powers and split up ethnic groups (Easterly and Levine, 1997). The linguistic diversity of Africa is an important factor to take into account. Some authors count over three thousand native languages (Epstein and Kole, 1998). In recent years, SSA’s ethnic diversity is understood as source of the political and economic problems (Green, 2012). Social polarization may be increased by ethnic diversity and thus obstacle accords of public interest, in favour the groups in power. These differences have been deliberately fostered by colonial rulers, concerned about the appearance of an urban proletariat detached from tribal prejudices which might lead the spread of nationalist anti-colonial movements (Mandani, 1996), which through urbanization might come closer to other ethnic groups, acknowledging their similarities and form new and more powerful ethnic identities.

The fast upcaling cultural and creative industries (CCI) sector in Africa is considered to have enormous potential to drive economic growth and sustainable development. Despite the substantial growth, African creative products are still under-represented with only 0.54% of the world markets (UNCTAD, 2016). The digital revolution has allowed Africa to be a pioneer for frugal innovation. (Lopes, 2015). In the Southern African region, South Africa and Botswana are the countries with bigger investments in the CCI (Oyekunle, 2019).

Regarding of civil rights, most of the countries in Southern Africa have relatively recent approved constitutions that ensure freedom and prohibit discrimination in terms of modern developed societies of the Global North. However, in practice, some governments do not apply the legal framework and harassment, discrimination and effective separation of powers are implemented. Nongovernmental organizations report pressures and monitoring from governments in the rest of the region, especially those working on human rights and governance. In addition, customary laws are usually applied in rural areas and superstition still have negative impact on certain communities and ethnic groups (Freedom House, 2020).

c) Governance

Land government in Southern Africa is typically addressed under ex-colonial legal frameworks and indigenous customary laws. This states differences between citizens depending on the location of the residence affecting legal rights (Mandani, 1996). The implications in terms of spatial distribution are considerable: colonial-era and modernized urban areas depend on formal land government frameworks, whereas rural areas with mostly poor and low-income indigenous African residents depends on informal land government (UN, 2014). In between of the two systems mentioned, informality can be seen as a tactic and strategy of governments to contain the ‘ungovernable’ and politically manipulate urban space (Yiftachel, 2009).

Only 7 of the 54 African nations are considered free. 27 are considered partially free and 20 are considered not free. The impact of armed conflicts and authoritarian regimes in the area affect economic growth. Political stability plays a major role in socioeconomic development. In the sub-Saharan region, only Namibia, South Africa and Botswana are considered fully free (Freedom House, 2020). Democratic backsliding events are still present in the region, particularly during election time. The military has some influence over politics in some countries of the region. In some cases senior military officials have transitioned to leadership positions in political parties in power (Freedom House, 2020).

The right of political parties to form is legally guaranteed and respected in practice in all Southern African countries. However, transfer of power is rare and it seems that there are no a real chance for the opposition to boost its support or increase power under electoral processes in most countries. The power is usually hold in majority by one ethnic group in particular (Freedom House, 2020).

The public education expenditure in SSA seems to comply with the Education 2030 Framework for Action (UNESCO, 2015b). Nevertheless, the region faces many institutional, infrastructural and policy challenges. One fifth of the primary schools and half of secondary schools have access to electricity (UNESCO, 2017c). Common regulations for educational facilities follow medium to high income countries models. In most cases these high expectations are not fulfilled and have a negative impact and tend to be unrealistic (UNESCO, 2017c). The facilities are usually understaffed, and teachers are undertrained and underpaid. Learners with disabilities face particular obstacles (UNESCO, 2017c).

Corruption is endemic in the region. Anticorruption agencies are limited funded which restrict the efficacy of institutional safeguards against corruption. Government accountability although reflected in most constitutions of Southern Africa, is still to be consolidated (Freedom House, 2020). Regarding the judiciary independence, the situation changes across the region (Freedom House, 2020).

d) Mobility

African cities continue to unsustainably build new roads, regardless of the fact that new roads increase dependence on cars, and the consequent increase of GHG emissions, and reduce the area of productive urban space (Sietchiping, Permezel and Ngomsi, 2012). Despite the short-term benefits on road-based transport, the long-term associated costs, such as social exclusion, maintenance and traffic accidents are serious(UN, 2014).

Only one third of Africans live within two kilometres of a paved road (AfDB and World Bank Group, 2011). It is the last-mile delivery that makes transportation infrastructure so expensive. SSA's cities are among those with the highest annual traffic expansion (Mbara, 2002) although have prominently underdeveloped urban networks. In most Southern African countries, urban mobility depends on income. The development of an array of transport alternatives or to improve rail, bike or walking paths has been largely neglected (Sietchiping, Permezel and Ngomsi, 2012), albeit walking and cycling are often the main option available for most of city commuters, especially for the urban poor (Godard, 2011).

SSA is inundated by poor and under-developed transportation infrastructure, hampering intra-regional trade, limiting accessibility to consumers, and increasing international trading costs. The absence of development in Central Africa is a fundamental obstacle for connectivity between North, West, East, and South (Tancott, 2014). SSA has the lowest road density and moreover, roads have lost nearly one-third of their value due to underinvestment and constant postponement of maintenance (Herfindahl and Treat, 2009). A similar experience applies to rail infrastructures, which have decreased due to decay and endemic unreliability in operations (Herfindahl and Treat, 2009).

Most of the international trade of SSA is conducted via maritime transport. However, a large number of ports face insufficient physical capacity to handle volumes (Herfindahl and Treat, 2009). Regarding air services, Africa is the smallest region in the world. Only a 10% of African airports receive regularly scheduled services (Foster, 2009). SSA's civil aviation authorities experience budget constraints and cannot fulfil their duty as safety regulators (Foster, 2009). Air navigation services and air traffic control concentrated in a few centres (Foster, 2009).

The Fourth Industrial Revolution could increase inequality, particularly in its potential to disrupt labour markets despite its well known benefits. Talent, more than capital, would represent the fundamental factor of production (Schwab, 2016). The UN implemented a few programs and pilot projects addressing the ICT skills development in Africa, with the purpose of testing the impact of such methods on cultural, social and economic areas in underdeveloped regions (Davison *et al.*, 2013). Telecommunication leapfrogging appears as a strategy for IT spread, acting as a key that can improve competitiveness and facilitate growth rates (Antonelli, 1991).

The uncontrolled spatial growth of cities due to inefficient and biased planning, has located a number of low-income housing development in the periphery lacking of all types of basic services. Jobs remain moderately concentrated in new districts and the centre, which are more and more distant from residential areas. The transport system available compensates very poorly for the spatial disparity in the availability of urban services (Diaz Olvera, Plat and Pochet, 2013). This situation has resulted in the proliferation of informal settlements nearby business hubs and public services in order to reduce the impact of the cost of public transport (Lucas, 2011).

The number of road fatalities is considerably higher than the world average, despite having the lower quantity of registered cars (WHO, 2019). Both public and informal transport vehicles are poorly maintained and overcrowded.

e) Environment

Sunshine hours and green space share are the environmental indicators considered to have a decisive impact on the rating related to natural conditions appeal. Southern Africa is one the regions in the world with the higher number of annual sunshine hours (de Jong *et al.*, 2017). The quality of the green space as enjoyable areas within the city is not always achieved. Road sides or inaccessible river banks are included, which can be considered positive indicators as environmental features for climate change alleviation but have little impact on the quality of life.

In Southern Africa pressing development priorities and human rights typically clash with environmental considerations instead of consider then a base for planning (Roberts, 2012). The superficial “environment versus development” paradox remains prevalent. Thus, recognition of climate change adaptation as inter-reliant with development, including economic growth and poverty alleviation represents a key challenge (UN, 2014).

Less than one fourth of GHG emissions have the origin in developing countries (Stern, 2007). Many cities in the Southern African region depend on water bodies for fresh water needs. Recently, industrial developments increased water demand. However, increasing water infrastructure networks is probable to render massively costly (UN, 2014) when basic services are already unavailable. Poor informal residents turn to natural resources, gathering wood for cooking and heating and drawing water from rivers. In addition to the uncontrolled use of natural resources, the lack of service delivery in slums has a big impact on solid waste disposal and management. Almost half of the urban solid waste is not collected (Zandamela, 2016).

Most African households expenditure on food represents more than 50% of their resources (Banerjee *et al.*, 2008). Supporting the poor by lowering household associated costs via upgraded infrastructure might be an evident strategy. However, low levels of GDP per capita make challenging conventional infrastructure investment (Pieterse, Parnell and Haysom, 2018). The contribution of the informal economy to urban sustainability is rarely acknowledged. Informal traders often source locally and make less use of single-use plastic packaging, and municipal schemes that use informal recyclers emit lower rates of GHG (Vergara, Damgaard and Gomez, 2016).

f) Living

The level of well-being, measured taking into account time issues, information elements, competence using technological every-day-devices or freedom of making choices as key elements (Craglia *et al.*, 2004), is unquestionable low.

Southern Africa is gifted with immense cultural diversity namely languages, traditions, ethnic groups, communities, religions, archaeological sites, industrial sites, museums, townships, cuisine and vineyards, stone age cave paintings, rural landscape, and other heritage treasures (Saarinen and Rogerson, 2015). The growth of the creative industries experienced in the last decade seems not to come in hand with the development of cultural facilities, traditionally scarce in Southern Africa (UNESCO, 2021a). Poverty alleviation and economic growth tend to prioritize the development agenda. Moreover, the image of Africa has been historically bonded to wilderness which constitute the opposite to culture and civilization to western eyes (Nash, 1967; Saarinen, 1998) and relegating local people and cultures to a complement to wildlife (Manwa, 2007).

Only one third of the African population have access to improved sanitation in the terms of UNICEF (WHO, 2016). The life expectancy in Africa is the lowest in the world, equivalent to the mortality rate, which is the highest in the world (WHO, 2019). Health care facilities experience big backlogs and therefore life-saving operations, accurate examinations such as x-ray and ultrasound cannot be performed (Knoth, 2015). Blood and vaccines storage is inappropriate (National Coordinating Agency for Population and Development *et al.*, 2011; WHO, 2012). Communication with other facilities for referring patients is not always available. Incubators are inexistent leading to high rate of neonatal death (Knoth, 2015).

Personal social freedoms are highly impacted by customary laws in the region. Domestic violence and rape are endemic problems and far from being solved in the near future. Customary marriage practices vary among different ethnic groups, and often restricts women's rights within a marriage (Freedom House, 2020). Human trafficking is still a current challenge in Southern Africa. The rate of homicides in South Africa and Lesotho is four times the regional average and six times the world average. Except for these two countries, Southern African does not experience a particularly high violence (World Bank Group, 2010).

In SSA, 80% of primary schools do not have electric supply, compared to half of lower secondary schools (UNESCO, 2017c). The number of primary school with basic sanitation was below 50% in 28 out of 145 countries assessed, including 17 in SSA (UNESCO, 2017c). Additional equipments such as libraries are also below requirements (UNESCO, 2017c). A considerable percentage of children cannot read after a few years of schooling (UNESCO, 2017c). SSA has the highest of out-of-school rates and the lowest level of participation in pre-primary age (UNESCO, 2017c).

SSA is home of a number of World Heritage natural sites, outstanding wildlife and active habitat conservation programs with international impact. However, when it comes to travel and tourism attractiveness, the region ranks at the bottom of the Travel and Tourism Competitiveness Index (TTCI) 2019. SSA's travel and tourism market is very small, 1.6% of the GDP. SSA lacks the strong financially sound middle class required to boost tourism investment and intra-regional travel. Lack of ICT adoption and health and hygiene concerns are obstacles to attract visitors (Calderwood and Soshkin, 2019).

The high level of inequality in Southern African cities contains the seeds of significant political discontent in urban areas and strengthen an “identity of exclusion” among the urban poor (Srinivas, 2017). Whilst racial dimensions of unbalanced urban development are fading out slowly, social inequalities and spatial segregation are expected to be persistent (Robinson, 2008). Lack of associationism, high rates of crime and corruption with no accountability from an organized civil society are symptoms of communities composed by misplaced people.

1.2.4 Urban priorities for Southern Africa

The analysis of the literature review and extraction of relevant indicators for the region leads to consider poverty alleviation, inclusive zoning in the urban planning and climate vulnerability mitigation as the most urgent elements to address efficiently from the city management perspective.

The monthly budget of most African households is lower than $180, which 50% is spent on food. On average, urban households have $100 more than rural ones (Banerjee *et al.*, 2008). However, this pattern is shifting and urban poverty is quickly increasing in Southern Africa (SACN, 2011a). Poverty alleviation is considered in all major international programs related to Southern Africa including the Agenda 2063, the UN- NUA and the UN-SDGs. In fact, Goal 1 is: *End poverty in all its forms everywhere.* Poverty alleviation must be addressed holistically, considering improvement in health and education, inequality reduction, and economic growth, together with environmental matters such as climate change and conservation of endangered flora and fauna (UN, 2015b).

Equality and inclusivity are to be included in the urban planning debate. Participatory processes and acknowledgement of the social reality are crucial. In recent years, the trend for new large urban projects in SSA is to skip the possibility of rejuvenation of existing urban centres and look at rising new satellite cities. The private sector has become a dominant player in most of these projects and global economic forces are interacting with local governments behind the back of the majority of the people (Watson, 2014).

These new planned cities are advertised through the appropriation of narratives that evocate modern principles (Watson, 2014). Labelling new developments as “smart” or “eco” is certainly part of a marketing ploy (Hollands, 2008) and usually located in tribal land with result of conflict and eviction processes (Watson, 2014). Principles of inclusivity and equality are hardly considered.

In the case of urban regeneration, physical improvements due this urban entrepreneurialism, increase substantially their economic potential, resulting in gentrification. The area exerts a big financial pressure on the existing communities, forced to social displacement.

In a highly fragmented managerial structure, where municipal departments operate independently and lacking of interdepartmental communication, the analysis of the area of study from a holistic perspective articulates a polyphonic narrative aiming to include as many actors as possible. Smart initiatives have the capacity of computing inputs from many different sources.

Sustainability emerges as the primary concept under which developing the whereabouts of the city, ahead of competitiveness. Sustainability understood as social, environmental and economic. The Smart City cannot neglect the sustainable component and not only boost capabilities for urban management but direct decisions towards sustainable results. In addition to this, the capacity of smart initiatives to constantly adjust the outputs based on the constantly changing urban parameters, offers a hard to refuse occasion to achieve urban resilience in a sustainable and harmonious way. The ultimate goal of smart technologies is the one of perpetuating a sustainable resilience of the city.

1.3 Purpose of the Study

The intent of this research is to determine the capabilities of the urban environment in Southern Africa to embrace policy-making, projects and initiatives on smart cities that tackle the specific regional issues, specially related to social and environmental matters.

There are two relevant components to approach on the basis of a critical analysis of the historical and recent theories and findings on Smart City concept and models. Firstly, the understanding of the meaning of ‘smartness’ by extracting a taxonomy of the concept ‘Smart City’ from the scientific literature, and secondly, the identification of the main features, barriers and challenges of urban environments in the Southern African context through the review of recent reports published by international organizations working actively in the African Continent.

The findings from the literature and analysis of southern Africa in particular are then applied to a specific urban landscape as a case study introduced in section 1.6.3 and detailed in chapter 5. The features of the area identified in eThekwini render the selection a micro-scale urban ecosystem that contains multiple stakeholders interacting.

The outcome resulting from overlapping the aforementioned components highlights the dark areas in the implementation of smart initiatives on developing countries, as well as points the strong aspects found in the Southern African urban environment that are able to successfully embrace the implementation of smart initiatives.

1.4 The significance of the study

The study aspires to achieve a significant level of understanding of Southern African urban dynamics from a strong insider approach. The researcher embraces the idea of knowledge development based on genuine local realities in opposition to imposed principles that emanate from forums aligned to the concept of capitalist globalization. Borrowed narratives from developed countries are put under scrutiny. These ideas might either apply or are rather irrelevant. The concept of relevance is therefore associated with the social impact on the majority of the population. Irrelevance is hence stressed and linked to increasing of inequality.

As Pieterse, Parnell and Haysom (2018) state, “African academics can no longer defer to established Eurocentric or Western theories, norms and perspectives, particularly in the planning and economic disciplines, as best practice”. The research aspires to contribute to a growing body of work that is produce locally, with results that may help not only to open discussions on future research fields regarding the African Continent but also to define roadmaps for managers and policy-makers.

The outcomes of the research play as well a role of assistance in policy making and are expected to be a convincing set of recommendations for public managers, particularly stressing the importance of service delivery and highlighting the holistic and multifaceted nature of all urban fields through the example of the urban waste sector. Durban as a paradigm of Southern African city, offers an optimal platform to develop and promote the values of the New Urban Agenda, in which principles this research is inspired. Moreover, Durban is part of the 100 Resilient Cities project pioneered by the Rockefeller Foundation (The

Rockefeller Foundation and UNDRR, 2016). Therefore, tackling sustainability and resilience related to the environment and social structures at the core of the urban fabric becomes crucial for the future of the city.

1.5 Research questions. Aims and objectives

As indicated in the precedent sections, countries in Southern Africa show similarities in the urban realm. This research aims to identify sustainable ways for long-term implementation of up to date technologies in Southern African cities for an effective leapfrog that would bring Southern Africa up to nowadays standards without losing local references.

It is important to strength the link between common features for a better understanding of the region and therefore, a better rating on the feasibility of future projects that come from bottom-up processes and fit into a genuine caseload or solutions demand that reach the mass. For this research, as stated in the section 1.6.3 Case Study, the questions inquire on achieving resilience intrinsically linked to sustainability through smart solutions.

The research focuses on the Umgeni River catchment as a case study introduced in section 1.6.3, in order to analyze the interaction at urban level of a number of actors and therefore the potential for Smart City projects. The area is characterized by many different features that make it representative of urban dynamics at micro-city level: environmental concerns, climate change vulnerability, ocean pollution, poverty, regional business, mining, commercial activities, informal settlements and formal planning.

From a practical perspective, the urban waste is identified as a paradoxical topic: it is considered of great importance in the Global North although it does not represent a big challenge due to long-term implemented planning in the sector. On the contrary, urban waste is typically undermined in the Global South, which represents a great threat not only at environmental level but also social and economic.

The **questions** to be addressed are:

a) Are there common features for the Southern African cities?
b) If cities are considered intrinsically resilient systems, how far is a typical Southern African city in the transition from current status to long-term sustainably resilience through smartness?

c) Which are the indicators to implement the cycle RESILIENT> SMART>SUSTAINABLE> SUSTAINABLY RESILIENT?
d) What are the possibilities for evaluating Southern African cities through already tested measurement systems like the “6 key-fields” of performance of the Smart City?
e) How can measurement systems of urban performance be applied to the Umgeni River area and the waste sector in particular, to assist decision making and strengthen the sustainable resilience?

The **objectives** of this research are:

a) Identification of common features in Southern African cities.
b) Conceptualize smartness, sustainability and urban resilience applied to the city, and summarize the indicators.
c) Identification of gaps in the methodological approach in transitioning from a typical Southern African city to sustainably resilient through smart initiatives.
d) Recommendations to assist municipalities in the correct and appropriate planning of this transitioning.
e) Definition of a framework of waste management strategies for sustainable resilience in the Umgeni Area.

The primary target beneficiaries of the findings of this research are the citizens followed by Municipalities/Local Authorities Officials, Practitioners, SMMES, Scientists, Local/Provincial Government, Policy Makers, Waste Managers and Solid Waste Unit Personnel, Formal and Informal Recyclers, and University Students.

1.6 Research methodology

In this section the research design, which is discussed in detail in Chapter 4, is introduced. The research design, boundary conditions, sampling, data collection procedures, qualitative data analysis and limitations of the study are briefly explained.

1.6.1 The research design

This study is considered a field research and uses mix methods. A quantitative approach is needed in order to profile significant urban features recognizable across Southern Africa through the use of statistics from official governmental offices and secondary data analysis from recognised organizations.

A deep dive into the literature about the African city is needed in order to understand localities and real challenges. The research looks at worldwide urban trends and aims to extract those parameters that are useful to Africa today. The vast array of indicators varies depending on the aspirations of cities around the world. Some cities aspire to be more competitive and others more sustainable. In others, quality of life occupies the bulk of the agendas of policy makers. For Africa, some indicators that are irrelevant in the Global North mean the difference between life and death situations and vice versa. This is the case of natural hazards and climate change vulnerability. The definition of a tailor made array of indicators helps in the definition of a planning framework.

A three layers mapping of the area selected for the case study, the Umgeni River catchment, will lead to define the selection of the indicators and further conclusion on how a resilient and sustainable African city might look like.

Moreover, the social nature of the research required of the use of qualitative methods. Leedy and Ormrod (2000) consider qualitative methods "useful in answering questions about any phenomena that aim to describe and understand the phenomena from the participants' point of view". In order to understand the perception of the different stakeholders involved in the city management on one hand, and the residents and taxpayers on the other hand, testimonials from officials from the eThekwini Municipality, members of the civil society, ICT companies and scholars have been extracted from their interventions in task team meetings held by videoconference in which the researcher was present. These task teams are directly involved in the assessment of the case study

The variety of data sources has had a positive impact in the diversity and quality of this study. Books, dissertations, journals, reports, newspapers articles and official documents and policy regarding city planning, management and ICT technologies in eThekwini were reviewed and analyzed.

1.6.2 Boundary conditions

Africa is a vast and diverse continent, with a rich culture and socially woven traditions. Although it is a fact that some features in terms of development and stability can be applied continent wide, especially in relationship with the deployment of advanced technology, the history of urban settlements varies immensely. The development of the Mediterranean shore is strongly interconnected with Southern Europe, and the overlapping of ethno-cultural layers, with levels of self-governance along thousands of years, has occurred until present times.

On the contrary, the dawn of Southern Africa urban development is essentially related to colonialism starting in the 15th century, with the foundation of new cities without a prior historical background and unrelated to the local traditions and culture. Moreover, the fact that most of countries gained independence in a very close period in history, the following armed conflicts and the achievement of a certain level of stability and claim of the previously denied urban space by de local population in an almost orchestrated and synchronized way, increases the number of common aspects that take lead to consider the area a case study as a whole.

In order to narrow down the boundary conditions to a scale that is manageable for the research in the context of a PhD research, the selection of Durban as a case study becomes appropriate. Durban represents a paradigm of the Southern African megacity: large population with high levels of inequality, dysfunctional service provision, lack of heritage and historical references, strategic location with geopolitical interest and a tightly imposed urban vision from the colonial era. Durban is at the same time a coastal city that is prone to natural disaster due to climate change. Therefore, social and environmental challenges meet together to conform an interesting breeding ground for the development and testing of creative solutions that are forced to look at problems from a holistic perspective.

The research focuses on the Umgeni River catchment as one of the few urban rivers in the WIO region. This area has been case study for a number of research projects in the University of KwaZulu-Natal and it is characterized by a conjunction of urban features that will be explained in detail in chapter 5. In addition to this, the area is highly exposed to natural disasters in the form of floods and plastic pollution that have an impact at many levels: economic, environmental and social. Through the analysis of this particular area, the research defines in chapter 7 a series of guidelines applicable within the Southern African context.

1.6.3 Case study

Durban represents a paradigm of the Southern African megacity: large population with high levels of inequality, dysfunctional service provision, lack of heritage and historical references, strategic location with geopolitical interest and a tightly imposed urban vision from the colonial era. Durban is at the same time a coastal city that is prone to natural disaster due to climate change (Hansen, 2019; Nsibande, 2019). Therefore, social, economic and environmental challenges meet together to conform an interesting breeding ground for the development and testing of creative solutions that are forced to look at problems from a holistic perspective.

The Umgeni River is one of South Africa's largest river systems, with a catchment area of over 4,400 square kilometres (Raper, 2014). The Umgeni has also been described as one of South Africa's most polluted rivers, as serves as a major conduit of plastic waste to the Indian Ocean (Carnie, 2013; Rall, 2019). The Umgeni is also historically prone to flooding, leading to displacement within river-adjacent communities, and a sharp increase in the amount of plastic waste exiting the river mouth and accumulating on Durban's beaches with great impact on the local economy (Hansen, 2019; Nsibande, 2019).

The area is already the centre of several studies and has called the attention of a number of stakeholders including the SARCHI Chair in Waste and Climate; the Group of Marine Biology at UKZN; The Ocean Cleanup, a non-profit organization developing advanced technologies to rid the oceans of plastic through the development of specialized vessels; DGC, an NGO focus on sustainable solutions and plastic pollution alleviation, its potential use through circularity and community upliftment; the eThekwini Municipality and a coalition of national and international experts under the umbrella of the South African Council for Scientific and Industrial Research (CSIR), aiming at using this unique urban case study to attempt to address the effect of climate change on the waste sector and methods for retention of plastic in riverine and estuarine habitats.

The case study was used as an exemplary field of application of possible innovative methods for addressing critical indicators and sectors emerged from the analysis of the barriers to sustainable/resilient cities in Southern Africa. The focus is not on the technology application, but on the need for a context-based holistic, interdisciplinary and innovative approach to address urban and peri-urban problems in Southern African cities. The selection of the case study is based on the line of argument developed through the research, which led to the focus of waste management as one of the most critical sectors to achieve target of sustainability and resilience in Southern African cities, which greatly impacts on the environment and quality of life of the majority of local population, needing an innovative planning able to reshape urban infrastructure and waste management methods.

The case study of Durban and the focus Umgeni River catchment has been selected in consideration of the above-mentioned line of argument, which finds evidence in the inclusion of the Umgeni River catchment as one of the priority projects identified by the CSIR. The selected case study therefore enables to apply the indicators emerged from the analysis to environmental and social issues, link those indicators linked to urban and infrastructure planning greatly impacting on the quality of life of citizens in Southern Africa.

1.6.4 Data collection procedures

The data collection strategy overlaps three layers that are directly related to the scale of the mapping requirements. The acknowledgement of the city as a complex socio-economic system leads necessarily to a holistic approach to the study and analysis of the territory.

Layer 1 will compress data collection from satellite mapping. The information gathered through these systems will lead to the analysis of the urban fabric, the position of the current pollution alleviation means and the waste treatment plants. Layer 2 will use drone mapping for the analysis of the performance of the pollution alleviation means, such as litter barriers and storm water nets, and characterization of the plastic. Layer 3 will include ground mapping related to the efficiency of the pollution alleviation means as well as qualitative data from the stakeholders involved.

In addition to the aforementioned mapping, eThekwini municipality has developed an online GIS consultation interface together with downloadable GIS information. This is of high importance in the measurement of the level smartness, transparency and social engagement. At the same time, it will provide information of indirect but important data to for a better understanding of the spatial relationships that affect the Umgeni River catchment.

The COVID-19 pandemic has disrupted enormously any mean of social engagement. In fact, the completion of this research has been postponed for one year due to COVID-19 protocols instated by national and local governments, together with internal policies from the UKZN. In order to overcome the challenge and give room to relevant voices that are needed to comprehend the research problem, the initial plan of gathering information from of interviews with key stakeholders involved: members of the local government, representatives of the civil society in the form of NGOs that are actively working on the area, academics currently working on the Umgeni River catchment and residents and taxpayers in the area, has been substituted by testimonials from officials from the eThekwini Municipality, members of the civil society, ICT companies and scholars have been extracted from their interventions in task team meetings held by videoconference in which the researcher was present. These task teams are directly involved in the assessment of the case study: plastic pollution in the Umgeni River. In addition to this, mass media items have been analyzed in order to understand the sense of the general public. The researcher acknowledges the risk of bias in this last source of data and media with different orientation have considered in the study.

1.6.5 Data analysis

The dataset composed by the addition of both, primary and secondary data, was checked for missing or redundant data and ensure consistency. For the GIS model, the data was filtered and organized based on the municipal composition of KZN as detailed in section 4.3.5.

The analysis of indicators started with the literature review and the selection of the most relevant measurement systems cited. Two types of systems were then selected: international holistic systems and local systems applied to specific geographical locations.

Testimonials by eThekwini officials, members of DGC, TOC, Save Our Rivers, Durbanites Against Plastic Pollution, DUCT, Umgeni Estuary Conservation and the paddling community were recorded by note-taking, and two task team events in Zoom were recorded with consent. Afterwards, transcriptions of the testimonials were done, indexed and categorized. A narrative analysis from testimonials was structured based on these categories and connected with the data.

The analysis of data was conducted under a triangulation system. According to Davies (2007), this method assists to ensuring consistency on the data. The literature review, observations made during the data collection, and testimonials from local government officials and members of civil society were the main sources of information.

The qualitative data was overlapped to the results of the GIS and helped to identify gaps, and challenges. It also assisted to create an inventory of current initiatives and assess their efficiency and propose improvements.

1.6.6 Limitations of the study

The data source corresponds to the geographical region of Durban, South Africa. It is to be acknowledged the particular socio-cultural features. However, although the findings are specific, the principles and theories developed can be extrapolated to other geographical realities with similar urban features.

The African context is frequently approached as a whole in numerous pieces of research and studies (UN-Habitat, 2016). The acknowledgment of the cultural and regional diversity is overseen in many cases. The researcher has noticed that the literature and reports often include the region of Southern Africa the geographical context of SSA. The region of SSA is mentioned in the study when no specific data on the Southern African region are available.

The eThekwini Municipality state a disclaimer in relationship with the GIS data provided as follows: "The eThekwini Municipality makes no warranty – implied or expressive – with respect to the accuracy, correctness, completeness or appropriateness of any information contained in this site. The eThekwini Municipality undertakes no duty to or accepts no responsibility to any third party who may rely on this information." However, this service represents an important source of data that can be confirm as accurate through comparison methods with the data collected for this study.

The data collection from organizations involved in the solution of the plastic pollution in the Umgeni River does not follow certified standard procedures hence a level of tolerance for the reliability of data is to be considered.

1.7 Hypothesis

The hypothesis is that the implementation of Information and Communication Technologies (ICT) in the urban areas of Southern Africa is overlooking specific features that differentiate the region. The disruptive impact of the fast development of the ICT in the urban arena, rather than allowing for a solid development of the African cities, is exacerbating the gap between Southern Africa and the so called "Global North", increasing inequalities and subjugating, once more, the African population, exposed to environmental, social and economic threats. The trends show that the current technology, almost miraculously solving all problems in the "Global North", does not show results in the African context. Adopting the international narrative of the ICT has little impact on the urban Africa. The implementation of foreign technological frameworks and the consequent superficial technology appropriation encounters a weak foundation lacking of accumulated knowledge, rendering the African urban context vulnerable to external actors.

Hence, looking at the advent of the Fourth Industrial Revolution with concern, the hypothesis acknowledges the regional backlogs but also the great potential for leapfrogging. However, successful initiatives will produce results only through a previous strategic selection of operational fields, those that will look after tailor made solutions for the regional context. This selection might classify smart technologies in primary fields of action; focusing on people, living condition and environment, that are more relevant to the context. A succession of successful project overtime will set the base for a further implementation of a secondary field of action: economy, governance and mobility.

The case study represents a benchmark to validate the findings of the research. The Umgeni river plastic pollution demands the application of technical solutions and comprehends the involvement of city managers. At the same time, it affects the social context and it is not exempt of serious environmental implications. Holistically, the case study represents a suitable socio-technical framework in which develop this research.

1.8 Structure of the thesis

This thesis is divided into six chapters. Chapter one is the introduction to the research study. It provides a background and research gaps to the problem of the worldwide accepted concept of Smart City and the challenges for implementing smart initiatives in the SSA urban context. It then outlines the specific problem of transitioning from smart to sustainable with a case study within eThekwini Municipal boundary and introduces the research objectives and research questions all of which aimed at addressing the research problem. The expected outcomes are presented followed by the methodology adopted.

Chapter Two addresses the conceptual and theoretical framework of the research. It explores the key structuring concepts of the terms “Smart City”, “sustainable city” and “social urban behaviour”, and their underlying theories. The chapter continuous by setting the framework for sustainability giving particular attention to urban realities and how the triple bottom of sustainability; environmental, economic and social, is embedded in the city.

Chapter three provides an extensive literature review on the evolution and current trends of the term “Smart City” and “sustainable city”. An updated portrait of the state of sub-Saharan cities and Southern African cities in particular, is also contained in this chapter, together with a focused look at the cities from the region from a “Smart City” lens, highlighting the features that are relevant in the evaluation and capability of a city to embrace smart initiatives from the universal and well accepted conceptualization of the “Six Key-Fields of the Smart City”.

Chapter four describe the research design, strategies on data collection and analysis and the reasons for selecting the case studies. The variety of data sources has had a positive impact in the diversity and quality of this study, including a review and analyses of peer reviewed papers, books, dissertations, reports, newspapers articles and official documents and policy regarding city planning, management and ICT technologies in eThekwini.

Chapter five defines the case study and describes the background of the research in detail. A territorial analysis of the province has been conducted with a particular focus on relevant urban and peri-urban components such as population, transportation, status of ICT and specifically waste management. The analysis is structured in three layers, provincial, catchment scale and municipal scale.

Chapter six presents the data from the main sources used in the research: GIS, literature and testimonials from the stakeholders involved in the case study. The analysis and results are presented through figures and tables, whereas raw data is organized and categorized in tables included in the correspondent annexure. The meaning of a Southern African suitable sustainable resilience and Smart City has been stressed through the analysis of systems of measurement specific for sustainability, resilience and Smart City. The chapter looks in detail at the socio-political readiness for the implementation of smart initiatives in the province of KwaZulu-Natal based on basic requirements found in the literature which overlap with statistical data translated to GIS models. The case study is detailed mapped and testimonials from the stakeholders, and presence of the case in the media, has been systematically catalogued and analysed.

Chapter seven presents the conclusion and recommendations of the study. The researcher’s findings are discussed and main objectives of the research assessed. It discusses the possibilities for a genuine Southern African approach to the smart paradigm in the seeking of urban sustainable resilience, together with present challenges.

1.9 Expected outcomes

The most important outcome expected from the research is the revision of the concept of resilience of urban settlements in Southern Africa, in a sustainable manner, through the implementation of smart solutions. Moreover, the optimization of means to fight and mitigate natural disasters risks, with special focus on river pollution, through bottom-up solutions, is in the core of the study.

The results of the analysis of the data will lead to a catalogue of recommendations for both, the improvement of the current solutions and the development of a more efficient planning and management.

2 THEORETICAL FRAMEWORK

The thesis is structured over three primary concepts that have become popular in the last years, a sort of mantra to categorize projects in order to make them fit in innovative agendas. The researcher acknowledges the risk of dealing with concepts that have been used without sufficient precision and often abused. Therefore, they have become marketing brands to superficially varnish old initiatives that are not so sustainable, resilient or smart, making them more appealing or even masking hidden agendas.

Consequently, the researcher aims to deeply understand the constructs of smartness, sustainability and resilience for an adequate use of the terms, which will guide the study and help to finding an appropriate research approach, analytical tools and procedures for his inquiry.

2.1 The Smart City

In the last four decades, the term Smart City has gone through a few meanings and conceptualizations. Although academics and policy makers have embraced the concept from different perspectives, there is a common factor that applies to all different views: the acceptance of the city as a key element for the future and the acknowledgement of the fundamental role of the city in social and economic aspects worldwide, but especially the impact on the environment (Mori and Christodoulou, 2012). This is based on the prospects for urban growth already mentioned in this document. Today, most resources are consumed in cities, between 60% and 80% of energy worldwide. The challenges ahead have sparked the interest for integrated solutions with a holistic approach. The complexity of such endeavour set the perfect scenario for the use of new technologies, including ICT. However, the use of the term 'Smart City' has also rooted in many sectors, aiming to make a city 'smart', in which technology is not relevant.

2.1.1 Evolution of the term 'Smart City'

The construct 'Smart City' was used for the first time in the 90's. Back then, the focus was on the impact of ICT on new urban infrastructures. One of the first institutions that tackled the topic was The California Institute for Smart Communities. The interest at that time was fundamentally on how ICT could be embedded in the city planning and make smart (Alawadhi *et al.*, 2012). From purely technology perspective, a Smart City is the one with a strong presence of ICT which are interwoven in key urban services and infrastructural components (Washburn, D., 2010). ICT is therefore infiltrated into a kind of new thinking machines (Klein and Kaefer, 2008). The work of Hancke and de Silva (2013) with available sensors which are utilized for monitoring urban infrastructure and weigh in on a great concerns during application, such as sensors to improving mobility or energy sensors for a more accurate metering and upgrade of 'smart grids'.

A few years afterwards, the idea of smart cities was openly criticised by the Center of Governance at the University of Ottawa for excessive focus on technology. They envisioned the Smart City as an engaging social environment with active linkage with governance, emphasising the importance of social capital and in urban planning (Center on Governance, 2003).

Nam and Pardo (2011) confronted the idea of the Smart City to other associated concepts; ubiquitous, intelligent or digital city, from the social perspective. They examined the label 'smart' in the marketing language. "The term *'Smartness'* is a more user-friendly term than the more elitist term *'intelligent'*. Moreover, *'smart'* contains the term *'intelligent'*, because the smartness is realized only when an intelligent system adapts itself to the users' needs".

In an IBM corporate document, Harrison *et al.* (2010) stated that *"the term "Smart City" denotes an "instrumented, interconnected and intelligent city." "Instrumented" refers to the capability of capturing and integrating live real-world data through the use of sensors, meters, appliances, personal devices, and other similar sensors. "Interconnected" means the integration of these data into a computing platform that allows the communication of such information among the various city services. "Intelligent" refers to the inclusion of complex analytics, modelling, optimization, and visualization services to make better operational decisions".*

The terms 'Smart City' is generally addressed with ideological character in the town planning arena: becoming smarter requires intentional planning. City managers and policy makers at all levels are using the construct to specify a certain level of sustainability, economic competitiveness or upgrade of the quality of life for citizens, and generating joy (Ballas, 2013).

Batty *et al.* (2012) stressed the need to extend the concept of the Smart City concept beyond the diffusion of ICT, to people and community needs, linking the spread of ICT at urban scale to improve the quality of life through the integrated operation of every subsystem.

2.1.2 Predominant trends in smart cities

a) Hard domains vs. soft domains (01-P033)

This multiplicity of visions regarding the Smart City concept is a manifestation of the multiple urban spheres to which ICT and governance can be applied. There is a common consensus on the fact that a Smart City must have the ability to optimise the utilization and exploitation of both tangible and intangible assets. The numerous perspectives to the concept of Smart City are mostly related to two components: one is how cities operate in the aim of optimisation, and another is related to the spheres that are essential for a wise utilization of resources (Neirotti *et al.*, 2014).

The notion of the city as a life factory welcomes the extensive use of technology that facilitates operational centralization and an integrated understanding of urban processes. Consequently, the importance of this approach is on tangible assets: Residential buildings and offices, natural resources, energy grids, energy and water management, environment, waste management, mobility, transport and logistics; and it looks at the way technology can tie together data processing in urban areas. Hard domains denote tangible assets. In these settings, the deployment of ICT systems guarantees an improvement in efficiency and sustainability, along with the inclusion of suitable legislation and town planning. That is to say, with the use of ICT to process ‘‘big data’’, hard domains can be summarized as an interpretation of the city that ‘senses and acts’. (Manyika *et al.*, 2011).

Positions focused on soft domains consider the city as a platform to access data and enables inhabitants to make their own choices. Therefore, they emphasize the importance of strengthening intangible assets: human capital, organisational capital in public administration bodies, and intellectual capital of companies; in which the role of technology is minimized and not considered essential to process and integrate real-time information. Culture, education, policies that promote entrepreneurship, social inclusion and innovation, are examples of soft domains. Fluent communication between local public administrations and the people is considered fundamental and areas to firmly build with the assistance of ICT. Thus, soft domains oriented smart cities are the leeway for creating social values.

b) Top-down vs. Bottom-up (01-P035)

Odendaal (2016) indicates that "technologically determinist notions tend towards a top-down approach that favours the 'if you build it, they will come' notion of technology-led policy". Top-down initiatives happen to be orchestrated at the back of the citizen. The city management becomes a market niche for big technology corporations that get the ear of the policy makers with promises of efficiency and sustainability goals achievement through the implementation of smart products. This market is generally globalized and the brochures contain standardized solutions with worldwide adoption capacity. Research groups working on specific technological applications for smart cities and international events such as World Intelligent Cities Summit and Smart Cities Summit, tend to neglect the essence of the place, the genius loci.

Some authors emphasise the role the Smart City as empowerment of community, and highlight the capabilities for connection rather than control (Nam and Pardo, 2011). Inspiring a sense of community among citizens is usually achieved through bottom-up knowledge schemes. The significance of this feature rivals the concept of smart communities where citizens and institutions engage to change their environment (Berardi, 2013). This indicates that the citizens of a Smart City need to feel the wish to endorse a (smart) development. In fact, bottom-up initiatives are mostly driven by the civil society. Grassroots movements, technology enthusiasts and forward-looking software developers take part in developing and using Smart City services and applications. Non-profit and public organizations also participate in the Smart City dialogues, such as the case of the World Bank and the Intelligent Community Forum.

c) Technology push vs. demand pull

The advancement in ICT in recent years has generated feasibility in the expansion of a massive selection of products that pursue to make possible the Smart City. The technology drive suggests new products are launched as a consequence of fast technological and scientist developments. The availability of new solutions is therefore irrespective whether they are needed (Angelidou, 2015). A estimation technologies to support Smart City development related products by Navigant Research (2011) accounts a market volume $100 billion worldwide in the following ten years..

These product focused methodologies for the successful Smart City highlight the need for an array of 'smart' products for the monitoring urban utilities management and urban environment in areas such as energy, transport, health care, water and waste. The background is a lively market of such products. The trend has been boosted by the growth of the knowledge and innovation economy, which has lead to a radical change in the way knowledge, becoming a product itself, is accomplished in cities.

The demand pull regards to solutions developed through academic research and further marketed as a response to social demands. The urban challenges of the 21^{st} century can be summarized in rapid urbanization rates, the climate change, the impact of the recent financial crises, the aftermath of the COVID-19 pandemic and the impact of globalization (Angelidou, 2015), affect in different ways different cities around the world: global north vs. global south, developing economies vs. recession economies, consolidated democracies vs. recent democracies, free vs. non free states, etc. In order to overcome these challenges, governments will have to offer custom-made services. Local governments epitomize the imperative pull for the Smart City dialogue (Wolfram, 2012). Cities want to take advantage of the promising effectiveness and excellence that technology brings in urban systems. They seek to achieve economic growth and investment attraction, social Inclusion, quality of life, and prestige.

At the same time, the innovation economy and knowledge, which is now produced and distributed collectively, have allowed for a high level of penetration of technological developments in the common culture. In this context, new ideas are produced throughout social collaboration allowed by technological networks (Komninos, 2009). As Angelidou (2015) points out, "the broad input of knowledge, creativity and collective intelligence of the populace underpin further knowledge creation and enhance innovativeness the multi-perspective confrontation of the city's problems and the delivery of new and improved services. On the whole, governance becomes more efficient, advances progressive urban change and yields broader acceptance and proper uptake of Smart City solutions".

2.2 Urban sustainability

Undoubtedly, the concept of 'sustainability' is used without sufficient correctness, and therefore, often misused. This section aims to look at the concept of sustainability, and more specifically urban sustainability, from the widest perspective in order to set the foundation for the further analysis on the SSA context.

In this current era, urban processes have attributed causal significance in generating global challenges including climate change, ecosystem degradation, peak oil, systematic inequality, food insecurity and persistent poverty, and energy transitions (Swilling, 2011). The understanding is that these challenges now have their roots in specifically urbanised patterns of accrual, consumption, and interaction. Simultaneously, cities and localities are now portrayed as having all kinds of prospects and potentialities for rearranging those global processes (Barnett and Parnell, 2018).

2.2.1 Evolution of the term 'sustainability'

The origin of the concept of sustainability is agreed to date back to 140 years ago from the idea of "spaceship earth" (George, 1881). Present conceptualizations of sustainability can be related the late 19th and early 20th century conservationist movement, in particular from German foresters and their ideas on forest management: "*sustained yield*". Fundamentally these techniques consisted in selectively cutting certain old trees from a forest while leaving others to grow and perpetuate the forest community. This vision impacted natural resource scientists such as Aldo Leopold who further developed German forestry concepts; his believe of a "*land ethic*", a human liability to care for ecosystems and land, discussed in *A Sand County Almanac* (Leopold, 1949): *"species and ecosystems have intrinsic value in their own right and should be sustained indefinitely into the future".*

After World War II period, a number of writings and essays such as Fairfield Osborn's *Our Plundered Planet* (1948), William Vogt's best-selling *Road to Survival* (1948), Rachael Carson's *Silent Spring* (1962), and Barry Commoner's *The Closing Circle* (1971), environmentalist who pointed out concerns on the global ecological situation, setting the stage for explicit discussions of sustainability. They argued that pollution, wasteful resource use, the accumulation of toxins in the environment and overpopulation, were jeopardizing the future of many species, including humans, and their work sparked the creation of a strong environmental movement worldwide. The publication of *The Limits to Growth* (1972) by Donella Meadows, Dennis Meadows, John Forrester and Jurgen Randers helped catalyze the discussion about global patterns of population growth, pollution, agricultural production and resource use, and how the trends in human practices would lead to a collapse in the 21st century. In addition to this, the UN (1972) Conference on Environment and Development helped to pay global attention on environmental matters and associate the increasing ecological concerns to patterns of industrial development.

The literature on sustainability got one of its strongest impulse in the late 70's from the Worldwatch Institute, with the publishing of multiple articles regarding global topics: soil erosion, depletion of non-renewable resources, deforestation, overpopulation and overgrazing; and steps toward sustainability. At that time, futurists, social critics, and new age writers further equipped the way for debates on sustainable development by critiquing existing ideas of development and looking for more specific forms of paradigm change. Books such as Marilyn Ferguson's *The Acquarian Conspiracy* (1980), Theodore Roszak's *Where the Wasteland Ends: Politics and Transcendence in Postindustrial Society* (1972), David Spangler's *The Rebirth of the Sacred* (1984) and Alvin Toffler's *The Third Wave* (1980), suggested that *"an alternative to existing development patterns was inevitable and necessary",* highlighted the natural, the human and the spiritual over values of profit and conventional economic growth. Many other writings, such as Marge Piercy's *Woman on the Edge of Time* (1976) or Ernest Callenbach's *Ecotopia* (1975) also assisted to create images of what a sustainable society would look like, from specific topics like ecology, forestry and agriculture to very utopian work: self-feeding communities through organic agriculture, or alternative energy sources.

The subsequent breakthrough in the conceptualization of sustainability emanates from the International Union for the Conservation of Nature's influential World Conservation Strategy (IUCN, 1980). Their positions continue the preceding approaches on raising the flag on global environmental difficulties due to the exiting notion of development, although generally accepting economic growth, which improved the reception from mainstream governmental officials and academics, giving to their findings, particularly those contained in the World Commission on Environment and Development, (the Brundtland Commission) and the report Our Common Future 1987, a voice of substantial authority getting further the "alarmist" reports of the Limits to Growth.

The Brundtland Report gave rise to what is now the standard definition of "sustainable development" and entwined many current concerns and challenges, including resource exploitation, wasteful energy use, urban decline, poverty, militarism, and the destruction of environmental systems. The Commission determined that equity issues and other Third World fears needed to be addressed, but did not put these as the aim of its work, which remained centered on world-wide environmental problems, population growth, and resource exhaustion. However the Brundtland method has been condemned for being anthropocentric as well as too tolerant of existing economic models and the concept of continual economic growth. The report defined sustainable development as the “development that meets the needs of the present generations without compromising the ability of the forthcoming generations to meet their own needs” (UN, 1987). The 1992 U.N. Conference on Environment and Development, otherwise referred to as the Earth Summit, produced an increasing global agreement on the necessity for sustainable development, and codified many connected principles in the long document known as Agenda 21 (Keating, 1993).

Hart, Milstein and Caggiano (2003) defined sustainability as “the prospects of improving the social and environmental performance of the current generation without compromising the ability of forthcoming generations to meet their social and environmental requirements”. To Dyllick and Hockerts (2002), sustainability embodies the development of society and advancement of a prosperous and happier world where cultural endeavours and the natural environment are earmarked for generations to come.

2.2.2 Predominant trends in sustainability

Taken into account the aforementioned narratives, and the fact that most scholars share common concerns, it is important to point out how shared foundations and outcomes can also be addressed through big differences in the approach to achieve them.

a) **Growth vs. degrowth.**

These antagonist positions summarize an intense debate between those who believe in technology and economic growth and who blame on economic growth the barrier to a sustainable development. The first one fits in well with the mainstream conservation movement in the Global North. Technocratic approaches aim to achieve ecological goals by quantifying environmental impacts, regulating private industry more effectively, fine-tuning government policies, and adjusting market mechanisms. They have access to detailed scientific, economic and policy analysis. On the opposite, others believe that sustainability is essentially irreconcilable with current trends on economic structures, attitudes, and lifestyles. A sustainable society must be based on highly self-sufficient and small-scale local economics, and on zero economic growth (Trainer, 1986), which requires an integral transformation of economy, society and lifestyles.

b) **Ecologist vs. socialist**.

There is tension between focusing on ecological crises and emphasizing social needs. Again, societies from the Global North tend to fall into the first vision whereas the need for development and caching up in the technology race in the Global South pushes in favour of the latter.

c) **Static vs. dynamic visions**.

The notion that ecological systems naturally arrive at a point of balance has been recently disputed by authors who consider that ecosystems are constantly changing and have no "natural" point of balance. The debate has important political implications. The first approach tends to set the importance on political efforts to overturn social and environmental degradation and get to the balance point. On the contrary, the second approach leads to the acceptance of ever-shifting ecosystems where the impact on political decision has little effect in potential changes, reducing the sense of political urgency.

d) **Vernacular sustainability vs. vernacular unsustainability.**

Indigenous peoples are seen as role models of sustainability. On the one hand, many radical ecologists concur with the International Society for Ecology and Culture that "traditional societies are the only tested models of truly sustainable development" (Norberg-Hodge and Goering, 1992). On the other hand, others argue that indigenous peoples typically behaved with frequent waste of resources due to abundance at past times, with no sense of future limitations which is considered ultimately unsustainable.

In practice, advocates of sustainable development often have complicated mixtures of interests and viewpoints. While it is important to be aware of certain common gathering points on the political terrain and certain common rifts between the parties, the debate over sustainability is a complex and multidimensional one that is rapidly evolving.

2.3 Urban resilience

2.3.1 Evolution of the term 'resilience'

There is a conceptual blurriness in the terms 'resilience' that plays in its advantage to be perceived as a "boundary object", shared by multiple social fields and therefore, able to promote interdisciplinary collaborations. This flexibility in its meaning allows different actors to engage around a common term without even sharing the view on the exact definition of resilience. However, this ambiguity can bring difficulties to practically define indicators for its measurement (Meerow, Newell and Stults, 2016).

The modern theory on resilience is frequently associated to the research paper about resilience of ecological systems "Resilience and Stability of Ecological Systems" by Holling (1973), who used resilience to outline the capacity of an ecological system to functionally "persevere" when altered, but not to inevitably stay the same. In contrast, "engineering resilience" considers resilience the ability of a system in equilibrium to relapse to such state of equilibrium after a disturbance. On the contrary, resilient socio-ecological systems have the capacity to absorb disruption and reorganize at the same time, maintaining functional capabilities.

Holling's conceptual definition expanded to "a way of thinking". Consequently, resilience progressed to become a normative vision and not just a characteristic that could be measured (Meerow, Newell and Stults, 2016).

Many ecological and socio-ecological systems research have tackled the resilience theory, and thereafter, the application of resilience to other focus areas increased, including natural disasters and risk management, climate change adaptation hazards, international development, engineering, energy systems and planning, to name a few. The urban resilience literature is extensive to a large variety of fields, from urban theorists, urban ecologists, to social scientists which can be grouped in two principal categories: conflicts attributed to climate change or hazards and disasters.

Urban resilience refers to the capacity of urban systems, their components and networks, namely ecological, technical and social, to withstand or rapidly recover a determined functional status after facing a commotion. Within temporal and special scales, the system is able to acclimatize and adapt to future demands of capacity (Meerow, Newell and Stults, 2016).

Over the last few years, resilience has become a core topic regarding any discussion on urban development. International institutions for development together with humanitarian matters have adopted resilience as part of the very foundation for strategic intervention at technological and economic level. Resilience focuses on both, the response of urban systems at all levels; citizen and communities; infrastructure and business; and also addresses the opportunities for transformation through development. It is this look at the future what makes resilience a constituent part of sustainable urban development or even the driver for element of development. Adopters of resilience as the steering force for development acknowledge the city as vibrant and multifaceted systems expected to acclimatize to multiple challenges in a cohesive and holistically way (UN-Habitat, 2015).

It seems clear now that environmental stress has a tremendous impact on urban areas and testes the level of resilience of cities in multiple manners. Ecosystem degradation and resource scarcity coupled with endogenous socio-economic stresses such as unemployment, poverty or low housing quality.

Despite the increasing focus on the resilience theory as a beacon to address extraordinary changes in climate and urbanization patterns, urban resilience remains a challenged concept and lacks clarity due to contradictions and vagueness (Meerow, Newell and Stults, 2016).

2.3.2 Predominant trends in urban resilience

a) Top-down vs. Bottom-up

The pressure between top-down versus bottom-up visions is at constant debate regarding environmental challenges. A risk professed as minor by some actors might be seen as priority by others (Borie *et al.*, 2019).

Despite the fact that science and technology are unevenly distributed and perceived, with strong social and cultural implications, information presented by natural sciences addressing natural hazards are perceived as more reliable and therefore easily accepted than other approaches to understand the phenomenon. However, in opposition to this direct science-policy relation, some voices have stressed the necessity to reorder knowledge and acknowledge local understanding (Borie *et al.*, 2019). A sample of this may be found in the ASPIRE (A Sustainability Poverty and Infrastructure Routine for Evaluation) toolkit developed by Arup and Engineers Against Poverty (EAP). This initiative seeks for the integration of the agendas of poverty alleviation and development for community-based projects related to infrastructures (Woolf *et al.*, 2016).

The responsibility of addressing issues of public concern lies under the domain of government technocrats who wish for holistic solutions to natural and economic hazards. The use of high technologically implemented plans leaves out disadvantaged segments of the population. These top-down initiatives prioritise in favour holistic benefits and overseen social matters that might affect the disadvantaged.

b) Conservative vs. Transformative

Policy preferences are biased towards short term concerns over economic growth and sectorial approaches or long-term solutions. The understanding of resilience as a predominantly protective strategy stands against the idea of challenging the established development practices and processes, with the aim of transformation. Narratives focused on natural hazards management and engineering are at the core of resilience organize top-down methods. They tend to prioritize strategies that aim the upgrade of the existing status quo instead of making room for new alternative strategies (Borie *et al.*, 2019).

The drivers of conservative approaches are concerns over infrastructure and security whereas transformative trends stress the values of nonprofessional knowledge and the potential of participatory processes that might have the capacity to empower alternative actors able to increase transformative results, and consider. Transparent procedures are considered key to guarantee that resilience is accepted as genuine by the communities whose future is affected by these (Borie *et al.*, 2019).

Emancipation narratives, associated with bottom-up approaches, articulate resilience as an instrument to challenge mainstream positions and public plans for the city. Science is an assistant to embrace alternative strategies for cities to strength linkage with nature and connecting environmental and social sustainability to resilience (Borie *et al.*, 2019).

c) Modernization vs. Environment

Modernization implies the use of science and technology, based on their capabilities to observe, anticipate and foresee, to implement the idea of progress in resilience planning. Despite these strategies being focused and efficient, their tendency is to close down different ways of performing. Alternative emerging opinions coexist with combined narratives and establishments.

Quantitative approach to problem solving detaches these initiatives from environmental issues, especially those regarding the interaction of people: social cohesion and the need for emancipation, which find place in trends with a stronger environmental character. Placing the spotlight on the environment enlarges the scope of resilience, including diverse scenarios interacting in multiple feedback loops.

d) Security vs. Social justice

The source of knowledge and how it is setup has an important impact on the role of science and technology when applied to resilience planning related to urban areas. Science can either encourage or obstacle understanding between stakeholders. Security trends line up to visions of protection, either the economic or natural ecosystem. They are usually characterized by a technocratic essence, which is geared towards systematic approaches.

Information and instruments from natural sciences are typically professed as more reliable and appealing. Despite local or qualitative knowledge are omitted, they would allow other relevant factors and perceptions of resilience to be noticeable. This could assist, for instance, to find out reasons or persistent settlement in areas indicated as dangerous in geo-hazard maps (Borie *et al.*, 2019).

In order to plan for resilience, more attention needs to be paid to issues of justice, place, identity, culture and, to be specific, frameworks of higher inequality and poverty. Methods such as calculated mapping and participatory processes, accompanied by conventional planning instruments, can assist in the understanding of diverse point of views and values and build up more inclusive methods (Burgess et al., 2007; Meerow, Newell and Stults, 2016). Trends with social justice approaches develop more open science methods linked to transformative approaches. Where dialogues are structured around social justice, science and technology are capable of giving voice to the marginalized and vulnerable, and help to challenge the opinions of public authorities.

2.4 Convergences between theoretical positions on Smart City, Urban Sustainability and Urban Resilience. A summary for Southern Africa

The three primary concepts around which the thesis is structure have gained popularity within the urban arena in the last decades, at the point of becoming part of marketing strategies for aspiring innovative agendas: Smart City, Urban Sustainability and Urban Resilience. Therefore, the researcher seeks to deeply understand these constructs for an adequate use of the terms. Moreover, it is important to contextualize these concepts within the Southern African region as they have been used without sufficient precision and often abused. A meaningful understanding of what sustainable, resilient and smart represents for the region starting from a compilation of narratives and subsequent practical application in the urban context.

The conceptualizations of sustainability, resilience and smart city are diverse and many points of view seem to merge or collide within one of the three overarching umbrellas. Opposite visions claim to hold the pennant and therefore, it seems important to approach them from with clinical attitude and learning who is who prior to take positions about suitability for a region at the dawn of urban development. A taxonomy of each can be found in annexure 1.

The plethora of definitions and theoretical concepts included in this chapter has been cross-referenced with the purpose of finding common positions for all three fundamental topics studied in the chapter: Smart City, Urban Sustainability and Urban Resilience. These several conceptualizations can be classified in seven categories (see Table 1): integrative, imposed, future, economic, environmentalist, participatory and human capital.

Table 1. Classification of narratives on Smart City, Urban sustainability and Urban Resilience

SMART CITY	URBAN SUSTAINABILITY	URBAN RESILIENCE
Integrated city	Environmental problems first	Natural hazards
Intelligent city	Negative sustainability	Social Cohesion
Knowledge city	Positive sustainability	Planning Ahead
Social gain	Small planet	Technocratic Resilience
Quality of life	Holistic and dynamic view	Co-Producing Resilience
Competitive city	Balance between environment and economy	Emancipation
Sustainable development	Intergenerational solidarity	Full display
e-Governance and public participation		Environmental feedback loops
Neoliberal discourse		

Integrative	Imposed	Future	Economic	Environmental	Participatory	Human capital

Integrative visions approach the city from a holistic perspective and don't concede particular emphasis to specific components but the interaction between all elements of the city. The boundaries between governance, technology, economy and citizen are rather blurry.

Imposed narratives look at the citizen as an entity to be managed and governed. These visions have little trust in public engagement and strategies are through top-down processes. Elite of technocrats makes the decisions motivated by the lack of technical knowledge of the common citizen.

Another group of narratives identified across the three topics focus their actions on the consequences that these may have in the **future**. It is strongly linked to the very meaning of sustain. These narratives consider the implementation of restricting actions and constrains in the present for the sake of a better future.

Economic narratives are possibly the most honest of them all and align to the fundamental reason for the existence of cities. For the same reason, they lack of touch when considering other priorities of human nature. Decisions turn around economic performance and some compromises are to be met with social and environmental matter.

Environmental narratives focus on the impact of urban realm on nature, particularly natural hazards and ecosystems damage. Preserving a healthy environment under control allows for potential economic growth and quality of life. The environment is the key for the city life.

The citizen is at the core of **participatory** narratives. At the time of decision making, no class is preponderant. Through participation, citizens gain responsibility for their own destiny.

Technology and knowledge are at the service of processes that give voice to all citizens, breaking barriers and strengthen social cohesion.

Knowledge development is the key for a well performing city in narratives grouped around **human capital**. Creative citizens are more likely to impact positively on decision making and participatory processes.

Historically, imposed strategies have been implemented in Southern African cities. Colonial governments did not recognize the same rights for the majority of the population, restricting decision making to the colonial elite. This was exacerbated in South Africa during the apartheid regime. The choices in the area may be constrains to historic problems as well as current challenge to follow the pace of global development. For instance, narratives that look at a better future would be put on hold as big efforts are to be made to secure a stable present, hampered by poverty, economic performance, service backlogs and lack of education. In fact, there is a vivid debate on setting the boundaries for environmental damage to achieve economic growth, employment creation and poverty alleviation.

Participatory processes that give voice to the citizens are typically driven by middlemen in the form of NGOs or governmental offices which makes room for a risk for bias and misinterpretation. There is an evident lack of self-organized civil society. Moreover, digital literacy may be seen as a condition for the implementation of initiatives based on participation.

Despite traces of economic growth, these records give evidence of an increase of inequality which means that decisions framed into the prioritization of economic performance benefit only a small portion of the population, with the majority still unemployed or in vulnerable employment.

It might be naïve to expect that a sole particular position would be applicable to the region. A combination of different visions from a local perspective could bring steady progress to Southern African cities. For instance, creative and sustainable industries that may tackle economic growth do not necessary fit into the world narrative of development through manufacturing. Human capital, economy and environment could coexist within a highly integrated urban development framework.

As shown in section 5.2.3, access to ICT is very poor in the region. The aspiration of an informed citizen able to contribute to the discussion of a desirable city is a challenge. The access to information is very weak, generally reduced to radio and terrestrial TV for the majority. This sets the citizen in a passive position whereas the possibilities for contrasted information and source comparison is limited to an average 40% of the urban population.

3 LITERATURE REVIEW

3.1 The Southern African city today

Southern Africa, lately considered as the last frontier for investment, tend to be presented with confusing bias in order to attract foreign capital. This approach leads to a blurry vision of the reality and chaotic and problematic situations that only aggravate the challenges and difficult development. This section reviews literature from academics and reports from international institutions with an extensive body of work related to the region. Understanding the Southern African city becomes essential for the success the prioritization of problems and implementation of technology.

3.1.1 Understanding the Southern African city

In a globalized world, the use of the same language can lead to misunderstandings, taking for granted a set of concepts automatically associated to words. It is acceptable worldwide to understand the word city as a defined territory with a highly densify concentration of people, present of second and tertiary sector, absence of primary sector and common services and infrastructures managed by a reduced group of people in comparison with the entire population of the city. Nevertheless, the way each and every element is present or absent in the city, the relationship between them and the performance of each of them define complete different scenarios across not only different regions of the world but also even within the same country in some cases.

Southern Africa has suffered for centuries of imported-imposed foreign technologies, not only foreign due to origin but most important, due to conceptualization. It is not rare to find buildings designed in Great Britain or Holland in the 19th and early 20th century, built in Southern Africa with South orientation whereas the sun in the Southern hemisphere goes through the North. It is a reality difficult to deny that in the case of underdeveloped regions of the world, new technologies are mostly to be imported. It is then the selection of available technologies and the way to implement them that matters. This research must look at the local features of the Southern African city in order to avoid, once more, another foreign approach with little impact.

In fact, the features that define the Southern African cities and differentiate them from not only the Global North or developed regions but also other developing regions of the world such as Asia or South America, are rather overwhelming.

There is a Zulu term for city: *esilungwini*. It means “the place of the white man” or “where the white man stays”. It pictures very clearly the origin of the relationship of indigenous African people with the western concept of *polis* inherited from Greece, which still relates to the nowadays concept of city. This culture clash, together with the socio-political events in the last 350 years, from Dutch colonization, going through British military protectorate, to apartheid economic dictatorship based on a racist organization of the state, to finally transit to faulty democracies under pressure of neoliberal powers, have lead to a series of features that apply specifically to the Southern African city.

Through an extensive literature review, this section extracts a set of urban features that are not likely to find in the Global North but very present in developing countries, with different origins though.

a) The concept of urbanization and its misleading application to Southern Africa

The process of urbanization is generally associated to the increase of population living in urban areas. When urbanization is addressed as a demographic event, it is typically misleadingly depicted as equivalent to urban population growth (Mcgranahan and Satterthwaite, 2014). The Population Division of the Department of Economic and Social Affairs of the United Nations includes a more integrated definition in the 2018 Revision of World Urbanization Prospects: “Urbanization is a complex socio-economic process that transforms the built environment, converting formerly rural into urban settlements, while also shifting the spatial distribution of a population from rural to urban areas. It includes changes in dominant occupations, lifestyle, culture and behaviour, and thus alters the demographic and social structure of both urban and rural areas. A major consequence of urbanization is a rise in the number, land area and population size of urban settlements and in the number and share of urban residents compared to rural dwellers”. This conceptualization of urbanization not only considers the geographical location of the population but also critical changes in the built environment and sociologic implications such as types of jobs, culture and lifestyle implications.

Therefore, the level of urbanization in a region risks to be wrongly interpreted based on demographic trends only. The case of Southern Africa is a good sample of misleading urbanization increase. A pocketful of megacities host most of the urban population, poorly connected to each other due to the lack of infrastructures and services delivery out of the urban boundaries.

b) Dysfunctional megacity.

- Colonial city. Large and dominant nationwide.

Despite high rates of urban population growth, the colonial city model in which one large city, dominant nationwide and usually the capital has the political power, the economic activity and most of the population. This one city is several times bigger than the next largest city and receives most of attention and resources in comparison to other urban centres and towns throughout the country (Güneralp *et al.*, 2018). Unplanned and unregulated growth characterizes the urban expansion in Southern Africa, aggravated by the legacy of colonialism, structural adjustment and neo-liberal policies with the result fragile town planning institutions (Parnell and Pieterse, 2014).

Generally, Land government in Southern Africa is typically addressed under ex-colonial legal frameworks and indigenous customary laws. This sets differences between citizens depending on the location of the residence affecting legal rights (Mandani, 1996). The implications in terms of spatial distribution are considerable: colonial-era and modernized urban areas depend on formal land government frameworks, whereas rural areas with mostly poor and low-income indigenous African residents depends on informal land government (UN, 2014). In between of the two systems mentioned, informality can be seen as a tactic and strategy of governments to contain the 'ungovernable' and politically manipulate urban space (Yiftachel, 2009).

- Decay of Central Business Districts

The shift of the residents profile in the Central Business Districts (CBDs), with different lifestyles and lower income, led to a progressive decay of the Southern African urban centres after independence and the end of apartheid. Householders changed drastically the spatial configuration they were used to, from standalone homesteads to apartments' blocks. Lack of agreement in building maintenance duties among the new householders, and lack of maintenance from landlords due to lower rental incomes led to a progressive decay of the housing landscape. Together with this, a shortage of public investment, on one hand intentionally neglecting zones owned by the former oppressors and on the other hand, paying more attention to traditionally disadvantaged zones and the new housing delivery programs. This led to a progressive decay of the urban fabric.

It is important to highlight the clash of zoning unable to acknowledge population growth, with industrial and residential sharing the space. Planning is developed under pressure from the private sector instead of determinant decisions for the common good. Public and private sector are now focusing on urban rejuvenation with a number of initiatives happening in the CBDs. However, there is a high risk of gentrification, especially in private developments. The public statement from most local governments on agreement with the Goal 11 from UN-Habitat III for a more sustainable and inclusive city is incoherent with the real trend.

- Fragmented city

High levels of sprawl in Southern African cities are a sign of inefficient land-use planning and management, and leads to increased costs of basic urban services provision: electricity, water, mobility and waste management, through centralized structures as well as goods such as food (UN, 2014).

The racially segregated population distribution patterns reflected spatially, are the remaining from the colonial era and later apartheid governance, aggravated by an additional class-based socio-economic segregation (Hart, 2002). Endemic challenges in Southern African urban contexts: housing delivery and service provision and land availability, are responsible for the persistence of social inequalities and spatial segregation (Robinson, 2008). The historic poverty of rural areas in Southern Africa is now shifting to increasing poor urban settlements (SACN, 2011b).

- Infrastructure backlogs/deficit

Urban services provision in Southern Africa is troubled by great infrastructure deficits due to lack of adequate adaptation and preparation for the increasing population (UN, 2014). This situation, in combination with severe financial challenges, lead to a scenario with immense budgetary pressure on existing infrastructures and prioritization strategies. Private stakeholders come to public decision-makers with promises of investment and development in major infrastructures: airports, business parks, railways, and typically get on top of the local approvals pile. The sectors boosted by these investments affect very little to the public good and the result is an uneven distribution of revenues and the problems affecting the majority of the population: poverty, housing and employment to mention a few, remain unsolved. This effect generates a cycle in which the wealthy population, owner of privatized infrastructures, continuo to segregate themselves, with the help of new technologies, from the urban dynamics and rest of the population. Not affected by service provision deficits in their new privileged gated estates, these wealthy citizens lobby to resist investment in the public good (Pieterse, Parnell and Haysom, 2018).

Energy supply deficit is the most prominent infrastructure shortage. This is aggravated by lack of transport systems, water networks, ICT to mention a few (APP, 2015). There is 3.6 Km of road per 1000 persons (AfDB, 2013) in comparison with the world average of 7 Km per 1000 persons. This situation aggravates when analysing the location of the current infrastructures, typically in areas where utility bills can be paid, hence settlements of the urban elite (Pieterse, Parnell and Haysom, 2018). Mobility deficits are especially significant in African contexts due to the impact of urban sprawl in the distribution of the population throughout a vast territory.

c) Socioeconomic challenges

- Informality

The deepest mean of the city is ultimately the achievement of a well planned piece of territory, in order to harmoniously organize all resident actors and their interaction. The business niche for the Smart City industry lays on the optimization and improvement of such interaction. Informality is considered a failure and needs to be eradicated. Nevertheless, the overwhelming scale of urban informality in Southern Africa leads to consider informality a feature rather than an anomaly to be fixed. The contribution of the informal sector to the GDP in the area exceeds the 50% in several countries. The informal employment constitutes the 66% of non-agricultural employment. This situation leads to the formal sector to lobby and pressure the governments to criminalize the informal sector rather than engaging and negotiate a transition from informal to formal (Skinner and Watson, 2019). Despite the figures, the current trend in policy making addressing informal economy appear to be creating condition merely for an informal economy of survival rather than an economy of growth (Rogerson, 1992). However, the investment addressing the improvement and upgrade of informal settlements put a high pressure on the public budget (Boaden and Taylor, 1992). The vision of the informal sector as a chaotic outlaw socio-economic system operating under a high level of randomness is aligned to one: the inability from the public sector to recognize failure; and second: the aforementioned pressure from formal economy agents. The reality is that the informal sector tent to organize and gather in multiple associations with the aim of having a voice and be part of the urban discussion. Taxi associations, street vendors and waste pickers are a good sample of informal guilds organizing themselves in associations of different scale, from urban to international, in order to enter the urban policy and planning venue, as well as social protection and public health systems. These scenarios are often overlooked because the role as worker is invisible (Bonner *et al.*, 2017).

- Consumers behaviour and fragmented retail market

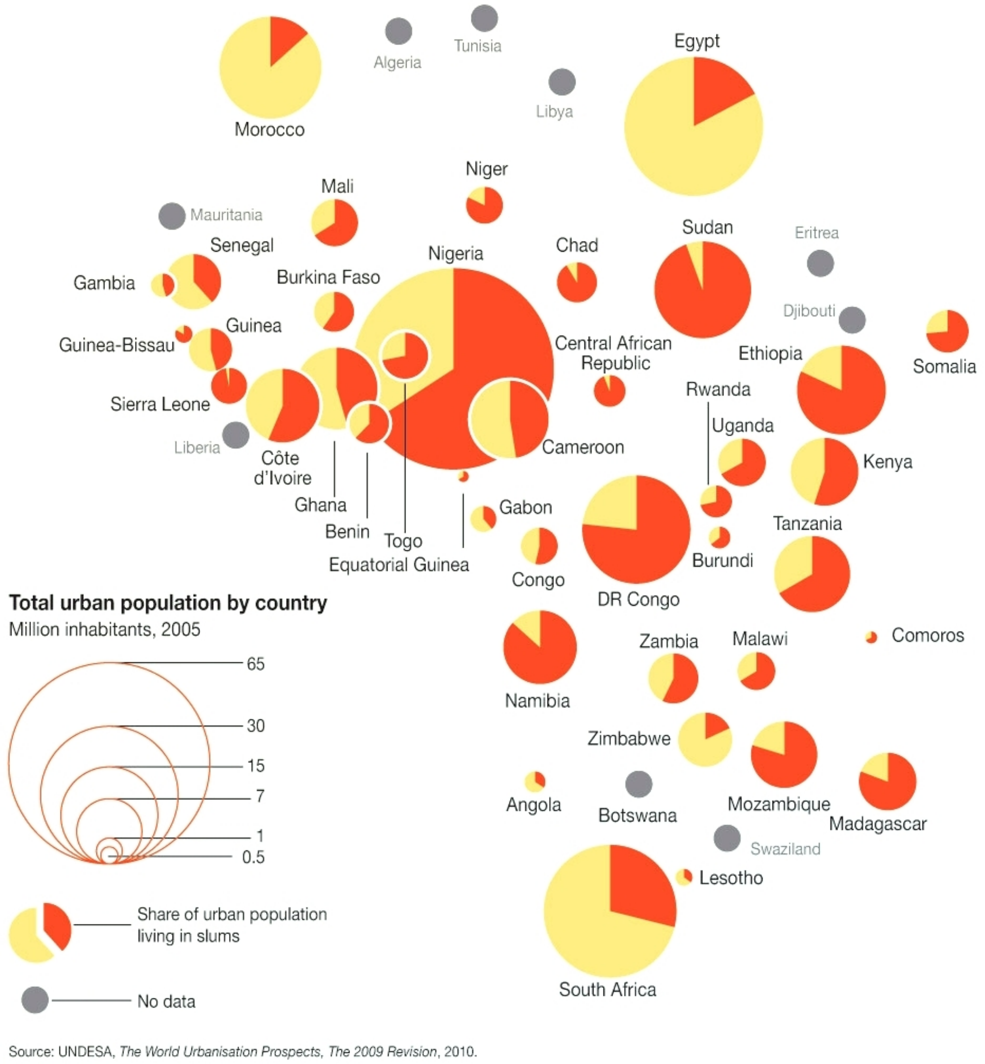
Consumer behaviour changes from one region to another. In-country teams are fundamental to gather consumer insight and conducting pilot projects. In the case of the Consumer Packaged Goods industry this is absolutely essential due to the high competition based on high market saturation and low consumer switching costs. While the majority of Angolans look for the better price, only 27% of Kenyans do it (Hattingh *et al.*, 2012). Lagos consumers perceive low-price food to be of questionable quality whereas consumers in Nairobi wouldn't be reluctant to buy discounted food.

Nigerians have a big concern about disclosing their home address or paying online. They feel more comfortable exchanging products for cash. Nigerian e-commerce pioneer Konga established pickup locations and "pay on delivery" services. Jumia, another e-commerce platform, also accept cash on delivery.

Africans buy groceries from local vendors and independently owned convenience stores. The presence of big supermarket chains is low in most countries with the exception of South Africa where supermarkets hold a 75% of groceries sales (Agyenim-boateng, Benson-Armer and Russo, 2015). This fragmented scenario forces companies to employ a big number of salespeople to build relationships with thousands of small retail outlets. Key drivers for succeeding in this business environment are metrics tracking and updated database building related for instance to productive call ratio (the percentage of calls that end up in orders) and effective distribution ("out of stock" products dynamics).

- Informal land use management/imposition

Most countries in Southern Africa are former British colonies. Their cities were planned based on British spatial models and land use zoning criteria. Traditional mono-functional zoning demarcated the area into five land use zones, namely residential, business, education, tourism and industry, (Watson, 2014), with a car-dominated traffic mobility, aiming to meet the ideal image of a modern British city, whereas only 18% of South Africans have a driver´s license. This single-use zoning approach clashes with the acceptance of informality. For example, urban farming and homes as workspace has been historically banned in the colonial planning (Skinner and Watson, 2019), repressed on the ground of public health concern, which has been used as an excuse for repressing also informal housing and informal economy. However, informal food markets have a decisive role on food security and access to fresh food for the poor, forced to consume highly processed nutritionally poor foods, leading to obesity and diet-related diseases (Rogerson, 1992; Bhan, Goswami and Revi, 2017).



UN-HABITAT defines a slum household as a group of individuals living under the same roof in an urban area who lacks one or more of the following: 1. Durable housing of a permanent nature that protects against extreme climate conditions. 2. Sufficient living spaces, which means not more than three people sharing the same room. 3. Easy access to safe water in sufficient amounts at an affordable price. 4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people. 5. Security of tenure that prevents forced evictions.

Figure 1. Slum population in Africa. (UNDESA, 2010)

The majority of urban Africans live in slums: 61.7% according to UN Habitat. Land management in the informal sector is also subjected to under covered forms of power: Informal leaders' power emanates from the control over the land. To retain power, the leader must retain control over the settlers, whose ownership of the land is not accepted, leading to tenure insecurity and therefore inability to prove residence on paper and line of financing (Bhan, Goswami and Revi, 2017). In addition to this tenure uncertainty, tribal land adjacent to the city logical expansion areas, experience a similar situation. The chief is the 'gatekeeper' of the land.

The land therefore constitutes his source of power and any alteration of the integrity of the land represents an alteration of his power (Boaden and Taylor, 1992).

- Inequality

In spite of the economic success of Southern Africa regarding GDP growth, widespread inequality and social fragmentation characterize the primary condition of Southern African cities. This good economic performance a macroeconomic levels, resulting from urban economies, has been unable to increase income levels and living standards at regionally which encloses a considerable socio-political risk (UN, 2014).

Instead of implementing strategies of collaboration with informal settlers, governments prioritize their strategies on the elimination of slums with no alternative plans for relocation considering employment opportunities and decent living condition. These residents are typically displaced to the outskirts of the city, bearing with intensified pleasures derived from longer distances to commute, even lower level of service provision available, particularly social and healthcare. The poor is considered the problem to solve and lack of holistic vision of urban problem makes perennial underlying structural inequalities (UN, 2014).

The increasing level of inequality and fear of social conflict is translated to physical spatial planning: proliferation of gated communities with their own amenities and high securitization provided by armed private security companies (Lemanski, 2004). These gated estates for the elite reflect the aspirations for a lifestyle detached from the urban reality 'polluted' by the unavoidable poor (UN, 2014). As Pieterse (2019) eloquently summarized, "there is an unmistakable backlash against the so-called rules-of-the-game that has produced unthinkable levels of inequality and a deep sense of cynicism in part because elites deploy the rhetoric of liberal democracy to mask unjust enrichment and large-scale social stagnation or exclusion".

- Poverty

The monthly budget of most African households is lower than $180, which 50% is spent on food. On average, urban households have $100 more than rural ones (Banerjee *et al.*, 2008). Food insecurity is shifting from rural to urban areas. Accessibility and effective utilization are concept substantially dependant on urban planning. Spatial location, access to clean water, sanitation, storage, refrigeration and healthcare (Battersby, 2014) 'Cities, planning and urban food poverty in Africa' are parameters which are not taken for granted in the Southern African cities.

- Vulnerable employment

One distinguishing characteristic of Africa is that the most of the labour force is trapped in vulnerable employment (Pieterse, Parnell and Haysom, 2018). The transition from a primary economy, to a secondary such as manufacturing and industrialisation did not take place in most African countries. Yet, workers who from primary sectors with informal employment, do not evolve into manufacturing and industrial jobs in the formal sector and stay trapped in occupations of a service nature in vulnerable condition, characterised by irregular and very low wages (Pieterse, 2019).

d) Management constrains

- Shortage of money

Financial constrains at municipal levels affect city management and town planning deliverables. In addition, staff costs of municipalities consume significant proportions of municipal funds, between 50 and 60% (UN, 2014). This situation has an impact on the capacity of municipalities to address present challenges and most important, planning for future development (UN, 2014).

- Weak capacity

Local governments are often most accustom to issues related to vulnerabilities and risks (Bulkeley, 2010), and many also oversee duty on managing services and infrastructure that are fundamental for quality living standards (Anguelovski, Chu and Carmin, 2014). Mainstreaming adaptation into different development agendas is a practical challenge for many cities in the developing countries due to staffing capacity, supportive cultural values, financial deficits, information and local leadership (Anguelovski, Chu and Carmin, 2014). The lack of capacity also constrains how municipal planners, engineers and service delivery professionals are able to foresee gradually more severe climate impacts (Anguelovski, Chu and Carmin, 2014).

e) Environmental constrains

- Climate change vulnerability

Mainstreaming climate adaptation into different development agendas is a practical challenge for many cities in developing countries because it requires them to technical capacity, strong political leadership at local level, performing financial status and support and participation from the citizens as well as cultural acceptance. The lack of capacity also constrains how municipal planners, engineers and service delivery professionals are able to foresee or deal with growing acute climate impacts.

Urban areas in Southern African are enormously prone to climate change disasters. The region is warming (SADC, 2010) which will lead to more frequent droughts in the future (NCAR, 2005). The development and growth of Southern African cities will exert extreme pressure on water demand. Their dependence on aquifers for an important quantity of fresh water is currently compromised by industrial expansion and outdated unsustainable water infrastructure (UN, 2014).

The effects of climate change will affect in different ways at local scales. However, raising temperatures, change of rain patters and the rise of the sea level will impact on food security, environmental diversity, agriculture and infrastructures and ultimately human health. The predictions for coastal areas are severe increase on storms frequency and rise of sea level, whereas inland areas will experience increase of temperature and decrease of rainfall. Residential settlement, both poor informal slums and wealth holiday resorts along the coast are located in already compromised flood-prone areas, either ignoring planning regulations or through special permits which often come through bribes or political influence. In any case, these residents will be affected and forced to (UN, 2014).

In the best case scenario, insurance premiums increase after a sequence of natural disasters if not withdraw from the regions marked as environmental ‘red zones’. Insurance however is a luxury that the poor cannot afford, remain at risk and subsequent aid from relief funds, community assistance or NGO interventions (UN, 2014).

- Biodiversity threat and growth constrain

Insufficient capacity and poor engagement with experts are among the major constrains in environmental governance in Africa (Güneralp *et al.*, 2018). Moreover, ecological matters are typically seen as impediment to development instead of essential foundation for sustainable growth and human rights in Southern Africa (Roberts, 2008; Scott and Oelofse, 2009; Leck and

Simon, 2013). The origin of such point of view is based on historic marginalization of vulnerable communities, exposed to livelihood and land deprivation due to racially addressed political approaches on conservation and ecological protection. Despite progress being made on awaking awareness the negative consequences that the conflict “environment versus development” may perpetuate, political agendas still prioritize economic growth disregarding environmental losses. Consequently, a holistic approach that acknowledges climate-change in association with development is required to address poverty and economic development (UN, 2014). Urban services backlogs have considerable environmental implications regarding poor dwellers, usually residents of informal settlements. When municipal service provision does not exist, they tend to look at natural resources: water extracted directly from river streams and the use of wood for heating and cooking when electricity supply is not available (UN, 2014).

Africa is home of regions with exceptional biodiversity (Mittermeier *et al.*, 2011), with protected areas covering about 4.5 million Km^2 across the continent (Brooks *et al.*, 2016). 500 km^2 of this territory is urban land. Even the smallest towns have ecological impacts, for instance in Western Africa, forest are experiencing a decline and turned into farm land to respond to the increasing food demand in urban areas (Anderson *et al.*, 2013). Despite the importance of peri-urban agriculture to ensure food security, it comes in hand with environmental degradation and habitat loss. In addition to this, FDI has been used for land purchasing addressing food supply in other countries out of Africa (Wouterse *et al.*, 2011).

The development of transport infrastructures frequently results in habitat fragmentation. At the moment, there are 33 major transportation corridors under construction or planned and approved which go through 400 protected areas (Güneralp *et al.*, 2018). Increasing deforestation around urban areas and transportation routes are evidence of the negative impact of urban development (Abernethy, Maisels and White, 2016).

3.1.2 Concept of municipality in South Africa

From lower to higher hierarchical order, the territory in South Africa is administratively organized in wards, local and metropolitan municipalities, district municipalities, provinces and finally, the state. Wards are geographical subdivisions of municipalities used for electoral purposes. Municipalities have as many wards as there are seats on the municipal council. Each ward then elects one councillor directly. Local municipalities include one or more towns and the surrounding villages and rural areas. District municipalities are the result of grouping several local municipalities. They are responsible for municipal functions that affect more than one local municipality, including development planning, infrastructure and service supply, public transport and principal roads. Metropolitan municipalities put into effect all municipal functions within their boundaries, in contrast with the divided responsibilities in areas with the district/local system. The boundaries of the provinces are designated in the constitution. They group a number of district municipalities.

Common concepts can be found in the several definitions of municipality worldwide. For the Cambridge Dictionary, "municipality is a city or town with its own local government, or the local government itself"; for the Britannica Encyclopaedia, "municipality is an urban unit of local government. It is a political subdivision of a state within which a municipal corporation has been established to provide general local government for a specific population concentration in a defined area"; for the Collins Dictionary, "municipality is a city or town which is governed by its own locally-appointed officials". Therefore, government, city, local and urban appear as recurrent concepts to explain the meaning of municipality.

Although the administrative organization of the country matches with international standards of territorial management, the nomenclature used can mislead, in actuality, the conceptual interpretation of the real status of the level of urbanization in the country. The reality is that only the metropolitan municipalities have urban features. For most of local and district municipalities, 80% of the population live in rural conditions (Stats SA, 2011). The meaning of municipality remains therefore associated to the organization of political power only, with no translation into living conditions.

The KwaZulu-Natal Province is divided into 1 metropolitan municipality and 10 district municipalities. The district municipalities are in turn divided into 44 local municipalities.

3.1.3 Present and prospects for urban areas in Southern Africa

a) Demographics

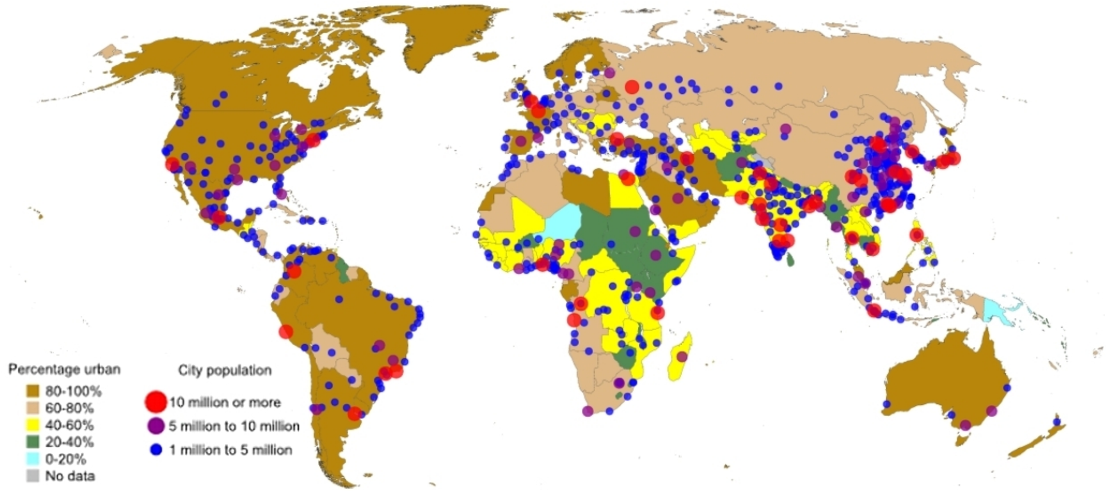
With more than 1.1 billion people living in Africa today, the forecast for 2025 is that the population will increase to become one fifth of the world, and 2.5 billion by 2050 (UNDESA, 2019), with tens of millions emerging from poverty and thus conforming a middle class and therefore gaining purchasing power. 303 million African households will have discretionary incomes (Agyenim-boateng, Benson-Armer and Russo, 2015). The age distribution related to income earners, 53% between 16 and 34 years old, seems to have a positive impact in both, economic growth and technology penetration, for example mobile technology already at 90% (Agyenim-boateng, Benson-Armer and Russo, 2015), enables not only communication but financial operations and e-commerce. In 2014, only 34% of sub-Saharan Africans have a bank account (Demirguc-Kunt *et al.*, 2014). By 2019 this figure has growth to 43% (Klapper *et al.*, 2019). The mobile money market is leading with 43% of the accounts worldwide (GSMA, 2021).

Since 2008, the urban population is higher than the rural one worldwide. 55% of the world's population lives in urban areas and 68% of the world population is estimated to be concentrated in urban areas by 2050 (UNDESA, 2019). Africa is expected to experience an enormous urban growth in the forthcoming years. By 2025 half of the African population will live in cities. Africa already has as many cities as North America with over one million inhabitants (Agyenim-boateng, Benson-Armer and Russo, 2015). Nevertheless, the pace of population growth about 2.7% per year slows advances against poverty and consolidation of an emerging middle class, which understanding is important to contextualize. Deloitte noted that the African Development Bank considers middle class those expending US$ 2-10 a day and upper middle class those with a level of expenditure of US$10-20 (Gounden and Nkhumeleni, 2012; Watson, 2014).

Rural poverty is considered the reason behind high levels of migration to urban areas. In South Africa, the end of apartheid did not mean a change in rural production systems, which areas remain as source of cheap labour for mining and low-skill urban services. AS mention before, poor urban households have a monthly budget $100 higher than their equivalents in rural areas (Stats SA, 2012). However, this higher income does not mean better live condition and the result is an equally increase of urban population living in poverty. In addition, the major sector of the population is young between 20 and 34, which brings further pressure on employment demand and service delivery (Stats SA, 2012). Rural-urban migration has therefore affected income distribution in metropolitan areas (Ruhiiga, 2014).

b) Level of urbanization

The term urbanization is typically used to indicate the increasing population living in urban areas. The most urbanized regions in the world include Northern America (82%), Latin America and the Caribbean (80%), and Europe (73%). In contrast, Africa (40%) and Asia (48%) remain mostly rural. The estimates for Africa raise the urban population to 1.33 billion in 2050 from the current 471 million, surpassing the 50% in 2035 (UNDESA, 2019).



Data Source: World urbanization prospect. The 2018 Revision
The designations employed and the presentation of material in this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any county, territory, city or area of its authorities or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan has not yet been determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

Figure 2. UN estimation for the world urban population by 2030

African cities are considered as the “last development frontier”. However, these new urban trends seem to ignore the fact that the majority of the population in SSA cities live in extreme poverty and reside in informal settlements at the moment (Watson, 2014).

In the revision of the World Urbanization Prospects by the Department of Economic and Social Affairs Population of the United Nation in 2018 (Figure 2), the estimation for 2030 is that most countries in the region will reach a level of urbanization over 80%, with only Zimbabwe under 40% (UN, 2021).

c) Trends in African urbanism.

The new narrative of African rising and the re-visioning of African cities as 'future cities', reflected in new master plans referred to by Watson (2014) as 'new urban fantasy plans' that seems to actually look far from urban realities. This is due to the bigger presence of large private sector actors, viewed as 'partners in development' by the state, in planning the city mostly based on economic development agendas (UN-Habitat, 2015).

In recent years, the trend for new large urban projects in SSA is to skip the possibility of rejuvenation of existing urban centres, which fits into the narrative of post-colonial transition, and look at rising new satellite cities. The private sector, well connected with international economic powers, has become a leading stakeholder in most of these proposals. This indicates that global economic forces are interfering with local African contexts behind the back of the majority of the people (Watson, 2014).

These new planned cities are advertised through the appropriation of narratives that evocate modern principles. Smart cities or eco-cities are the most ordinary 'rationales' used by their designers and developers (Watson, 2014). The labels 'smart' or 'eco' branding new developments are surely part of a marketing strategy to persuade investors, masking other occulted agendas (Hollands, 2008) . These projects are claimed to be developed on "empty land". It is hard to believe that peripheral land in large cities is empty. What usually happens is that the land is either included in an environmentally protected area or actively farmed. Landowners rarely hold land title on customary land, and forms of compensation are unlikely in these eviction processes (Watson, 2014). Principles of inclusivity and equality are hardly considered in the new development, and therefore, low-income service providers, unable to afford the housing offer within the boundaries of the new development, settle informally around the edges.

At the beginning of 2013, there were approximately 143 completed or under construction self-assigned 'Smart City projects of which ten were located in the African continent (Lee, Hancock and Hu, 2014). However, Watson (2014) analyzed the rhetoric of the term in the new developments in Africa and concluded that in most cases the label of smart cities is closer to marketing strategies through which emphasize the “modern-ness” of the approach. She also extracted a group of common characteristics:

- They are large scale, in that they involve the re-planning of all or large parts of an existing city or (more often) restructuring a city through the creation of linked but new satellite cities;
- They consist of graphically represented and three-dimensional visions of future cities rather than detailed land use plans, and most of these visions are clearly influenced by cities such as Dubai, Shanghai or Singapore;
- There are clear attempts to link these physical visions to contemporary rhetoric on urban sustainability, risk and new technologies, underpinned by the ideal that through these cities Africa can be “modernized”;
- They are either on the websites of the global companies that have developed them or are on government websites with references to their origins within private sector companies;
- Their location in the legal or governance structures of a country is not clear – where formal city plans exist these visions may simply parallel or over-ride them; and
- There is no reference to any kind of participation or democratic debate that has taken place.

- Post-colonial transition.

A common feature of all Southern African urban development is their colonial past. Unlike the Northern of Africa, with an ancient history of cities foundations and cross-cultural contamination, Southern African remained rurally pristine until the arrival of the Europeans in the 15^{th} century. The foundation of cities was not based on a spontaneous way of spatial organization by locals but rather, coastal base port for extractive economic activities. In fact, the inland areas remained rural until late 18^{th} century during the Industrial Revolution happening in the European powers.

African economies have been historically managed to play a complementary role to the metropolitan economies of the colonizers, supplying cheap workforce and raw materials. This situation has been perpetuated when after independence, the economic power were transferred to companies based on coloniser countries. This situation traps former colonies to a vicious cycle starting from the lack of resources for domestic investment and challenges related to secure convenient international financial aid that may help implement R&D and technological innovation, and therefore catalyse economic growth (Pieterse, 2019).

‘Town planning’ often drew from British colonial traditions and priorities, with an emphasis on sanitation engineering and cantonment architecture, but rarely incorporating development realities such as informal work, migration, the need for jump-starting industrial scale and scope investments or evolving to respond to the cultural tensions of nation-building (Srinivas, 2017).

The colonial heritage is also reflected on the absence of professional bodies to deal with developmental policies and practices. The spatial planning imposed by colonial powers, characterized by rigid mono-use zoning is rarely disputed by incapable planning authorities, resulting in the expansion of slums and increase of urban sprawl (Anderson *et al.*, 2013).

There is a conflict in recognizing a national identity in the region, especially in South Africa and Namibia. This is reflected not only actively neglecting the colonial past but also the through the acknowledgement of the presence within a geopolitical border, and forced to an understanding, of numerous ethnic groups with their own identity features and sometimes animadversion to other groups due to old alliances with the colonizer that favoured some over others.

Monuments are crucial in national identity building and collective memory. The Mediterranean, Asian and South American urban landscape are dominated by tradition and historical memory to a much higher degree than the Anglo-American ones, and by extension Africa and Australia.

In South Africa, the implementation of racial segregation and its consequences in urban planning made cities especially interesting. The Group Areas Act stated residential segregation, dividing the territory into separate ‘white’, ‘coloured’, ‘Indian’ and ‘African’ areas, with buffer areas in between. Informal settlements were banned on cities and towns at that time. Apartheid cities were thus extremely ordered spatially, achieved only through the enormous oppression through political power. However, although the end of the apartheid allowed to non-white middle-classes moved into formerly white residential neighbours, it has not implied an automatic racial integration which has been faster where there were no African areas near the city centre. Nevertheless, the slow pace in poverty alleviation holds back racial integration (Seekings, 2000).

- Urban regeneration of CBDs

The trend on urban regeneration in many Southern African cities couples with an "increased interest for the qualities of place". Urban areas affected by significant economic, physical, social decay are typically selected for this form of 'planning'. The concept of urban regeneration has evolved from merely tackling physical problems to further soft-oriented strategies including the many actors involved in urban coexistence; from urban management to commercial activities, housing provision, service provision, crime reduction or leisure-oriented initiatives. This holistic vision strength existing assets and increase the interest on the area. (Burzynski, 2012).

The North American narrative of 'Business improvement districts' (BIDs), a linking forms of public–private partnership as an international model of urban rejuvenation, have been largely imported in South African cities under the term 'city improvement districts' (CIDs) since the mid-90's. At the time of the greater competition for attention between cities at global level, the spreading of CIDs has been associated to the rise of 'urban entrepreneurialism' and the implementation of neoliberal policies. CDIs consist in an organized group of property and business owners at neighbourhood level, managing service provision in degradated areas where municipal governments fail to deliver, upgrading the commercial and residential value of the area (Didier, Peyroux and Morange, 2012).

The undeniable physical improvement of the regenerated districts due this urban entrepreneurialism, increase substantially their economic potential. The area becomes attractive for both new business and residents to move in which automatically activates the market rule of offer and demand. As a result, the area becomes more expensive - rental price, grocery shopping, coffee shops, bars and restaurants and school fees increase –and exerts a big financial pressure on the existing communities. The result is social displacement. All narrative concerning inclusivity and equality become void.

The case of the Western Cape in South Africa is rather extreme and paradoxical. Bo-Kaap and Woodstock are suburbs where mix-race communities were resilient to apartheid, largely untouched by the Group Areas Act. The resident of these districts are struggling to stay. For more than 50 years, these consolidated communities have engaged in social activism, now are being evicted and forced into low-quality housing on the city's outskirts. The rise of the property price has a double effect. Small owners are selling to bigger developers. At the same time, the price of the rent is rising due to wealthy new residents moving in the areas. Old residents on the contrary, are likely to fell into arrears on the payments which the owner activates and eviction court process with. City councils unable to provide a solution without engaging with private sector, and based on the legal framework, recognize the inability of including a mandatory social agenda.

The pursuit for a more sustainable city could result in environmental social displacement. The greener the district becomes the more desirable and expensive it gets. Common interventions in the urban fabric: parks, walkability, bike lane, public transport and organic food vendors to name a few, become amenities (Wachsmuth, Aldana Cohen and Angelo, 2016). Planning that pushes these improvements do not usually link to a larger social-equity agenda. The low-income resident is therefore displaced into peripheral areas, potentially hazardous, with higher risk of flooding, droughts, disease and heat. “Many sustainability gains are simply a regressive redistribution of amenities across places” (Wachsmuth, Aldana Cohen and Angelo, 2016).

- Liveability and competitiveness.

The official narrative from local governments tends to highlight the benefits of the city in order to attract investment and financial power to undertake such transformation: strategic location, the presence of a consolidated business fabric, the advantages of increasing competitiveness in the region and the feasibility of implementing an ICT strategy. At the same time the risks of being left behind are also exposed with similar emphasis (Department of Transport and Public Works, 2011). As mentioned already, the invitation to engage with the public sector starts at the very early stages of any process of regeneration. The public sector seems unable to strategize infrastructure investments in order to generate a suitable landscape in which urban developments and economic activities will blossom and therefore generate public revenue in the form of taxation.

A lack of inclusiveness is also detected. Although informal traders and poor householders are officially mentioned and taken into account, the absence of a social interwoven strategy leaves these collectives in a vulnerable position.

The rather ambitious goals tackle absolutely every mainstream topic on discussion at the moment: competiveness, sustainability, smartness, resilience, social cohesion, quality of life and Goal 11 as a summary (Department of Transport and Public Works, 2011). The literature reveals how contradictory those concepts can be at certain levels. A competitive city cannot be fully sustainable and vice versa (Monfaredzadeh and Berardi, 2015). The strategies addressing an increase of the quality of life usually lack of a holistic approach, understanding “place making” as the creation of business appealing areas whereas gentrification exclude the poorer strata of the population increasing inequality. As hard as can be to find a balance between all different goals, the reality shows that these several topics are dealt by different departments with a silo organization and lack of communication and integration (Uys and Jessa, 2019). Moreover, instead of undertaking a research process which will determine what are the best decisions to make, a priority driven strategy is put in place, with shorter terms, based fundamentally on economic indicators.

However, the good news is that public space, amenities, public transport, pedestrianization, ICT connectivity and green energy infrastructures have taken over the planning agenda in detriment of motor vehicle, high density, and disconnected monocolor zoning (African Union, 2015; De Vries and Kotze, 2016).

Johannesburg has acknowledged the significant role that parks and open-space areas play in improving a city and benefitting to the surrounding communities. Therefore, sufficient provision has been made for parks and open spaces to be considered as important components in inner-city rejuvenation plans. A number of parks have been redeveloped and improved in the inner city as part of the regeneration of Johannesburg. Nevertheless, lack of resources required for redevelopments and, most decisively, for the successful maintenance of the amenities, has been detected (De Vries and Kotze, 2016).

This recognition of the importance of open public space clashes with the proliferation of gated communities, considered by many South Africans as a needed place to stay in a safer environment in a high violence context. At the same time, these developments can also challenge planning pursuing greater integration and accessibility. This reflects the growing contrast between the planning ideal and practice in South Africa. The development of gated communities has sparked debates on whether gated communities are a solution to present problems of increased insecurity in cities worldwide or a new form of development that promote exclusion and segregation (Landman, 2012).

Competitiveness nowadays is linked with specialised business services and infrastructure, and a socio-economic environment that boosts innovation and attracts high skilled individuals and favour investment (OECD, 2016). The concept of “competitiveness” is attracting much attention of academics and policy makers as globalization and the transition to green economy is urging cities to compete with each other (Porter, 1995; Martin and Sunley, 2003). Over the past few decades, the paradigm of competitiveness has also seen an important change. The introduction of frameworks for “sustainable competitive advantage”, as an example of sustainable deliberations in economic development and industrial policy, has been distinguished by some scholars (Pitelis, 2005, 2010). It is therefore acknowledged from the academia the important role that the existence of competition on the local market, together with human capital and innovation play in tracing competitive advantage (Porter, 1990; Zhang and World Bank Group, 2010).

History also plays an important role. Historical legacy and agglomeration economies play a significant role in steering competitiveness. Agglomeration may be achieved through either ‘localization economies’, this is grouping businesses in clusters based the specialization; or ‘urbanization economies’, grouping business in clusters with a level of diversity (Zhang and World Bank Group, 2010).

As cities aim to be competitive against other cities, they may gauge the risk of being too focused on the macro-dynamics and enabling powerful economic actors. Additionally, negative aspects of large cities, such as increased inequality and poverty, can bring a risk to the general urban resilience. Finding equilibrium between competitiveness and inclusive growth is necessary to building the resilience of cities.

The Global Competitiveness Index for 2019 of the World Economic Forum ranked Mauritius 52 out of 141 countries, being the highest in Southern Africa, whereas 26 SSA countries out of the total of 34, occupy the bottom 30 globally and the lowest median regional average (46.3). Nevertheless, many countries in the region improved their competitiveness performance that year, making SSA one of the most improved regions worldwide, behind the Middle East and North Africa region. These movements, together with the persistent great competitiveness gaps across regions, emphasize the but steady slow progress in the convergence of emerging economies, which is estimated to be completed in decades (World Economic Forum, 2019).

Table 2. World Economic Forum Global Competitiveness Index for 2019. Regional score for SSA (World Economic Forum, 2019)

Sectors		Score	Change from 2018 (%)
Enabling Environment	Institutions	46.9	–1.2
	Infrastructure	45.0	–2.9
	ICT adoption	34.3	15.8
	Macroeconomic stability	69.4	3.7
Human Capital	Health	50.8	5.8
	Skills	44.3	2.1
Markets	Product market	49.3	–2.3
	Labour market	54.6	1.5
	Financial system	50.8	0.7
	Market size	40.4	4.0
Innovation Ecosystem	Business dynamism	51.8	1.4
	Innovation capability	29.4	3.6

- The commitment to Habitat III, the Sustainable Development Goals (SDGs) and Agenda 2063.

In 2015, all United Nations Member States adopted the 2030 Agenda for Sustainable Development which in its own words “provides a shared blueprint for peace and prosperity for people and the planet, now and into the future”. The 17 Sustainable Development Goals (SDGs) included in the 2030 Agenda represent an imperative call for action by all countries to work in collaboration. The SDGs acknowledge the importance of “ending poverty and other deprivations” in combination with “strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests” (UNESCO, 2017a).

The Sustainable Development Goals are:

- Goal 1. End poverty in all its forms everywhere
- Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- Goal 3. Ensure healthy lives and promote well-being for all at all ages
- Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
- Goal 5. Achieve gender equality and empower all women and girls

- Goal 6. Ensure availability and sustainable management of water and sanitation for all
- Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
- Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- Goal 10. Reduce inequality within and among countries
- Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
- Goal 12. Ensure sustainable consumption and production patterns
- Goal 13. Take urgent action to combat climate change and its impacts*
- Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
- Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Numerous initiatives that are defined by Africans can be improved and reinforced through international partnership, and according to international standards as contained in the Paris Climate Agreement, the Sustainable Development Goals and the New Urban Agenda (Pieterse, 2019).

Speeding up structural transformation in order to control the rapid urban transition is basic to confront challenges derived from poverty and inequality in Africa. This transformation must look at the promotion of economic diversification, especially focus on job creation through industrialization, improvement of access to basic services and policies addressing poverty and inequality (UNECA, 2017). This structural transformation is agreed to be achieved through the principles of sustainable development as concretized in the SDGs and the New Urban Agenda (NUA). The biggest impediment on Africa’s developmental potential lays on its limited infrastructure. Habitat III encouraged Africa to embrace a holistic approach to cities and not just to address housing or services such as electricity or water independently. In this regard, there were three new areas of focus for discussion: holistic land-use management bonded to effective planning systems; meaningful fiscal and political decentralization; and integrated human settlements strategies that considers working with the poor to attain the realization of service rights and housing (Pieterse, Parnell and Haysom, 2018).

Investment on strategic infrastructure may be the only feasible method to achieve multiple goals at the same time: tackling employment, poverty and green industrialization through the upgrade of basic services and the creation of R&D institutions. Evidence of this trend has been found in recent investment patterns, which reflect consensus among African leaders (Pieterse, 2019).

Africanists have been historically reluctant to address urban matters, focussing on national sovereignty, natural resources or agriculture (Pieterse, Parnell and Haysom, 2018). Goal 11 declares a commitment to "Make cities and human settlements inclusive, safe, resilient, and sustainable". The inclusion of a dedicated Urban SDG was the culmination of an explicit, public campaign to have urban issues recognized as core to future development agendas. The mobilization of expertise to secure an Urban SDG in global development frameworks was followed soon after by the formulation of the so-called New Urban Agenda (NUA), led by UN-Habitat, and concerned with human settlement improvement and territorial development. It represents the recognition of local and regional territorial action as an important dimension of global changes. Urban issues have traditionally been thought of as symptoms, as the place-specific manifestations of more general processes. By contrast, in the twenty-first century, urban processes are now ascribed causal significance in generating global challenges including ecosystem degradation, climate change, peak oil, systematic inequality and persistent poverty, food insecurity, and energy transitions (Barnett and Parnell, 2018).

Five decades after the foundation of the Organisation of African Unity, nowadays the African Union, the Agenda 2063 was adopted at the 24th Ordinary Assembly of the Heads of State and Governments of the African Union on the 31 January 2015. The Agenda 2063 is "Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. It is the continent's strategic framework that aims to deliver on its goal for inclusive and sustainable development and is a concrete manifestation of the pan-African drive for unity, self-determination, freedom, progress and collective prosperity pursued under Pan-Africanism and African Renaissance" (African Union, 2015).

Table 3. Agenda 2063 goals (African Union, 2015).

Aspiration	Goals	Priority Areas
1) A Prosperous Africa, based on Inclusive Growth and Sustainable Development	(1) A High Standard of Living, Quality of Life and Well Being for All Citizens	Incomes, Jobs and decent work Poverty, Inequality and Hunger Social security and protection Including Persons with Disabilities Modern and Liveable Habitats and Basic Quality Services
	(2) Well Educated Citizens and Skills revolution underpinned by Science, Technology and Innovation	Education and STI skills driven revolution
	(3) Healthy and well-nourished citizens	Health and Nutrition
	(4) Transformed Economies	Sustainable and inclusive economic growth STI driven Manufacturing / Industrialization and Value Addition Economic diversification and resilience Hospitality/Tourism
	(5) Modern Agriculture for increased productivity and production	Agricultural Productivity and Production
	(6) Blue/ ocean economy for accelerated economic growth	Marine resources and Energy Ports Operations and Marine Transport
	(7) Environmentally sustainable and climate resilient economies and communities	Sustainable natural resource management and Biodiversity conservation Sustainable consumption and production patterns Water security Climate resilience and natural disasters preparedness and prevention Renewable energy
2) An Integrated Continent Politically united and based on the ideals of Pan Africanism and the vision of African Renaissance	(8) United Africa (Federal or Confederate)	Framework and Institutions for a United Africa
	(9) Continental Financial and Monetary Institutions are established and functional	Financial and Monetary Institutions
	(10) World Class Infrastructure criss-crosses Africa	Communications and Infrastructure Connectivity

3) An Africa of Good Governance, Democracy, Respect for Human Rights, Justice and the Rule of Law	(11)Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched	Democracy and Good Governance Human Rights, Justice and The Rule of Law
	(12) Capable institutions and transformative leadership in place	Institutions and Leadership Participatory Development and Local Governance
4) A Peaceful and Secure Africa	(13) Peace Security and Stability is preserved	Maintenance and Preservation of Peace and Security
	(14) A Stable and Peaceful Africa	Institutional structure for AU Instruments on Peace and Security
	(15) A Fully functional and operational APSA	Fully operational and functional APSA Pillars
5) Africa with a Strong Cultural Identity Common Heritage, Values and Ethics	16) African Cultural Renaissance is pre- eminent	Values and Ideals of Pan Africanism Cultural Values and African Renaissance Cultural Heritage, Creative Arts and Businesses
6) An Africa Whose Development is people driven, relying on the potential offered by African People, especially its Women and Youth, and caring for Children	(17) Full Gender Equality in All Spheres of Life	Women and Girls Empowerment Violence & Discrimination against Women and Girls
	(18) Engaged and Empowered Youth and Children	Youth Empowerment and Children
7) An Africa as A Strong, United, Resilient and Influential Global Player and Partner	(19) Africa as a major partner in global affairs and peaceful co-existence	Africa's place in global affairs. Partnership
	(20) Africa takes full responsibility for financing her development	African Capital market Fiscal system and Public Sector Revenues Development Assistance

The pan-African manifesto in the Agenda 2063: The Africa We Want, states:

"The aspirations reflect our desire for shared prosperity and well-being, for unity and integration, for a continent of free citizens and expanded horizons, where the full potential of women and youth, boys and girls are realized, and with freedom from fear, disease and want. Africa is self-confidence in its identity, heritage, culture and shared values and as a strong, united and influential partner on the global stage making its contribution to peace, human progress, peaceful co-existence and welfare. In short, a different and better Africa." (African Union, 2015)

At international level however, the world seems to be withdrawing from human rights, liberal democracy, multilateralism, openness and cosmopolitanism. The scenario for large-scale reforms is not the most suitable at this moment (Pieterse, 2019).

The African Union acknowledges the convergence of both UN-SDGs and the Agenda 2063 goals, linking the strategies in a unified document:

Table 4. UN-SDGs and the Agenda 2063 goals convergence (African Union, 2015)

Agenda 2063 Goals		**Agenda 2063 Priority Areas**	**UN Sustainable Development Goals**
1.	A high standard of living, quality of life and well-being for all citizens.	Incomes, jobs and decent work	1. End poverty in all its forms everywhere in the world
		Poverty, inequality and hunger	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
		Social security and protection, including persons with disabilities	8. Promote sustained, inclusive and sustainable Economic growth, full and productive employment and decent work for all.
		Modern, affordable and liveable habitats and quality basic services	11. Make cities and human settlements inclusive, safe, resilient and sustainable.
2.	Well educated citizens and skills revolution underpinned by science, technology and innovation.	Education and science, technology and innovation (STI) driven skills revolution	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
3.	Healthy and well-nourished citizens.	Health and nutrition	3. Ensure healthy lives and promote well-being for all at all ages.
4.	Transformed economies.	Sustainable and inclusive economic growth	8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
		STI driven manufacturing, industrialization and value addition	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
		Economic diversification and resilience	
5.	Modern agriculture for increased productivity and production.	Agricultural productivity and production	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

6.	Blue/ocean economy for accelerated economic growth.	Marine resources and energy Port operations and marine transport	14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
7.	Environmentally sustainable and climate resilient economies and communities.	Bio-diversity, conservation and Sustainable natural resource management. Water security Climate resilience and natural disasters preparedness	6. Ensure availability and sustainable management of water and sanitation for all. 7. Ensure access to affordable, reliable, sustainable and modern energy for all. 13. Take urgent action to combat climate change and its impacts. 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
8.	A United Africa (Federal or Confederate).	Frameworks and institutions for a United Africa	
9.	Continental financial and monetary institutions established and functional.	Financial and monetary institutions	
10.	World class infrastructure criss-crosses Africa.	Communications and infrastructure connectivity.	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
11.	Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched.	Democracy and good governance Human rights, justice and the rule of law	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
12.	Capable institutions and transformative leadership in place.	Institutions and leadership Participatory development and local governance.	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
13.	Peace, security and stability are preserved.	Maintenance and preservation of peace and security	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

14.	A stable and peaceful Africa.	Institutional structure for AU instruments on peace and security Defence, security and peace	
15.	A fully functional and operational APSA	Fully operational and functional APSA all pillars	
16.	African cultural renaissance is pre-eminent.	Values and ideals of Pan Africanism Cultural values and African Renaissance Cultural heritage, creative arts and businesses	
17.	Full gender equality in all spheres of life.	Women and girls empowerment Violence and discrimination against women and girls	5. Achieve gender equality and empower all women and girls.
18.	Engaged and empowered youth and children.	Youth empowerment and children's rights	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. 5. Achieve gender equality and empower all women and girls.
19.	Africa as a major partner in global affairs and peaceful co-existence.	Africa's place in global affairs Partnerships	17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.
20.	Africa takes full responsibility for financing her development Goals.	African capital markets Fiscal systems and public sector revenue Development assistance	10. Reduce inequality within and among countries. 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

The discussion around the SDGs meant a global shift in urban policies that affected Africa in particular. It clearly stressed the incompatibility between extractive models of economic growth and limited natural resources, and therefore, require "a radical shift towards more sustainable patterns of consumption and production and resource use" (UN, 2012). It was acknowledged that poverty and inequality are connected, especially unequal access to resources and energy at all levels; from residential units, to neighbourhoods, to nations. The Agenda 2063 reflected a shared African perspective on these global debates, which vision focussed on “(1) a prosperous Africa based on inclusive growth and sustainable development; (2) an integrated continent, politically united and based on the ideals of Pan-Africanism and the vision of Africa’s Renaissance; (3) an Africa of good governance, democracy, respect for human rights, justice and the rule of law; (4) a peaceful and secure Africa; (5) an Africa with a strong cultural identity, common heritage, values and ethics; (6) an Africa where development is people driven, unleashing the potential of its women and youth; and (7) Africa as a strong, united and influential global player and partner”.

In order to adhere to the SDGs and UN-Habitat III agenda, African countries have made efforts to upgrade knowledge-based sectors and strength manufacturing capacity which implies structural changes for the transition from primary economies towards secondary sectors focussed on processing farming products and manufacturing (Pieterse, Parnell and Haysom, 2018). In order to boost a real change in urban planning patterns in Southern Africa, poverty must be recognized as urban and not only a rural (Turok, 2016). Preventing the aforementioned reluctance of wealthy sectors of the population to resist investment in the public good is essential for the deployment of a new urban agenda for Africa in the context of the SDGs (Pieterse, Parnell and Haysom, 2018).

3.1.4 Competitiveness, Equality and Sustainability

The historic path to economic growth neglecting the environment and social inequalities is heavily impacting the planet and the people. Increasing inequality worldwide, instability and inefficient social mobility are detrimental for the social cohesion with a increasing perception of injustice, loss of identity and dignity, eroding social fabric and confidence in public institutions including political engagement and ultimately the failure of the social contract (World Economic Forum, 2019).

It is finally obvious that economic, social and environmental agendas must be addressed in conjunction. They must merge into a unified inclusive developmental agenda under sustainable principles. This concept of triple bottom line of sustainability suggest precisely a holistic approach to development. (World Economic Forum, 2019). This integrated approach has been applied with different results, even between countries with similar competitiveness levels. Such is the case of the Scandinavian region for instance, where Denmark, Finland and Sweden have become among the countries with better social protection and living condition, less segregated societies and more sustainable together with achieving an outstanding level of technological innovation, surpassing their peers.

Over the past decades, income disparities have increased in both emerging and advanced economies. Growth and collective prosperity started to decouple in most of the advanced economies in the 70's increasing the gap since the early 2000's. Likewise, in emerging economies, growth has come with a considerable increase in inequality (Kanbur *et al.*, 2000). Capitalist globalization and technological advances are the most recognizable causes behind these trends. The impact of globalization on the displacement of low-skilled jobs from developed to developing countries (Kaplinsky, 2013) and the reduction of low-skilled labour and excessive rewarding to high-skilled jobs due to technological advances (Feenstra, 1998) are reasons for such disproportionate disparities. Kanbur *et al.* (2000) highlight other causes: "increased market concentration; decline in public and private productivity-enhancing investments; inequality of opportunities that limit social mobility; and hysteresis effects of economic downturns that disproportionately affects the poor".

Inequality is indeed the outcome of policy choices with little awareness to the negative impact on labour and income distribution (Dumont, Stojanovska and Cuyvers, 2011; Qureshi, 2018). Improving productivity at the same time that inequalities are minimized is in line with the holistic approach explained before and a possible pathway, if not the only one, for policy making in Southern Africa. Kanbur *et al.* (2000) propose four areas for intervention:

- ***Increasing equality of opportunities.*** *Inequality of opportunity, inequality of income and economic growth form a circular nexus. Among the factors that can create a virtuous cycle, family policies (parental leave and access to quality childcare), equitable access to quality education systems, equal access to quality healthcare, meritocratic processes to access fair and dignified employment, and social safety nets to shelter households from temporary hardship can form the basis for a fairer and more prosperous society.*
- ***Fostering fair competition.*** *Stronger enforcement of antitrust policies and a reduction of barriers to entry remain important but approaches that address the effect of concentration without stifling innovation could be adopted, including using technology*

to reduce barriers to entry and shifting the focus from price levelling to address broader socioeconomic effects of winner-take-all business models.

- ***Updating tax systems and their composition as well as the architectures of social protection.*** *Restoring greater tax progressivity with higher top tax rates should allow for more equitable income distribution without much impact on economic activity or productivity. As for corporate taxation, solutions need to consider the complexity of international tax architecture, the increasing importance of intangible assets and the digital economy which, together, are allowing for greater profit shifting.*
- ***Fostering competitiveness-enhancing investments****. As monetary policy is running out of steam, in countries with fiscal leeway, targeted fiscal policy towards productivity-enhancing investments in infrastructure, education and innovation could revive productivity growth, support employment and broaden aggregate demand.*

3.2 State of the art. Smart City: taxonomy, definitions and initiatives

In the last 30 years, the term Smart City has gone through a few phases. What started as an initial idealistic vision of the optimization of the city life through data collection and computerized processing at the effervescent dawn of the computer popularization became a business niche for companies in the ICT sector (Angelidou, 2014), which made a slogan out of the concept, targeting governments and marketing a number of ICT-based products. It did not take long to hear voices alerting about the absolute absence of the social capital (Albino, Berardi and Dangelico, 2015) and the danger of relying the decision making on the outcomes from the data processing only. Gradually, the social interaction in the city gained importance (Kanter and Litow, 2009).

- Conceptualization of the Smart City

The core of the ‘smart’ agenda is extremely disputed. The International Telecommunications Union (ITU) together with the UN have made considerable efforts to manifest a definition that includes public interest in order to avoid, in the words of Professor Pieterse, “the risk associated to an uncritical adoption of Smart City rhetoric” (Pieterse, 2019). They propose that: “A smart sustainable city is an innovative city that uses ICT and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects” (UN, 2017).

Angelidou (2015), presents the phenomena of Smart Cities as a result of four shaping forces that is not new, in which the constant presence of the concepts of knowledge and technology have had an enormous impact on the envisions of the future. The idea of the city of the future in the past 100 years has been filtered through utopian visions connected to advanced technologies in order to balance individual and community needs under the umbrella of a socio-economic system. In addition to this, the increasingly trend of knowledge as a driver of the economy leads to a situation where knowledge rather than labour happen and as a consequence, the intangible capital is expanding in comparison with the physical capital, playing a noteworthy role in the birth of the concept of smart cities. The other two forces are opposite visions to each other, thus in constant tension. *Technology push* and *demand pull* have ethic, economic, social implications. The first one proposes the application and commercialization of any new solution regardless of the needs of society. The second one alludes to solutions that are put in place as a result of scientist research attending the needs of society.

Today there is still no consensus on an accurate definition of a Smart City, even though a few concepts are now accepted by most stakeholders, establishing frameworks heading to enhance the life quality of citizens (Craglia *et al.*, 2004; Neirotti *et al.*, 2014), sustainable development and economic competitiveness (Monfaredzadeh and Berardi, 2014, 2015), and, most importantly, the optimal balance between these (Perboli *et al.*, 2014). The implications of spatial aspects (Angelidou, 2015) in policy-making are in many cases the main aspect to consider in the desirable model of Smart City. One of the most controversial and decisive approaches is the choice between *soft infrastructure oriented strategies*, where human capital is put in the centre, with the goal of increasing human interaction, versus *hard infrastructure oriented strategies,* where citizens seem to hold a more peripheral position and the main aim is computerized efficiency.

Together with Smart City, other terms come across in order to qualify the understanding of the city, its management through the technology available and strategies of facing future challenges nowadays. Digital city (Ishida, 2002), virtual city (Albino, Berardi and Dangelico, 2015), intelligent city (Yovanof and Hazapis, 2009) and ubiquitous city (Greenfield, 2006; Townsend, 2013) share a top-down character and the highly technologically oriented meaning, where government, economy and citizens compound a connected community through ICT, although this connectivity take place at a scarce inclusive level. On the contrary, there are concepts highly associated with the human capital: creative city (Thuzar, 2011) and knowledge city (Albino, Berardi and Dangelico, 2015), which aim for the creation of an ecosystem based on education, culture, training, learning and knowledge in order to generate creative citizens. An educated labour force has a direct impact on speeding up urban growth (Glaeser and Berry, 2006). The role of ICT in these cases is directly related with the popularization and massive diffusion of a number of different types of sensors, that are accessible and highly used by the citizens, included for instance in cars, smart phones, sport trackers, etc, in combination with recent advanced cloud technologies used for urban monitoring system.

- Digitalization as a common place

Despite the mentioned lack of agreement on the definition, it is safe to say that the understanding of the concept of Smart City today, in general terms, considers **digitalization** as a key factor of disruption of the traditional idea of the city as a socio-technical (Hillier, 2012) system structured, in two main components: infrastructures and services. These are related to each other with great complexity and interdependency. The addition of a new digital component based on the collection and processing of data from a legacy system, through the incorporation of new devices, their interconnection (ITU, 2005) and the analysis of data (Batty, 2013), allows mirroring in a digital dimension the physical value chains, which expands the possibilities of creating new tools not only for the management of the complexity mentioned above, but also for the creation of new forms of services delivery.

For instance, looking closer to energy, one of the most important and complex components of the city as a socio-technical system among others like mobility, governance, liveability and economy, in order to evaluate the impact of digitalization, two boundary conditions affect the sector: First the environment, with climate change and consumption efficiency as main matters (Cities consume between 60% and 80% of energy worldwide (Albino, Berardi and Dangelico, 2015) and 75% of green house emissions are produced by cities (UNEP, 2014), and second, the location of energy generation, switching from centralized to decentralized production through renewable sources. Digitalization is mean to be the key for the transition to smart energy systems towards efficiency and coordination of decentralized production. At the same time and here is where the disruption takes place, digitalization allows a bi-directional flow, turning consumers into prosumers (Finger, 2017), due to local production of energy through renewable systems. The level of complexity grows with the appearance of new storage technologies and semi-off grid or completely off-grid operations, increasing this way the number and type of actors involved and the relationships between them. The services component becomes an open system with the constant addition and development of new components. Therefore, it is important to conceptualize this digital hinge which blends infrastructures and services. It can be divided in two sub-components, data generation including user behaviour, generator data and grid behaviour, and a second sub-component, smart services provider as data processor and previous step to the final service provider. The understanding of this smart services provider in two different ways, one as part of the electricity utilities that have data generation and provide services based on it, and another, as independent actors fed by data platforms, has regulatory implications regarding data ownership, access, availability, transparency, accuracy and pricing.

Taking into account the undeniable physical reality that constitutes the city, as a result of the development of a socio-technical system in a specific territory, it is important to analyze the spatial implications of smart initiatives. Angelidou (2014) identifies four key options with a spatial reference: *national versus local, new versus existing, hard versus soft infrastructure-oriented and sector-based versus geographically-based strategies.*

Cities are autonomous entities within a larger geographical field of influence and relation. Competitiveness cannot be considered if a certain level of independency and autonomy is not agreed as part of the city DNA on the one hand, but on the other hand, it is clear that cities evolve driven by common socio-cultural trends present in a bigger geographical context. In line with this, tailored local initiatives coexist with national strategies. The dichotomy national versus local embraces both positive outcomes and conflictive clashes. Small-scale pilot programs allow the accomplishment of short terms achievable goals and real-life context to test the viability of specific solutions (Carter, Rojas and Sahni, 2011; Bria, 2012; González and Rossi, 2012). Cities are more flexible in exploring and adjusting a variety of business and governance models to their own benefit. However, alignment of local strategies to complex national agendas and competition for resources with larger better equipped cities or regional context constitute challenges at the local scale. Although national strategies have a little presence in the literature in comparison with the overwhelming amount of references about small-scale projects, some elements can be identify as positive. The allocation of resources and top-level coordination ensure the continuity of mid-long terms projects. Large geographical range comparison platforms for results in different cities can be implemented. On the contrary, a generic approach may fail on spotting differences between cities. Local needs and priorities are under the risk of being ignored.

It seems obvious to say that the development of smart solutions comes from the identification of existing problems and the need to solve them through the available technology. Therefore, the Smart City can be considered an evolution of the existing city. Nevertheless, some governments are exploring the creation of new cities from scratch, driven by the potential of a promising efficient performance and management that new technologies can offer, avoiding the big challenges that existing cities represent. These new cities seek for the integration of infrastructures and buildings and the exploration of innovative business models. The clash of these ambitious projects with the reality seems to be relentless: budgetary constrains, inadequate planning and incapacity to attract both, capital and residents. Greenfield projects tend to be budgeted ten times higher. Replication of technological solutions does not warrantee suitable results for all cities and extremely efficiency driven solutions can lead to restriction of societal values such as quality of life and social cohesion. Residents are forced to deal with social structures that have been planned rather than evolved. On the contrary, existing cities host already a diverse ecosystem of stakeholders and most important, a network of infrastructures is already in place rendering the projects less demanding in terms of budget, even though part of them can be obsolete. The big challenges of the existing city lay on the organization of the institutions, people and stakeholders, and the prioritization process to identify smart initiatives at the same level of “ordinary” problems in order to allocate the city´s resources. In addition to this, the portion of new cities and its population impact in comparison with existing cities is very small.

As mentioned before in this section, one of the most controversial and decisive approaches is the choice between *soft infrastructure oriented strategies*, where human capital, knowledge and creativity are considered resources for development, versus *hard infrastructure oriented strategies,* where the instrumentation the city technically is the condition for development and citizens not only play a secondary role but are also controlled and monitored (Bria, 2012; Haque, 2012). In addition to this, unequal access and skills on ICT leads to digital divide (Guillén and Suárez, 2005; Odendaal, Duminy and Saunders, 2008) and social exclusion, which together with the uneven spread of technology throughout urban areas increases spatial polarization, gentrification and consequently lack of social cohesion. From a merely technical point of view, high cost, difficulties of integration, lack of trained staff and necessity of frequent updates are remarkable drawbacks for hard strategies. Nevertheless, the use of replicable solutions for common problems can be considered positive as city managers and policy makers are easier to approach with tangible results on precedent projects, even though same solution not always are applicable to every urban context with same levels of success. On the contrary, soft strategies are characterized by its human approach. Technology is responsive to needs, skills, interest and diversity of users. The citizen is empowered; informed, educated and participant. Knowledge creation, intellectual capital, and digital inclusion are key resources for development. Soft strategies seek the awakens of the sense of co-ownership among citizens through which they feel equally responsible of the city. In common with the hard initiatives, unequal access to ICT weakens the levels of participation and acquisition of knowledge and threats the success of the smart initiatives.

The fourth differentiating characteristic of the strategies is the reference area. The mainstream approach seems to be the application of new technologies to specific economic sectors such as housing, commerce, health, business, education, leisure, transportation, etc, in order to enhance its effectiveness and performance, leading to the transformation of the sectors. On the contrary, geographically based strategies place the spot light on districts and cluster, such as education hubs, business districts, leisure clusters or residential neighbours. The aim is to organize and support the effectiveness of these districts and to make them enjoyable to the specific user groups who experience them.

In order to tackle the analysis of the city and clarify what makes a city smart and the measurement of its performance, scholars split the complex entity in systems, sub-systems, fields, dimensions, components, features, etc. However, it is mostly agreed that the Smart City should behave as an organic integrated system, where all the components are interrelated (Dirks and Keeling, 2009). Table 5 by Albino, Berardi and Dangelico (2015) compiles the dimensions of Smart City stressed by various researchers and distils the following common characteristics:

- Interconnected infrastructural networks that allows for political efficiency and socio-cultural development.
- Empowered business-led urban development and creative activities for the support of urban development
- Inclusive social environment for residents and capital in urban growth.
- Nature and environmental care as a key component for the future.

Table 5. Key dimensions of a Smart City by Albino, Berardi and Dangelico (2015)

Key dimensions of a Smart City	**Source**
IT education IT infrastructure IT economy quality of life	Mahizhnan (1999)
economy mobility environment people governance	Giffinger et al. (2007)
technology economic development job growth increased quality of life	Eger (2009)
quality of life sustainable economic development management of natural resources through participatory policies convergence of economic, social, and environmental goals	Thuzar (2011)
economic socio-political issues of the city economic-technical-social issues of the environment interconnection instrumentation integration applications innovations	Nam and Pardo (2011)
economic (GDP, sector strength, international transactions, foreign investment) human (talent, innovation, creativity, education) social (traditions, habits, religions, families) environmental (energy policies, waste and water management, landscape) institutional (civic engagement, administrative authority, elections)	Barrionuevo et al. (2012)
human capital (i.e. skilled labour force) infrastructural capital (i.e. high-tech communication facilities) social capital (i.e. intense and open network linkages) entrepreneurial capital (i.e. creative and risk-taking business activities)	Kourtit and Nijkamp (2012)
management and organizations technology governance policy context people and communities economy built infrastructure natural environment	Chourabi et al. (2012)

- Measures of performance

Measuring the performance of the city is crucial for the design of strategies by policy-makers and city managers. According to the different approaches to the concept of Smart City and their organizational dimensions, different methods have been developed using rating systems based on quantitative indicators. Most of these indicators have room in one or more of the following categories: citizen interaction, workforce creativity, digital inclusion, connectivity, innovation, efficiency, optimization, real time monitoring, sustainability, availability of data, economic growth, and quality of life. Figure 3 by Cohen (2012) is based on the most common trend of considering 6 dimensions of a Smart City. It groups within the 6 dimensions 18 categories of indicators.

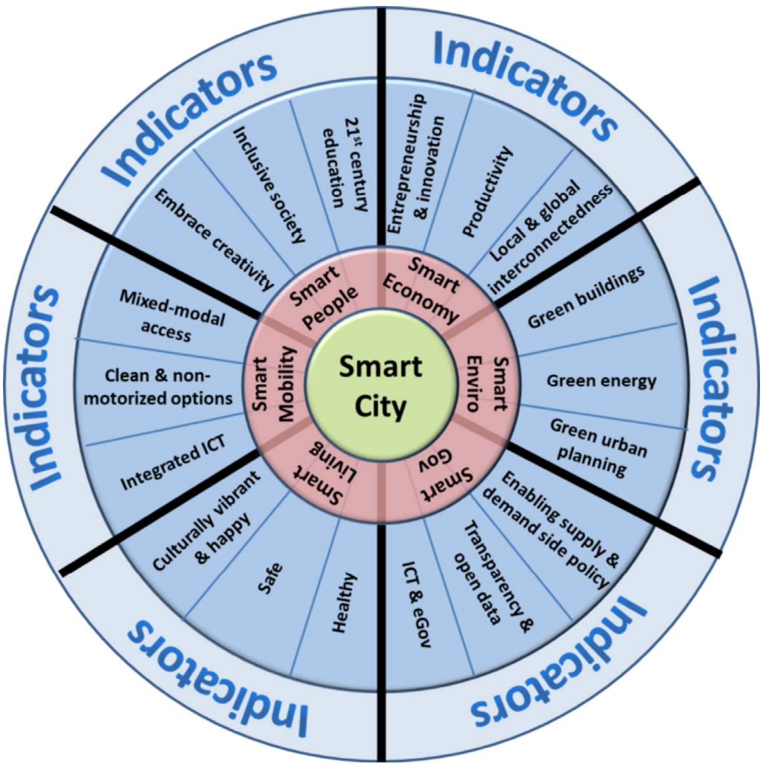


Figure 3. Boyd Cohen Smart City Wheel (Cohen, 2012)

Furthermore, the appearance of rankings developed by both, public institutions and private sector companies, has a big impact on the perception of smartness in the city, as national and international funds distribution, related to smart initiatives, is based on the position within the ranking in comparison with other cities. Again, there is no general consensus on rating criteria. Although the outcome of the scoring will be highly bias towards the particular field of interest of the institution, three distinguishing aspects can be identified by which city rankings can be compared and classified (Fertner *et al.*, 2007):

- Objective of the ranking specified by the aim and targeted audience, spatial scope, factors and indicators considered.
- Methodology of collection and processing of data, and criteria of selection of cities.
- Dissemination of the results, considering their evaluation, interpretation and presentation decisive for the impact of the ranking.

Based on these three aspects, Giffinger and Haindl (2007) carried an analysis of 20 city rankings published between 2000 and 2009, through which five types of rankings are identified:

1. Commissioned economy/consulting-oriented rankings with missing transparency.
2. Commissioned rankings with insufficient transparency created by expert panels or other private research institutes.
3. Rankings compiled by magazines or NGO´s without sponsoring.
4. Well-documented and methodically advanced rankings conducted by universities or economic research institutes with sponsoring in different areas.
5. Special cases non allocated on one of the four above.

For instance, Forbes publishes a list of Smartest Cities in the world rating higher those cities with favourable economic conditions. On the contrary, the Smarter Cities Ranking published by the Natural Resources Defence Council in USA places more emphasis on environmental and sustainable issues.

The Ranking of European medium-sized cities (Fertner *et al.*, 2007) is a good example of the type 4 mentioned above. Based on its impact on policy-making, interest awakens, number of references and the adoption of its principles in the later literature, it is worthy to include in this section an overview of the structure and the methodology approach of this ranking in particular.

It must be mentioned the importance of the availability of data and resources for the study to determine the scale of the spatial scope. The definition of the focus of the study on medium-sized cities responds to a series of characteristics highly eloquent. The majority of the

European population lives in those cities: Inhabitants sizes between 100.000 and 500.000. These cities are unexplored at certain degree as most of the studies deal with large metropolis. Medium-sized cities are less equipped in terms of resources and capacities and therefore have room for a proportionally bigger development than large cities. Finally, the selected cities had to comply with four criteria: to be functional urban areas in Europe, population between 100.000 and 500.000 inhabitants, to have at least one university and to be included in a catchment area of less than 1.500.000 inhabitants. From the 256 cities selected, data quality and availability reduced the number to 70.

The basic objectives of the ranking are: transparency, the elaboration of city profiles, the encouraging of benchmarking between selected cities and the identification of strong and weak areas for strategic analysis and policy making. Fertner *et al.* (2007) indentify six relevant key-fields (characteristics in older versions of the ranking) of the city: *economy, people, governance, mobility, environment* and *living*; and define Smart City as " a City well performing in six characteristics, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens". These six key-fields are broken down in 28 domains (factors in older versions of the ranking). Every domain is empirically defined through a group of corresponding components (indicators in older versions of the ranking) obtained from available open data bases from public institutions, which values are standardized through a-z transformation with average value '0' and a standard deviation of '1', in order to make them comparable to each other and appropriate to any aggregation procedure that will lead to a final value/score of smartness. The results are displayed based on the six key-fields, showing this way the level of heterogeneity within the city and pointing out in a very clear way strengths and weaknesses, essential for the city development strategy.

Nevertheless, Fertner *et al.* (2007) highlight some handicaps to be considered on city rankings:

- The question of validity and reliability of databases as they are elaborated by external source.
- The need to consider different spatial definitions as city rankings tend to neglect interrelations in regional developments.
- Dissemination and discussion take place on a narrow horizon, focussing exclusively on the rank only.

- The threat to long-term strategies as rankings can be taken as tools for immediate action.
- Existing stereotypes can be strengthened leading to a vice cycle compromising development.
- Bad results are usually undermined and ignored.

- Sustainability vs. competitiveness

A paradoxical question arises when considering rankings as a tool for competitiveness on one hand, and the definition of the Smart City itself as a well performing city in all six characteristics on the other hand. Policies related to competitiveness address this concept from an economic perspective in most cases, with little consideration of the impact on other components of the city and even falling into environmental threats. Monfaredzadeh and Berardi (2014) compared indicators of ranking systems looking at the city from three different points of view: Smart City, Competitive City and Sustainable City. They identified how each type emphasises particular themes more than others. Smart City focuses more on “people” and “living”; Competitive City emphasizes “economy” and “business opportunities”; and Sustainable City looks mainly at “energy” and “water management”. Their results identify conflicts between one system´s strategies and other systems’ goals. For example, air transport, considered the least sustainable means of transportation is positive rated from the competitiveness point of view as it increases city connections worldwide. Education and culture are hardly considered in sustainable ratings whereas they are among the most relevant factors for smart cities. Therefore, an integrated model of Smart City must take into account all different approaches and study them together as side effects on one type of policy might be not evident immediately, extending the meaning of concept of sustainability not only to environmental issues but also looking at the economy and lively of the city.

- The role of the citizen

To close out this section, it is obliged to pay attention to the role of the citizen within the socio-technical system and socio-economic system that the city is, and its position in relationship with the concept of Smart City.

Some authors raise a flag for the risks of the too smart and little human cities (Gutiérrez Rubí, 2016), where the role of the citizen is limited to a consumer of technology and as a data source (Greenfield, 2013), rather than an intelligent and active user who conscientiously takes advantage of the available tools, and through it takes possession of the public domain. The response to a number of citizens' demands can come through technology but cannot be only technological. In fact, a growing number of initiatives are dealing with the idea by which the concept of smartness should not be linked to innovation in technology (Opportunity Peterborough, no date).

Nevertheless, most of approaches in the field of research of the Smart City and urban development look at the citizen as a key factor for prosperity and economic growth of cities. The economic impact of the citizen lays on the background, in most of the occasions, when evaluating the outcomes of research and analysis. There is in fact a lack of interest on researching about other aspects, maybe closer to sociology, like happiness, personal development, identity, level of social engagement or individuality, etc, and how they are affected by smart initiatives. Even approaches that put the citizen in the centre analyze the capacity or positive impact of citizens on creating value, as if there were a need for justifying that looking after the citizen can be profitable too. The concept of Human Capital looks at parameters that analyse the revenues on investing in people´s education and skills development. The recently published Global Human Capital Report 2017 by the World Economic Forum defines Human Capital as "the knowledge and skills peoples possess that enable them to create value in the global economic system" (Schwab, 2017).

The research on the identification of indicators to measure quality of life is definitely challenging. Craglia *et al.* (2004) state that nowadays the concept of quality of life is no longer related to the satisfaction and availability of resources but also access to use of services in terms of real functioning capabilities. Level of competence as users, information elements and freedom of choice between different solutions constitute important elements at the time of measuring well-being, which highlights the importance of addressing disparities within the population. This is particularly sensitive in the African context where not only access to services is difficult but also inequalities are very high. The importance that measuring quality of life has for policy makers is related to the level of attractiveness and visibility of the city in a broader context, which at the same time connects with the tendency noted by Jane Jacobs (Diebold and Jacobs, 1984) through which the ability of cities to attract creative people spurs economic growth. This is in fact the base of the human capital as a driver for urban development.

As successful as controversial, Richard Florida (Florida, 2002) goes beyond the concept of human capital and postulates the idea of the creative class. It differs from the human capital concept in two aspects: Firstly, the identification of the creative and not only skilled people as key for economic growth and secondly, Florida identifies a shift in the geography of both workforce and corporate centres respect location decisions. This creative people don´t follow traditional business hubs yet the concentration of this creative class becomes attractive to corporations to establish their centres. Although this economic blossom is based on what Florida calls the 3Ts of the economic development: technology, talent and tolerance, there is little room for dealing with inequality, which rising trend is higher in creative centres. The way this approach looks at tolerance is far from the idea of social cohesion. Tolerance is understood as "low barrier to entry for innovative and energetic people from around the world" as well as the acceptance of gay communities within the city, which has little to do with cohesion among different income, race and skills levels. Lack of clarity in some of the data sources as well as difficulties to replicate Florida´s methodology in different contexts have made arguable such theory by some scholars (Peck, 2005; Nathan, 2008).

Inequality is definitely reflected on the access to the internet and ICT. The uneven development of the internet throughout the world over time is known as Digital Divide. Less than an average 10% of the world population has access to internet. Less than 1% in underdeveloped areas in Africa, South Asia and Central America, whereas 60% of the population has access in United States, Scandinavian countries and South Korea (Guillén and Suárez, 2005). Internet tends not only to reinforce existing class and social relations (Guillén and Suárez, 2005) but exacerbate social inequalities. Guillén and Suárez (2005) identify three variables that affect the access to internet: socioeconomic status, existence of an enabling infrastructure and the cost of access. The "knowledge gap" hypothesis by Star and Hughes (1950) states that "people differ in the extent to which they use means of mass communication to acquire information. Those of a higher socioeconomic status use them at a higher rate". At the same time, democratic political governance allows for a quicker development of the internet than authoritarian or totalitarian regimes, as the internet is a decentralized means of communication more difficult to control.

Literacy is another key element for the internet usage. Being literate is essential to self guided learning, political participation and to the use of internet. Some scholars stress the absolute need of leapfrogging for developing countries in order to reduce the technological gap and catch up acceptable levels of competitiveness, skills development and quality of life through service delivery. As technology has evolved exponentially in the last century, particularly in the last twenty five years, there is the belief that the Fourth Industrial Revolution will leave behind and isolated those societies which won´t update their socioeconomic model. Nevertheless, there is an optimistic climate related to the options of this leapfrog to occur hence to a numerous possibilities that ICT offer to spread out and the fast impact and immediate results (Davison *et al.*, 2013). Both, social and technical consideration must be previously analysed at the time of implementing leapfrogging policies, ensuring that technology is not embedded to the detriment of the social. In fact, social contexts will have more than only one technical solution.

However, whether if the citizen is considered a data transmitter or on the contrary, an active participant, both approaches need the citizen to be connected, which at the same time requires a certain level of knowledge regarding the available technology.

- Initiatives on Smart Cities

While the conceptualization of the idea of Smart City has been profusely treated at a theoretical level over the last years, little has been done at the time of classifying and typifying the practical applications of those concepts, and so the evaluation of their results. This is in fact an important gap in the research literature. Therefore, there are no officially recognized institutions that record and manage the development of Smart City Projects (SCPs). A database of this nature might help to understand the successful outcomes of past projects and initiatives, to analyse trends and to indentify fields of application.

Description

Objectives	Tools	Project initiator	Stakeholders
Water	*Cloud Computing*	*Private*	*City*
E-Governance	*Data Base*	*Public*	*Consumers / Citizens*
Buildings	*DSS*	*Mixed*	*Administration*
CO_2 Emissions	*ICT*		*SMEs*
Energy	*Innovative Sensors*		*University*
Security	*Legal and financial tools*		
Social Innovation	*Other new technologies*		
Transportation	*Portable Smart Devices*		
	Smart Grids		

Business Model

Management	Infrastructure financing	Financial Resources
Private	*Private*	*Private*
Public	*Public*	*Public*
Mixed		

Purpose

Client	Product	Geographical target
Private	*Specific*	*Urban*
Public	*No Specific*	*National*
Mixed		*International*

Figure 4. Dimensions and categories of the taxonomy from Perboli *et al.* (2014)

However, some scholars have already started to look at this matter. Perboli *et al.* (2014) define a taxonomy of SCPs (see Figure 4). They identify three main structural axes present on every SCPs: *Description, Business model* and *Purpose*. "The first one, description, identifies the project context and it is composed by four categories: objectives, tools, project initiator and stakeholders. The second one, business model, analyses project management and finance through three categories: management, infrastructure financing and financial resources. The third one, purpose, analyses customers, type of product and spatial implication through three categories: client, product and geographical target". These categories are subdivided in fields. Figure 4 shows a breakdown within each category in specific fields that are identified through the analysis of 28 SCPs in 24 countries, with a population impact from 20,000 to 15 million inhabitants in cities and up to 273 million on national scale projects.

Beyond what the outcomes show in this particular analysis, the fact of having results shed some light about the actual trends and are encouraging to understand the importance of such tool. There is a sensitive propensity to SCPs focus on energy, 64%, and those focused on transport, 32%. The projects that have multiple goals are 43%, which 75% include also energy. Looking at the field of Tools, ICT projects have the highest presence with 86%. The result about the initiators shows also a well defined trend where public institutions are responsible of 56% of the projects but also take part on the majority of the projects in partnership with the private sector. From the management perspective, 82% of SCPs are managed by governments or in partnership with private companies. In the same line, 86% of the projects have public financial resources or in partnership with the private sector. The public sector also provides infrastructures and equipment for 72% of the SCPs. The axis of the purpose of the project shows a tendency of 86% oriented to clients, public or mixed, and 57% are experimental or pilot projects.

Based on the results, it looks obvious the substantial implication of the public sector on SCPs. Consequently, high levels of corruption and low skilled public officers have a huge impact on the level success of SCPs. It is also important to be aware of the risks of highly neoliberal approaches to SCPs, where the financial resources are public whereas the benefits and profits are concentrated on a minor portion of both population and territory.
The fact that more than half of the projects are experimental highlights the importance of the engagement with high education institutions and the presences and stimulation of a creative environment.

Dispersion of information and the absence of SCPs monitoring can lead to redundant projects, in space and time, repetition of failed initiatives due to the difficulty on looking at what other similar context have done in order to implement similar solutions or even tailored initiatives based on previous ones.

3.3 Indicators in rating systems for urban resilience, smart cities and urban sustainable city

City performance is assessed within a defined themed framework with the use of a set of indicators aiming to translate urban realities into numeric values. The theme will have a correlation with the selected set of indicators. This measurement method is intentional and seeks results that allow for further decision making and management supported by a solid base. The selection of the topic to address is of vital importance as it will determine the data to be collected and therefore, oversee other realities that are happening in the city simultaneously. The topics tackle overarching concepts such as competitiveness, sustainability, equality, resilience, development, smartness, etc.

Most systems approach the task in a similar way: firstly, the main topic is subdivided in categories or fields of performance that break down the main topic in multiple dimensions. Secondly, these categories might or not be subdivided in subcategories that will ultimately group indicators with a common nature in order to gain a level of gradient in the values related to such subcategories and therefore allow for a wider spectrum of urban features.

These measurement systems are genuine tools to detect lacks of performance and fix where and when needed. The update of indicators' value will determine the agility and capabilities of the system. A biased selection of indicators will intentionally hide existing problems and deploy a red carpet to the implementation of intentional urban agendas.

In this section, the researcher has selected a number of international measurement systems with the purpose of understanding the mechanism of such systems and moreover, identifying a group of indicators that might be relevant for the Southern African urban context in line with the three main topics of the research: urban resilience, Smart City and urban sustainability. The pool of selected systems of measurement included in this study is composed by systems highly cited in the literature related to urban resilience, Smart City and urban sustainability. The selection points at systems from three different scales of application: systems that aim to be applied anywhere, *ISO/37120:2014 Sustainable development of communities. Indicators for city services and quality of life* or *UN Sustainable Development Goals*; systems that have been applied to diversified broad geographical contexts, *Ranking of European medium-sized cities* or *European Green City Index*; and systems that have been applied to specific geographical contexts: *Framework and indicators to measure urban resilience: assay in Caldas da Rainha and Evora urban systems* or *Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience*.

A similar number of systems have been selected for each topic: 9 for resilience, 10 for smartness and 8 for sustainability (see Table 6). However, the total number of indicators is not as important as the distribution of indicators per categories, which defines the approach of the system. For example, systems focused on environmental matters contain a bigger number of indicators in categories related to the ecosystem in comparison with indicators regarding economic issues. For the purpose of defining a relevant matrix of indicators for the Southern African context, the exact number of systems per topic is not determinant and therefore, systems that are considered influent have been included.

Table 6. Selected measurement systems

URBAN RESILIENCE	SMART CITY	URBAN SUSTAINABILITY
ARUP + Rockefeller Foundation - City Resilience Framework	Ranking of European medium-sized cities	Environmental Performance Index (EPI)
Habitat Agenda	Smart City Indicators for Smart City Pilot in Knowledge Oasis Muscat (KOM), Sultanate of Oman	Sustainability Tools for Assessing and Rating (STAR)
Assessment of Urban Resilience to Natural Disasters with a System Dynamics Tool: Case study of Latvian Municipality	ISO/37120:2014 Sustainable development of communities. Indicators for city services and quality of life	Global City Indicators Facility
Framework and indicators to measure urban resilience: assay in Caldas da Rainha and Evora urban systems	ISO/37122-2019. Sustainable cities and communities. Indicators for smart cities	European Common Indicators (ECI)
Monitoring Urban Climate Change Resilience and Adaptation (MONARES)	ETSI TS 103 463. Key Performance Indicators for Sustainable Digital Multiservice Cities	European Green City Index
Asian Cities Climate Change Resilience Network (ACCCRN)	ITU-T Y.4901-L.1601. Key performance indicators related to the use of information and communication technology in smart sustainable cities	The UN Indicators of Sustainable Development
Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience	ITU-T Y.4902-L.1602. Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities	The Urban Sustainability Index: Urban China Initiative
OECD Indicators for Resilient Cities	ITU-T Y.4903-L.1603. Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals	UN Sustainable Development Goals (SDG's)
WHO - Healthy Cities Project	Smart cities. Croatian Large Cities Assessment	
	REPLICATE PROJECT. Renaissance of Places with Innovative Citizenship and Technology	

3.3.1 Categories and subcategories of indicators

A pyramidal hierarchical structure is identified in the organization of urban measurement systems with the following levels: category, subcategory, core indicator and supporting indicator. Each level is described by the results of the level below (Fertner *et al.*, 2007). These categories and subcategories form the framework for the indicators and the following assessment of city's performance in any particular topic.

It is clear that each topic: resilience, smartness and sustainability, uses a narrative consisting in adapting general concepts to their particular field, sometimes as a form of slogan. For example, the concept of development is treated as resilient development, sustainable development or development through ICT, depending on the context in which the concept is framed in. ARUP + Rockefeller Foundation - City Resilience Framework names a subcategory as *sustainable economy*, as if unsustainable economy were something one might dare to openly propose anymore. Another example is the GIZ project: "Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience", which name 3 out of 4 categories with the prefix "climate resilient-", namely, *"climate resilient economy"* or *"climate resilient infrastructures and ecosystems".*

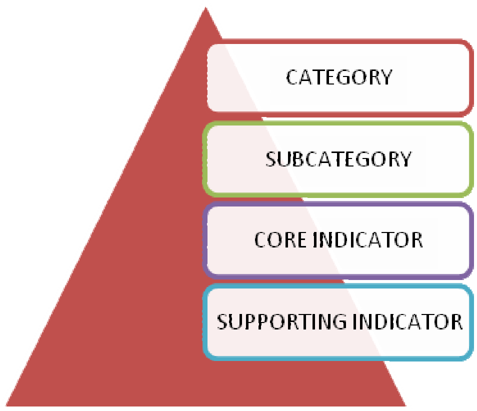


Figure 5. Structure of measurement systems

There are not a consistent number of categories for all systems. For instance, the World Bank's *Global City Indicators Facility* defines only two categories whereas the UN Sustainable Development Goals and the *ISO 37120:2018 Sustainable Cities and Communities* consider seventeen. Nevertheless, a group of categories seems to be recurrent in most systems. These categories deal with economic matters, politics and governance, social issues affecting people's live, natural ecosystems and urban services and infrastructures. Table 7 shows all categories in the systems analyzed in this research.

Systems with a high social orientation bring to the top level of categories concepts that could be included as subcategory: *Poverty* in the *UN Indicators of Sustainable Development* could be included in Economy; *Shelter* or *Social Development and eradication of poverty* in the Habitat Agenda, could be included in Living and Economy respectably; and for the *SDG's* each category is titled with a statement. On the contrary, a system developed in the Global North such as *European Green City Index*, does not contain any category related to social issues, bringing to the top of the structure *CO2* or *Air Quality*, which may be included in the broader category of Environment.

Highly specialized systems of measurement such as the *WHO - Healthy Cities Project*, tackle specific concepts and lack of holistic approach to the analysis of the city.

Systems tackling resilience subdivide the assessment in a lower number of categories in comparison with sustainability and smartness. However, in some cases, categories might include one or two indicators. In other cases, they might include over 10. The number of categories is to be analysed in combination with the number of indicators.

Table 7. Categories of the selected systems of measurement

URBAN RESILIENCE	
SYSTEM	**CATEGORIES**
ARUP + Rockefeller Foundation - City Resilience Framework	Health and well-being
	Economy and society
	Infrastructure and ecosystems
	Leadership and strategy
Habitat Agenda	Shelter
	Social Development and eradication of poverty
	Environmental management
	Economic development
	Governance
Assessment of Urban Resilience to Natural Disasters with a System Dynamics Tool: Case study of Latvian Municipality	Social dimension
	Economic dimension
	Infrastructure dimension
	Environmental dimension
Framework and indicators to measure urban resilience: assay in Caldas da Rainha and Evora urban systems	Economic Base
	Demographic Structure
	Process of urbanization
	Social cohesion
	Human capital

Monitoring Urban Climate Change Resilience and Adaptation (MONARES)	Environment
	Infrastructure
	Economy
	Society
	Governance
Asian Cities Climate Change Resilience Network - ACCCRN	Institutional
	Social
	Human
	Economics
	Physical
	Ecological
Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience	Climate-resilient infrastructure and ecosystems
	Integrated and enabling governance
	Climate resilient economy
	Climate resilient economy
OECD Indicators for Resilient Cities	Social
	Economic
	Environment
	Institutional
WHO - Healthy Cities Project	Health
	Health services
	Environmental
	Socio economic

SMART CITY	
SYSTEM	**CATEGORY**
Ranking of European medium-sized cities	Smart Economy
	Smart People
	Smart Governance
	Smart Mobility
	Smart Environment
	Smart Living
Smart City Indicators for Smart City Pilot in Knowledge Oasis Muscat (KOM), Sultanate of Oman	Environment
	Quality of life
	Infrastructure
ISO_37120_2014 Sustainable development of communities. Indicators for city services and quality of life	Economy
	Education
	Energy
	Environment
	Finance
	Fire and emergency response
	Governance
	Health
	Recreation
	Safety
	Shelter
	Solid waste
	Telecommunication and innovation
	Transportation
	Urban planning
	Wastewater
	Water and sanitation
ISO_37122-2019. Sustainable cities and communities. Indicators for smart cities	Economy
	Education
	Energy
	Environment and climate change
	Finance
	Governance
	Health
	Housing
	Population and social conditions
	Recreation
	Safety
	Solid waste

	Sport and culture
	Telecommunication
	Transportation
	Urban/local agriculture and food security
	Urban planning
	Wastewater
	Water
ETSI TS 103 463. Key Performance Indicators for Sustainable Digital Multiservice Cities	People
	Planet
	Prosperity
	Governance
ITU-T Y.4901-L.1601. Key performance indicators related to the use of information and communication technology in smart sustainable cities	Information and Communication Technology
	Environmental sustainability
	Productivity
	Quality of life
	Equity and social inclusion
	Physical infrastructure
ITU-T Y.4902-L.1602. Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities	Environmental sustainability
	Productivity
	Quality of life
	Equity and social inclusion
	Physical infrastructure
	Environmental sustainability
ITU-T Y.4903-L.1603. Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals	Economy
	Environment
	Society and culture
Smart cities. Croatian Large Cities Assessment	Economy
	People
	Governance
	Mobility
	Environment
	Living
REPLICATE PROJECT. Renaissance of Places with Innovative Citizenship and Technology	City description
	Energy & environment
	Mobility
	Infrastructures for innovation
	Governance
	Social
	Economy & finance

URBAN SUSTAINABILITY	
SYSTEM	**CATEGORY**
Environmental Performance Index (EPI)	Biodiversity
	Ecosystem Services
	Fisheries
	Climate Change
	Pollution Emissions
	Agriculture
	Water Resources
Sustainability Tools for Assessing and Rating (STAR)	Built Environment
	Climate & Energy
	Economy & Jobs
	Education, Arts & Culture
	Equity & Empowerment
	Health & Safety
	Natural Systems
Global City Indicators Facility	City Services
	Quality of Life
European Common Indicators (ECI)	No categories defined
European Green City Index	CO2
	Energy
	Buildings
	Transport
	Water

	Waste and land use
	Air quality
	Environmental governance
The UN Indicators of Sustainable Development	Poverty
	Governance
	Health
	Education
	Demographics
	Natural hazards
	Atmosphere
	Land
	Oceans, seas and coasts
	Freshwater
	Biodiversity
	Economic development
	Global economic partnership
	Consumption and production patterns
The Urban Sustainability Index: Urban China Initiative	Society
	Environment
	Economy
UN Sustainable Development Goals (SDG's)	1. End poverty in all its forms everywhere
	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
	3. Ensure healthy lives and promote well-being for all at all ages.
	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
	5. Achieve gender equality and empower all women and girls
	6. Ensure availability and sustainable management of water and sanitation for all.
	7. Ensure access to affordable, reliable, sustainable and modern energy for all.
	8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
	10. Reduce inequality within and among countries.
	11. Make cities and human settlements inclusive, safe, resilient and sustainable.
	12. Ensure sustainable consumption and production patterns.
	13. Take urgent action to combat climate change and its impacts.
	14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
	15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
	17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Some categories and indicators cover multiple fields. For example, energy includes environment and infrastructure; quality of life includes people and living. The aim of the researcher is to simplify to a smaller number of categories.

The group "Miscellaneous" is defined in this early stage of the analysis in order to contain categories and indicators that are not clearly included in any of the thematic categories mentioned. The group description considers categories and indicators that are merely descriptive, such as city density, population, area, etc.

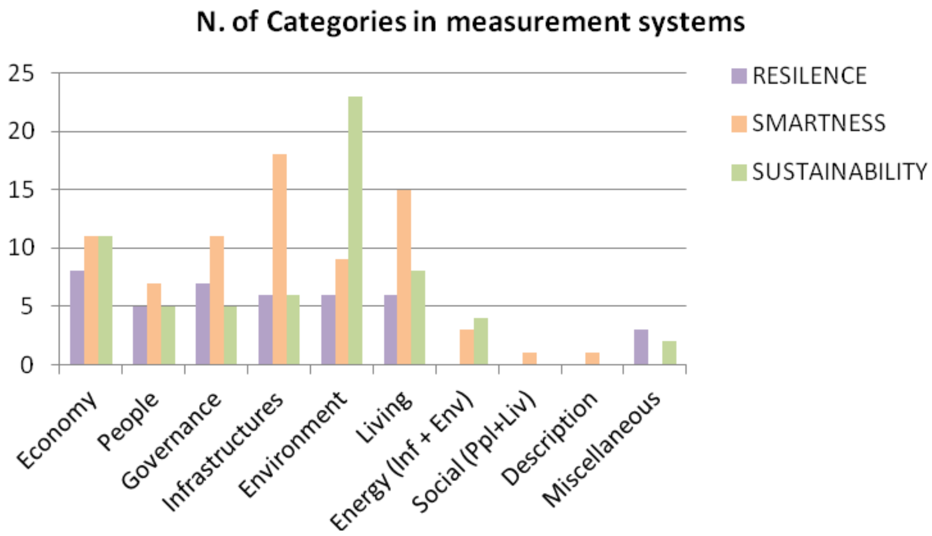


Figure 6. N. of Categories in measurement systems

Looking at the number of categories by topic (see Figure 6), the systems included in the resilience group deal with urban matters in a rather even manner, with no substantial differences in the number of indicators per categories. On the contrary, sustainability systems show a considerable difference between environmental issues and the rest. In the case of smart systems, infrastructures and quality of live are the most important groups of categories. Economic matters show also an important relevance within all systems.

The groups miscellaneous and description contain a small number of indicators. These indicators will be relocated within the other thematic categories in a process of rearrangement of indicators at a later stage of the analysis.

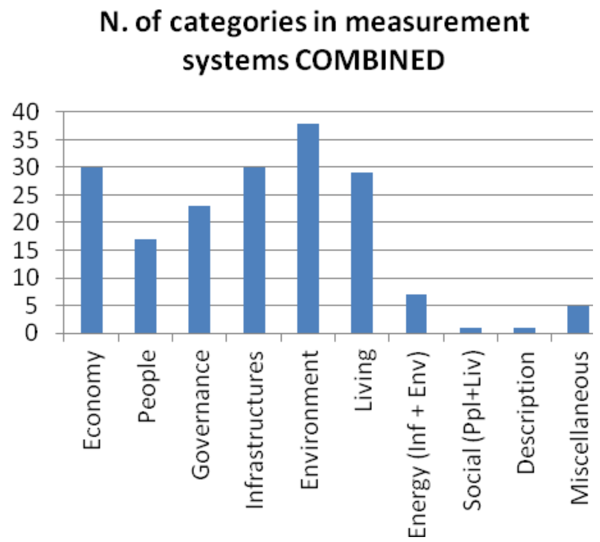


Figure 7. N. of categories in measurement systems COMBINED

When combining categories from all three topics (see Figure 7), matters concerning environment, economy, infrastructures and quality of live are the dominant in comparison to governance and social issues such as human rights and education.

3.3.2 Indicators

Indicator is defined as “a quantitative, qualitative or descriptive measure” (ISO, 2008) that makes available information about a complex phenomenon, such as the active urban context, to be rationalized into a scheme that is reasonably easy to handle and understand (Huovila, Bosch and Airaksinen, 2019). When consistently monitored and measured, they help to identify trends and changes in the phenomenon (Haapio, 2012). The three main functions of indicators are quantification, simplification and communication (ISO, 2011). City indicators therefore help city managers in defining goals and measuring their performance over time (ISO, 2018).

ISO 37120:2014 establishes three levels of indicators:

a) Core indicators: indicators that are required to demonstrate performance in the delivery of city services and quality of life.
b) Supporting indicators: indicators that are recommended to demonstrate performance in the delivery of city services and quality of life.

c) Profile indicators: indicators that provide basic statistics and background information to help cities determine which cities are of interest for peer comparisons. Profile indicators are used as an informative reference.

The dimension of the indicators in the selected systems differs from one system to another. Some systems define generic indicators that contain a number of topics under a common umbrella. For example, the system Sustainability Tools for Assessing and Rating (STAR) defines the indicator *BE-7: Transportation Options* which contains a number of alternative transportation options. This is a rather generic indicator. On the contrary, *Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience* defines a very specific indicator in relationship to mobility: *NMT paths as a percentage of the total municipal road network length*.

In addition to this, not all indicators have the same weight for the final results. It will depend on several factors such as accuracy of information, methodology carried out to obtain the data, population assessed, implementation and monitoring of consistent assessment means. For example, the REPLICATE Project and ETSI TS 103 463 establish a scale from 1 to 7 points to rate the indicator 'Climate resilience strategy', which measures the extent to which the city has developed and implemented strategies to address climate resilience. For qualitative indicators, the literature suggests self-assessment techniques using scales or thresholds (Demirgüç-Kunt and Klapper, 2012). The indicator provides a qualitative measure and is rated on a seven -point Likert scale. This Likert scale is based on the steps suggested by the "Mayors adapt" initiative for climate change adaptation in urban areas (Mayors Adapt, 2014).

1. No action has been taken yet.
2. The ground for adaptation has been prepared (the basis for a successful adaptation process).
3. Risks and vulnerabilities have been assessed.
4. Adaptation options have been identified.
5. Adaptation options have been selected.
6. Adaptation options are being implemented.
7. Monitoring and evaluation is being carried out.

ARUP + Rockefeller Foundation's City Resilience Framework uses both, qualitative and quantitative indicators for different but complementary purposes: "Qualitative indicators assess the capability of the mechanisms and processes in place to achieve the outcome articulated. Quantitative indicators identify quantitative metrics that can be used by cities as proxies for past and current performance. The system establishes a differentiated scoring system for qualitative and quantitative indicators: qualitative indicators are scored on a linear scale between 1 and 5, based upon consideration of a 'best case' and 'worst case' scenario relevant to a particular area of city performance. Quantitative indicators are scored on relevant city data in a specific unit as a globally applicable metrics of resilience. A score from 1 to 5 is then automated, based on a standardised performance scale" (The Rockefeller Foundation and ARUP, 2015).

Testing resilience measurement models or evaluating program attribution accurately demands the use of quantitative methods. Nonetheless, these processes are often complex and costly, and do not always provide program implementation teams with the needed results in order to make adjustments to their theory of change, or course-correct in their estimations. The use of qualitative methods can frequently afford information quicker, and offer a richer insight into certain events. A decision to use qualitative, quantitative or a combination of both methods should be carefully considered against the specific objectives of data collection, usability, and costs (Mercy Corps, 2018).

For Li *et al.* (2020), the measurement of a Smart City should include an extensive array of representative indicators, through realistic data collection methods, with a majority being qualitative, supplemented by qualitative indicators.

This approach is argued as citizens' perception on governance, quality of life or labour market, together with strategies and policies implementation (Economist Intelligence Unit, 2009) would play a secondary role in the final outcome of the assessment. Existing qualitative information is to be systematically collected and analysed together with quantitative information. This qualitative data helps to contextualize the dynamics through which policies work and their interaction (Figueiredo, Honiden and Schumann, 2018).

Collection of quantitative data relays on accurate implementation of methods and display of sensors. This might clash with the low level of technological deployment in Southern Africa.

For example, the periodicity of demographic census in South Africa is 10 years due to both, technical and human capacity. In summary, both qualitative and quantitative indicators are to be combined in any urban assessment that aims to achieve a multifaceted and complete understanding of holistic situation and the complexity of urban processes.

One of the most important aspects of the analysis of indicators lays on finding to what area the several systems of measurement pay more attention. The researcher has analysed whether there is a coupling effect on the definition and number of indicators per category or on the contrary, each system has developed a genuine approach and the results vary from one system to another.

In order to unify the way in which different systems name and classify categories, a new set of categories composed by 10 items has been established in this research: Economy, People, Governance, Infrastructures, Environment, Living, Energy (Infrastructure + Environment), Social (People + Living), Description and Miscellaneous. The set is applied across measurement systems from different topics. The category named Miscellaneous refers to *ARUP + Rockefeller Foundation - City Resilience Framework; MONARES, Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience;* and *ECI* which don't allocated an specific category for a group of indicators. Moreover, systems like *Global City Indicators Facility*, define only two categories including a big number of indicators with different nature. In a later stage, indicators included in the category Miscellaneous will be relocated in one of the categories in the final set.

Some trends have been identified among the systems. The initial pool of indicators contains 1458 indicators. There is a correlation between the number of categories and the number of indicators. Measurement systems related to resilience include the lower number of indicators (see Figure 8).

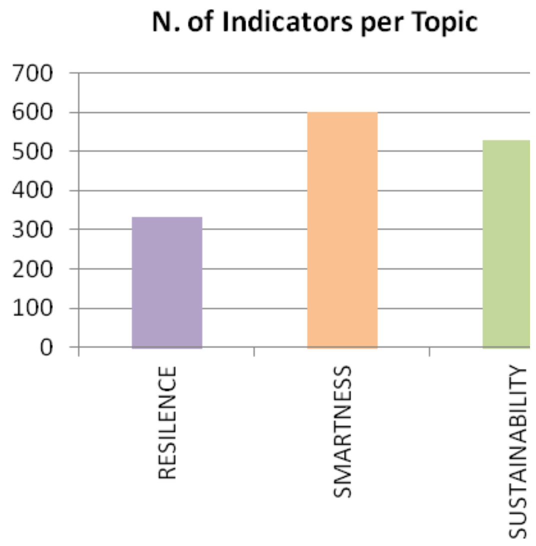


Figure 8. N. of Indicators per Topic

By number of indicators, systems related to resilience put the accent on governance and living conditions and give a secondary role to infrastructures, environment and economy. For Smart City systems, the higher number of indicators is concentrated in infrastructure and economy, with environment and living conditions in a lower step. Finally, for sustainability systems, environmental matters rank the highest in number of indicators, with economy and living conditions very close in terms of importance, establishing a big gap with the rest of categories (see Figure 9).

Similarly to categories, indicators identified as miscellaneous are indicators initially organized by the measurement systems with either not specific categories or included in categories that are generic. These indicators will be relocated in a later stage of this analysis within a established group of categories according to specific concepts.

When combining indicators from all three topics, economic indicators are the most numerous of all categories, followed by environmental and living conditions indicators. This outcome, which would have been expected from measurement systems of competitiveness, not considered in this research, indicates the key position of economic factors within urban contexts. In the case of Southern Africa, development comes in hand with economic boost and poverty alleviation, together with the economic dynamics associated to infrastructures development.

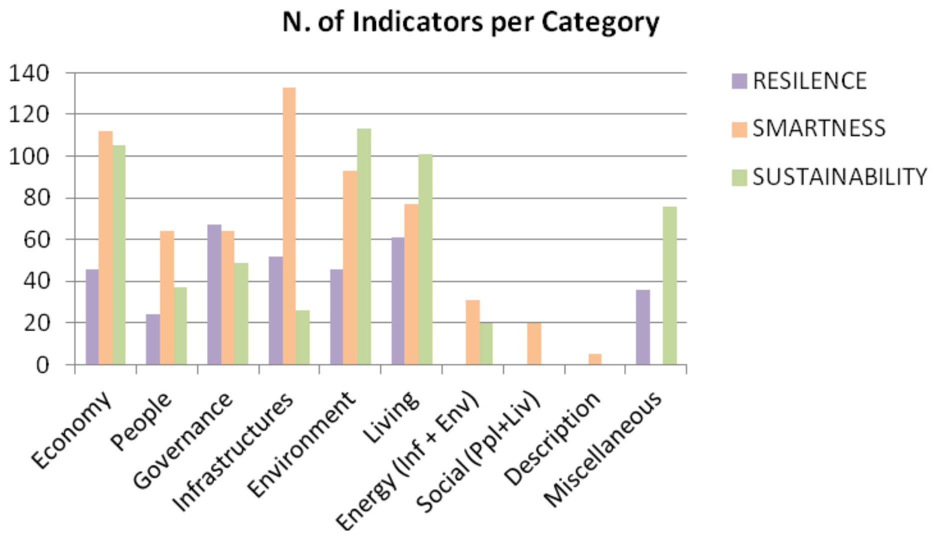


Figure 9. N. of Indicators per Category

Indicators related to social matters, namely those included in the categories people and living, combined form the most numerous group. This highlights the social component of any city. However, they are generally split in two or more categories by most measurement systems.

Smart indicators for governance put the accent on the possibility of engaging online with political decisions, without stressing the level of engagement offline. The SDG's system highlights the importance of social matters even when dealing with environment or economy.

The approach to employment is particularly important in the Southern African context. A few systems include the indicator youth unemployment. While it might not be relevant in developed countries with aged populations, it is of high importance in the Southern African region, being the average population age younger than 25 years. It means that the majority of the population in working age fits into the category of youth. Along the same lines, indicators looking at young population with no access to employment neither study opportunities appear relevant in Southern Africa.

When it comes to measure natural attractiveness, the indicator *sunshine hours* might play a decisive role in Northern Europe but definitely not a factor that applies with the same importance to Southern Africa, one of the regions in the world with average 3,600 sunshine hours per year. However, other factors such as wildlife and natural features of international interest: Okavango Delta, Namib Desert, Drakensberg Mountains or Victoria Falls to mention a few, play an important role in the rate of natural attractiveness. Nevertheless, this indicator might be considered as support for sustainable energy production.

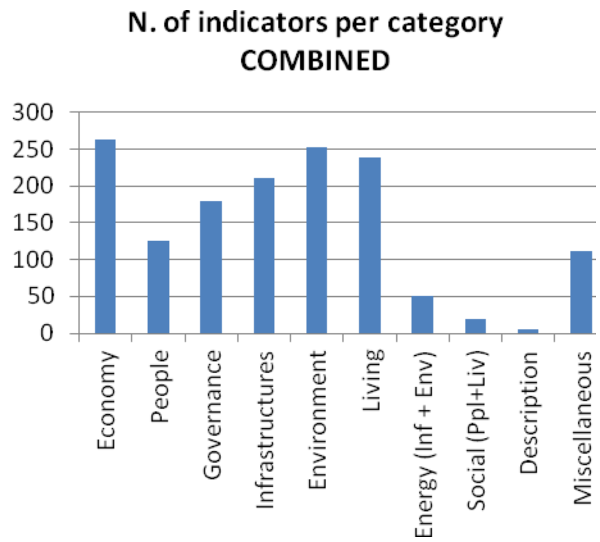


Figure 10. N. of indicators per category COMBINED

Some indicators are defined based on sex, age or race. This can supply additional layer of information related to equality and inclusivity within urban contexts.

Only a few systems acknowledge the existence of informality, especially when approaching housing. Informality in Southern Africa, already discussed in the literature review, far from being anecdotic is an overwhelming reality for more than half of the population and affects not only housing condition but the economy, employment and access to services. New indicators have been added to the final set in order to include this situation present in the Southern African cities.

Whereas for social oriented systems such as SDG’s access to energy is highlighted, for systems implemented in developed countries such as *European Green City Index* or *The Urban Sustainability Index: Urban China Initiative*, access is taken for granted and the focus is set on energy consumption. Therefore, for a region of the world in which 60% of the population live in informal settlements, access to energy might be an indicator with priority.

3.4 Overlapping the 6 Key-Fields of the Smart City to the Southern African context

The study of the Smart City from an African perspective seems to be scarce. In 2016 Purnomo et al analysed a systematic literature review, identifying the hundred more relevant papers since 2004. No paper from Africa was on the list (Purnomo, Meyliana and Prabowo, 2016).

The initial two-ways approach of this research starts from a well established and internationally accepted concept of Smart City and overlap it to the SSA existing reality. Afterwards, analysing the clash and defining a tailor-made smart solution for such context. Therefore, both the smart framework and the Southern African context will be subjected to adaptation in order to merge in a functional system.

- Information and communication technologies (ICT)

If digitalization and the use of ICT are key drivers in the implementation of smart solutions, a look to the existing capacity is to be taken.

The share of most developing countries in the global information society remains irrelevant. This is regarded to multiple causes namely: lack of economic or human capital to obtain and use technology, an idealistic preference for self-reliance and apparent incompatibilities between cultures and technologies. Efficient use of ICTs is affected by location, race and gender (Davison *et al.*, 2013). A small portion of Africans are able to connect to Internet, 0.01% outside South Africa (Amoako, 1998b). Whilst developing countries represent 80% of the world population, their total global spending on informatics accounts for just 2% (Hanna, 1991).

Inequality is definitely reflected on the access to the internet and the use of ICT. The uneven development of the internet throughout the world over time is known as Digital Divide. Less than an average 10% of the world population has access to internet. Less than 1% in underdeveloped areas in Africa, South Asia and Central America, whereas 60% of the population has access in United States, Scandinavian countries and South Korea (ITU, 2000). Internet tends not only to reinforce existing class and social relations (Mosco, 2009) but exacerbate social inequalities. Fewer than 20% of Africans have access to the Internet. Broadband access can cost one thousand times that of people´s monthly income in many parts of the continent (Shah and Jaisinghani, 2014). Moreover, online content is mostly produced by the global north (Graham, 2014).

In South Africa, Internet access is mainly restricted to urban areas with age, gender, income, race and education important factors; most of Internet users in South Africa are white and male, have a tertiary education and are younger than 50 (Langa, Conradie and Roberts, 2006). The spatial allocation of ICT access shows an expected urban bias with Western Cape and Gauteng at the top in terms of access at provincial scale. In KwaZulu-Natal, ICT is strongly concentrated in Msunduzi and eThekwini (Thlabela *et al.*, 2006). An extensive scrutiny of Durban shows that spatial changes have been informed by global market trends and private investment decisions. Urban place making does not depend anymore on the only decision of the town planner but influenced by markets and private interests. The additional 'layer' of ICT increases this trend. The spatial expression of this shows that access to ICT correlates with higher incomes households and grouped private sector. (Odendaal, Duminy and Saunders, 2008).

Nevertheless, creative approaches and new spatial modalities of ICT in developing countries mitigate the cost barrier. Telecentres in shipping containers, informal phone shops on sidewalks or the so called "beeping": a code of missed calls are examples of imaginative ways to reduce the technological gap (Donner, 2008).

- Poor infrastructures

The Fourth Industrial Revolution (4IR) is defined as a confluence of the new technologies, which are developing at exponential velocity (Schwab, 2017). Considered the current lack of industrialization in Africa, the most important impact of the technologies of the 4IR is expected to be a leapfrog to bypass some of the challenges on developing the industry sector (Nulens and Van Audenhove, 1999; Aurik, 2017b). The possibility of a decentralized smart grid will finally make possible a broad access to electricity in remote locations. At the same time, the transition to a circular economy can help to mitigate the need of imports, as the concept of waste becomes obsolete due to the ability of the Internet of Things in tracking material and energy flows (Harvey, 2017).

The present reality points a few challenges to take into account. Africa, together with Latin America, holds less than 8% of the market in main new production technologies (the Internet of Things, AI, 3D printing, robotics and enterprise wearables) (Aurik, 2017b). SSA ranks at the bottom of the Frontier Technologies Readiness Index, with an index score lower than 0.2 (UNCTAD, 2021). New technologies threaten to magnify inequalities and concentrate value in the hands of the already wealthy. For instance, mining is slowly turning into driverless trucks, robots and non invasive extraction systems. Half million of mine workers in South Africa may lose their jobs (Harvey, 2017). The risk of getting left behind is a real menace.

Some companies are addressing the education based on digital skills. With the switch from the primary sector industry to a secondary sector industry based on manufacturing, the demand of services oriented jobs will increase (Aurik, 2017a). In these terms, acquaintance of digital skills must be fostered as a natural transition from low skill and low wage jobs to high skills and high wage jobs. Initiatives like Cisco Networking Academy, Vodacom Foundation e-Learning and Telkom Futuremakers among others are providing training programs within the frame of the digital inclusion (Meads and Africa, 2019).

The implementation of ICT strategic plans is basic on the coordination and integration of different regions within common frameworks, economic and infrastructure wise, as it is the case of the Continental Free Trade Area (CFTA), East African community, Common Market for Eastern and Southern Africa (COMESA), the SADC and the Northern Corridor (Schneidman, 2014) by not only improving but in fact allowing the development of e-services, borders control and migration, standardisation of telecommunication and connectivity among others (Meads and Africa, 2019). The expectation of grow for the share of intra-African trade is over 50% in ten years in an effective continental trade area (Mevel and Karingi, 2013).

In the business report 'Africa is ready to leapfrog the competition through smart cities technology', the consulting and audit company Deloite stresses the benefits of the lack of infrastructures as cities can directly apply new smart technologies from scratch (Deloitte & Touche, 2014). The African city is therefore seemed as a blank canvas for development of the new urban typology (Vanolo, 2016).

- Low data availability and quality

Southern African governments collect primary data detailed enough to give government decision-makers an accurate picture of their economies and societies. The sources of this primary data are regular censuses and sample surveys, and also administrative records in the course of governing. (Lane, 2003). Nevertheless, the findings from survey research has poor direct impact on decisions taken by the governments of these countries (Hoffman, 1995).

As Woolfrey (2014) identifies series of quality features for microdata in order to be optimally functional:

a) It should be relevant and correlated to the users' information needs
b) It must be accurate
c) It must contain minimal disparity between official estimates and real values
d) It should be easy to find and use
e) Quality data is expected to be timely available
f) It should be comparable across time and type to allow for the merging of disparate datasets
g) It should be readily interpretable

Data security is to be added to these traditional quality features. Woolfrey (2014) highlights the importance of data access: *"Access is the cornerstone of data quality. Better access may boost other aspects of data quality because proper data curation becomes a by-product of sharing. Opening up their microdata compels official data producers to confront the challenge of how to handle their data".* However, despite the digital revbolution allowing governments to produce data faster, this situation has not been taken as advantage for a better planning through the use of data (Woolfrey, 2014).

Institutions in charge of collecting and storing basic data such as censuses: demographic, health survey and population are often underfunded and understaffed, affecting the availability and reliability of data (Güneralp *et al.*, 2018). The challenges of access are dual in many African countries: Firstly, microdata that is needed for planning is not provided to government ministries. Secondly, large datasets of government microdata do not reach academia. National statistics agencies are the principal producers of data in Africa. However, most of them do not have policies for allowing researchers access to their datasets (Woolfrey, 2013). Surveys in 2009 and 2012 confirmed such situation. Requests for data were either handled on a case-by-case basis or declined, using confidentiality concerns to motivate both reactions (Woolfrey, 2013).

It is extensively documented the lack of adequate urban data handled by most African governments (Pieterse, 2019). Poor statistical data is collected and put together at city level. Productivity estimates and about census are particularly complex due to the blurry nature of the income sources in the informal sector in SSA (Bryceson, 2010). Additionally, the availability of data in informal settlements and slums is close to null despite the efforts of members of the civil society and academia in recent years (Georgiadou *et al.*, 2020).

Parnell and Pieterse (2016) point out "either Africa must be ignored or the theory, method and data of urban studies must change. The former is not possible and so we need to better understand the barriers to finding appropriate new methods of (African) urban research".

- The 6 key-fields of the city

As initial approach, a discussion on at what extent the current status of Southern Africa whether complies or lacks of smart capabilities can be articulated by using the 6 key-fields of the city: *people, economy, environment, governance, mobility,* and *living* (Fertner *et al.*, 2007).

3.4.1 Economy

Africa is home to six of the world's twelve fastest growing economies from 2014 to 2017 (Knowledge@Wharton, 2017). The strategy put in place by successful companies is based on a careful selection of the market they are entering. They have targeted fast growing cities rather than building a continent or countrywide presence. In fact, the forecast for consumption spending by 2025 concentrates the 60% of the spending in the 20 biggest cities (Agyenim-boateng, Benson-Armer and Russo, 2015).

- Innovative spirit

Southern Africa is committed to harness science, technology and innovation (STI) to sustainable development. The economies of the SADC are extremely reliant on natural resources (Pieterse, Parnell and Haysom, 2018). The plummet in public investment on R&D on agriculture by SADC countries is, therefore, a reason for concern (UNESCO, 2015c).

The region is characterized by great disparities in R&D intensity, from almost inexistent in Lesotho with a 0.001% to an active interest to develop the private sector in Malawi, reaching 1.06%. South Africa stands out on FDI attraction, getting about 45% of the total FDI in the SADC and at the same time, becoming the leading investor in the region, particularly in mining, telecommunications and retail. However, the shortage of funding in the private sector between 2008 and 2012 has dropped its gross domestic expenditure on R&D from 0.89% to 0.73% (UNESCO, 2015c). South Africa's GDT constitutes the 25% of the entire continental GDP and has a strong innovation environment, filing 96% of patents in the SADC region between 2008 and 2013 (UNESCO, 2015c).

STI policies in the SADC region are strongly bonded to the state. The collaboration with the private sector is poor and public agencies lack of human and financial capital. Implementation planning and budget are typically not included in the policies, rendering the STI narrative a smokescreen to capture FDI. In the *Science report: towards 2030 elaborated* by UNESCO, additional obstacles to national innovation programs are indentified: "poor science education at school with lack of qualified teachers and an appropriate curricula, a serious scarcity of scientific and technological skills at all levels, ongoing brain drain, a poorly developed manufacturing sector, few incentives for private-sector investment in R&D, poor legal protection of intellectual property rights, and lack of co-operation in science and technology" (UNESCO, 2015c).

Despite this desolate atmosphere, the private sector aims to render itself up to date. more than a half of the companies in the SADC describe themselves as innovative, for instance, 65.4% in South Africa, 51% in Zambia and an outstanding 58.5% in Lesotho if we consider the 0.01% of GDP allocated to STI mentioned above (UNESCO, 2015c). Currently, trending professions on the region include the creative industries, 3D designers, food technologists, education and health and data centre workers and care. There is great potential for growth in the ICTs, STEM and green jobs in the longer-term (World Economic Forum, 2017a).

This finding from the World Economic Forum contrasts however with the current situation. While the services sector continues to absorb jobs throughout the region, employment makeup in SSA countries varies significantly, although participation in agriculture remains persistently high in most places. However, the lack of employees in the highly productive industrial sector is remarkable, mainly due to a lack of supply of workers or a emerging industrial sector (Bhorat, Naidoo and Ewinyu, 2017). STEM graduates represent only the 2% of the continent's college-age population in Africa (World Economic Forum, 2017a).

The contribution of creativity and talent in economic growth has capitalized increasing interest to the social science community. Human capital is considered to be unevenly distributed geographically. The conventional measure of human capital is based on educational achievement rates. Recent research suggests that measuring what people do is more important than what they study, and therefore occupationally based measures, associated with the creative class. Mellander and Florida (2007) identify three alternative factors that play an important role: universities, amenities, and openness and tolerance. Therefore, knowledge and skills would compose the 'human capita' that unlocks value creation and in a global context. A schematic picture of Florida's general model of talent, creativity, and regional development is shown in Figure 11.

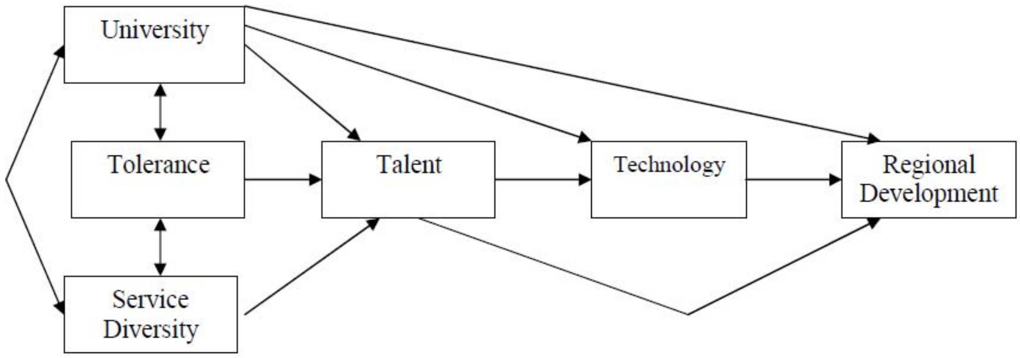


Figure 11. Model of key regional development paths (Mellander and Florida, 2007).

The Global Human Capital Index, revised in 2017, assesses the level of improvement of human capital through which countries have benefited not only their economies but also their citizens. SSA is the region with the lowest rank below the regional average regarding deploying their current workforce. South Africa (ranking 87), the second largest economy in the region, has the highest share of workers in high-skilled employment in Africa and it is valued for its labour force training. However, South Africa lacks in performance in school quality (World Economic Forum, 2017b).

An estimated 15 to 20 million well-educated young people are expected to join the African labour market every year for the next three decades. Nevertheless, vocational and technical education, and training is a strategic area which is currently underperforming at only 6% of total secondary and post-secondary enrolment (World Economic Forum, 2017a).

- Entrepreneurship

The reasons for individuals to starting new business are varied but can be classified in two groups: *pulling and pushing factors*. The earlier includes family tradition, philanthropic aspirations, pursuit of financial success and independence. The later includes poor skills and education, insufficient job opportunities and economic struggles. This second group is known as ‘necessity’ entrepreneurship: small tuckshops or micro business to either supplement low wages or to ultimately make a living. These entrepreneurs usually operate within the informal sector at subsistence level. The number of companies in Africa with more than 10 employees represents only the 2% (Sriram and Mersha, 2006).

Small and medium enterprises are the major employers in SSA. Economies in the region are improving their scores at a rate three times that of OECD high-income economies. Despite this achievement, though, running economic activities in SSA is still difficult, as it requires a tedious time consuming process to even get the business started alone to obtaining permits and electricity. Border crossing is also concerning in terms of time consuming and officials corruption, which have a negative impact on agricultural exports. The business environment in SSA is challenging, particularly regarding contract enforcement, control of corruption, hurdles in starting business, and regulation quality (Spring, Rolfe and Odera, 2013).

In the case of Africa, transformation means not only and ability but a mandatory task that Post-colonial African governments of any political sign have undertaken. Enormous bureaucratic public sector companies have been created, and still lead economic activity. However, the lack of satisfactory incentive for skill development at management level to efficiently handle these enterprises held back any chance to generate profits due to most of these being subsidised by the public sector. Protectionist policies blocked any foreign competition and therefore, enterprises were not pressed to control costs, develop competitive products, innovate, and acquire new managerial skills as the private sector managers operating in competitive economies. Consequently, when transition to open economies and privatisation began, the absence was filled by international companies instead of home-grown enterprises, except for South Africa, where international boycotts and sanctions due to apartheid policies demanded the indigenous private sector to develop (Mbeki, 2005).

- Economic image & trademarks

Patent filings exceeded 3.3 million and trademark filing activity totalled 14.3 million around the world in 2018. The African region represents 0.5% and 1.7% respectively. Although Africa experienced a growth of 2.5% in total filings between 2008 and 2018, in terms of intellectual property, the region has an insignificant role worldwide, except for South Africa which is the highest ranked African office, in 24th place (OMPI, 2019).

- Productivity

SSA has the lowest share of employment in manufacturing worldwide. Job creation is generally associated to agriculture and traditional services, basically low productivity sectors, which has sparked the alarms as fast economic growth is associated to manufacturing, thus offering a better chance at development. The lack of agglomeration economies in urban areas is reflected in the slower pace of income per capita growth relative to urbanization. Cities in SSA are typically congested but not economically dense, reflecting inadequate planning, highly fragmented with lack of reliable mobility, limiting effective workforce and goods movement, increasing cost of food and transportation, and putting pressure on formal employment salaries (Lall, Henderson and Venables, 2017).

The advent of the 4IR has awakened great expectation in relationship with the productivity improvement, although great uncertainty in regard of the impact on possible displacement of jobs even for developed even for developed economies, with an estimate of 55% of jobs may be at risk from automation. Demographics play an important role in the penetration of new technologies and it is a key difference between advanced economies and SSA. In advances economies, these technological changes are coupled with a shrink of working population. They are therefore extremely welcoming to the opportunity to maintain or even increase results with smaller workforce.

Expectation of GDP growth in the next ten years goes from the current 4.9% to 6.2%, whereas the global rate would be 3.7% (Agyenim-boateng, Benson-Armer and Russo, 2015). Sub-Saharan manufacturing exports have doubled between 2005 and 2015. African internal exports have also increased from 20% to 34% for the same period of time. This positive trend offers African countries helps increasing resilience to economic instability (te Velde, 2016). At the same time, this situation is also attracting foreign direct investment, which shows positive figures in the last decade, as the case of Mozambique and Tanzania with a 25% and Rwanda with over 40%. The Manufacturing FDI Potential Index highlights the positive climate especially in Rwanda, Ethiopia, Tanzania, Kenya, Zambia and Nigeria. Despite of this positive trend, Africa's exports pattern is still vulnerable to commodity price changes, accounting around 60% of export on oil and mining (Page, 2016).

The unemployment rate in urban areas SSA is high and the informal economy represents about 60% of jobs opportunities. This has an enormous impact on taxation and accountability as they are difficult to be monitored by public institutions. The result is a large misleading disparity between the GDP and the actual size of the economy in SSA countries (Güneralp *et al.*, 2018). Empowering the manufacture sector could balance the sometimes volatile commodity prices, and bring stability to the economic model.

- Flexibility of labour market

Job creation and population growth have coupled since 2000, at a rate of 9 million jobs per year. Nevertheless, most of the job opportunities in the region are limited to small farm, reason why over two thirds of workers are stuck in extreme poverty, and one quarter in moderate poverty, unable to prosper. In addition, employers report scarcity of skilled workforce as an important limitation to their operations (World Economic Forum, 2017a). Self-employment has continued to be predominant with a 67% of total employments due to push factors aforementioned. This modality of jobs provides no security or stability as workers typically operate informally (Abdychev *et al.*, 2018), and fail to paid any kind of insurance, subjected to inadequate public services. Almost 50% of the countries in SSA account unemployment rates below 5% (exceptionally South Africa reports a rate over 20%). The reason for such low rate is the impact of informal employment, which accounts to 76.8% in urban areas (ILO, 2020).

The region also accounts for the larger disparity between unemployment and labour underutilization, which is three times bigger. The reasons for at least 50% of labour underutilization are time-relate, which indicates the low quality of employment in the region (ILO, 2020).

It is difficult to find reliable data about employment in Africa. Only a few countries have reliable data. For instance, the LABORISTA Database, by the International Labour Organization (ILO), only manages to present unemployment rates for ten African countries. Moreover, lack of consistency across the data due to time, sample population, collecting methods, etc, makes very difficult to cross reference indicators and compare. This results in misleading diagnoses of employment. Classic measures of unemployment and the perception of unemployment by households do not correspond. labour markets in SSA require new forms of assessments, considering specificities of labour markets in the region such as quantity and quality of jobs and not only the traditional level of unemployment and the number of hours worked (De Vreyer and Roubaud, 2013). In this sense, De Vreyer and Roubaud (2013) identify several key points that make SSA labour market characteristics differ:

- 75% of employment in the informal sector, highly insecure, in poor working conditions, with no provision of social security coverage.
- Lack of unemployment benefits and reliance on social networks in job-seeking.
- Unpaid family members and child labour divert accuracy of paid work accounting.
- The level of education and the unemployment rate are inversely related in SSA.
- The seasonal nature of many jobs in SSA raises a reference period problem.

In order to designing urban plans and policies to reduce urban poverty it is critical to understanding urban informal employment. Urbanisation is typically associated with increasing levels of employment, income, manufacturing, economic and social infrastructure (Olowu, 2017). In contrast to the historical experiences on other parts of the world, urbanization processes in many developing economies have not evolved together with industrialization, resulting in the majority of people who work outside of the agricultural sector are in the informal economy in most cities of the global South. Additionally, most of these workers fail to meet state regulations and find themselves classified as illegal. While urban rejuvenation strategies in many cities worldwide are actively wiping out urban informal livelihoods.

The small and medium-scale activities have become major employers and have also managed to combine informal connections between business, governance, family life, religion, and politics to create and maintain networks for problem-solving to overcome the lack of adequate institutional and financial structures. New forms of urban-based activities are being originated by the primarily informal economy that proves entrepreneurship and inventiveness of the youthful population that dominate in Africa’s cities (Simone, 1999). This however translates into an interesting challenge to town planning and urban policy and as they are often seen as opposite to those with ambitions for ‘world-class’ cities. Despite the individual incomes of informal workers are typically low, their activities, rather than marginal, are a key contribution to gross domestic product (GDP), representing a central part of the economy, with Sub-Saharan countries ranking at the top (Skinner and Watson, 2019).

The urban elite or private sector land developers often put pressure on municipal representatives which sometimes results in planning being biased to remove or inhibit informality. Three notable narratives illuminates on this exclusionary policy trend: The first narrative is 'private sector players': put in place exclusionary practices to achieve their goals. Samples of this group are retailers, property developers, waste companies, etc (Harvey, 2012). The second narrative is 'world class city': at the core of this narrative lays urban competitiveness through which city managers focus on attracting FDI and domestic funds, Informality is an obstacle to achieve modernity and economic growth (Robinson, 2019). The third narrative is 'technocratic planning': town planning reduces any consideration to the informal through activities designation either authorized or unauthorized (Roy, 2009) and informality is perceived by the planning as spatial pathologies that must be whether corrected or eliminated (Kamete, 2013; Chen and Skinner, 2014).

- International embeddedness

SSA is the least integrated region with the rest of the world and within itself. Looking at exports and trade partners, and the volume of trade as indicators, the level of integration is half of other emerging economies. Reasons for this may be found in socio-economic disparities, physical distances not corresponded by efficient infrastructures and cultural differences (Abdychev *et al.*, 2018). This situation is acknowledged by African governments though.

January 2012, the 18th Ordinary Session of the Assembly of Heads of State and Government of the African Union was held in Ethiopia, and a decision to establish a Continental Free Trade Area (CFTA) by an indicative date of 2017 was adopted. The agreement was signed on by 44 of its 55 member states on March 21, 2018.

Table 8. Scope of the African Continental Free Trade Area CFTA

Protocol establishing the Continental Free Trade Area	Agreement on trade in goods
	Agreement on trade in services
	Rules and procedures on dispute settlement
Parts and appendices under negotiation	Liberalization of trade (imports and export duties, and rules of origin)
	Movement of persons and economic operators
	Customs cooperation, trade facilitation and transit
	Non-tariff barriers
	Technical barriers to trade
	Sanitary and phyto-sanitary measures
	Trade remedies and safeguards
	Exceptions (general and security exceptions, balance of payments)
	Agriculture, fisheries and food security
	Technical assistance, capacity building and cooperation
	Complementary policies (special export zones, capacity building and cooperation)
Phase 2 negotiations	Agreement on Intellectual Property Rights
	Agreement on competition policy
	Agreement on investment

There are high expectations about the outcomes of the agreement in terms of jobs and wealth creation, poverty alleviation, jobs creation and reduction of inequalities. The agreement align to the African Union's Agenda 2063 and the Sustainable Development Goals (Gathii *et al.*, 2017).

Despite the population increase, the continent develops only the 3% of its generating capacity. About 70% of the African population has no access to electricity (Agyenim-boateng, Benson-Armer and Russo, 2015). Most of the existing power infrastructures have not been upgraded or replaced. South Africa and Nigeria, which represent approximately half of the GDP of SSA, run often out of power with constant blackouts. In other cases like Zambia and Malawi, hydroelectric plants don't work during dry season.

This does not only affect consumer demand but service supply. Distribution networks are inexistent in most African countries. Companies are adapted to the real scenario. Consumer Packaged Goods realized that there was no need to put their product on supermarket shelves, rather they deal with open market stands and neighbour scale kiosks. In Ghana for instance, remote kiosks receive goods six times a week via motorized adapted vehicles as 4x4 and tricycles, whereas large kiosks in more accessible areas are supplied two or three times a week via light and medium trucks (Agyenim-boateng, Benson-Armer and Russo, 2015). Other companies like Jumia have developed their own motorbike fleet in order to overcome the "last-mile" transportation challenge.

The current share of global manufacturing exports of Africa stands at less than 1% (Aurik, 2017b). The rise of the labour cost in China is making its light manufacturing industry to be relocated in other emerging market economies, such as Brazil and India. Africa is potentially an attractive destination for light manufacturing due to the young labour, its proximity to the US and European market and the convenience of zero tariffs polices on its exports, such as the US African Growth Opportunity Act and the EU´s Everything But Arms. This situation provides a fantastic scenario for African countries to speed up their industrialization, transforming the economic structures from mining and agriculture to modern industry (Hai, 2016). Nevertheless, Africa faces a few challenges at the time to making industrialization a consistent reality: The lack of knowhow on producing high-quality goods at a competitive price, Lack of confidence among international partners on the capacity of achieving deadlines, the lack of business infrastructures to reduce the transaction costs in reaching the international markets.

Positive signs on the evolution in SSA of key economic factors such as the increase of GDP and FDI as well as the increase of manufacturing. Infrastructure improvement in order to reduce costs and tax policy (US African Growth and Opportunity Act and EU Everything but Arms) to attract foreign investment are producing positive outcomes.

Southern African countries have made substantial efforts towards upgrading an appealing investment atmosphere. It is extensively acknowledged that FDI comes with great contribution to economic growth, development and improves the integration of the economies with the rest of the world. A number of initiatives and policies have been put in place. For instance, liberalization of investment regulations and incentive to foreign capital. However, despite the improvement in economic performance since the mid 90's, the effects to attract FDI are not noticeable as international investors usually disregard Africa due to a holistic conflicted image based on the complex diversity of economic performance (UNCTAD, 1999)

SSA has received over 0.43 trillion and 1.071 trillion USD in FDI and official development assistance (ODA) respectively since 1970. FDI furnish an important source of funding for development purposes to countries with resource constrains, and is stated to encourage growth and investment, transfer superior technology and management skills, improve job creation, generate effective spill-overs and help in development of infrastructure. Notwithstanding the funding provided for socio-economic development by foreign aid, the region persists to fail and attract FDI. The connection between foreign aid and FDI has become important in the discussion. Foreign aid is generally provided to strength incentives for FDI inflows: development of human capital, upgrading infrastructure, consolidating fair governance and promoting macroeconomic stability. In addition, SSA has received two thirds of the total amount of official development assistance (ODA) for the African continent (one third of the world total) (Amusa, Monkam and Viegi, 2016). New infrastructures in South Africa and Mozambique have had a positive impact on FDI inflows, doubling from 2007 to 2013 to $13 billion (UNESCO, 2015c).

In terms of international competitiveness, the SSA region ranks the lowest in the world, with 25 of the 34 countries assessed below 50 in the competitiveness index. Mauritius (52nd) and South Africa (60th) lead the region. However, most of the economies have improved their performance compared to previous assessments (World Economic Forum, 2019).

The air transport infrastructure in Southern Africa (extensively addressed in section 3.4.4), is characterized by a lack of airport density and weak domestic airline industry, deeply undermines the capability to develop tourist and increase business travel, which are already troubled by the great size and geographic barriers of the region. International openness is lower that the world average, which contributes to this factor (Calderwood and Soshkin, 2019).

3.4.2 People

40% of the global population will be African by the end of the century (UN). The total population of SSA amounted to over 1.09 billion inhabitants (UNDESA, 2019).

- Level of qualification

SSA has the highest rates of education exclusion in the world. About 20% primary school children (6- 11 y/o), 34% of lower secondary (12-14 y/o) and almost 60% of upper secondary school youngsters (15-17 y/o) are not enrolled in schooling (UNESCO, 2021b). Only 40% of the countries in SSA have at least 9 years of mandatory education, 30% lower than the world average (UNESCO, 2017c). With a 42%, SSA has the lowest level of participation in structured learning at the pre-primary level, 27% lower than the world average (UNESCO, 2017c). The gross registration rate in grade one is up to 96%, which means that most children do have the chance to enrol in primary schooling. However, school dropout is also high, with completion rates of 67% at the end of the primary cycle, 37% at the end of the lower secondary cycle, and 19% at the end of the upper secondary cycle. In addition, the enrolment ratio for pre-primary is 26% and 5% at university level (Majgaard and Mingat, 2012).

Less than 60% of individuals are satisfied with their education systems in SSA. The UNESCO Institute for Statistics has estimated that in SSA 87% of primary school students did not achieve the minimum level in reading. A considerable percentage of children are not able to read after years of school (UNESCO, 2017c).

The literacy rate among adults is 60% and 70% for the youth in the region (UNESCO, 2015a). Education systems conducted in indigenous languages have been more effective in ensuring adult literacy in the region (UNESCO, 2017c).

In South Africa, the distribution of persons older than 20 years by level of education reported in the Stats SA Community Survey 2016 resulted as follow: no schooling 7.1%; primary education 81.5%; secondary education 43.7%; bachelor's degree 4.1%. Notice that due to accumulating persons, the percentages do not add up to 100% (Stats SA, 2016).

South Africa has the greatest number of researchers in the region and definitely the greatest output in terms of patents and scientific publications which number increased by 23% from 2009 to 2014. However, the growth rate by Angola and the Democratic Republic of Congo, was the strongest for the same period(UNESCO, 2015c). The citation rate of the most research productive countries in the region is above the G20 (UNESCO, 2015c). In terms of publications, Mauritius and South Africa are at the level of developed countries than other SADC members. The most prolific topics are centered on mathematics, chemistry, engineering and physics. In the same line, these two countries also stand out for international collaboration (UNESCO, 2015c).

- Affinity to lifelong learning

Preece (2013) pointed out that the understanding of lifelong learning has rooted differences to the Western and the Southern African perspective. It is clear when looking at European

Memorandum of 2000, and 2003 Lifelong Learning Report by the SADC Technical Committee (Preece, 2013):. The tone of the European document steers towards competitiveness and individual improvement in the context of economistic growth in Europe. Its definition of lifelong learning was:

“All purposeful activity, undertaken on an ongoing basis with the aim of improving knowledge, skills and competence. . . To adjust to the demands of social and economic change and to participate actively in the shaping of Europe’s future”.

On the contrary, the African understanding of lifelong learning is expressed with a stronger accent on a collective, interconnected and holistic way

“Lifelong education is a comprehensive and visionary concept which includes formal, non-formal and informal learning throughout the lifespan of an individual to attain the fullest possible development in personal, social and vocational and professional life It views education in its totality, and includes learning that occurs at home, school, community and workplace, and through mass media and other situations and structures for acquiring and enhancing knowledge, skills and attitudes”.

A key reason of lifelong learning is to create stronger bonds for individuals to connect with the rest of the community: political and social activity and economic structures at local and international levels (Aichison, 2003). The positional world view in the SADC document is usually promoted in the Southern Africa but undermined at the time to structure agendas for foreign aid (Aichison, 2003). Nevertheless, the SADC’s Technical Committee interrogated fundamental challenges regarding the concept of lifelong education (Aitchison, 2004).

The reality is that strategic plans and initiatives continuo not to remain persistent and fail due to other financial priorities, as it is the case of the South African Strategic Plan for Lifelong Education and Training: 2002 – 2006, active for only a few months. South Africa seek to implement lifelong learning as a structural principle of its educational system was proving as difficult to apply as in the whole region (Aitchison, 2004).

- Social and ethnic plurality

The African national borders were agreed by European powers in the nineteenth century, taking into consideration the territory explored through expeditions funded by those countries rather than the existing distribution of different ethnic groups. This resulted in the split of ethnic groups between neighbouring countries (see Figure 12) and increased pre-existing levels of ethnic and linguistic conflicts. Negotiations about African nation borders (Easterly and Levine, 1997).

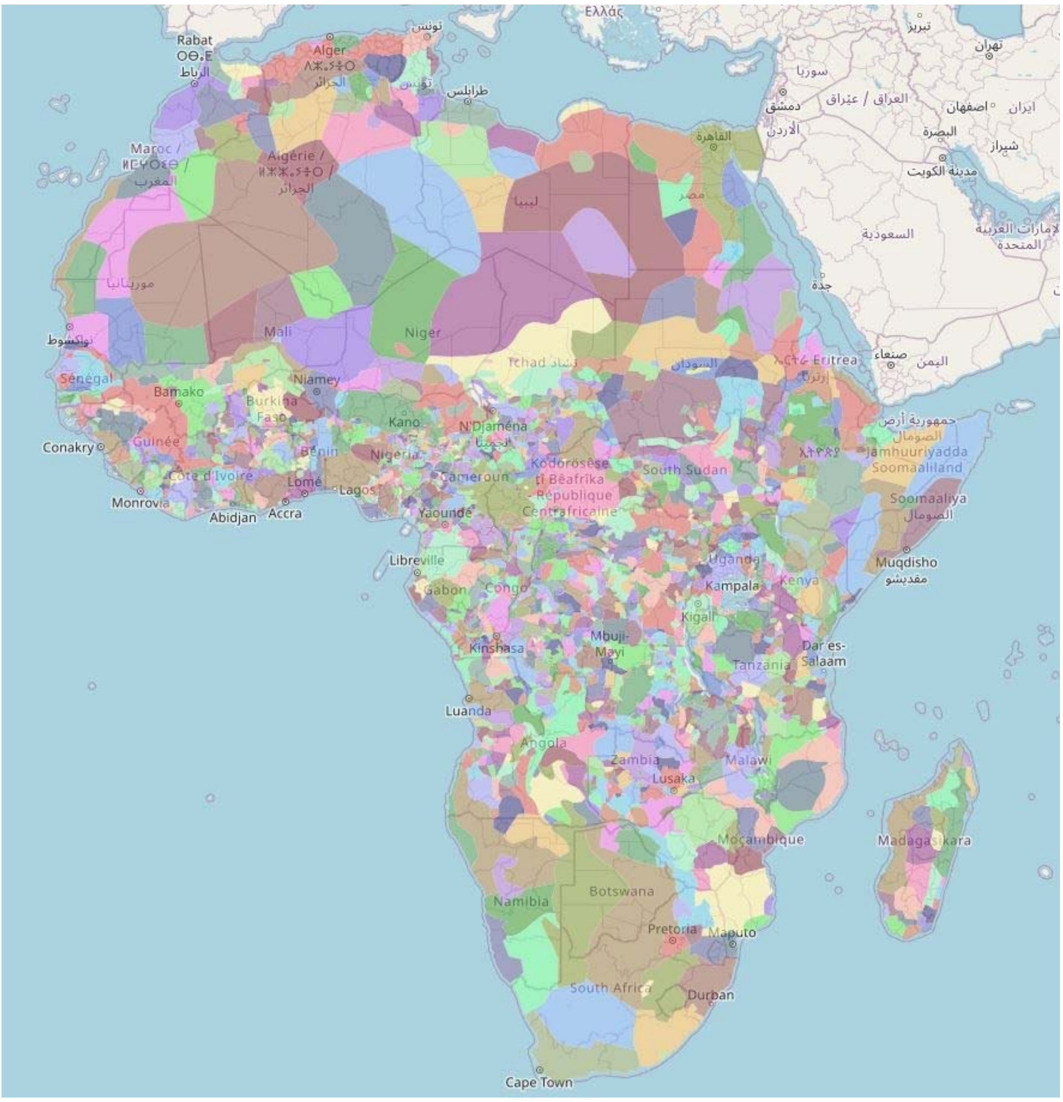


Figure 12. Ethnic diversity map of Africa
Center for Geographic Analysis at Harvard University

The linguistic diversity of Africa is an important factor to take into account (see Figure 13). Some authors count over three thousand (Epstein and Kole, 1998) native languages. Only in

Nigeria, one of the greatest concentrations of linguistic in the world has over five hundred. Ethno-linguistic diversity indicates the ethnic origin of randomly selected individuals in the same country. This outstanding sociological feature could represent a drawback at the time of service delivery. In addition to this, the continent's literacy rate is 62%, with areas where the literacy is below 30% (Agyenim-boateng, Benson-Armer and Russo, 2015).

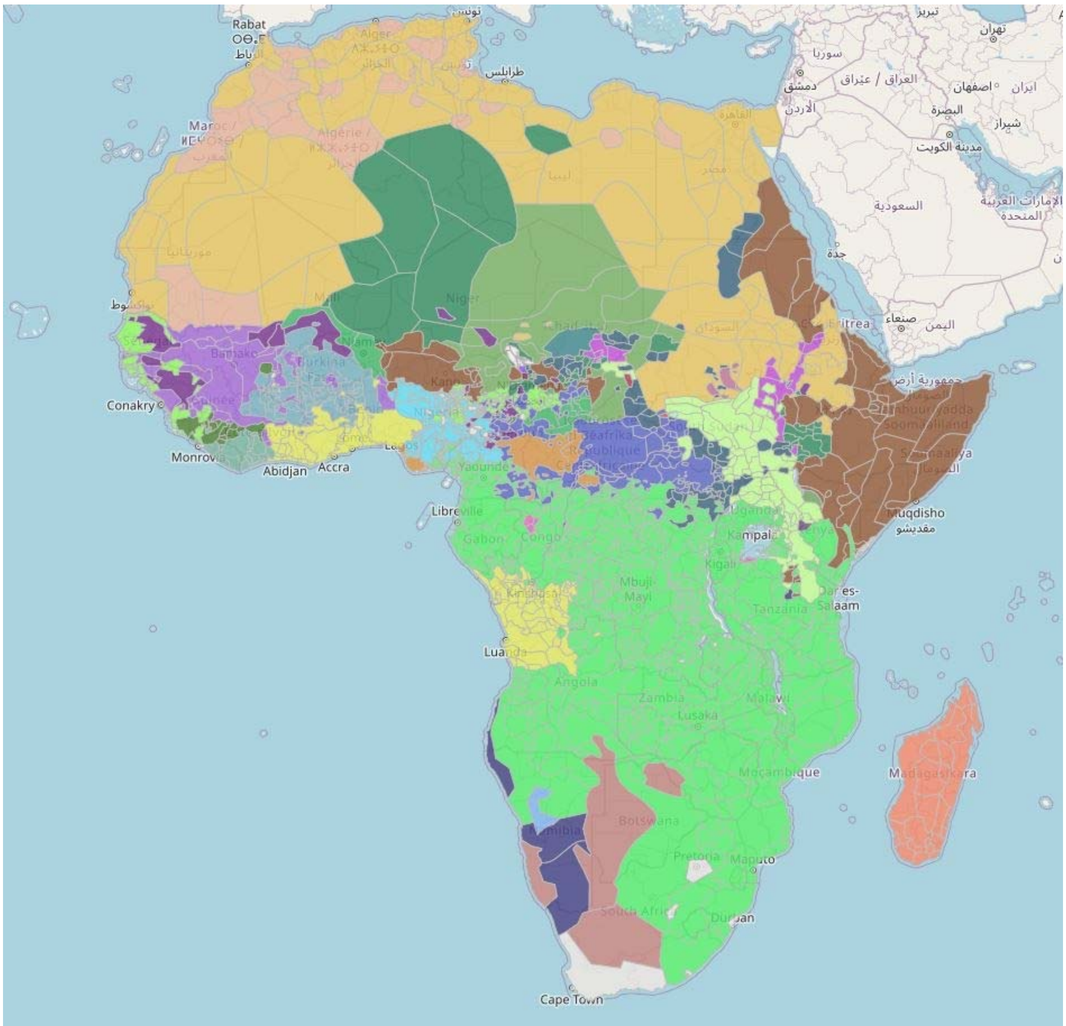


Figure 13. Language families map of Africa

Center for Geographic Analysis at Harvard University

In recent years, Scholars have argued that Southern Africa's ethnic diversity has been considered an important reason for the continent's economic and political troubles (Green, 2012). Linguistic and ethnic fragmentation variables, but not religious ones, are influencing factors on institutional quality (corruption and freedom), efficient policies (health and education), economic accomplishment and output (GDP growth) (Alesina *et al.*, 2002). Ethnic diversity may exacerbate division and thus obstruct collaboration and agreements about the evenly distribution of public goods, resulting in favour of specific groups in power in detriment of the majority of the society.

Urbanization has been used by governments to impose nationalist ideology through propaganda and education. At the same time, urbanization is the vehicle through which people from diverse ethnic origins come in contact, share their commonalities and create new forms of identities (Green, 2012). The lack of urbanization in African until recent days may explain the immense ethnic diversity in the continent, but at the same time, it shows how colonial powers deliberately avoided urbanization and its effects on the identity of the population, progressing to a new urban 'detribalized' proletariat that might grow to a level of becoming a significant threat to colonial ruling (Mandani, 1996).

When public institutions are composed by individuals from different ethnic groups, the presence of multiple bribe-takers may be particularly damaging. The problem occurs when the effects of bribes are not internalized by the one bribe-taker to the rest of one bribe-takers, resulting in multiples bribes per outcome and the potential reduction of number of outcomes (Shleifer and Vishny, 1993).

- Flexibility

In terms of satisfaction with the current employment status, those looking for a job are the least satisfied, with a rate close to zero. On the contrary, public sector workers are more likely to want to keep their job than workers in other sectors. When it comes to the private sector, informal workers are surprisingly happier than formal workers, however, the level of satisfaction increases as the socioeconomic conditions of the job improve. Managers and directors rate the highest in satisfaction. Contract benefits such as steady time schedule, associated benefits such as bonus and health care coverage and fixed salaries have positive effects on the perception of job (De Vreyer and Roubaud, 2013).

One third of jobholders in SSA declare being happy with their position and do not have the intention change to a new job in the near future. Half of jobholders would like to find another job, either by being promoted within their current organization or changing establishment (41%). Young public servants are happier keeping their jobs (59%) than young informal workers (37%) (De Vreyer and Roubaud, 2013).

The level of displeasure is negatively correlated with salary. Simultaneously, the divergence between young people's ambitions and real chances to get that job is enormous and are unrealistic. For example, almost 35% of young people want to hold managing positions, although management only accounts for 5% of positions. This suggests that young job-seekers are expected to experience important dissatisfactions, which could cause great social tensions if not corrected. (De Vreyer and Roubaud, 2013).

- Creativity

The fast growing sector of CCI is considered a great contributor for economic and sustainable development in Africa. African nations have been increasingly acknowledging the potential of the CCI as a tool of achieving greater development goals, integrating the development of the CCI and their poverty reduction strategies. Exports of CCI products increased from $740 mil in 2002 to $2.2 bil in 2008. Nevertheless, African creative products are still under-represented with only 0.54% of the world markets. The CCI encounters many obstacles: limited infrastructure, lack governmental funding, low priority in the development agendas, lack of skilled and professionally trained people. In addition to this, the intellectual property law is not properly enforced; and the quality of products requires a considerable increase of quality (UNCTAD, 2016).

The digital revolution has allowed Africa to be a pioneer for frugal innovation. Nolliwood in Nigeria for instance, whose digital cinematography has grow to be the third in the world and the second largest Nigerian employers by sector only after agriculture. 'Digital' is the way for the creative industry in Africa to move forward. Research highlights the important growth of technology-centered industries in the sector of CCI in opposition of the slow pace that traditional artistic expressions such as film and music are experiencing (Lopes, 2015).

CCIs are included in political agendas as catalyst for economic growth. UNCTAD's Creative Economy Reports are published periodically. The Convention on the Protection and Promotion of the Diversity of Cultural Expressions encourages for bigger investment in the sector and two thirds of African nations have adhered to this convention (Lopes, 2015).

In the Southern African region, South Africa and Botswana are the bigger investors in the CCI. The Accelerated and Shared Growth Initiative of South Africa (ASGISA) has recognized the creative industries as an important driver of sustainable economic growth and livelihoods for while increasing business options for small, medium and micro enterprise (SMMEs), particularly the film and craft sectors (UNESCO, 2017b). For the past 20 years, the CCI sectors in South Africa has been acknowledge as participant of growth in FDI, employment and tourism together with having a positive impact in urban rejuvenation, contributing to community development and prosperity. It is therefore an important factor in building the city's image (Oyekunle, 2019).

- Cosmopolitanism/Open-mindedness (Freedom House, 2020)

Theory and practice are not always correlated in Southern Africa. Legal frameworks specifically prohibit any kind of discrimination: race, gender, disability, and social status. However, these are verified to be inconsistent. Women are exposed to endemic inequality based on tradition and culture, customary laws in particular, which cause them important economic and social difficulties. San people suffer from social and legal discrimination in both South Africa and Botswana, with no access to adequate education and economically marginalized. Extended superstition makes people with albinism to constantly face discrimination. Homosexual activity is either illegal or recently decriminalized. Laws that might be perceived outdated nowadays: "vices against nature" recently excluded from the Angolan criminal code or "acts against the order of nature" in Zambia, still active today, and punishes offenders with between 15 years and life in prison. This law is vigorously enforced unlike other rights mentioned in this section, that might have a more positive impact on people's quality of live and rights.

Refugees are often excluded from basic services. They are generally contained in camps with no options to work and form part of local communities. They are exposed to gender-based violence as well.

South Africa however, enjoys a more sophisticated and diverse approach and efforts to achieve inclusiveness. Any type of discrimination based race, sexual orientation, and culture is prohibited by the constitution. The South African Human Rights Commission (SAHRC) and the Office of the Public Protector are state bodies with the mandate to investigate and prosecute discrimination cases. However, women still experience discrimination related to workplace, with lower salaries and representation at management level. Xenophobic violence against immigrants from other African countries sparks periodically and administrative errors and delays hold back the asylum system.

- Participation in public life (Freedom House, 2020)

Freedom of expression is constitutionally guaranteed in the region, however, except for South Africa, independent media endured harassment, pressures and limitations. The broadcasting sector is dominated by state-run media, which result in progovernment bias. In South Africa, the media landscape is diverse and makes room for opinion rivalry, allowing independent civil society to defy government’s manoeuvres to limit freedom of expression. On the opposite, Zambia, Zimbabwe and Angola experience the most of obstruction strategies to independent media from governments: arbitrary closure by authorities or license granting. Radio licensing is controlled by the government. Media diversity is limited and community radio stations struggle to obtain the license. Commercial licenses are typically in the hands of companies with links to the ruling party. This is particularly concerning as radio is the prevalent information means for many people in the region.

Unlike freedom of speech, freedom of religion is evenly respected in across the region. It is guaranteed in the constitution and actively protected by the government. Minor clashes between different religious groups have been reported. The Muslim community has experience some obstruction in Madagascar and Angola, and Zambia has declared in the constitution to be a Christina nation.

Despite academic freedom is respected in general, underfunded institutions and conflicted environments in public universities disturb normal operations in academia.

Freedom of personal expression varies across the region. In most countries, criticism of the government posted online is monitored by authorities. Although engaging in private conversation is not prosecuted, self-censorship persists. In some countries cybercrimes laws prohibits and prosecutes online defamation, including social media.

Freedom of assembly is guaranteed in the constitution in all countries of the area, however, in practice, some governments have not granted permission for demonstrations or used police to quash ongoing demonstrations violently. South Africa has a vibrant protest culture and like in Botswana, demonstrations are rarely prohibited.

Except for South Africa and Botswana where NGOs, including human rights, normally work without restrictions, they experience pressures and monitoring from governments in the rest of the region, especially those working on human rights and governance. They remain subject to restrictions under laws and threat of deregistration or even worse, charges of treason or subversion.

Workers unions are allowed but many restrictions limit the right to strike and therefore rarely happen. Certain employees who provide services considered essential may not legally strike. In Mozambique, public-sector employees are not allowed to strike. Union rivalries in South Africa occasionally draw on violence to recruit and attack opponents.

The right to freedom of movement, both domestic and international, is constitutionally protected. Nevertheless, corruption and bribes' demands by police frequently impede internal movement. The remains of war periods such as mine field in Angola and Mozambique, as well as bandit attacks in Madagascar inhabit freedom of movements in certain areas of the country. Refugees experience restriction of movement is the region.

Property rights are generally protected in Southern Africa. Nevertheless, women are subjected to discrimination by customary laws, particularly regarding property and inheritance. For instance, omen in Botswana have no right to inherit her husband's property. Regarding agricultural land, South Africa and Mozambique represent the two extremes. In the first one, the land ownership is still influenced by the past apartheid system and stays in hands of the white people which represents a 9% of the country's population. In the second one, private land ownership outside urbanized areas is not recognized by law and land use permits are to be granted to citizens. Land reform represents an intense public debate in South Africa today.

3.4.3 Governance

Land government in Southern Africa is typically addressed under ex-colonial legal frameworks and indigenous customary laws. This sets differences between citizens depending on the location of the residence affecting legal rights (Mandani, 1996). The implications in terms of spatial distribution are considerable: colonial-era and modernized urban areas depend on formal land government frameworks, whereas rural areas with mostly poor and low-income indigenous African residents depends on informal land government (UN, 2014).

From lower to higher hierarchical order, the territory in South Africa is administratively organized in wards, local and metropolitan municipalities, district municipalities, provinces and state. Wards are physical subdivisions of municipalities for electoral purposes. Municipalities have as many wards as the number of seats on the municipal council. Each ward then elects one councillor directly. Local municipalities include one or more towns together with surrounding villages and rural areas. District municipalities are formed with the addition of multiple local municipalities. They are responsible for municipal functions that affect more than one local municipality, typically infrastructures and environmental matters. Metropolitan municipalities are big urban and periurban areas and exercise all municipal functions. The provincial boundaries are defined in the constitution. They group a number of district municipalities.

Although the administrative organization of the country matches with international standards of territorial management, the nomenclature used can mislead, in actuality, the conceptual interpretation of the real status of the level of urbanization in the country. The reality is that only the metropolitan municipalities have urban features. For most of local and district municipalities, 80% of the population live in rural condition (Stats SA, 2011).

Yiftachel (2009) reflects about the linkage between informality and power. It can be used by governments as a tactic to control the 'ungovernable' and politically manipulate urban space. "The informality of the powerful is often authorised by the state, whereas alternative forms of informality remain indefinitely grey or are officially blackened".

The scarcity of affordable formal housing results in the formation of slums. Land becomes an instrument of power. The guardian or warlord syndrome is an example of this. The power to allocate land to residents lays on someone who assumed this role, illegally. Disputing this role implies confrontation (Boaden and Taylor, 1992). Analogue to the warlord situation is the management of tribal land at the upskirts of cities, the control over the land empowers chief and therefore, control the residents who settle (UN, 2014).

- Participation in decision-making

Only 7 of the 54 African nations are considered free. 27 are considered partially free and 20 are considered not free. The impact of armed conflicts and authoritarian regimes in the area affect economic growth. Political stability plays a major role in socioeconomic development. In the sub-Saharan region, only Namibia, South Africa and Botswana are considered fully free (Freedom House, 2020). Democratic backsliding events are still present in the region, particularly during election time. Internet shutdown and threatened media free expression, violence against antigovernment protesters or interferences with the judiciary in order to block opposition candidates resurface as soon as the power is challenged. East and Southern Africa experience disparities across the region. Independent civic and political activities are subjected to pressures from the state in Tanzania, Zimbabwe, and Uganda. Nevertheless, mild reforms are to be acknowledge in some authoritarian regimes (Freedom House, 2020).

In all Southern African countries, the president serves a five-years term and is eligible for re-selection. All countries in the region held elections in the past 5 years, with 50% of them free and fair electoral processes certified by domestic and international observers. In Zambia and Mozambique, although international election observers accepted the results credible, election related violence was reported between the two most prominent parties' supporters. In Zimbabwe, the elections in 2018 were held after the military coup that forces Mugabe to resign after 37 years.

The fairness of the electoral law and framework and the impartiality of their implementation by the relevant election management bodies are coincident with the evaluation of the electoral process mentioned. Zimbabwe, Mozambique and Angola have either politicized supervision of the electoral management or a legal framework that favours the party already in power. The rest of the countries in the area relay on an independent electoral commission although in some cases under pressure by the executive which controls members' nominations and budget allocation.

The right of political association and formation of parties is guaranteed by the legal framework and respected in practice in all Southern African countries. However, opposition parties in Zimbabwe, Mozambique and Angola report continuous cases of harassment, arrests and aggressions that obstacle their activities. Moreover, the presence of opposition leaders on state-run media is practically insignificant, limiting their capacity to access to the public and compete. In addition to the above, the foundation of new political parties is populated with numerous hurdles and bureaucratic obstacles.

Except for Malawi, no country in the region has experience transfer of power since independence or in the case of South Africa, the end of apartheid. Real opportunities for opposition parties to gain support or ultimately wind the elections seen unlikely to happen in the near future. In South Africa, opposition parties have a change in municipal elections due to the taxation system that confers a certain level of power and autonomy to municipalities. Opposition gains in local elections allow them to demonstrate governance capacity.

Despite the apparent freedom of political choice unaffected by unelected groups, economic lobbies strategically support political candidates. In return, a small political elite favour their private-sector supporters. Democratic accountability is reduced and the line between public-private expenditure unclear. Angola's ruling party, MPLA aligns to economic oligarchies perpetuating a patronage system that can influence the ability of voters to freely choose their political preferences. In a similar situation, traditional chiefs, who receive public allowances, are supposed to keep themselves away from politics. On the contrary, some chiefs publically endorse political options, influencing this way, the orientation of voters.

The military has some influence over politics in some countries of the region. In South Africa however, the military is professional and generally stays out of politics. In Zimbabwe, the military participates in elections preparations and obstacle opposition activities. Moreover, senior military officials migrate to political leadership position in ZANU-PF and therefore the government.

The constitutions of all countries in the region guarantee equal political rights for all citizens, but in practice. In practice though, discrimination prevent the representation of some groups. The power is usually hold in majority by one ethnic group in particular. Women again, despite having full political rights, experience limitations due to cultural factors, and their interests are underrepresented in the political system. Cultural norms and believes can restrict the political participation of women.

- Public and social services

Budgetary constraints and small scale economies have great consequences in the public service delivery. This situation primarily affects mobility, healthcare and education together with unemployment aids. 75% of employment in the informal sector have no provision of social security coverage (De Vreyer and Roubaud, 2013).

More than 30% of the healthcare facilities in SSA, attending 25% of the population, have no electricity. This situation constrains enormously the array of services delivered in public hospitals, including life-saving treatments (Knoth, 2015). Only Namibia, Botswana, Zambia, Ruanda and Gabon have free and universal healthcare (WHO, 2019).

Enforcement of free and mandatory enrolment in education is one of the fundamental strategies to fight school dropout. SSA has the highest out-of-school rates (UNESCO, 2017c). UNESCO (2015b) identified two fundamental goals for public funding of education in their Education 2030 Framework for Action report: at least 4% to 6% of GDP; and/or 15% to 20% of public expenditure should be allocated as education national budget. The public expenditure to education in the region is 16.9% and 4.1% of the GDP (UNESCO, 2017c). However, the region faces many institutional, infrastructural and policy challenges. Political commitment is a decisive factor. In 16 countries of the region, the chance of school fee elimination increased by at least four times during election campaigns.

The omnipresent 'silo' organization within municipal governments affects the primary mobility strategies, where the inclination is to stay focused on departmental mandates with almost inexistent inter-departmental interaction (UN, 2014). Institutional fragmentation remains an irritating drawback (Pirie, 2014). Travel needs and financial status of urban dwellers, mainly the most underprivileged, are unlikely addressed by municipal managers (Diaz Olvera, Plat and Pochet, 2008).

- Transparent governance

In Southern Africa, despite Executive and legislative representatives being able to rule unobstructed, clientelism is common practice in the region and economic powers make considerable pressure on elected officials. The mining and agriculture sectors are the most affected by this situation (Freedom House, 2020).

Corruption is endemic in the region. Anticorruption agencies are usually ineffective in the prosecution of high-level cases. Enforcement impediments and limited budget reduce the efficacy of these public agencies to fight corruption. In some cases, political leaders undermine their performance. Despite the mediatic repercussion of major corruption cases, high-level officials remain unpunished. Government accountability although reflected in most constitutions in the Southern Africa, is still to be consolidated. The legal framework does not clearly support the constitutional mandate and access to information is laborious and bureaucratic in the best case scenario. Although high-level officials are requested to declare their assets, only a few declare (Freedom House, 2020). There is a correlation between the countries tagged as free by the Freedom House and the least corrupted countries as per the Transparency International (2020) Corruption Perception Index from 2020, with Botswana raking at the top of the region in the 35 position globally, followed by Namibia as 57 and South Africa as 69.

Regarding the judiciary independence, the situation changes across the region. For instance, the president of Angola appoints judges to the Supreme Court for life terms. Corruption and pressure from the ruling party are factors that impact efficacy and independence, resulting in hindrance to proceed with investigations. On the contrary, in Malawi, Botswana and South Africa, judiciary independence is normally respected, especially in high courts, although judges can experience political pressure.

The effectiveness of the justice system is compromised by lack of skills and training, appropriate budget and understaffed departments. Due process protection is a constitutional right. However, suspects are held in pretrial detention, incarcerated in poor condition, with no access to lawyers for long periods. Arbitrary arrest and lengthy pretrial detention remain problems and sometimes affecting political opposition members. Prisons are overcrowded, unhygienic and present terrible health conditions. Cases of violence and sexual abuse are common (Freedom House, 2020).

Police brutality and use of torture are common in the region. Security forces normally operate with impunity and many confessions are reported to be extracted through violence and torture.

The political elite usually get benefitted from state-run industries. In South Africa, the levels of inequality are among the highest in the world. The economy is in hands of a pocketful of people from the political elite and private sector. A similar case happens in Angola. Revenues from state-run oil companies are not evenly distributed to affect the entire population (Freedom House, 2020).

Infrastructures and service provision together with opportunities for prosperity are the main concern of citizens across South Africa when it comes to rate the performance of municipal management. The five leading challenges faced by the municipalities perceived by South Africans are lack of safe and reliable water supply, lack of/inadequate employment opportunities, cost of electricity, inadequate housing and inadequate roads (Stats SA, 2016).

3.4.4 Mobility

Primary mobility strategies are troubled by the rooted 'silo' organization within municipal governments where the inclination is to stay focused on departmental mandates with almost inexistent inter-departmental interaction (UN, 2014). Institutional fragmentation remains an irritating drawback (Pirie, 2014).

Transport infrastructure plays a fundamental role in giving shape to public space, linking different zones in the spatial planning. It is important that policy makers and urban planners consider the entire array of transport alternatives and therefore bring them all not only into town plans but also at management spheres. Department managers need to anticipate to these dynamics and engage beforehand with multiple participants, including civil society, the private sector and the property industry (Todes, 2012), instead of being responsive only when eventual political pressure is felt (Kumar and Barrett, 2008).

African cities continue to unsustainably build new roads, regardless of the fact that new roads increase dependence on cars, and the consequent increase of GHG emissions, and reduce the area of productive urban space (Sietchiping, Permezel and Ngomsi, 2012). Despite the short-term benefits on road-based transport, the long-term associated costs, for instance social exclusion, maintenance and traffic accidents are serious (UN, 2014). Municipal authorities must improve their town planning and consider restrictions on the use of motor vehicle. Using smart systems can also assist to alleviate traffic congestion. To aim a better integrated and managed mobility, hazardous driver behaviour should be addressed by policies and enforcement (Haq and Schwela, 2012).

- Local accessibility

In this section accessibility refers to the availability of any location to be reached. Consequently, the level of accessibility will depend greatly on the setup of transport infrastructure.

Transportation in Africa is one of the biggest challenges. Only one-third of Africans live within two kilometres of a paved road (AfDB and World Bank Group, 2011). This shortage of infrastructure, together with the vast distances, increase transportation cost to eight times the cost in potential competitor emerging markets like Brazil (Agyenim-boateng, Benson-Armer and Russo, 2015). It is the last-mile delivery that makes transportation infrastructure so expensive (Kanter and Litow, 2009).

Urban networks in SSA's cities are underdeveloped; there is about 128 meters of road per thousand residents whereas the average for low income countries is 700 meters. Carruthers, Krishnamani and Murray (2008) specify the condition for condition for urban connectivity: "urban connectivity is based on the concept of ready access to a one lane paved road capable of supporting year-round access by a bus service or equivalent motorized vehicle, such as an ambulance or a fire engine".

In Southern Africa, urbanization and population growth is no coupled with development or even maintenance of transport infrastructures. Samples from cities such as Lagos, Johannesburg and Luanda evidently demonstrate the impact of expanding highways and roads on the fast urban sprawl, which makes it challenging to put into practice efficient people-oriented modes of transport (Sietchiping, Permezel and Ngomsi, 2012).

The rapid residential sprawl, result of inadequate anticipating town planning, together with inefficient management, puts extraordinary pressure on existing transport infrastructure and alternatives for mobility are very limited and dependent on income. Although walking and cycling represent cost effective and affordable mobility options for the majority poor population of Southern African cities, development of such infrastructure is hardly considered in urban planning. Moreover, provision of cycle paths is complicated in contexts where street space is rapidly appropriated by street vendors (Pirie, 2014). Unlike the Global North, bicycles have a negative social status connotation in Southern Africa as some potential users regard them as shameful evidence of poverty (Godard, 2011).

Liveability and citizens development aspirations are highly compromised by inefficient public transport mobility due to traffic jams, poor governance and the increasing cost of living (Sietchiping, Permezel and Ngomsi, 2012). The promotion of motorised mobility goes in opposite direction of the global trends towards environmental awareness, compact and sustainable cities and healthy practices. The situation worsen for smaller urban areas (UN-Habitat, 2010).

The primary road network is plagued by deficiencies, making it slow with constant traffic jams and bottlenecks. Ownership of motorized vehicles is very low. With the informal sector prevalence, the share of formal transport companies is particularly undersized. The public transport is generally present on the major paved network (Diaz Olvera, Plat and Pochet, 2013).

Railways do not show better conditions. Underfunded in railway signalling infrastructure and outdated rolling stock are at the origin of some of the problems. Inadequate policing and vandalism (pyromaniac actions and copper cable theft) provoke considerable operational challenges. Long distance commutes by train in cities are poorly serviced, which results in the expansion of the informal taxi operators (Pirie, 2014).

- (Inter-)national accessibility

In SSA, accessibility to markets is limited by a generally underdeveloped transportation infrastructure, which limits domestic and international trade. In this sense, Southern Africa is the most developed region. It is somehow remarkable the intense use of rail as essential transportation mode for freight in Southern Africa in comparison to other countries in SSA (Tancott, 2014).

Three decades of political instability have resulted in a considerable lack of infrastructure in Central Africa, which remains among the most complicated and expensive regions for enterprises to fruitfully penetrate despite the abundance of natural resources. Intercontinental connectivity is compromised by the absence of development in Central Africa. Unfortunately, a real improvement in transport and Logistics infrastructure can only be expected by 2040 (Tancott, 2014).

With only 49 km/km^2 of paved roads, SSA has the lowest road density of any developing region in the world (Foster *et al.*, 2009). In addition, lack of maintenance and development has led to a loss in value of about 35%. There are fewer kilometres of roads in Africa today than there were three decades ago (Teravaninthorn and Raballand, 2008). As a sample of feed-back loop linking policy enforcement and maintenance cost, uncontrolled used of roads by overloaded trucks contributes to a faster decay of the transport infrastructure, increasing the already demanding maintenance costs and it does not end there: damaged roads are likely to break vehicles or reduce usage, negatively affect tire lifespan as well as increase fuel consumption (Teravaninthorn and Raballand, 2008).

Similar to the situation with the road network, rail capacity has shrunk affected by lack of maintenance and development and prevalent unreliability in operations. In 2002, only 10,000 km of rail lines were in used out of the 20,000 Km available in the 80's in Southern Africa (The Economist, 2002). For instance in South Africa, where the rail sector is ahead compared to the rest of the countries in the region, the capacity does not respond to the demand at the moment of the rail sector, The Johannesburg-Durban line operates at 25% capacity due to congestion and operational deficits (Herfindahl and Treat, 2009). The lack of competition in freight transport translates into a lack of innovation in the truck sector (Herfindahl and Treat, 2009).

Intermodal transitions are especially time consuming and ineffective throughout Southern Africa. They are essentially the bottleneck to avoid in freight transport. In fact, the Johannesburg-Durban N3 road has become the preferred route for shippers in South Africa, which has set as strategic priority the upgrade intermodal links. Operational inefficiency makes freight transport by train extensively time consuming. For instance, with an estimated travel time of 20 hours time from Johannesburg to Durban by train (similar to trucks), containers take an estimated seven days for collection at the City Deep container terminal in Johannesburg (Herfindahl and Treat, 2009).

The total share of global goods trade for SSA is 2%–3%, and 2% of the world sea freight departures or arrives to SSA ports. More than 90% of the trade between the region and foreign countries is channelled by maritime transport (UNCTAD, 2006). However, many ports experience inefficient capacity to face trade demands (Radebe, 2005). These limitations are increased by incompetent, and corrupt, customs management (Herfindahl and Treat, 2009). The port of Durban is the biggest with regard throughput per year, processing almost three times more volume of container freight than the second biggest port, Cape Town (UNCTAD, 2006).

Historical reasons related to the extractive approach of colonial development are behind the current lack of capacity of most SSA ports, which were design to transport specific types of raw materials and growth of trade for other reasons was not conceived. For instance, being the Richards Bay Coal Terminal originally designed in the 70’s for the transport of coal, only 30 years later the port accounts for 50% of all freight in South Africa (Byrne, 1996). In recent years, some ports in the region such as Walvis Bay in Namibia have made efforts to upgrade their capacity and adapt to changing trade patterns (U.S. Embassy Port Louis, 2008). Nevertheless, such planning seems to be insufficient and SSA ports continue to experience physical capacity constraints, particularly regarding container shipping (Kent and Fox, 2004).

Regarding air transport, Africa is the least region in the world, a result of the small economies and lack of air transport infrastructure. The profits per passenger kilometre on African traffic (including both intra-Africa and inter-continental routes) accounted only 2.1% of the world total in 2017 (ICAO, 2018). Flying within Africa is more expensive than internationally, particularly for distances shorter than 4,000 kilometres. Domestic flights are generally subsidised which distorts an accurate calculation of costs and fares (Foster, 2009).

Intercontinental traffic in SSA is greatly associated the three biggest transport hubs of Addis Ababa, Johannesburg and Nairobi. Shipping routes to Germany and the United Kingdom from South Africa are the most congested. It is noteworthy to mention that the routes to Middle East from all from three hubs have experienced an exceptional growth in traffic. Within the region, international traffic has also growth at a rate of 25% per year with North Africa since 2001 to 2007. Over one third of this international traffic is still concentrated in the aforementioned three main hubs (Foster, 2009).

There are only 280 out of an estimated 2,900 airports in Africa, receiving regularly scheduled flights. The main gateways are South Africa and Egypt. Together with these two, Senegal, Morocco, Algeria, Tunisia, Kenya and Ethiopia experience intensive traffic as well. Despite runways specs and maintenance status do not seem to affect traffic load, other factors including passengers processing space in the terminals, apron space for parking and taxiway availability have a negative impact (Foster, 2009).

Air navigation services and air traffic control concentrated in a few centres. There are several radar installations in Kenya and South Africa for air traffic monitoring. Ethiopia on the contrary, being the third biggest airport in the region, is not equipped with traffic surveillance systems. As a general rule, away from the main centres, communications and navigation aid are scarce of non-existing at all (Foster, 2009).

Civil aviation authorities in SSA experience budget constrain and fail to commit to their responsibilities as safety regulators. Technical but also human capacities do not achieve the required standards. Safety inspectors are poorly trained and sometimes ignore or deliberate neglect procedures adherence. This is reflected in the current accidents rate which is the highest for Africa (Foster, 2009).

- Availability of ICT infrastructure

ICT leapfrogging is seen as a way of diffusing technology and the decisive factor for growth rates and competitiveness. Developing countries have the chance to plan and upgrade infrastructure with the assistance of advanced technologies instead of conventional intermediate technology that are time and resources consuming. (Fong, 2011). For instance, the use of mobile phones in Senegal allowed farmers to double the revenues for their crop by sharing information. In Angola, farmers are using GPS trackers to find their cattle (oneworld radio, 2006). At least half of small enterprises in South Africa reported an increase in profits related to the usage of mobile phones (Vodafone, 2005). Moreover, wireless technologies cost on average one fifth of conventional physical wiring (UN. Secretary-General, 2000).

The idea that technologies are able to impose their own ways to proceed is a myth: the ultimate responsible for the use of technology and its outputs is the social order: people and institutions. The absence of past experience using any particular technology implies a possible lack of social context. As an advantage, this situation may make easier to implement new technology as there would be no clash with customs and old values. Nonetheless, a social context to support such implementation is to be built. Furthermore, it is important to be cautious to identify both social and technical aspects, making sure that the technological is not achieved to the disadvantage of the social. Therefore, technology distribution must be focused on local user rather than technology (Davison *et al.*, 2013).

Developing countries typically adopt technology as ‘ready to go’ products in a ‘plug and play’ mode. This technology has been developed in industrialized regions of the world with an extensive background and past experiences of previous technology implemented over time.

This background guides in the customization of technology and production of tailor-made solutions to an specific social context(Davison *et al.*, 2013). The use of ICT demands more than a simple 'plug and play' installation and adaptation of standard products is essential for successful results. These alterations usually require a high level of skill (Davison *et al.*, 2013). The absence of such previous experience may reduce the knowledge build up for future generations (Davison *et al.*, 2013).

Developing countries place their faith in leapfrogging, through the use of technology, to speed up modernization processes. In this sense, it is important to consider that these are typically contexts lacking resources, both financial and human, and therefore, an accurate assessment of the existing situation is to be conducted to consider multiple factors related to the comprehension, diffusion, application and further development and innovation of the technologies implicated, prior to embracing any 'miraculous' efficient piece of technology (Antonelli, 1991). Failing to do so would incur in costly failures

Table 9. Factors relevant to conditions for technology leapfrogging (Fong, 2011)

Factors	Example of issues	Source
Market condition: • Market demand • Market competition	•Market competition for rational pricing of ICT & access, •Development of locally relevant content and languages to promote advanced technology uptake, •Foreign participation through investment to break down monopoly structure.	Adzadi, 2001; Alzouma, 2005; Choucri, 1998; Davison et al., 2000; Ensley, 2005; Garcia & Gorenflo, 1999; Grace et al., 2001; Haddad & MacLeod, 1999; International Telecommunication Union, 2004; Mansell, 1999; Mbambo, 1996; Nkwae, B. (2002); OECD, 2005, 2006; Praskash, 2005; Pringle & David, 2002; Raji et al., 2006; Sehrt, 2003; Sinha, 2005; UNDP, 2001a, 2001b; United Nations General Assembly and Economic & Social
Institutional capacity	•Support for intellectual capital development, •Development of stable learning and attractive investment environment, •Ensuring security and stability in the environment, •Establishment of an enabling regulatory and legislative framework, •Economic, social, and political stability.	
Social	•Ensuring equity in digital access, •Narrowing or erasure of digital divide.	

Human capabilities	•Improvement of literacy and computer literacy levels, •Nurturing of requisite skills and expertise. •Continuous investment.	Council, 2000; Vodafone, 2005; Wijkman & Afifi, 2002.
Government	•Definitive guiding policies, •Strategic deployment of ICT, •Coordination and linkages among actors in the system.	
Stakeholders	•Interaction and strategic links among actors in the system, •Regional and international cooperation and collaboration, •Identification of e-champions and e-leaders to spearhead technology leapfrogging projects.	
Utility infrastructure	•Electricity, transportation networks, etc.	

At the Telecom 95 Conference, Nelson Mandela encouraged cooperation on education and skill transfer at regional level in Africa, in order to guarantee that developing countries have a chance to take part in the ‘global communications marketplace’ and ICT revolution (Fong, 2011).

The UN's Economic Commission for Africa plans to develop training centres for ICT in Africa. "These centres of excellence would develop and strengthen the capability to generate advanced level policy, regulatory, managerial and technological expertise in developing countries around the world" (ITU, 1998). Additionally, the UN Special Initiative on Africa is developing rural Multipurpose Community Telecentre projects as a "means of providing affordable access to modern information and communication technology tools for development. The purpose of these demonstration pilot projects is to test new technologies and applications, innovative policies and tariff structures and new approaches to organising telematic services, and to demonstrate the impact of such methods on economic, social and cultural development in rural and remote areas, involving both public sector and private sector stakeholders and are expected to produce best practice models which can then be generalized at the national level, in Africa and perhaps in other developing regions" (Davison et al., 2013).

An opposite vision considers that the expansion of ICTs has imposed smaller demands on the user in terms of skills due to user-friendly digital environments and reduced costs (Ensley, 2005). Leapfrogging in technology remains a controversial idea. In the case of Africa for instance, the investment on the implementation of this technology would unlock global markets, increase integration and enhance education although with an economic vision (Chisenga, 2000). In contrast, allocating funds for these projects would compromise service delivery and basic provisions for the poor (Ochieng, 2000). One of the arguments against leapfrogging has been the concerns that highly indebted states in developing countries may worsen their situation due to incurring in new loans for the quick implementation of ICT (Chen, Farinelli and Johansson, 2004).

The 4IR has the potential to either increase the income levels and quality of life of the people worldwide, or exacerbate inequalities due to its impact on production methods. One of the most concerning risk lays on the effects of automation displacing labour across the whole economy and the consequent increase of returns to capital in detriment to returns to labour. However, for such way of production, talent will be a more important factor than capital. An eventual labour market divide based on ‘high-skill/high-pay’ and ‘low-skill/low-pay’ jobs would lead to increased social disparities and ultimately tensions (Schwab, 2016).

Looking at the case of high-income economies, technology is among the key reasons salaries have not increased; in some cases even decrease, in the past decade. There is an increasing demand for high-skilled labour in detriment of low-skilled ones. Therefore, the job market trend is to polarize: great demand of high and lower skilled workers and little demand for middle-skilled labour (Schwab, 2016).

The workforce of the future does not seem to be only human and more tasks will become automated. This does not mean that the robots will completely replace humans, although the demand for skills will shift. The outputs from new technologies like 3D printing, the Internet of Things, robotics, wearables and AI will still demand human input and decision making. Software is to become the building block of every industry and development skills will be in high demand (Aurik, 2017a).

Africa’s pathway towards industrialization has been irregular. It basically missed out on the globalization boom. Except for Ethiopia, Kenya, Nigeria and Tanzania, its manufacturing growth has remained significantly low, equal or below the growth rate of GDP. Africa’s total share of global manufacturing exports stands at less than 1% today. Furthermore, together with Latin

America, it holds less than 8% of the market in the big five new production technologies (3D printing, AI, the Internet of Things, robotics, and enterprise wearables). Nevertheless, given its relative lack of industrialization to date, the technologies of the 4IR could allow it to bypass some of the traditional pathways to development in some industry sectors. Along with an improving business environment, the 4IR could potentially furnish Africa with a catalyst to speed up its industrial development (Aurik, 2017b).

The Agenda 2063 of the African Union expressed the ambition of being part of the industrialization switch. It is also included in the United Nations' New Urban Agenda, World Bank's Africa's Cities report and the UN-Habitat's State of African Cities reports. The role of African cities and urbanization must echo, in the long-term, physical, demographic and economic planning of Africa in the age of globalization and the emerging 4IR (UN-Habitat, 2018).

- Sustainable, innovative and safe transport systems

The uncontrolled spatial growth of cities due to inefficient and biased planning, has located a number of low-income housing development in the periphery lacking all type services (water, sanitation, education, healthcare, etc.). Together with basic services, jobs remain in the located in the centre. New districts also offer jobs opportunities and services but are developed far from the centre either. This special discontinuity is poorly compensated by the mobility system (Diaz Olvera, Plat and Pochet, 2013). The result of such situation is the increasing growth of informal settlements nearly business hubs and areas with access to public services, mainly water and electricity.

The cost of public transport appears to be a burden on low incomes households in peripheral areas (Diaz Olvera, Plat and Pochet, 2008). Access to the city is becoming increasingly expensive and difficult because of the uncontrolled sprawl, which increases distances, and the inefficiency of mobility systems. Travel needs and financial status of urban dwellers, mainly the most underprivileged, are unlikely addressed by municipal managers (Diaz Olvera, Plat and Pochet, 2008). Several studies on mobility and urban poverty indicate that mobility and limited access to resources have common origins, locking chance to spark prosperity and escape from poverty (Lucas, 2011).

Africa experiences 20% of the world's road fatalities despite the continent has fewer than 2% of the world's registered motor vehicles. It represents the highest rate in the world. Traffic accidents are the main cause of death among men aged 15–29 years (WHO, 2019). Public transport vehicles are uncomfortable, overcrowded, poorly serviced, and recklessly driven.

Pedestrians and cyclists share space with motorised vehicles, with the result of numerous accidents. Pedestrians account for two-thirds of fatalities (Kumar and Barrett, 2008). South Africa experiences between 14,000 and 18,000 fatalities due to road accidents per year. This rate is five and eight times higher than European cities (Vanderschuren, 2008). At the 1st African Road Safety Forum in November 2018, African ministers of transport committed to improving road safety in the WHO African Region by enhancing legislative and regulatory frameworks, increasing funding, prioritizing the development of their systems for civil registration and vital statistics and creating agencies to manage road safety. Laws enforcement and best practice for behavioural risk factors are weak in the region. The systematic deficit of transport alternatives makes some social groups, predominantly children, women and young people, more dependent on walking (Diaz Olvera, Plat and Pochet, 2013). Despite the low rate of motorization in the African continent, the problems of mobility inherited in the post-colonial city are persistent. There are 44 registered vehicles per 1000 inhabitants (Davies and Schiller, 2018), yet cities are designed considering the car first. The unprivileged sector of the population is generally located in residential-only neighbours, far from job's centres, thus forced to use inefficient public transport at a higher cost, minimizing this way their purchasing power and prosperity opportunities.

Town planners and city managers in the urban areas of Southern Africa seen to pay poor attention to understanding daily commuting behaviour. Building new road infrastructure has priority in the development agenda. The provision of quality transport service is assigned a secondary role (Alcántara Vasconcellos, 2001). Moreover, planning mobility infrastructures lack of a holistic approach, disregarding the correlation physical space and transport. In most cases, new projects unconnected to each other, either to satisfy patronage or to react to pressure from the civil society to minimize previous problems (Dimitriou and Gakenheimer, 2011).

The economic impact of dysfunctional mobility systems is not a minor thing. 1 million working hours per day are estimated to be lost in Dakar due to traffic jams. In 2010, the South African

Chamber of Commerce and Industry assessed the impact of traffic congestion on the economy: the cost in lost productivity was 15 million Rand ($1 million) per hour. Among the reasons for traffic jams are poor infrastructural design and maintenance, reckless driving and slow response to accidents (Pirie, 2014).

In South African cities, mobility strategies are one of the results of the segregation policies that affected town planning in the years of the apartheid, designating great areas of low-income residents to peripheral locations. Workers were moved in and out the commercial and industrial zones. From1998, traces of quality decay started to be noticed in both passenger rail and scheduled bus. In the 70's nonetheless, the taxi industry initiated to take over all existing routes, becoming the prevailing transport system in the majority of urban areas (Clark and Crous, 2002). The volume of this industry is to be acknowledged. 72% of Johannesburg's and 90% of Nairobi's daily commutes (Kumar and Barrett, 2008; EDF, 2016). Despite this big share in the economy, safety issues and unreliability became the norm as informal services are typically of low quality.

Generally operating outside formal regulations framework, informal urban transport services are usually unreliable (unplanned and unscheduled). They usually begin as illegal services and obtain legality as they become more established. These forms of mobility are road-based, with multiple vehicle types: from motor-tricycles to buses. The vehicles are not necessarily periodically serviced, habitually lack minimum safety, roadworthiness and are often dangerous and inconvenient harsh driver behaviour (Schalekamp and Behrens, 2010; Salazar Ferro, Behrens and Wilkinson, 2013; Pieterse, 2019).

Government strategies in Southern Africa tend put the effort on the eradication of informal settlements, instead of engaging with residents of slums. As a reminiscence of apartheid times, these residents are then displaced, often to city upskirts, further negating them employment opportunities, social care, public services delivery and networks (UN, 2014). These strategies are proved to intensify the pressure on the already inefficient mobility systems and energy delivery.

Bus rapid transport (BRT) was implemented in a number of African cities in the first decade of the twenty-first century as a tentative to formalise public road passenger transport. BRT has become the trend in Johannesburg, Cape Town, Accra, Lagos, Kampala and Dar es Salaam.

Since opening in 2008, the 22-kilometre BRT-Lite scheme in Lagos has reduced fares, waiting times and journey times for some 200,000 passengers daily. After two years, the Lagos BRT reported 113 million passenger movements, with an employment impact of 2,000 new direct and indirect jobs, reduced travel time by a third, and cut CO_2 and GHG emissions by 13% and 20% respectively. However, strong leadership is essential to deal with the interests of informal paratransit operators. In Johannesburg this was handled by selling a half share of the BRT to taxi owners. Nevertheless, complicated negotiations have led to expensive delays to the inception of the second phase of BRT in Johannesburg (Pirie, 2014).

From the European perspective (EDF, 2016), there are a some issues to consider in future policies in order to upgrade the public transport systems. Coupling with the Agenda 2063 vision and the PIDA vision, their long-term mobility strategy for Africa should be “to provide sustainable, reliable, modern, efficient, cost effective and fully integrated transport infrastructure and freight and passenger transport services that support continental and regional integration; meet future transport demand and support African business through easy and seamless logistic systems; provide a safe and secure transport system; and minimizing the impact on environment”.

The European Union’s European Development Fund (EDF) for ACP Group of States Transport, Policy Framework document for the Implementation of the Support to the Transport Sector Development Programme, clearly aims to address the necessary guidance from, once again, out of Africa, in order to achieve an integrated, sustainable and harmonious/inclusive transport system among others. It is not clear if the bullet points list above acknowledges poverty rates or corruption when it comes to fare policy, urban sprawl and fragmentation when it comes to transport networks, the weight of the informal economy when it comes to deal with paratransit systems or crime and safety when it comes to pedestrian opportunities. The document even recognises as one challenge “how to develop appropriate urban transport solutions for individual African cities, applying common principles favouring sustainable urban transport”, which translates into how to apply already well known technologies handled by European companies into such opposite scenario. Although, this set of indications is coincident with most of the conclusions of several transport researches in the Southern African region, the suspicion of a prospect “First World” model relying on overseas equipment and loan capital emanates from the lack of alternatives and genuine African approaches.

Little progress has been made on improving accessibility in African cities despite decades of surveys, research, policy making and implementation. Reports stretching 20 years back advocate sustainable, pro-poor, inclusive and energy efficient urban transport. Successive governments have championed better transport. Underachieved, the same targets remain on agendas (Pirie, 2014).

3.4.5 Environment

- Attractiveness of natural conditions

Sunshine hours and green space share are the environmental indicators considered to have a decisive impact on the rating related to natural conditions appeal. Southern Africa is one the regions in the world with the higher number of annual sunshine hours: between an average 2400 hours per year for most of the areas in the region to more than 4000 hours a year in the Kalahari desert (de Jong *et al.*, 2017).

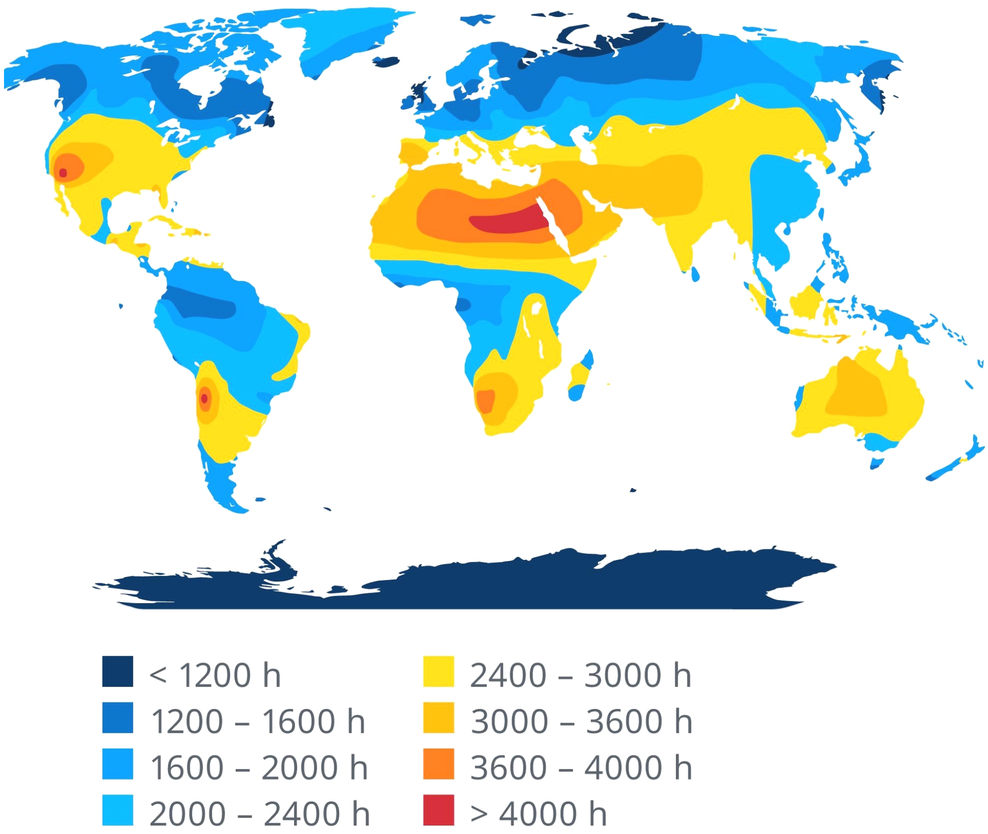


Figure 14. Annual sunshine hours. The Hague Centre for Strategic Studies (Fertner *et al.*, 2007).

The Husqvarna Urban Green Space Index (HUGSI) is an AI-powered satellite solution aiming to assist city managers to monitor the status of green spaces in cities worldwide (Husqvarna Group AI Lab and 20tree.ai, 2019). HUGSI collect data about the size, proportion, distribution, and health of green space in cities. This allows identifying accurately how green cities are, and the effects of urban development in urban green areas. The HUGSI-index compares the level of 'greenness' in 98 cities from 51 countries, divided into 7 regions.

The city selection is based on C40 members. C40 is a network of the world's megacities committed to addressing climate change. Only four cities from Southern Africa were selected and all of them South African. The rest of megacities in the region: Harare, Maputo, Lilongwe, Luanda and Lusaka, are not members of C40 and therefore no data has been collected in the study in order to determine an accurate global position of the region. Durban was ranked first in the global HUGSI 2019 index and also scored the highest percentage of green space in urban areas and highest percentage of urban area covered by trees.

However, the index does not consider the quality of the green space as enjoyable areas within the city. Road sides or inaccessible river banks are included, which can be considered positive indicators as environmental features for climate change alleviation but have little impact on the quality of life.

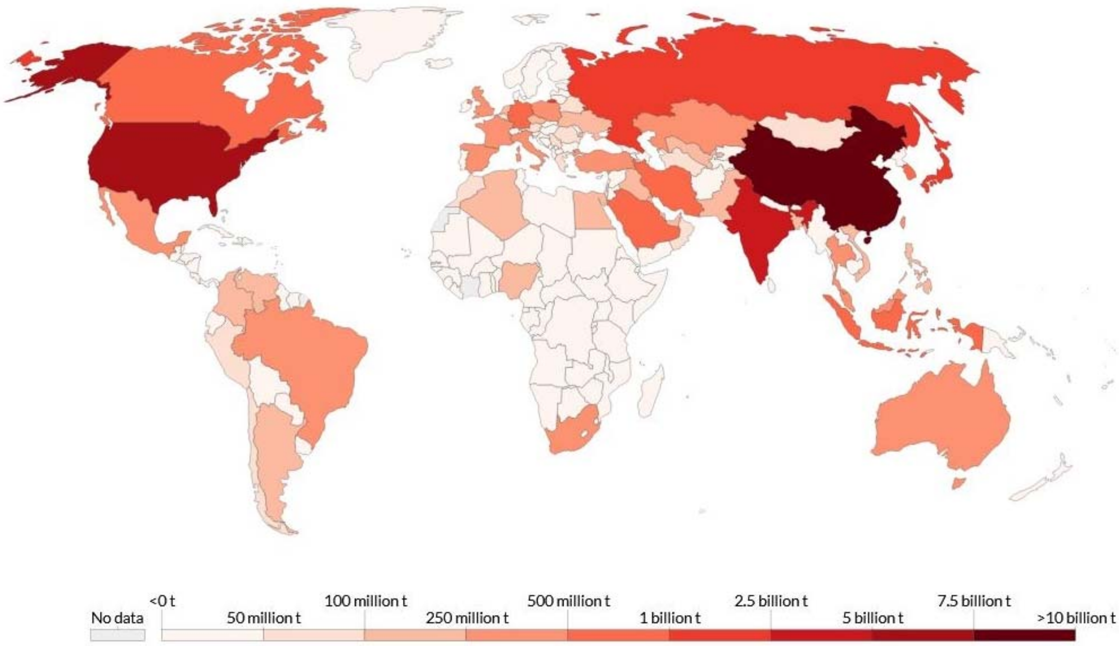
- Pollution

The apparent conflict between environment and development is very present in Southern Africa. Environmental matters are typically overseen in favour of human rights, poverty alleviation and economic growth, instead of considering then the foundation for development (Roberts, 2008). The reason for this perspective can be linked to the historic approach to environmental protection resulting in marginalization and lose of land and livelihood of unprivileged and vulnerable communities, losing their land and livelihood. The perceived "environment versus development" conflict remains prevalent due to political pressure to implement formulas for economic growth despite environmental damage may be caused (UN, 2014).

Southern Africa is extremely vulnerable to climate change effects. The region is warming (SADC, 2010) which in the future, will result in increased drought. Growing urban areas and the consequence increase of water demand will exert enormous pressure to the environment. A big concern for the region is that shifting rainfall patterns, sea level rise and predicted increases in temperature, will compromise water availability, agricultural productivity, livelihood and food security, vital infrastructure, biological diversity, forestry and human health (UN, 2014).

- Environmental protection

Historically, the cumulated GHG emissions by developing countries was lower than 25% globally (Stern, 2007) (see Figure 15). In 2000, they accounted for about 55% of the annual global emissions (WRI, 2009). A reason for this is the high demand of energy needed to implement plans for economic growth which has pulled the use of fossil fuels fundamentally and therefore the emissions have also been rising.



Carbon dioxide ($C0_2$) emissions from the burning of fossil fuels for energy and cement production. Land use change is not included.

Source: Global Carbon Project Carbon Dioxide Information Analysis Centre (CDIAC)

Note: CO_2 emissions are measured on a production basis, meaning they do not correct for emissions embedded in traded goods.

Figure 15. Annual CO_2 emissions by country in 2019

Estimates forecast the persistence of this trend unless the energy sector, electrical in particular, shifts to renewable sources. The International Energy Agency (IEA) estimates that energy-related emissions will increase 45% between 2006 and 2030 worldwide. 97% of this rise is likely to happen in non-OECD countries due to the dependence on coal (IEA, 2008).

In developed regions, per capita consumption of natural resources declined about 12% between 2000 and 2010. Nevertheless, it was still 72% higher than developing regions (UNSTATS, 2016). The rapid growth of urban areas is challenging their sustainable development. Cities become crowded, congested and more industrialized, affecting the quality levels of air. Health consequences seem to me particularly high in Africa (AfDB, OECD and UNDP, 2016). Only eight countries in Africa have operational routine monitoring system for air quality.

Aquifers represent a key source of water for many Southern African cities. Recently, city-scale industrial development has augmented water demand. Centralized bulk wastewater infrastructure is under pressure under high urban growth and urbanization rates. At the same time, the high level of sprawl will render increasing bulk infrastructure networks is expected to be massively expensive (UN, 2014).

Poor informal dwellers resort to natural resources when basic services are not covered in conventional manners. Water is often drawn from rivers and wood is gathered for cooking and heating when electrical energy is unavailable. This can potentially alter ecosystems that support livelihoods and the production of food, together with deplete storm-abatement capacity (Wong *et al.*, 2005).

In addition to the uncontrolled use of natural resources, the lack of service delivery in slums has a big impact on solid waste disposal and management. Almost 50% of urban waste generated in developing countries, including South Africa, is not collected. Uncollected waste is dumped on streets, open spaces, and landfields without control (UN-Habitat, 2012). Waste collection and disposal in informal settlements is ignored by the city management (Freduah, 2007). Unregulated communal dumping sites are organized by groups of households although are poorly maintained. Municipal Solid Waste Management involves the accumulation, exchange, treatment, reuse, asset recuperation and transfer of solid waste in urban zones (Zandamela, 2016).

The irregular services rendered by municipalities force residents to adopt alternative and cost effective ways to dispose of their waste. These include composting, burning, or indiscriminate dumping (Malombe, 1993). This indiscriminate disposal of waste into drains, gutters, and sidewalks, leads to the pollution of drainage channels and natural watercourses.

Shortage in waste management has direct health implications. inadequate water supplies and provision for sanitation for high proportions of the population lead to diarrhoeal diseases which can evolve in serious health problems at city scale (UN-Habitat, 1996).

- Sustainable resource management

Infrastructure budgets are enormously conditioned to the existing lack of infrastructure capacity and general financial burdens. Prioritization and decision on whom and why new infrastructure projects will attend are a controversial topic. Private-sector stakeholders persuade political decision-makers with promises about job creation, economic activation, etc. by-passing this way the development approval queue. Their vision of development is typically within a fenced area which impede distribution of resources (Pieterse, Parnell and Haysom, 2018). Infrastructure upgrade would have a positive impact in reducing household cost and could be a reasonable strategy. The scale of the economy however, seen to be a great obstacle. With a GDP per capita at $2,000, infrastructure development to serve most of inhabitants in Southern African cities is simple not affordable (Pieterse, Parnell and Haysom, 2018).

Electricity in Southern Africa has experienced steep price increases over the past 20 years and Wood-based fuel energy remains a primary source of energy for heating and cooking in low-income households (IEA, 2002; MEA, 2004). As the case of water, increasing population and new industrial developments are stressing the demand, threatening urban energy security. Since 1994, the three South African metros have implemented large scale electrification of informal settlements and previously unconnected areas with no proportionate expansion in energy supply alternatives. Scheduled load-shedding due to power-shortages have been experienced since 2007.

Inequalities are reflected in energy consumption patterns. The poor majority of the population in Southern African cities consume less energy than the advantaged minority of the middle-to-upper income citizens with energy intensive lifestyles. 75% of the budget of poor urban households in South Africa is allocated to food and energy (UN, 2014). However, the contribution of the informal economy to urban sustainability is rarely acknowledged, generally considered as responsible of direct environmental pollution, and planning, health and environmental regulations make efforts to remove and repress it. Yet informal traders often source locally and make less use of single-use plastic packaging, and municipal schemes that use informal recyclers emit lower rates of GHG (Vergara, Damgaard and Gomez, 2016). In addition, the household waste generation in informal settlement is lower than formal lower density residential areas. Tsheleza *et al.* (2019) revealed through a study in Mthatha, South Africa, that the waste generation rate increases about 54% from informal settlements to low-density high-income residential areas.

A group of Southern African cities (Maputo, Cape Town and eThekwini) have initiated anticipatory climate change adaptation plans ahead of national level mandates, support or policy. Whilst national expenditure for urban-scale environmental strategies implementation remains low, some of metropolitan municipalities have bonded at international level with organizations through strategic plans for environmental adaptation initiatives (UN, 2014).

The positive impact of the implementation of walkability oriented policies as sustainable strategy is now notorious (Gilderbloom, Riggs and Meares, 2015). In addition to this, Africa has the lowest rate of car ownership in the World, with only 44 registered cars per 1000 inhabitants. However, there is an intensive use of motorized transportation of people due to the lack of diversity in the spirit of the urban planning, in both, the colonial and post-colonial city in the last century. The colonial city, designed with the car at the centre as a statement of the modern city, lacks of features that make walkability feasible without undertaking structural reforms of the urban layout. The urban planning based in zones, together with the economic segregation, increase the distances allowing for a limited walkability. In addition to the above, the lack of security and the fear of crime, increases the reticence to a walking mobility

3.4.6 Living

The level of well-being, measured taking into account time issues, information elements, competence using technological every-day-devices or freedom of making choices as key elements (Craglia *et al.*, 2004), is unquestionable low.

- Cultural facilities

Southern Africa is gifted with an immense cultural diversity. Multiple ethnic groups and communities, with different traditions and languages; cuisine and vineyards; a number of archaeological sites, industrial sites, museums, vibrant townships, San rock art paintings and carvings and rural landscape (Saarinen and Rogerson, 2015). The colonial planning, and later the apartheid, focused on economic activities, proved little interest in developing cultural infrastructures, relegating the pocketful of cultural facilities to entertainment of the colonial elites, and denying any driver for the spread and development of native cultural practices.

Cultural Resources and Business Travel rank the lowest in the TTCI 2019. Although South African holds the 23rd position in the global ranking, this is due to the world class stadiums for football, rugby and cricket, and not the quality nor number of cultural facilities (Calderwood and Soshkin, 2019). Additionally, the apparent lack of cultural tourism is to some degree the result of a powerful prevalence of wildlife and nature tourism, giving prevalence to 'Big 5' and pristine wilderness experiences without human interference (Saarinen and Rogerson, 2015).

Culture and civilization represent the opposite of wilderness in western cosmology (Nash, 1967; Saarinen, 1998). The strong association of the image of Africa to nature-based tourism has left local cultures and people in a rather smaller role in the tourism industry. Cultural features are typically branded as complement to wildlife attractions, playing a secondary role (Manwa, 2007).

The growth of the creative industries experienced in the last decade seems not to come in hand with the development of cultural facilities in Southern Africa. The lack of reliable data in most countries of the region make difficult to quantify the footprint of such infrastructures. However, UNESCO manages to gather data from a reduced group of African countries and the numbers are low, with the exception of Mauritius (UNESCO, 2021a).

Poverty alleviation and economic growth tend to prioritize the agenda of the urban development in the region, relegating the cultural expenditure to a secondary row (Pieterse, 2019). Moreover, indigenous people associate local culture features to a rural environment and underdevelopment. For instance, the lack of recognition on local gastronomy, which unlike countries like Spain, France or Japan, where traditional recipes and locally available ingredients become the foundation of a sophisticated palate, indigenous cuisine is related to poverty and lack of refinement, with not a single Michelin starred restaurant in the entire African continent.

- Health conditions

Only 33% of the population in Africa have access to improved sanitation in the terms of UNICEF (WHO, 2016).

More than 30% of the healthcare facilities in SSA, attending 25% of the population, have no electricity (Knoth, 2015). The consequences are obvious: Life-saving operations, accurate examinations such as x-ray and ultrasound cannot be performed. Blood and vaccines storage is inappropriate (National Coordinating Agency for Population and Development *et al.*, 2011; WHO, 2012). Communication with other facilities for referring patients is not always available. Incubators are inexistent and probability of neonatal death in the first 28 days is 28%. 70% of the African population has no access to electricity so they are forced to use heavily polluting and toxic kerosene lamps, responsible to a death rate higher than malaria and AIDS combined (Knoth, 2015).

The data reported by the World Health Organization in its 2019 edition (WHO, 2019) are dated not newer than 2013. The life expectancy in Africa is the lowest in the world, with an average of 60 years for women and 57 years for men. However, since 1990, the total life expectancy has grown from 50 to 58 years. This is equivalent to the mortality rate, which is the highest in the world with 306 deaths per 1000 inhabitants yearly. The maternal mortality ratio is also among the highest in the world, with the Sub-Saharan countries ratio being the highest (WHO, 2019). However a decrease since 1993 has been experience in Africa, from 965 to 542 per 100,000 live births. The five leading causes of death in Africa are in order of impact: HIV, lower respiratory infections, diarrhoeal diseases, malaria and stroke.

The United Nations Millennium Declaration signed by all 191 member states in September 2000 contain The United Nations Millennium Development Goals (MDG): eight goals that address poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women and all countries agreed to achieve (or at least try) by 2015 (UN, 2015c).

The Eight Millennium Development Goals are:

- Eradication of extreme poverty and hunger
- Achievement of universal primary education
- Promotion of gender equality and empower women
- Reduction of child mortality
- Improvement of maternal health
- Fight against HIV/AIDS, malaria, and other diseases
- Guarantee of environmental sustainability
- Development of a global partnership for development

Most of the goals have not been consistently achieved in the region, except for the reduction of the HIV impact.

In terms of universal health coverage, Only Namibia, Botswana, Zambia, Ruanda and Gabon have free and universal healthcare. SSA region rates the index value lowest than 45, although Southern African countries do lightly better between 45 and 69. The proportion of countries with insufficient health care professionals between 2013 and 2018 is, once more, higher for the African region. Most countries have no comprehensive monitoring and evaluation plan or financing strategy in place as well as no data is available related to the status of the national health accounts (WHO, 2019).

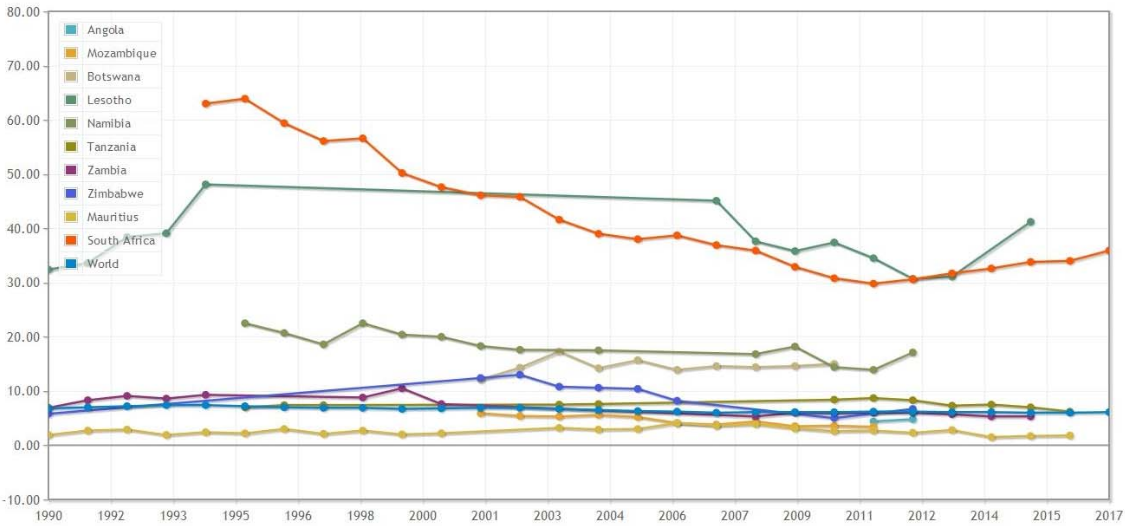
In comparison with upper-middle income and high income countries, the proportion of the population that makes out-of-pocket health payments is doubled for the African region, with more than 10% of the population expending more than 10% of the household income in healthcare. In addition to this, Africa has the second lowest domestic general government health expenditure.

It is worthy to mention that the 2019 Atlas of African Health Statistics reflects no data availability for the health system assessment from South Africa. Being the first economy in the

Sub-Saharan region, with a well established private healthcare industry, further investigation should be conducted in order to determine the level of lobbing of the sector and its possible impact on the decay of the public health system.

- Individual safety

The rate of homicides in South Africa and Lesotho is four times the regional average and six times the world average. Except for these two countries, Southern African does not experience a particularly high violence (World Bank Group, 2021b). This indicates that not only poverty and lack of service delivery but specially inequality have a direct impact in crime levels (see Figure 16).



Intentional homicides are estimates of unlawful homicides purposely inflicted as a result of domestic disputes, interpersonal violence, violent conflicts over land resources, intergang violence over turf or control, and predatory violence and killing by armed groups. Intentional homicide does not include all intentional killing; the difference is usually in the organization of the killing. Individuals or small groups usually commit homicide, whereas killing in armed conflict is usually committed by fairly cohesive groups of up to several hundred members and is thus usually excluded.

Figure 16. Intentional homicides (per 100,000 people). (World Bank Group, 2021b)

Such anomaly in the region deserves a closer look. Social cohesion is a rather complex concept that could be outlined as the group of that ‘hold a society together’ (RSA, 2004). It has to do with the social features that contribute to solidarity at a given spatial framework: local, national or even international. Community interaction and collaboration, common identity and values, participation in common organisations and sense of belonging are some of these features. Therefore, a society lacking cohesion would experience great social inequality, social conflict and disorder, low levels of place attachment, disparate moral values and low levels of social interaction among communities and within them. Literature about 'collective efficacy', a recent construct for social cohesion, address the correlation between social cohesion and violence (Sampson, Raudenbush and Earls, 1997). When levels of social cohesion are low, the efficiency of crime is compromised. Moreover, lack of social cohesion is generally perceived as the reason for conflict itself.

The ability of local communities to face problems cohesively can be affected by increasing fear of crime. Whilst the composition of neighbourhoods do influence in the levels of fear of crime and crime itself, neighbourhood trust and attachment may be influenced by fear of crime as a kind of feedback look. In South Africa, about three-fifths of adults express 'worry' as occasionally and one fifth as constant. In spite of the moral philosophy of ubuntu and common references to the 'rainbow nation', research studies confirm that the reality is actually the opposite to a cohesive society, characterized by low levels of trust (Institute for Security Sudies, 2016).

Personal social freedoms are highly impacted by customary laws in the region. Domestic violence and rape are pervasive problems and far from being solved in the near future. Customary marriage practices vary among different ethnic groups. In many rural areas, girls are married before age 18. Customary law restricts women's rights within a marriage (Freedom House, 2020).

Human trafficking remains a big problem in Southern Africa, with active criminal syndicates targeting mostly people from rural areas and foreign migrants for sex trafficking and forced labour (Freedom House, 2020).

- Housing quality

Shortage of quality housing stock is common in Southern Africa. The absence of reliable data about quality and quantity of the housing stock together with occupancy ratios makes challenging the planning of initiatives without a great level of uncertainty (World Bank Group, 2015). Moreover, the housing sector is compromised by great inefficiency at all levels, regulatory, institutional, and technical, which condition an effective delivery of quality housing the compliance in the terms that a large and increasing demand requires. This situation has led to an overwhelming growth of slums and informal housing, become the dominant form of housing across the region: 75% of the housing stock in SSA (World Bank Group, 2015). Investment in formal housing is not following the pace of the rising housing needs. The sector in unable to attract FDI and most of housing projects are public funded (World Bank Group, 2015).

There is an extreme spatial disparity between residence and workplace, inherited from the strict monocolor zoning from the British colonial planning and apartheid spatial policies. The cost of housing is lower in peripheral areas and poor residents, and most of the newly arrived immigrant from other African countries, settle despite the lack of public capacity to expand the infrastructure network together with healthcare and education services. In addition, inefficient mobility systems put great pressure on households' budget (World Bank Group, 2015).

The conventional formal housing delivery system seems not to acknowledge the reality. The urban poor cannot afford the established process, which is also sustained as the only legal and therefore formal: it starts with land owning (title deed), to move into the appointment of professional services to produce a rational design (architect and engineers), within a legal framework (standards and municipal land use polices), and all of this paid through a financial institution that will grant a mortgage loan. This is simply not going to happen any time soon for the overwhelming majority of Southern Africans. (World Bank Group, 2015).

The processes that support the market of formal housing in Southern Africa are weak and high-income oriented. On the contrary, the reality is rather characterized by low-income communities and barriers that increase construction time and costs, and the final housing price. These challenges include unreliable and incomplete infrastructure grids (roads, electricity, water, sewage and drainage); lack of institutions and capacities to manage land value in with financial purposes to address public infrastructure investments; limits to capital markets for providing financial assistance to consumer and developers; and weak land tenure systems (World Bank Group, 2015).

Nevertheless, Informal housing does not automatically mean shack. Somewhat, informality is a compendium of elements as a response to the problem of insufficient formal housing delivery- In Southern Africa, informal housing does not mean illegal either although they do not comply with the legal framework. Typically self-constructed, small scale and low quality, humble and sometimes inadequate building materials, lacking compliance with building standards and/or local bylaws and tenure insecurity are the features of informal housing (World Bank Group, 2015).

Table 10. Comparative Summary of Housing Delivery Conditions in SSA (World Bank Group, 2015)

Comparative Summary of Housing Delivery Conditions in SSA. Source: World Bank Group			
	Housing Delivery Component	**Formal**	**Common SSA condition**
Supply	Land Tenure and Administration	Freehold or leasehold title; title or deed registry	Competing tenure systems and or absence of title: Squatting, land invasions, illicit subdivision and sales
	Planning Standards and Regulations	Compliance with floor area ratio (FAR), plot coverage, site setbacks, heights, building codes	Variation in site density, design and lot coverage
	Construction sector	Sector with professional, licensed contractors/workers	Self-built, or use of informal unlicensed labourers
	Building Materials	Mass produced materials with standardized quality	Variation in type and quality of materials: Scavenged items, traditional manufacturing techniques, some use of manufactured materials where they can be obtained
	Infrastructure	Trunk lines and utility connections	No trunk lines: Illegal wiring, pit latrines, household cisterns
Demand	Formal savings accounts	Savings account deposits used for mortgage lending	Little formal savings: Reduces capital available for lending to consumers or developers
	Underwriting and verification	Assessment of income and creditworthiness to create mortgage terms	Lack of formal income and land or property title for collateral: Reduces eligibility for housing subsidy programs, raises risks profile for commercial mortgage lending
	Mortgage loans	Long term loan for obtaining complete, titled house	Few mortgages: Most households use personal savings, microcredit, savings groups and/or other non-commercial sources

Spatial conditions for domestic activities in informal settlements are rather subhuman: shortage of space; water filtration problems; great heat transfer, the interior space is cold in winter and hot in summer; inadequate ventilation and sanitation; and units are generally overcrowded with the consequent lack of individual privacy. The space outside the units does not show better conditions: Public space in informal settlement accounts for a 2% of the total footprint (Clos, 2016), there are no leisure areas, playgrounds or parks; light and stormwater are almost inexistent; dangerous for women and children; and they are exposed to environmental hazards when located in flooding areas near aquifers of sliding hilly locations (Pieterse, 2019).

Tenure security represents a fundamental problem to settling informally, and hence the derived shortage of rights associated to formal tenure. Tenure security emanates from the access to land and property through a legal framework (Payne, 2004). Insecurity of tenure can result in the inability to exist on paper, which is a primary barrier to access to most of entitlements from public programmes, services and utilities that may want to provide water supply to all neighbourhoods in the city, for better health and ethical commitments, or as a response to political pressure from residents, without violating regulations. In contrast, it is also probable that public agencies are hesitant to provide services to 'illegal' neighbourhoods find the illegality of the neighbourhood a mode of legitimate exclusion (Bhan, Goswami and Revi, 2017).

In the KwaZulu-Natal for instance, the trend does not differ from the aforementioned for the Southern African region. The informal settlement in the metropolitan area of eThekwini represents the 35% of the housing forms available (eThekwini Municipality, 2020b). It is the response of the urban poor to a public denial and inefficient approach to urban growth and affordable housing provision (Boaden and Taylor, 1992).

- Education facilities

Access to basic sanitation facilities is was not available for even 50% of primary schools among the 145 countries with data, 17 of them in SSA. Data about separate facilities by genre and maintenance status was not detailed. In SSA, only 22% of primary schools and 49% of lower secondary schools have access to electricity. Additional equipment and services are difficult to find. In 2015, about three quarters of primary schools in Uganda and South Africa had libraries despite requirements. By 2021, 25% of primary school students are expected to attend private schools (UNESCO, 2017c).

A study about private schooling regulations in 21 countries in SSA found general requirements to comply with: registration fees (15 countries); number, type or size of classrooms (17 countries); and teacher qualification standards (19 countries). This regulatory framework does not acknowledge the reality and consider such requirements and overkill and self-defeating.

More realistic demands should be implemented and focus on student outcomes together with accessibility of private schools to the most disadvantaged children (UNESCO, 2017c)

Over one third of primary schools in South Africa are affected by shortage of resources for students with special needs. Students with disabilities struggle with particular obstacles: unsuitable curricula, lack of mobility equipment, negative social attitudes, inappropriately designed buildings and absence of teaching aids. (UNESCO, 2017c). One in four of children with a disability between 5- to 15-year-old were not attending school. There is a significant shortage of social service and health professionals, and new special schools have been built with no specialized provisions for learners with severe intellectual disabilities (UNESCO, 2017c).

The quantity of teachers under fixed-term contract has increased considerably in SSA. Underpaid, younger and undertrained teachers are appointed locally and regularly work in the more remote and marginalized areas. In fact, the use the incentive of contract renewal to improve teacher performance and motivation is widely used. Only 62% of primary school teachers are trained. (UNESCO, 2017c).

In South Africa, a human rights organization: the Legal Resources Centre brought a court case against the governments (at both national and provincial levels) in support of a group of rural schools in the Eastern Cape Province with inadequate infrastructure. A legally binding agreement forced the Department of Basic Education to address the upgrade and construction of adequate infrastructure and educational facilities in the shortest time possible, nationwide (UNESCO, 2017c).

- Touristic attractiveness

SSA is home of numerous World Heritage natural sites, extraordinary wildlife and active habitat conservation programs with international impact. However, when it comes to travel and tourism attractiveness, the region ranks at the bottom of the Travel and Tourism Competitiveness Index (TTCI) 2019 (Calderwood and Soshkin, 2019). SSA's travel and tourism market is very small, 1.6% of the GDP. Only South Africa, Seychelles and Mauritius score above the global average on the index.

Southern Africa lacks of a strong middle class and economic fabric needed for boosting intra-regional tourism, and investment in the sector does not achieve the levels of other regions in the world, limiting competitiveness. The infrastructure in the region is the least developed in the world which worsens the situation by blocking the vital arteries of travel and tourism. There is a marked lack of ICT adoption, an important requirement taking into account that travellers and industry players gradually more depend on technology. SSA's most substantial gap with global averages lays on health and hygiene concerns. All these obstacles may explain the low ranking on the TTCI cultural and natural indicators in spite of worldwide recognized natural treasures (Calderwood and Soshkin, 2019).

- Social cohesion

Southern Africa has an urban growth rate of 4.58% per year, the highest worldwide. In spite of poor economic growth, the urban population of some Southern African cities has grown. However, urbanization in many developing countries has not coupled industrialization growth, economic development or even by development per se. This situation, together with anti-poor policies and unbalanced distribution of resources, has rocketed urban poverty, which impacts the economic viability of cities and blocks their sustainability (UN-Habitat, 2006).

Southern African cities experience the highest level of inequality worldwide, with South Africa on top of the ranking (López Moreno and Oyeyinka, 2010). The shift of changes in social values, particularly among the urban population, in Southern Africa is as symptom of the shocking inequality that has come along with economic growth. The tremendous disparities and the social fragmentation that characterizes class and ethnic distinctions and urban socio-spatial relations fuel considerable political discontent in cities, and generate and strengthen an "identity of exclusion" among the poor urban dwellers (UN, 2014).

Whilst racial dimensions of the unbalanced urban growth are gradually fading out, social inequalities and spatial segregation are expected to continue shaping the urban landscape in Southern Africa at economic level due to the linkage of key challenges: land availability, housing delivery and infrastructure provision to financial constrains (Robinson, 2008). Historically, rural poverty has been more intense but is gradually shifting to urban settlements (SACN, 2011b). In Africa, the percentage of urban dwellers living in poverty (43%) is catching up much faster with the percentage of rural areas residents (59%). The figures for SSA countries are even worse, with urban poverty affecting more than 50% of the urban population (UN-Habitat, 2006).

Except for Zambia, Mozambique and Angola, Southern Africa has the smallest population living in slums compared with the rest of the continent. Nevertheless, Gini coefficient indicators in the region are shockingly high, with RSA leading the region in inequality (UN-Habitat, 2009).

Although economic growth in Southern Africa has an urban origin, it has not couple with an expected increase of quality of life and income levels. On the contrary, the fast growth of GDP has affected urban communities with great fragmentation, inequality and consequently amplified considerable socio-political risk (UN, 2014). Unequal societies are more violent, with greater incarceration rates and lower life expectancy (Harvey, 2017).

Great vulnerability emanates from the circumstances of spatial patterns: planning , service provision and infrastructure shortage are particularly sensitive for poor residents (UN, 2014). Inequality conflicts are most prominent in areas where wealth and poverty coexist in proximity (Nel, Hill and Maharaj, 2018).

Robert Putnam, the father of the "Social Capital Theory" believes that a healthy civic-minded society is essential for prosperity. He points out the danger of the lack social capital. A declining trend in social capital makes that society become less trustful and less civic-minded (Putnam, 1993). The effects of the African colonialism in urban settlements, where massive displacements of people took place in order to guarantee labour to accommodate economic agendas, without looking at social implications as breaking family structures and a constant feeling of misplacement in people. Post colonial cities are places with no social bonds, and new housing policies are no helping to change the situation. Lack of associationism, high rates of crime and corruption with no accountability from an organized public are symptoms of communities composed by misplaced people.

In SSA, the average per capita income today is lower than five decades ago (Sriram and Mersha, 2006) and the number of people living in extreme poor condition has increased from 278 million in 1990 to 413 million in 2015, more people than the rest of the world combined representing an average poverty rate of about 41%. 27 of the world's 28 poorest countries are in SSA, with Nigeria expected to pass India in population living in extreme poverty and by 2030, 90% of the world population living in extreme poverty will be SSAn (Barne and Wadhwa, 2018; Jolliffe and Lugo, 2018).

Poverty has magnitudes of both material and psychological deprivation within the anonymous and impersonal setting of cities (Hove, Ngwerume and Muchemwa, 2013). Deprivations associated with urban poverty are linked to informally reside in the city. Lacking prove of residence limits the access to both public and financial services: applications to state grants or voter's register. The absence of formal provision of services may not only increase the price but substantially reduce quality for private operators (Tacoli, McGranahan and Satterthwaite, 2015).

Other characteristics of urban poverty include hunger. Nutritional deficiencies and unhealthy living conditions erode the health of individuals, whose main concern is centered on survival, with women and children often the most vulnerable. 24.9% of children under 5 are underweight, 39.4% stunted and 10.3% acute malnutrition. The increase of street children in African cities is a symptom (Hove, Ngwerume and Muchemwa, 2013).

The weak capacities of governments in enforcing the law and problems derived from poverty and social exclusion, result in the challenges of rising insecurity. Crime and violence have increased tremendously in some African cities. (Hove, Ngwerume and Muchemwa, 2013).

The African Development Bank reported that despite increasing inequalities, the economic growth and the shift towards a more stable urban job culture, distant from traditional farming, have had a positive effect on the increase of the African middle class over the last four decades. rising to 313 million people, over than two thirds of the continent's population (Ncube, Lufumpa and Kayizzi-Mugerwa, 2011). However, this numbers include a great quantity of 'floating class' whose hold on status is not guaranteed (AfDB, 2011).

Income level together with aspirations, professions, lifestyle and education, are characteristics that assist identifying who is middle class. In addition, the presence of a stable middle class is higher in countries with the presence of solid, well-paid employment, greater levels of higher education and a dynamic private sector (AfDB, 2011). They are unlikely to obtain their income from farming or even owning farming land. They are likely to be employed in pay-check jobs or to run small enterprises. The use of public healthcare is also rare among the African middle class and usually contract private healthcare services. Families are smaller, with less children per couple (Ncube, Lufumpa and Kayizzi-Mugerwa, 2011).

Human capital investment in health, education, vehicle ownership and internet users rise with the middle class as well. Schooling is very important for the middle class. Private schools provide an alternative option in countries where public schools fail to provide good education. The middle class is also more probable to subscribe to fixed broadband internet and to look for superior healthcare than is the case for the poor. (Ncube, Lufumpa and Kayizzi-Mugerwa, 2011).

However, the high expectations followed by the increasing numbers and positive trends are to be put in context. The African Development Bank considers middle class those living on US$ 2-10 a day and upper middle class those with a level of expenditure of US$10-20 (Ncube, Lufumpa and Kayizzi-Mugerwa, 2011). Some multinational corporations have found that their business in the region is underperforming, in some cases encourage them to deprioritize Africa in their global strategies (Manson, 2015). The fast expanding African middle class is often offered as the solution for the various governance problems on the continent (Hellsten, 2016). The Spanish Institute for Foreign Commerce (ICEX) reported that approximately 10% of the South African population can afford goods rated as luxury or good quality, which are considered standard or not luxury in the European understanding of middle class (ICEX, 2019).

3.5 The impact of waste management in the South African Megacity: a case of service delivery backlogs

Human activities are accountable for great deterioration of the biological diversity worldwide. The issue is of such importance that all human effects combined would contribute to extinction at rates ranging from 1,000 to 10,000 times the natural rate (Lovejoy, 1997; Derraik, 2002). In the early twenty first century, pollution by plastic waste has become the most destructive and fastest growing menace to oceans health. Again, human activity is the main contributor to plastic entering the hydrological system. Inefficient waste management implementation, public use of beaches for recreation, illegal dumping, faulty stormwater outlets and runoff, sewer overflow and fishing activities are found to have a significant impact on plastic pollution in water bodies. According to PlasticsEurope and Epro (2018), it is approximated that 348 million tons of plastic were generated globally in 2017.

Plastics have existed for just over 100 years and are the product of polymers synthesis (Gorman, 1993). Cost effectiveness and a vast array of applications have made the modern world highly dependent on plastics (Laist, 1987; Derraik, 2002). Durability, low mass and inexpensive manufacturing process make them suitable for a number of products (Derraik, 2002) but at the same time , these characteristics are the reason for plastics to become an immense environmental problem (Laist, 1987; Pruter, 1987; Derraik, 2002)

3.5.1 South African waste management system

Various types of waste are the result of multiple human activities from all three sectors of production, such as mining, agriculture, manufacturing, commercial, construction and residential (SAWIC, 2015). Waste is classified as either general or hazardous in terms of the National Waste Classification and Management Regulations. A product that is not longer capable to fulfil the purpose to which it was created becomes waste (Pongrácz and Pohjola, 2004). Despite waste prevention being the most efficient strategy to face the problem of waste pollution, it is typically the least considered in allocating resources (van Emmerik and Schwarz, 2020).

The Bill of Rights was established by the Constitution of South Africa (Act 108 of 1996) through which everyone has the right to an environment that is not harmful to their well-being and health (RSA, 1996). The South African government encourages an integrated approach to pollution and waste management environmentally and economically sustainable (Makgae, 2011). The waste sector in South Africa is currently regulated by multiple legislations being the most representative the South African Constitution (Act 73 of 1989); the Environment Conservation Act (Act 73 of 1989); the Waste Act (Act 59 of 2008) and The National Environmental Management Act (Act 107 of 1998) (Reddy, 2017).

This framework aims for a clean environment and a stable economic growth by preventing and mitigating waste pollution (Makgae, 2011). Nevertheless, the current problems in waste management in South Africa comprise the underdeveloped, and sometimes unlicensed, waste treatment sector; inefficient municipal management and inadequate collection systems; poor law enforcement and illegal dumping, lack of landfill sites, weak regulatory framework; and poor public waste awareness (Nahman and Godfrey, 2010).

Waste management in RSA has been uncoordinated and poorly funded in the past (Makgae, 2011). As a developing country, RSA is expected to seek improvement of standards in service provision despite the limited resources (Matete and Trois, 2008). In 2000, the Local

Government Municipal Systems Act (Act 32 of 2000) was developed to ensure municipal management within sustainable parameters (Matete and Trois, 2008). In order to compensate the lack of financial resources, the National Waste Management Strategy introduced the Polluter Pays Principle (Makgae, 2011), which stipulates that those who cause environmental damage must pay for it (Luppi, Parisi and Rajagopalan, 2012). In addition, all waste-generation activities must bear the cost linked to the waste produced, which goes beyond the directly related cost: waste collection, treatment and disposal, but indirect costs related to health and environment (DEAT, 1999).

Evolution of waste management legislation in South Africa:

- 1989, The Environmental Conservation Act
- 1994, The Constitution of the Republic of South Africa
- 1998, The National Environmental Management Act
- 2008, The National Environmental Management: Waste Act
- 2011, National Waste Management Strategy
- 2020, Extended Producer Responsibility

One strategic decision with big impact in the sector is threat South Africa adheres to the ‘waste management hierarchy’, considering landfill disposal as the least favourable option.

3.5.2 Environmental frameworks in eThekwini Municipality

Durban is among a small group of Southern African cities that have initiated anticipatory climate change adaptation plans ahead of national level mandates, support or policy (UN, 2014). In recent years, the eThekwini Municipality has approved the Durban Climate Action Plan 2019 (eThekwini Municipality, 2019) and the Strategic Environmental Assessment 2020/2021 (SEA) (eThekwini Municipality, 2020b). Aligned to the Paris Agreement (UN, 2015a) and the SDGs, the municipal government acknowledges the urgency to respond and implement policies against climate change and promote the engagement with the C40 Cities Preamble Climate Leadership Group (C40).

3.5.2.1 Durban Climate Action Plan 2019

The document shows concerns about the environmental vulnerabilities in relationship with global warming, rainfall and flood patterns changes. eThekwini is building the pathway to become climate resilient and ‘carbon neutral’ by 2050 (eThekwini Municipality, 2019). The strategy for the implementation of the Durban Climate Action Plan 2019 tackles a number of actions at multiple levels: government, public engagement, and human and technical capacity building. The document includes the definition of key performance areas by sector to monitor the adequacy of the implementation and the data collection for the creation of a GHG inventory (which account to 20,8 mill tones annually) in order to increase efficiency as crucial strategies for succeed (eThekwini Municipality, 2019).

The plan outlines a number of actions defined through a multidisciplinary and inter-departmental approach, addressing nine thematic areas: energy, transport, waste, water and flooding, health, biodiversity, food, sea-level rise, and vulnerable communities.

Regarding waste, the plan aims to “Divert all waste disposed to landfill sites by 50% in year 2023 (Phakisa targets) and by 90% by 2050 through reuse, recycle, recovery and re-engineer” which will potentially reduce GHG emissions and contribute to a significant improve to resilience. The benefits associated to this actions are expected to improve the air quality, save cost in waste management, improve the health condition of inhabitants, develop the waste sector and consequently the creation of employment associated, and promote innovation (eThekwini Municipality, 2019).

‘Zero waste’ targets are also included in the document. The municipality highlights some of the actions that are already put in place and may pave the road to the final goals. According to the document the following are strategies that are already functional:

- Waste separation at household source level through the use of a colour code bag collection system
- 23 recycling centres in eThekwini managed by DSW that are easily accessible by residents
- Public engagement to promote the reduction, recycling and reuse of waste through educational programs

- Two engineered landfills that produce energy from biogas at Bisasar Road and Mariannhill landfill sites

Reduction of waste to landfill and recycling are at the core of the actions proposed in the plan regarding the waste sector by the improvement of facilities, engagement with the private sector and simplifying waste dealings for communities.

Water and environmental quality are also key themes addressed by the action plan and related to the case study. The main concerns identified through the actions proposed regarding water are the change in rainfall and flood patterns and the water quality. Provision of water to disadvantaged communities is a great challenge for the municipality together with water waste treatment. Developing an overarching water use strategy to overcome these problems have to do with acknowledging the social composition of the city and implement infrastructure accordingly. The use of centralised networks seem to be put aside. Moreover, the study of flood lines is integrated with development plans in order to avoid future flood risks.

EThekwini is a member of the uMngeni Ecological Infrastructure Partnership (local municipalities, Umgeni Water, the South African National Biodiversity Institute (SANBI)), focused on the implementation of green infrastructures to face the challenges of water security in the Umgeni catchment.

The plan pays special attention to water bodies at environmental level as well, highlighting the inventory of 18 river catchments and 4,000 Km of river, 16 estuaries and great biodiversity (eThekwini Municipality, 2019). Conservation and quality of ecosystems are essential goals to be achieve through community and expertise engagement.

3.5.2.2 Strategic environmental assessment of eThekwini

The Strategic Environmental Assessment (SEA) is conceived as an instrument for the integration of environmental sustainability into the formulation or revision of urban plans. Moreover, an SEA is required by the Spatial Land-use Management Act, 2013, to be carried out included in the development of a Spatial Development Framework (SDF). An SEA is expected to cover 4 objectives:

- Definition of the environmental status quo

- Assessment of opportunities and development limitations regarding a sustainability framework
- Analysis of urban planning, either existing or in process, and development of alternative responses to implement the sustainability framework
- Monitoring and evaluation of the performance of those responses to achieve sustainable goals

The role of cities in the climate crisis is acknowledged in the document, and shows commitment to come with solutions through the implementation of the SEA and become Durban to be “the most caring and liveable city by 2030” (eThekwini Municipality, 2020b). By capitalizing a sustainable use of natural resources, the city highlights the benefits of a functioning natural environment as the base for “safe, healthy and liveable city for all citizens”.

The assessment approach is phased in three stages: Phase 1, natural environment focus; Phase 2, socio-economic focus; and Phase 3, integration and recommendations. In order to guarantee the efficiency of the process, a phase won’t commence until the previous phase is finished, and full understanding of the parameters assessed is achieved to unlock the next actions. At the moment, only Phase 1 has been conducted.

The strategy put in place to undertake the task of defining the environmental status quo is based on a Drivers-Pressures-State-Impact-Response (DPSIR) framework as indicated in Figure 17.

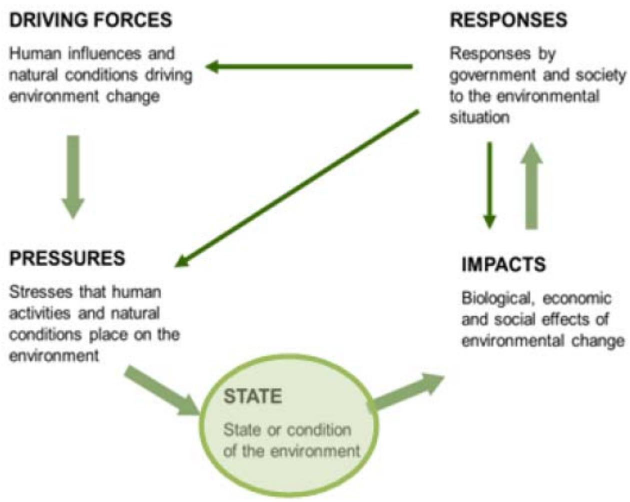


Figure 17. Drivers-Pressures-State-Impact-Response (DPSIR) framework in phase 1 of the Strategic Environmental Assessment of eThekwini (eThekwini Municipality, 2020b)

The driving forces of environmental change considered in the documents are: climate change, economic development and urbanisation. These are large-scale phenomenon which generates environmental hazards affecting humans and ecosystems. The document tackles the influence of climate change (Phase 1) in the region and how it is shaping governance, with reference to commitments to international sustainability frameworks. GHG, climate warming, sea-level and rainfall changes are the four major topics that compose this first phase regarding climate change.

The document defines ‘pressures’ as “stresses that human activities and natural conditions place on the environment” (eThekwini Municipality, 2020b). These pressures are infrastructure and urban services, and land transformation and fragmentation. The key findings in the assessment are in line with the features defined in this literature review regarding the Southern African city: rapid urbanisation and slow implementation of public transport, resulting In increasing congestion and travel time; energy reliance on fossil fuels and projected increasing demand of electricity; inadequate waste collection systems with environmental consequences; increasing demand of water and sanitation due to the rapid urban growth coupling decreasing resources to expand infrastructure networks; and finally, inadequate housing delivery strategies resulting in a 45-80 years timeframe to solve the housing deficit in eThekwini (eThekwini Municipality, 2020b).

The primary focus of the phase one is on the state of the environment, which understanding is achieved through the analysis of seven fields of study: biophysical hazards, air quality, terrestrial ecosystems, freshwater ecosystems, estuaries, coastal systems and ecosystem services.

The report highlights the impact of plastic waste in riverine ecosystems. However, the fact that no monitoring and quantification has been conducted in this regards, plastic pollution does not take part of the environmental assessment. South Africa ranks 11 in major plastic polluters worldwide. The perception of the public as rivers being waste removal free services is to be changed. The effects of such behaviour resulting on plastic waste deposited on urban beaches is also documented in the report (eThekwini Municipality, 2020b). The document reports great stress to the lower section of the Umgeni River due inadequate flows to sustain aquatic ecological integrity, with economic and social effects.

As a summary of environmental state of EThekwini, the report conclusions point at the great reduction of the natural assets as a subject of main concern. Sustainability limits may have been exceeded and this will affect the quality of life of the inhabitants. Moreover, current trends indicate the far from mitigating, the environmental quality will still decline and the aforementioned driving forces to escalate. There is a major need for urgent reaction in addressing the parameter of the future urban growth and a call for 'out of the box' thinking. New visions are to be explored to make room to any chance of success and actions to be taken at all levels of government: local, regional and national.

The report closes out with 10 key findings statements:

I. *"The sustainability of Durban's growth and development requires the protection and maintenance of the natural asset base".* The impact of natural loss at economic level is typically overseen. The way it would affect tourism and port operations could have irreversible consequences.

II. *"There is no scope for further loss of Durban's natural asset base".* The use of land has increased 18% over the last 15 years, most of it within traditional authority areas. 50% of the extent of estuaries has been lost.

III. *"There is a need to not only halt but reverse the declining trends in environmental quality"*. Ecosystems need to be in good shape to be able to deliver services. In general, natural systems in eThekwini show poor condition: only one out of 16 estuaries present a 'good ecological state'; the water quality is poor and 90% of sampled sites exceed the E.coli limits; the biotic state is C or D (moderated or highly modified); and non revenue water accounts for 40% of the total water supply.

IV. *"The drivers of the environmental state and associated pressures do not show signs of reversing or slowing"*. In fact, the population growth estimate for the next 15 years is an increase of half million. Currently, there are 600 informal settlements in eThekwini. In terms of solid waste, the landfill site capacity is under great pressure, with 2 landfill sites near closure.

V. *"The city's natural assets are not adequately recognised, protected or maintained"*. The asset register only records 0.6% of the total natural assets which derives in insufficient allocation of budget for maintenance. The contribution of natural assets to well-being is not recognized.

VI. *"Human wellbeing and economic activity will increasingly be influenced by declining environmental quality and climate related disasters"*. There is a potential increase of health risks linked to air pollution; the closure of beaches for poor water quality will affect tourism and other service industries; the real estate and industrial sectors will be affected by major climate hazardous events, particularly at the beachfront and Prospect area

VII. *"Responses are not keeping pace with the need, but there are opportunities to do things differently"*. However, the extent at which alternative options have been considered is inadequate at the moment.

VIII. *"Governance is a major factor in addressing the current situation"*. The current situation is compromised by a dual government that limits competencies in planning in traditional land; lack of departments' coordination addressing a single environmental problem; and inefficient data collection and analysis.

IX. *"Government cannot address the challenge alone"*. Environmental issues must be addressed collectively, including not only local, regional and national governments but also the private sector and civil society.

X. *"The environmental state is likely to be worse than depicted in this assessment"*. Complex interaction in the environment might be overlooked in the assessment due to the dormant events and later manifestation of natural events to become noticeable.

3.5.3 Plastic waste management in municipalities in South Africa

In recent years, the national waste management strategy is facilitating the development of new sustainable approaches to waste management, conceptualizing waste as a resource and highlighting its contribution to the 'circular economy' with applications in green energy production, climate change mitigation, employment opportunities and sustainable landfill management. Nevertheless, the technological transition and capacity within municipal departments is still poor and financially limited, often constrained by complex institutional and social requirements which increase the failure risk of appropriate technologies implementation. The private sector does not show signs of going ahead and lack of vision of the potential and revenues opportunities that the waste sector can provide (Trois and Jagath, 2011; Trois and Kissoon, 2018).

In RSA, there are 226 local municipalities, grouped in 44 district municipalities, and 8 metropolitan municipalities. The Municipal Systems Act No 32 of 2000 regulates the functions of the municipalities. In KZN, there are 68 licensed landfills but only 3 are engineered with the required infrastructure to conduct waste recycling treatments. Separated collection is not implemented in any of the municipalities in KZN and more materials recovery facility (MRF) Is fully equipped to process the entire waste streams (Trois and Jagath, 2011).

Despite the evolution of the waste sector since the approval of the Environmental Conservation Act No 73 of 1989, it is still at an early developmental stage. The Act was the first one to highlight the impact of human activities on the environment. Waste management got embedded in the legal framework with the development of the new constitution after the apartheid in 1994, which appoints local municipalities as the responsible of the collection and disposal of solid waste with sustainable development at the forefront.

3.5.3.1 Governance in plastic waste management in South Africa

Currently, waste management activities are ruled by the National Environmental Management: Waste Act 59 of 2008 (NEM:WA). It is a product of the comprehensive National Environmental Management Act (NEMA). This act took the place of the Environmental Conservation Act No 107 of 1998, which was the first one to pay attention to environmental conservation in the RSA. The NEM:WA states that recyclables not collected by the municipality at households, should be taken to designated facilities which must be accessible to the public.

The governmental sphere is structured in three levels: national, provincial and local. Each of these spheres has specific roles that are defined by legal mandates:

- National government: It is responsible for legislation and regulation according the National Constitution of the RSA. Regarding the NEM:WA, the national government is responsible for the overall implementation throughout norms and standards of the National Integrated Waste Management Plan (IWMP).
- Provincial government: It is responsible for the mediation between local and national governments and the coordination of local governments' activities and ensure adherence to the national government requirements.
- Local government: It is mandated by the Constitution of the Republic of South Africa to make waste management services available and responsible for the practical implementation of the waste act. According to directives at national level, local

governments are to promote source separation and the diversion of waste from landfill (Trois and Kissoon, 2018).

The waste act defines waste as:

"(a) any substance, material or object, that is unwanted, rejected, abandoned, discarded or disposed of, by the holder of the substance, material or object, whether or not such substance, material or object can be re-used, recycled or recovered and includes all wastes as defined in Schedule 3 to this Act; or (b) any substance, material or object that is not included in Schedule 3 that may be defined as a waste by the Minister by notice in the Gazette, but any waste or portion of waste, referred to in paragraph (a) and (b) ceases to be a waste - (i) once an application for its re-use, recycling or recovery has been approved or, after such approval, once it is, or has been re-used, recycled or recovered; (ii) where approval is not required, once a waste is or has been re-used, recycled or recovered; (iii) where the Minister has, in terms of section 74, exempted any waste or a portion of waste generated by a particular process from the definition of waste; or (iv) where the Minister has, in the prescribed manner, excluded any waste stream or a portion of a waste stream from the definition of waste." (DEA, 2009).

Recently, local municipalities are assessing new alternatives of waste management due to the increasing pressure from the development of legislation in waste and landfill compulsory requirements, particularly the introduction of the waste hierarchy (DEA, 2009). Recycling and the reuse of waste as a resource become therefore first options in dealing with waste. At the moment, local municipalities generally lack of technical and financial capacity for the implementation of new technologies and up to 40% of the population barely receives waste services, or not service at all, in the RSA (Stats SA, 2011).

The NEM:WA states that local municipalities must include the IWMP into the Integrated Development Plans (IDPs) in order to guarantee that waste management is at the same level of other essential infrastructures. The IWMP is required at all government levels that have responsibilities with waste management in terms of the Act.

The development of an IWMP includes:

- An assessment of the situation with a description of the population and development profiles of the area of application
- A waste characterization in the area
- A description of the waste management services available
- A motivated end-state for the integrated management of the waste system.
- Goals and targets for the implementation of the IWMP based on the end-state
- Detailed 5-year plan required to achieve the end-state
- IWMPs annual reviews to determine if the end-state would be achieved.

However, multiple barriers compromise the successful implementation of the IWMP: lack og huan and technical capacity within municipalities, uncontrolled urban growth resulting in a great sprawl that puts enormous `pressure to infrastructures and service delivery (Godfrey, Scott and Trois, 2013; eThekwini Municipality, 2020b).

3.5.3.2 Plastic waste management in both formal and informal settlements

Plastic items typically have a label imprint chemical resin identification digit code from 1 to 7 inside a triangle which allows for the later application of recycling methods as each type has different methods. Nevertheless, not all plastics are recycled in South Africa (WWF, 2018).

In formal urban areas, waste is collected once a week in the best case scenario, by west collection vehicles. Despite no separate collection available, some municipalities have implemented a waste differentiation strategy by a colour code in the garbage bags, where orange means recycling materials altogether (non separated paper, plastic and metals), appealing to residents collaboration to separate waste at the source. These bags are collected and dropped off MRF for either mechanical or manual separation (see Figure 18).

The public space in informal settlements are usually covered with garbage (Pieterse, 2019). Municipal waste services do not typically operate in informal settlements unless exceptional situations. Plastic waste is disposed into communal dumpsites, buried or burnt with the consequent environmental degradation. Informal waste picking becomes a source of income for the urban poor, who takes part in the overall waste collection system by sorting urban waste from kerbsides or even landfills and then transported to MRFs

3.5.4 Plastic waste streams in South Africa

Plastics are the product of synthesized hydrocarbons molded into a variety of solid object (van Emmerik and Schwarz, 2020). The derivation of plastic is various petrochemicals, which are formed by cracking crude oil (van Emmerik and Schwarz, 2020). Three main groups classify all different types of plastics: thermoplastics, elastomers and thermosets. Thermoplastics are plastics that can be easily molded for packaging purposes; elastomers are soft plastics with rubber-like qualities; and finally, thermosets are long-lasting plastics use for manufacturing in multiple industrial sectors (European Parliement, 2015).

Table 11. Types of Plastics and their identification codes (Plastics SA, 2018).

Resin identification code	Name of Plastic	Applications
1 PETE	Polyethylene terephthalate (PET or PETE)	Drinking water bottles, soft drink bottles, food jars plastics films, sheets
2 HDPE	High Density Polyethylene (HDPE)	Shopping bags, food containers, woven sacks, plastic toys, milk bottles, detergent bags
3 V	Polyvinyl chloride (PVC)	Pipes, hoses, sheets, wire, cable insulations, multilayer tubes
4 LDPE	Low Density Polyethylene (LDPE)	Plastic bags, zip-lock bags
5 PP	Polypropylene (PP)	Disposable cups, bottle caps, straws, yoghurt containers, car parts
6 PS	Polystyrene (PS)	Disposable cups, fast food packaging, trays, foams, packaging
7 OTHER	Miscellaneous Plastics	CD, melamine, shoe soles

The versatility and low production cost make plastic suitable for many uses (Streit-bianchi, Cimadevila and Trettnak, 2020). The properties that make plastic highly applicable are transparency, lightweight, and long-lasting resilience to biodegradation (Wabnitz and Nichols, 2020). Heavier and more expensive materials like glass, aluminium and steel have been replaced by plastics due its competitive qualities (van Emmerik *et al.*, 2019). The type of chemical resins used in the manufacturing process will determine the type of plastic formation (van Emmerik and Schwarz, 2020). The most common polymers are classified by 7 subcategories as indicated in Table 11.

The annual quantity of waste generated in RSA accounts for over 108 million tonnes (Mt) of which 90% is disposed in landfills (DEA, 2012) and categorised in 55% of 'general waste', 44% of 'unclassified waste' and 1% of 'hazardous waste'. Only 10% of the total waste is recycled (DEA, 2012). The contribution to GHG emissions of the waste sector is 5.3%, with a 37.2% of the total methane (DEA, 2012).

According to Babayemi *et al.* (2019), the share of plastic waste in the municipal solid waste in RSA accounts to about 630 000 tons per year, which represents the 12% of total urban solid waste. Moreover, approximately 90 000 - 250 000 tonnes of this plastic waste enters the ocean (Jambeck *et al.*, 2015). The 53 % of plastic in South Africa is used for packaging, in comparison with 39.9% of Europe. The implementation of regulatory frameworks addressing safe disposal of plastic may have an impact on the reductions of this use of plastic (Plastics SA, 2018).

Plastic use is applied to almost every production sector. The built environment, which impact is higher in urban areas, accounts for 13% of plastics, with PVC as the one largely used. Construction waste is typically combined with rubbles, entering the landfill unsorted. PR and PP are generally used in the agricultural industry (Plastics SA, 2018). Single-use plastic represents a large portion of packaging solutions and other applications, namely cutlery, food wrappers, containers, cups and straws. These are typically used and disposed within one hour (WWF, 2018). A recent study found that 2.79 kt/annum of plastic litter is windblown due to its low mass, ending up in urban drainage and river systems (Plastics SA, 2019).

3.5.5 Plastic as environmental hazard for urban areas

Plastic pollution as hazardous contaminant has been ignored for a long time, and its potential damaging power only acknowledged recently (Papatheodorou *et al.*, 1999). Fergusson (1974) for example, back then a member of the Council of the British Plastics Federation and a Fellow of the Plastics Institute, stated that ‘‘plastics litter is a very small proportion of all litter and causes no harm to the environment except as an eyesore’’(Derraik, 2002). This vision not only shows how plastic pollution was overlooked but also how the entire plastic industry failed to foresee the increasing trend of plastic production and consumption of the past 50 years (Derraik, 2002). The perceived abundance of marine life and infinity associated to the oceans have driven our modern society to the dismissal of the propagation of plastic waste debris as a probable menace to marine life and alternatively a threat to long term sustainability (Laist, 1987; Derraik, 2002).

The rising accumulation of plastic waste in the environment associated to poor waste management increases the risks of plastic waste as environmental hazard concern (van Emmerik and Schwarz, 2020). Since one of the main properties of plastic is durability, an inadequate disposal keeps it in the environment for a long time (Andrady, 2003). Sensitive ecosystems such as marine life or even human health experience great pressure due to the presence of polluting plastic (Derraik, 2002).

As addressed by the International Solid Waste Association (ISWA, 2009): ‘‘…the waste hierarchy is a valuable conceptual and political prioritisation tool which can assist in developing waste management strategies aimed at limiting resource consumption and protecting the environment’’.

3.5.5.1 Impacts of macro-plastic pollution

The pathway of plastic towards water bodies are determined by both oceanic and climatic conditions: tides, wind, coastal currents and wave motion (Browne, Galloway and Thompson, 2010; Doong *et al.*, 2011; Carson *et al.*, 2013). The transition of macro-plastic (>5mm in size) into micro-plastic – particles smaller than 5mm in diameter (Ziccardi *et al.*, 2016) - is based on physical degradation and weathering factors: sunlight and waves actions (Faure *et al.*, 2012; Muneer *et al.*, 2021).

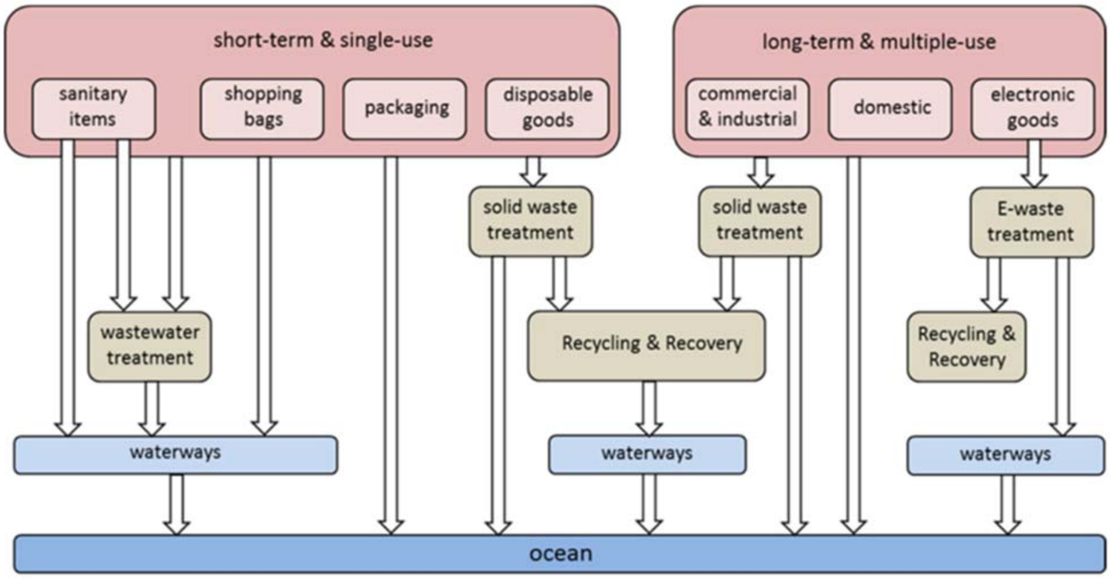


Figure 18. Pathway of macro-plastics waste. Source: (Verster and Bouwman, 2020)

The usual interactions of aquatic life with macro-plastics are addressed across the literature which highlights the indicates the entanglement in plastic debris by large mammals (Stelfox, Hudgins and Sweet, 2016) and the ingestion of plastic as taken for food (Andrady, 2011). Moreover, crustaceans use smaller plastic particles as portable shelter (Benton, 1995), while other invasive species are transported by plastic waste crossing through geographical areas (Yovanof and Hazapis, 2009). Kühn, Bravo Rebolledo and Van Franeker (2015) reported that the numbers of bird, turtle and mammal species with documented entanglement events increased from 21% to 30% over the period last three decades.

3.5.5.2 Impacts of micro-plastics pollution

Micro-plastics size range goes from 0.1 µm to 5 mm and are presented in multiple shape (e.g. fragments, fibres, beads, films, etc.), properties and colours (He *et al.*, 2018). They can be transported into aquatic environments through waste water (Napper *et al.*, 2015), rivers or degraded due to physical breakdown and climate exposure of macro-plastics (Jambeck *et al.*, 2015).

Ingestion and entanglement are the principal threats of micro-plastic to marine wildlife (Wright *et al.*, 2013). In fact, trophic transfer is considered a major pathway for micro-plastics in higher trophic levels including humans (Nelms *et al.*, 2018). Micro-plastics are extreme difficulty to degrade in the human body. Moreover, the particles may carry heavy metals

(Sharma and Chatterjee, 2017). Obesity, infertility, cancer and even chromosomes alteration are side effects of long-term ingestion of micro-plastics (Sharma and Chatterjee, 2017).

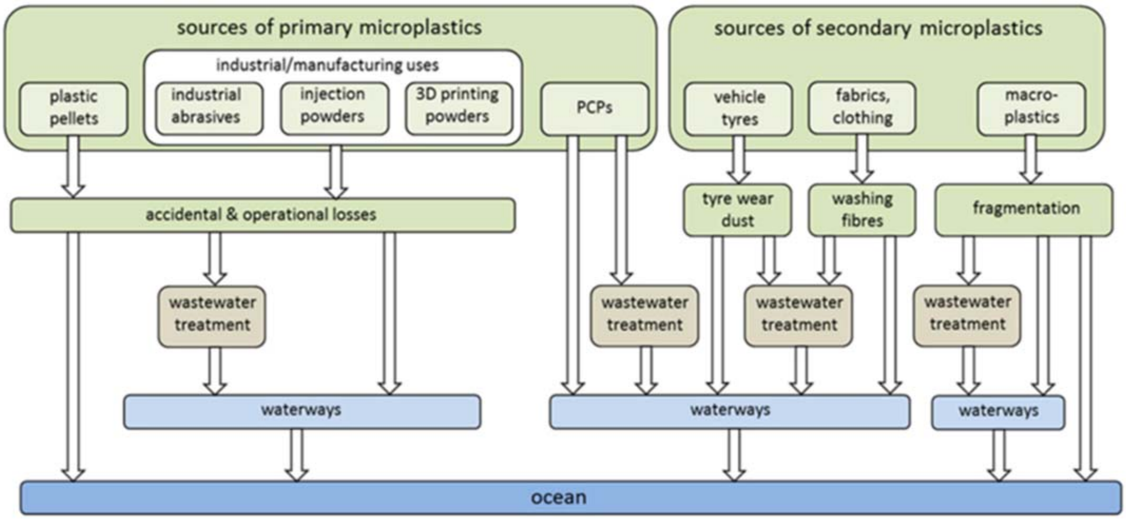


Figure 19. Pathway of micro-plastic waste. Source: (Verster and Bouwman, 2020)

3.5.6 Coastal plastic pollution in South Africa

South Africa has a coast length of 3400 km and about 300 estuaries (Harrison, 2004). Some of these estuaries are located near major industrial centres, with a concerning impact on plastic entering river streams (Ryan *et al.*, 2012). Durban, as the third bigger city in the country, is one of the principal industrial centres in the RSA (Ryan *et al.*, 2012).

In KwaZulu-Natal, the major threats to estuaries comprise sewage and chemical spills, habitat loss, freshwater abstraction and river mouth closures, sedimentation and plastic pollution (Forbes, Demetriades and Cyrus, 1996; Forbes and Demetriades, 2008). At the moment, the research conducted plastic pollution is rather scarce in the region. In the Western Cape, Ryan and Moloney (1990) sampled 52 beaches which findings point out plastic as the major pollutant, with 90% of debris, mostly in the form of polystyrene, fragments or even raw pellets. There is an average of 3640 plastic particles/km^2 of the same composition in waters off the same coast, which are believed to be displaced by the Agulhas current towards the east coast of South Africa (Ryan, 1988).

The only quantitative data on micro-plastics regarding South African marine systems was provided by Lamprecht (2013). Also in the Western Cape, she sampled two beaches in Table Bay and found the same aforementioned composition for the 93% of the debris.

3.5.6.1 Plastic waste distribution in eThekwini

Rivers are the major contributors for land-based plastic waste to enter the ocean (Lebreton and Andrady, 2019). The intensity of human activity in a given location is directly proportional to the quantity of plastic in freshwater bodies nearby (Best, 2019). Therefore, levels of urbanization and efficacy of waste management systems are correlative to the quantity of plastic in water bodies (Best, 2019). Natural and artificial origins cause plastic debris to enter river streams: rainfall, wind, surface run-off or illegal dumping are the most prevalent (Bruge *et al.*, 2018; Tramoy *et al.*, 2019).

There are 16 estuaries along the 80 km long coastline of eThekwini (Forbes and Demetriades, 2008). Only four estuaries are permanently open: Durban Harbour, uMkhomazi, Isipingo and Umgeni and therefore, they are the most probable to contribute with plastic to the ocean (Forbes and Demetriades, 2008). Once the plastic arrives to the river mouths, waves and currents will displace the plastic to either deposit a strandline of debris on the beach or bring it further out to the ocean. The semi-permanent presence of cyclonic activity in the areas, known as the Durban eddy, contributes greatly to the deposits of plastic from the estuaries (Cawthra *et al.*, 2012).

Ethekwini is a highly populated municipality with an extensive use of plastic. Unfortunately, in recent years, macro-plastics pollution has become a frequent sight in the estuaries and beaches. Data from Ezemvelo KwaZulu-Natal Wildlife (2014) indicate that annual coastal clean-ups for Durban marine environments are high in plastic load. It found that in 2014, 30,820 kg of litter waste was collected over 267 km of KZN beaches.

The composition of this litter was mostly food containers and cutlery, plastic bags, cigarette butts and packaging material. There is no quantitative data of the degree of micro-plastics on the beaches and in estuaries of eThekwini (Wabnitz and Nichols, 2020).

Durban was founded and has been developed around the port. Most of storm water drainage systems discharge from the city to the port. Plastics are also used as raw material for a number of industries in the areas (Clark *et al.*, 2016). The Bayhead mangroves in the Durban harbour were assigned a natural heritage status. It is a nursery area for numerous juvenile fish species. However, its proximity to the urban centre represents a major threat (Forbes, Demetriades and Cyrus, 1996). Originally, three similar larger mangrove forest existed although major developments around the port the majority of the natural habitat has been damaged and disappeared (Cyrus and Forbes, 1996). Great interaction between plastic debris and fish seems to be happening.

3.5.7 Adaptation and mitigation technologies

There is an urgent call for action to implement sustainable and efficient solutions to the plastic pollution in the oceans. As part of the solution, a number of innovative technologies for both, prevention of plastic from entering pathways to the ocean and collection of marine and riparian plastic waste (Schmaltz *et al.*, 2020).

Most investigations into the quality and quantity of riverine waste have utilised systems of either fixed or drifting nets of various sizes and compositions designed to trap and either contain waste, or direct it towards shore (Moore, Lattin and Zellers, 2011; Gasperi *et al.*, 2014; Lechner *et al.*, 2014; Morritt *et al.*, 2014; Sadri and Thompson, 2014), however, argues that these technologies do a poor job of capturing floating plastic debris, some fractions of which can be the most harmful to marine aquatic life. By the use of a floating boom network, their research is among the pioneers to provide reliable data on the quantity and quality of floating plastic debris carried by rivers in urban areas. They found an inconsistent composition of plastic waste across the samples captured in the several booms. They suggest that disparities in plastic distribution might be linked to local input discontinuities and differences in the hydrodynamic conditions locally along the rivers which results in erratic behaviours of the floating artefacts (Gasperi *et al.*, 2014).

Of the litter captured, the portion of plastic waste by weight represents between 0.8% and 5.1% of the total. Most of the debris consisted of food containers, wrappers and cutlery associated with recreational activities. The materials with higher presence were PP, PE and, to a lesser extent, PET. In regard to capture efficiency, they determined that although the direct link may be difficult to determine, it should nonetheless be considered to be high, though a lower capture efficiency should be expected during flooding (Gasperi *et al.*, 2014). Further investigations and research should be undertaken at field work level. Firstly, the plastic waste mapping of an area affected by marine litter flooding needs to be considered, and finally a case study emphasising the design of an adequate system of litters entrapment / boom system to be replicated at a larger scale should be undertaken. Depending on these studies, plastic waste valorisation should be understood as the next step to alleviate plastic waste debris marine pollution.

3.5.7.1 Litter booms

A litter boom is a provisional floating hurdle that traps plastic waste and other floating debris based on the action of the river current to gather the debris for later collection (RiverNetwork, 2020). The boom traps only surface level debris as they collide with it and deflect them to the river bank (Miliute-Plepiene *et al.*, 2018). River booms are simple and cost effective artefacts (RiverNetwork, 2020). In a section of the river, the boom is placed at a 30- to 45-degree angle to the middle axel, anchored to both banks. Objects divert to the lower anchor point flow wise. Alpha-MERS, Durban Green Corridors (DGC) and the Litterboom Project (TLP) are samples of river booms implemented.

Alpha-MERS is a litter boom manufacturer from India. Their system has been designed to take advantage of the natural flow of the water that transports the plastic to the river bank for later removal. the systems are sturdy designed to resist seasonal changes (Alphamers, 2020).

The Durban Green Corridors and the Litterboom Project are extensibly discussed in chapter 5. They are located in Durban, in the Umgeni River near the river mouth. These litter booms are made out of large PVC pipes anchored across the river (The LitterBoom Project, 2021).

3.5.7.2 Waterway litter traps

Waterway litter traps are typically floating cages used in rivers and streams to trap floating debris as it is directed into them (RiverNetwork, 2020). They are located in a position through which the flow of the water body brings the debris in (Schmaltz et al., 2020). They may be bulky structures that impede the movement of boats although the water flow is guaranteed (RiverNetwork, 2020).

SCG-DMCR Litter Trap and the Bandalong Litter Trap are samples of this type of barrier. The former is implemented in the Andaman Sea and Gulf of Thailand coast. It is built out of PE conducts and nets, with a load capacity of 700kg (The Nation, 2019). The latter is a floating artefact strategically located in waterways wider than 2 metres to trap waste (Bandalong, 2021a, 2021b).

Waterway litter traps are functional without mechanical assistance and do not allow upstream flooding (Bandalong, 2021a). Nevertheless, some maintaining costs are associated to these systems that make them expensive based on installation and location details (RiverNetwork, 2020).

3.5.7.3 Air barrier

Air barrier is an innovative technology still in an early stage of development and testing. Only a limited number of air barriers are implemented. The system is based on an air curtain as a barrier to prevent plastic debris from moving beyond. Air is forced through a diffuser to generate the curtain (Zielinski, Voller and Hondzo, 2011). A practical application of this concept is the Great Bubble Barrier which uses a long pipe placed diagonally across the river bed. Air is then pumped out creating a bubble turbulence that acts as a barrier (Spaargaren, 2018). This system is also effective for underwater debris as it is pushed upwards by the air bubbles.

3.5.7.4 Vacuum

Vacuum systems capture the plastic debris from the sand and seawater and push out the clean sand back (Brestovansky, 2019). It is a method to cleanup debris that has passed preventing systems and is deposited in riparian zones and beaches. A commercial application of the system is the HoolaOne. The equipment is able to process approximately 11 litres per minute (Peters, 2019). A great feature of this technology is the ability to collect micro- and macro-plastics and treat high volumes of sand in a short time (Hoola One, 2021).

3.5.7.5 Drones and Robots

Drones and robots are part of a group of innovative technology with autonomy capacity. Autonomous bots are faster and more efficient than human in specific cleaning task but also may be recommended for dangerous areas that otherwise would remain polluted (Ellis, 2018). Practical applications of this technology are found in the Floating Robot for Eliminating Debris (FRED) and BluePhin.

FRED is a semi-autonomous unmanned robot equipped with an array of arms (Thomson, 2019) and powered with PV and wind energy. It is designed for removal of floating plastic debris from water bodies and marine environments (Clear Blue Sea, 2021).

BluePhin is a smart robot capable to remove floating debris from water bodies (BluePhin Technologies, 2021). It uses artificial intelligence which allows it to differentiate types of debris (Leon, 2020). It is also equipped with a basic water analysis lab to determine water and air quality (BluePhin Technologies, 2021).

3.5.8 Summary

In section 3.5, a review to the literature related to the case stude has been conducted. The section has been structured in three blocks: governance on waste management and environmental policing at national and local level (South Africa and eThekwini); relevant literature on the case of plastic pollution; and available technology to mitigate or even solve the problem of plastic pollution in water bodies.

The section has paid attention to the main challenges and barriers, experienced with waste and plastic at urban level, to successfully implement sustainable frameworks in the Southern African city, eThekwini in particular. The next chapter presents a methodological approach to specifically tackle the case study.

4 METHODOLOGY

This chapter presents the research methodology, data collection strategies, selection of the case study, sampling methods, and the data analysis. It also discusses the research organisation, and ethical matter. The variety of data sources has had a positive impact in the diversity and quality of this study. Relevant journals, books, dissertations, reports, official documents and newspapers in the field of city planning, management and ICT technologies, sustainable planning and waste sector have been consulted and analysed, with special focus on the Southrn African city in general and eThekwini in particular.

4.1 Methodological approach

The study of the city, in the terms that this research pursues, goes necessary through a combination of methods among two principal categories: description and exploration. Based on the revision of the literature review, the researcher seeks an understanding of what is the accurate picture that describes the features of a typical Southern African city hence determine what indicators are relevant in a local context. In addition to this, the use of secondary data contain in the GIS maps from the city and primary data from drone flights and field work, allow for a positivist visualization of the current status.

However, a purely positivist approach to the study of any city would lack of panoramic perception. The city is social system: socio-cultural, socio-economic, socio-technical, socio-biological, socio-historical, socio-political and socio-spatial. It is not possible to remove the social aspect of the study of the city. It is the foundation of the existence of cities: socialization. Therefore, the exploration and interpretation of how the city is perceived by different strata of the social structure completes the multifaceted approach and brings coherence to the research.

Perpetuation of problems, inaction, and inability to implement functional policies might have an explanation based on qualitative research and tangible quantitative data might be the result of misunderstanding the earlier.

The sequence of the research follows a deductive approach: the hypothesis of the overlook of specific features that differentiate the region at the time of implementing ICT in the urban areas of Southern Africa is tested with the analysis and interpretation of quantitative and qualitative data.

4.2 Research Design

This study is considered an exploratory and field research and uses mix methods. A quantitative approach is needed in order to profile significant urban features recognizable across Southern Africa through the use of statistics from official governmental offices and secondary data analysis from recognized organizations.

A deep dive into the literature about the African city is needed in order to understand localities and real challenges. The research looked at worldwide urban trends and aims to extract those parameters that are meaningful to Africa today. The vast array of indicators varies depending on the aspirations of cities around the world. Some cities aspire to be more competitive and others more sustainable. In others, quality of life occupies the bulk of the agendas of policy makers. For Africa, some indicators that are irrelevant in the Global North mean the difference between life and death situations and vice versa. This is the case of poverty, healthcare, informality, shortage of human capital, natural hazards, climate change vulnerability, inequality and lack of technological capacity, especially at municipal level.

The analysis of the secondary data sourced by the literature review and national and international reports has led to the definition of a tailor made array of indicators related to urban resilience, urban sustainability and urban smartness that are relevant in the Southern African context.

A three layers mapping of the area selected for the case study, the Umgeni River catchment, has led to determine the selection of the indicators and further conclusion on how a resilient and sustainable African city might look like.

Moreover, the social nature of the research required of the use of qualitative methods. Leedy (2000) considers qualitative methods useful in answering questions about any phenomena that aim to describe and understand any event from the participants' point of view.

The COVID-19 pandemic has disrupted enormously any mean of social engagement. In fact, the completion of this research has been postponed for one year due to COVID-19 protocols instated by national and local governments, together with internal policies from the UKZN. In order to overcome the challenge and give room to relevant voices that are needed to comprehend the research problem, testimonials from officials from the eThekwini Municipality, members of the civil society, ICT companies and scholars have been extracted from their interventions in task team meetings held by videoconference in which the researcher was present. These task teams are directly involved in the assessment of the case study: plastic pollution in the Umgeni River. In addition to this, mass media items have been analyzed in order to understand the sense of the general public. The researcher acknowledges the risk of bias in this last source of data and media with different orientation have considered in the study.

The aforementioned array of urban indicators has been overlapped to the findings of the case study. As a result, a planning framework has been developed. This framework aspires to assist policy makers and municipal managers to identify fields of action and optimize municipal resources.

4.2.1 Selection of the case study

The case study represents a benchmark to validate the findings of the research. Durban as a paradigm of Southern African city, offers an optimal platform to develop and promote the values of the New Urban Agenda, in which principles this research is inspired. Moreover, Durban is part of the 100 Resilient Cities project pioneered by the Rockefeller Foundation (The Rockefeller Foundation and UNDRR, 2016). Unplanned and unregulated growth characterizes the urban expansion in Africa, exacerbated by neo liberalism, the legacy of colonialism and structural adjustment with the result of fragile urban planning institutions (Parnell and Pieterse, 2014), which have an impact on land administration as well (Mamdani, 1996). It also increases costs of administering electricity, waste management, water and transport services through centralized systems as well as goods such as food (UN, 2014). Urban services in the region are constrained by greater infrastructure deficits (UN, 2014).

As a practical approach, the urban waste is identified as a paradoxical topic: it is considered of great importance in the Global North although it does not represent a big challenge due to long-term implemented planning in the sector. On the contrary, urban waste is typically undermined in the Global South, which represents a great threat not only at environmental level but also social and economic. Within this context, the Durban’s Umgeni River, one of

South Africa’s largest river systems (Raper, 2014), has also been described as one of South Africa’s most polluted rivers (Carnie, 2013; Rall, 2019). The Umgeni River plastic pollution demands the application of technical solutions and comprehends the involvement of city managers. At the same time, it affects the social context and it is not exempt of serious environmental implications. Holistically, the case study represents a suitable socio-technical framework in which developping this research. Moreover, the complexity of the location and composition of the urban structure appears to be inviting to redefine the relationship between resilience and sustainability through the application of smart technologies that are relevant.

4.2.2 The Role of the Researcher

Although I am not part of the phenomena object of study and have not influenced the behaviour of participants, my position in the research has been ‘observer-as-participant’. I have been the principal tool for data collection, filtering and analysis from literature, reports and observations to expose the identified patterns and concepts.

The researcher plays a decisive role in qualitative research, as he conducts data collection and analysis (Creswell, 2007). Consequently, a potential for bias could influence the outcome of the research, which introduce a great challenge of controlling objectivity and prejudgments actions, observations and thinking. Potentially, that bias could be my experience as non-African born as well as my experience as city architect in a Spanish city for ten years. However, this could have had a positive impact as well, helping in the data collection, analysis, and the understanding of studied phenomenon.

4.2.3 Literature review

A review and analyses of books, dissertations, peer reviewed papers, reports, newspapers articles and official documents and policy regarding city planning, management and ICT technologies in eThekwini were reviewed and analyzed pertaining to the following topics:

- State of the art of the Smat City
- Measurement of the smartness
- Urban sustainability
- Urban resilience
- Urban competitiveness

- Social equality
- The Southern African city
- Urban planning in Southern Africa
- Plastic pollution
- Riverine waste
- Litter booms and Litter Traps
- Waste Management Strategies
- The Umgeni River Catchment
- Rivers as conduits of plastic waste

The literature material has been recorded and classified with Mendeley and Microsoft Access (see Figure 20). A total of 658 references have been handled in this research, 296 of which have been tagged within a number of fields: code, publication date; title; author; urban performance key-field; topic; location (continent, country and city); rating of relevance (personal opinion); format (paper, conference paper, lecture, article, news paper, website, report, course, workshop, policy, strategic plan, book, book chapter and graphic); comments; citation, url 1; url 2; url 3; root document (if the item is cited in another item); derived document (items cited in this item).

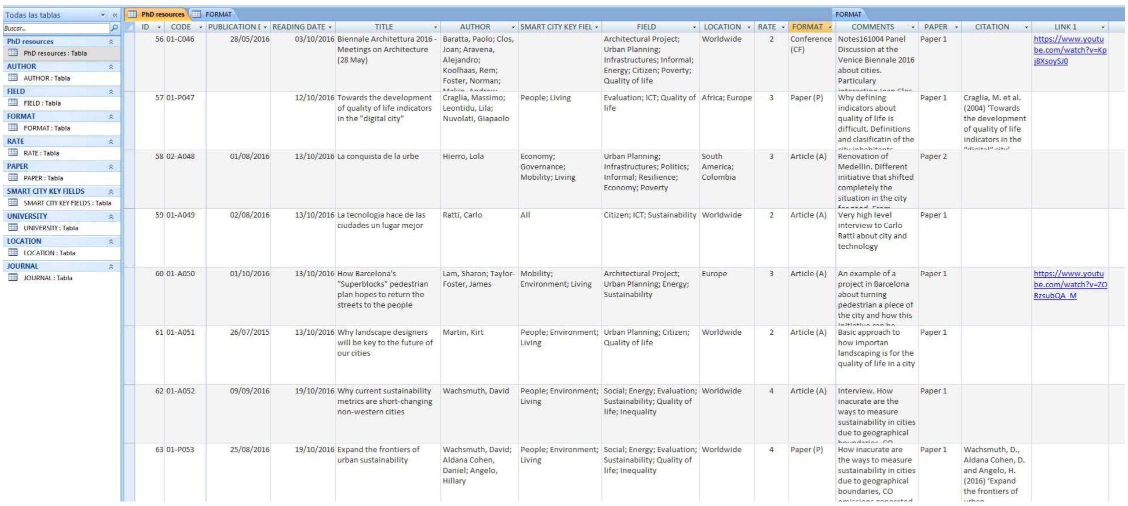


Figure 20. Screenshot of the MS Access research material data base

The literature review has helped to analyze and extract a matrix of indicators that define the paradigm of resilient and sustainable city. In addition to this, through the literature review, genuine features of the Southern African city have been identified. The overlapping of both has generated a third matrix with the relevant indicators applied to Southern African cities in the realm of the resilient and sustainable city.

4.2.4 Data-Collection Strategies

Initially, for the analysis and identification of common features of Southern African cities, secondary data sourced information from documented reports and scholar literature has been filtered by the structure of the 6 key-fields of performance of the city. The extraction of secondary data from the literature review has helped to establish a comparison with countries from other regions in the world. It has allowed as well the identification of key factors that affect the Southern African urban context in a relevant manner. It is to be acknowledged the lack of data in some cases for the specific region of Southern Africa. In some cases, data from the broader context of SSA has been considered.

The alignment of the research to the RDI Waste Road Map Research Proposal 2020 “Capturing (Plastic) Waste Streams: The Optimisation of the Umgeni River/Estuary Litter-boom System for Climate Change Resiliency and Sustainability” (Trois, 2021) has given the opportunity to work with experimental mapping technologies and data analysis that are applied to significant problems in the Southern African context. In a later stage, satellite imaginary, survey flight, satellite imagery drone technology, Geographic Information Systems (GIS) as well as participatory task team events (including local government, academia and civil society) has been utilised to identify major urban challenges in eThekwini from a multifaceted approach. At municipal management level, a closer look to what the perception of city managers and civic society is, through qualitative primary data, have brought understanding of the vision of policy makers and urban activists.

Zooming into the case study, waste entry points, dumping hotspots and environmentally vulnerable locations have been localized and have served as the loci for pollution alleviation barriers. Waste Stream Analysis and Characterisation involved the examination of waste that has been captured at the existing litter booms in an attempt to identify gaps and weaknesses in the current boom system.

4.2.5 Objectives of the Study

The fundamental aim of this research is to identify sustainable ways for long-term implementation of up to date technologies in Southern African cities for an effective leapfrog that would bring Southern Africa up to nowadays standards without losing local references. For this research, the questions inquire on achieving resilience intrinsically linked to sustainability through smart solutions.

The case study represents an exemplary field of application of possible innovative methods for addressing critical indicators and sectors emerged from the analysis of the barriers to sustainable/resilient cities in Southern Africa. The focus is not on the technology application, but on the need for a context-based holistic, interdisciplinary and innovative approach to address urban and peri-urban problems in Southern African cities. The selection of the case study is based on the line of argument developed through the research, which led to the focus of waste management as one of the most critical sectors to achieve target of sustainability and resilience in Southern African cities, which greatly impacts on the environment and quality of life of the majority of local population, needing an innovative planning able to reshape urban infrastructure and waste management methods.

The case study of Durban and the focus Umgeni River catchment has been selected in consideration of the above-mentioned line of argument, which finds evidence in the inclusion of the Umgeni River catchment as one of the priority projects identified by the CSIR. The selected case study therefore enables to apply the indicators emerged from the analysis to environmental and social issues, link those indicators linked to urban and infrastructure planning greatly impacting on the quality of life of citizens in Southern Africa.

The following table shows the alignment between research questions and objectives of the study, the relevant data source and further analysis:

Table 12. Alignment between research questions and objectives of the study.

Research Objective	Research Questions	Data source	Who	Where	Analysis
Identification of a Southern African city profile.	Are there common features for the Southern African cities?	Literature review		Southern Africa	To analyze the urban common features that are characteristic of the Southern African context
Conceptualize smartness, sustainability and urban resilience applied to the city, and summarize the linking	If cities are considered intrinsically resilient systems, how far is a typical Southern African city in the transition from current status to long-term sustainably resilience through smartness?	Literature review		Southern Africa	To determine which of the world wide narratives on smartness, sustainability and urban resilience are relevant to the Southern African context.
Identification of gaps in the methodological approach in transitioning from a typical Southern African city to smart>sustainable>resilient.	Which are the indicators to implement the cycle RESILIENT> SMART>SUSTAINABLE> SUSTAINABLY RESILIENT?	Literature review Mapping Testimonial Mass media	Municipal Managers Civil society	Municipal offices Umgeni catchment	To analyse a correlation between sustainability and resilience through smart initiatives and their implementation at municipal level.
Recommendations to assist municipalities in the correct and appropriate planning of this transitioning.	What are the possibilities for evaluating Southern African cities through already tested measurement systems like the “6 key-fields”?	Testimonial Mass media Mapping	Municipal Managers Civil society	Municipal offices Umgeni catchment	To establish the municipality’s view of urban sustainability in the process to consolidate resilience.
Definition of a framework of waste management strategies for sustainable resilience in the Umgeni Area.	How can measurement systems of urban performance be applied to the Umgeni River area and the waste sector in particular, to assist decision making and strengthen the sustainable resilience?	Testimonial Mass media Mapping	Municipal Managers Civil society	Municipal offices Umgeni catchment	To define recommendations on riverine waste management in eThekwini.

4.2.6 Rationale

This research strategy has been linked to a local perspective and looked at the problems from the inside in order to strength the impact of the findings at policy making level hence further applications based on these conclusions aim to tackle challenges through bottom-up directions. The selection of the literature on the Southern African city, through the filter of the 6 key-fields of performance, has grouped a number of data and indicators with the aim of identifying a focused picture of what the Southern African city represents in relationship with international narratives and clearly understands that there are enormous differences with the so called Global North. Therefore, it has highlighted that tailor made solutions are to be considered.

The analysis of the literature has helped to identify a hierarchy of importance in the city management realm. However, a number of feedback loops interconnect significant challenges with trivialities. For example, how poverty and public transport are strongly interconnected in the region. Another example is how land use is connected to pollution and plastic pollution in particular.

The thesis has been developed within the realm of engineering. Nevertheless, social aspects are intrinsically embedded in these topics. The research strategy has avoided a secluded path and has opened the door to unavoidable inputs with social character.

The research has looked in detail at riverine plastic pollution as a case study for the interwoven connection between resilience and sustainability boosted by smart strategies. It can potentially contribute to widespread ocean plastic reduction by the triplication of the finding in the Umgeni catchment to other rivers.

4.3 Research methods

4.3.1 Sampling criteria

Primary and secondary data from GIS mapping and reports are presented in a descriptive statistical form. This data contains information on the structure of the urban fabric and location of waste related facilities as well as the location of bulk deposit of riverine waste. The quantitative data samples related to plastic pollution and characterization are extracted from existing litter boom locations. In this case, the data is then analysed using descriptive statistical methods.

Regarding the qualitative research, and with the purpose of avoiding biased errors, the approach is to consider a heterogenic population, from municipal managers to informal settlers going through formal residents and industrial activities located on the area of the Umgeni River catchment. A stratified sampling method has been put in place and data from all categories have been grouped. The use of inferential statistical analysis helps to make conclusions beyond the data collected and extrapolate the results to other locations.

Convenience samples and voluntary response samples have been avoided in order to reduce biases in the research. However, In the case of municipal representatives, the selection of unrelated population has been excluded due to a lower impact of the testimonies as well as difficulties in understanding the relevance of their contribution to the research from inquired individuals.

Figure 21 shows a timeline of the various data collection activities carried out along the research period.

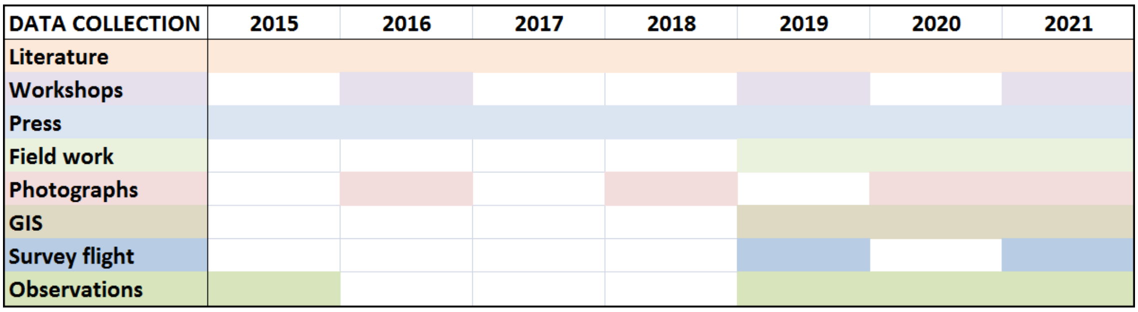


Figure 21. Timeline of the data collection activities

4.3.2 Primary data collection tools, procedures and materials

The study employed a variety of mapping methodologies, including survey flights, experimental drone technology, GIS, Field sampling and Laboratory analysis of plastics and biota; and participatory mapping with affected members of the civil society in order to map the Umgeni system, with a focus on identifying major waste entry points, dumping hotspots, and spaces vulnerable to climate change-related events such as flooding. These mapping exercises allowed for the optimal spatial arrangement of the litter boom systems, while providing data to support on-going waste mitigation and anti-dumping enforcement activities. The combination of deductive GIS mapping with inductive, participatory mapping exercises allowed for the creation of 'smarter' systems that incorporate more responsive inputs.

In addition to these mapping exercises, Phase II will also include a situated case study within Quarry Road, an informal settlement set along the Palmiett River, a flood-prone tributary of the Umgeni, with a focus on waste. Data collection activities will focus on gathering narratives of resilience and adaptation that have arisen organically in this community and will provide an important link to the connection between municipal capacity, technology acquisition, climate change and waste, which is a core focus area of the SARCHI Chair in Waste and Climate Change.

a) Field work

The litterbooms that DGC manages were visited and their processes of collection and transportation of waste were observed. The waste problems pertinent in the Mangroves at the Umgeni River mouth were observed, with help from the ADReach Team. The geolocation of the litterbooms were mapped onto ArcGIS, QGIS and GVSIG. The mentioned software packages were learnt and data provided by eThekweni Municipality and DGC were mapped. Additional layers were created utilising ArcGIS's in-built base map and data population. A waste characterization analysis was conducted for one week at the litterboom located in Johanna Road.

b) Survey flights.

Survey flights allowed for the comprehension of the Umgeni River catchment within the boundaries of eThekwini Municipality, from Inanda Dam to the river mouth. The flight was undertaken at an average altitude of 1,000 in a Rainbow Cheetah Aircraft, a lightweight plane which allowed for good approximation for photographs and video footage, later analyzed and included in the mapping.

c) Drone flights.

The drone images gave a close-up aerial view of area. The river was then filmed using drone technology to determine the accuracy of the drafted maps as well as further populate the maps.

d) Testimonials

eThekwini officials, UKZN, DGC, TOC, Save Our Rivers, Durbanites Against Plastic Pollution (DAPP), DUCT and Umgeni Estuary Conservation have taken part in several meetings and workshops, presenting their vision and involvement in relationship with the riverine waste situation at the Umgeni River mouth. Members of the ADReach and Litterboom teams were consulted to determine where they believed to be hotspots for waste entry, what they perceived to be the largest waste fraction and how the booms function. Answers were recorded by note-taking, and two task team events were recorded with consent in Zoom.

e) Observation.

According to Davies (2007) cautious observations of naturally occurring behaviour might suggest many fertile hypotheses for research. Accessibility and limited time during the site visits were the main challenges in the process of observing the context. The use of drone imagery helped to broad the perception of the studied areas. A survey flight from Inanda Dam to the Umgeni River mouth was undertaken at an average altitude of 1,000 ft in a Rainbow Cheetah Aircraft. The litterbooms installed by DGC were visited several times. The process of plastic collection from the litterbooms was carefully observed, assisted by the staff of DGC. The eThekwini Municipality Waste Beneficiation Centre was visited, guided and detailed explained by a municipal official.

4.3.3 Secondary data collection tools, procedures and materials

a) Literature review

Secondary data was collected from the literature review, past research on African urbanism and waste pollution in rivers and oceans. In addition to this, secondary data was sourced from documented national and international reports on demographics, urban planning, economy, environment, politics and governance, ICT, resilience and sustainability.

b) GIS

Open data is a key driver for public participation in smart solutions, policy making and governance, to create value for developers, businesses, researchers, civil society and the public at large. It is therefore a major indicator for the Smart City. At what extent the availability of open data in the Southern African context unlocks possibilities to conduct research becomes a fundamental factor for this study.

Open GIS Data from several sources have been consulted and included in the research. Generic geographical data has been collected from openAFRICA (2021), a civil initiative, maintained by Code for Africa, as a public service. The platform is a free resource available for civil society organisations, civic activists, ordinary citizens, government agencies and the media. Data from OpenStreetMap (OSM, 2021), a free data that is compiled by a community of mappers from all over the world, also been consulted as well.

Data related to infrastructures has been collected from a variety of sources: The provincial viewer from the Dept. of Transport of the KZN Regional Government (KZN Transport, 2021b, 2021a), the African Marine Atlas, the ODINAFRICA Project of the Intergovernmental Oceanographic Commission's (IOC) International Oceanographic Data and Information Exchange (IODE) Programme (IOC, 2021), the World Bank Foundation (World Bank Group, 2021a), the European Union Capacity4dev Program (AFRETEP, 2016)

Data related to natural ecosystems have been sourced from the department of SA Dept. of Forestry, Fishery and the Environment (RSA, 2020).

Data related to urban planning was sourced by eThekwini Municipality GIS Website (eThekwini Corporate GIS, 2021).

c) Google Earth

Data exchange with DGC was conducted via Google Earth. Moreover, the software was used to locate and compile a list of waste related facilities in Durban. Afterward, a KLM file would be exported and included in the GIS map of the study.

d) Mass media

Mass media items have been analyzed in order to understand the sense of the general public. The timeframe for this data is coincident with the timeframe of the research: from January 2014 to April 2021. The analysis of the media has looked at both, the content and the quantity of articles. The number of appearance of the topic in the media per month has been correlated with the rainfall historic records in order to identify possible trend-behaviour from the media.

e) Data from Civil Society

DGC and Save Our Rivers provided data on the quantity of waste that they had collected over the previous 6months. However, these records were limited to rough quantities and did not feature any details of the character of waste collected. As a result, an appeal was made to DGC and DSW for a field study to obtain reliable data. The study proposed:

I. A thorough cleaning of the Umhlangane Tributary (by foot and canoe). Informal dump sites needed to be removed and all waste within 20m of the river needed to be collected. This stage required heavy man-power so as to achieve a clean environment before it could be polluted again.

II. A timetable for emptying the booms (this timetable was designed with great consideration of the DGC's current timetable and collection system). During emptying the waste was weighed and recorded. The rainfall was also to be recorded. It proposed separation location as well as waste transport streams.

eThekwini officials provided insight on the challenges to harness the plastic entry into the river stream and pilot initiatives to minimize the riverine pollution.

4.3.4 Variables

Comparative analysis represents a key role in social science research. It is generally accepted that a well-established view in the social sciences should be based on variables (Heritier, 2007; Porta, 2008). This research does not aim to establish a cause-effect relationship between variables. The study of the city, the Southern African city in this case, is overflowing with variables that are not measured in this study. These confounding variables might influence changes on the expected outcomes or dependant variables. Therefore, it would be optimistic to consider independent variables in the urban arena. On the contrary, the researcher acknowledges that most variables might be influenced by other variables. A possible structure of variables of the study is summarized in Table 13.

Table 13. Research variables.

Explanatory variables	**Outcome variable**
Common features of the Southern African city.	Southern African city profile.
Link between urban smartness, urban sustainability and urban resilience in southern Africa.	Readiness of a typical Southern African city in the transition from current status to long-term sustainable resilience through smartness.
Jeopardizing gaps for urban sustainable resilience in southern Africa.	Consolidated sustainable resilience in Southern African cities.

Base on the difficulties indicated above, the researcher aims to extract conclusions from the analysis of the Umgeni River case study and extrapolate the findings to analogical scenarios. Therefore, the approach to the study from a case-oriented research strategy appeared more suitable.

4.3.5 Data Analysis

The dataset composed by the addition of both, primary and secondary data, was checked for missing or redundant data and ensure consistency. For the GIS model, the software used was QGIS, SVGIS and ArchGIS. The data was filtered and organized based on the municipal composition of KZN. The data from Stats SA was organized at municipal level using Microsoft Excel then imported to the GIS software. The projection used for the GIS model was WGS84 EPSG:4326.

The analysis of indicators started with the literature review and the selection of the most relevant measurement systems cited. Two types of systems were then selected: international holistic systems and local systems applied to specific geographical locations. This stratified sampling method is useful in gathering information at different scales. Some of the local measurement systems were in fact based on global holistic systems included in this study, which resulted helpful in the understanding of adaptive approaches to respond to local realities.

Testimonials by eThekwini officials, members of DGC, TOC, Save Our Rivers, Durbanites Against Plastic Pollution, DUCT, Umgeni Estuary Conservation and the paddling community were recorded by note-taking, and two task team events in Zoom were recorded with consent. Afterwards, transcriptions of the testimonials were done with Microsoft Word, indexed and categorized with Microsoft Access. A narrative analysis from testimonials was structured based on these categories and connected with the data.

Triangulation was used in the analysis of data. According to (Davies, 2007), this method assists in assuring reliability of the data. The literature review, observations made during the data collection, and testimonials from local government officials and members of civil society were the three main information sources.

The qualitative data was overlapped to the results of the GIS and helped to identify gaps, and challenges. It also assisted to generate an inventory of current initiatives and assess their efficiency and propose improvements.

4.4 Evaluation of the methodology

4.4.1 Validity and reliability

The current is a mixed methods research. Qualitative and quantitative data have been collected and analyzed. Qualitative research methods have often been criticised for not being objective in constructing significance without influencing or influencing the subject or site of study (Lincoln and Guba, 1985; Farmer *et al.*, 2006). Therefore, it is important in this thesis, to visibly present the methods involved in order to ensure validity and reliability through the analytical rigour of the researcher. The use of multiple methods of collecting and analysing data in a process of triangulation grants validity to qualitative research. Triangulation therefore appears as a guarantee for reliability and replication (Stake, 1994).

Nevertheless, it would be simplistic to expect entire replicability from observations and interpretations, particularly when accepting through triangulation the multiplicity of perception of the phenomenon (Stake, 1994).

Denzin and Lincoln (1998) identify a combination of varied methods, sources, researchers and theories to validate a study. In the qualitative component of this research, the researcher made use of comprehensive observations, testimonials, and photography as data collecting techniques. Webber (2008) concluded that despite difficulties in triangulation methods, it makes data credible. Farmer *et al.* (2006) advise that it requires the use of a number of data sources as it has been done in this research: testimonials from municipal official, NPOs' managers, members of civil society (including representatives of the community) and scholars and researchers directly involved in the case study were carefully taken and transcribed.

4.4.2 Limitations of the Study

The study was limited in terms of case study. Although the literature handled considers the entire geopolitical region of Southern African, the zoom in the case study had to adapt to the limited resources and research experience in the a study in the context of a PhD thesis. Therefore, further studies will be needed to define a replicable the planning framework aimed.

The data source corresponds to the geographical region of Durban, South Africa. It is to be acknowledged the particular socio-cultural features. However, although the findings are specific, the principles and theories developed can be extrapolated to other geographical realities with similar urban features.

The eThekwini Municipality state a disclaimer in relationship with the GIS data provided as follows: “The eThekwini Municipality makes no warranty – implied or expressive – with respect to the accuracy, correctness, completeness or appropriateness of any information contained in this site. The eThekwini Municipality undertakes no duty to or accepts no responsibility to any third party who may rely on this information.” However, this service represents an important source of secondary data that can be confirmed as accurate through comparison methods with the data collected for this study.

The secondary data collected from organizations involved in the solution of the plastic pollution in the Umgeni River does not follow certified standard procedures hence a level of tolerance for the reliability of data is to be considered.

A few challenges to overcome during the research are noteworthy:

The study on any topic within the Southern African region is automatically associated to a lack of reliable data. The deficit of public technical capacity has an impact even on basic data such as demographic census, which in the best case scenario, are updated every 10 years. This situation has forced the study to consider an extensive literature composed by both, academic literature and institutional reports. Moreover, the literature on specific studies concerning the region is scarce.

For most of the standards related to internationally accepted narratives on the implementation of smart initiatives and sustainability, the region typically ranks among the lowest in the world at a regular basis. Poverty, inequality and lack of strategic infrastructures make seem the topic of this study almost irrelevant, in most cases relegated by the public authorities as non priority. This however contrasts with the international trends on the labour market and human capacity, which foretell an unprecedented social crisis if low skill and productivity employment won’t transition to soft creative skill employment.

For a PhD study, the scale of the subject as a sub-continental region is to be narrowed down to a feasible size. Starting from the study of the Southern Africa, a of progressive reduction of the initial context to an urban scenario has been conducted. Southern Africa > South Africa > KwaZulu-Natal > eThekwini Municipality > Umgeni River estuary.

In addition, the impact of the COVID-19 pandemic, already mentioned in section 4.2, has altered the design research planned in 2015.

4.4.3 Elimination of Bias

Being the researcher a foreign national in South Africa has played a positive role in avoiding prejudices and aprioristic ideas. In fact, the cultural shock has strengthened curiosity and the intention to understand local dynamics.

The researcher has not discriminated against participates based on ethnicity, disability, gender, race, national origin, health or marital conditions, or any other applicable bias prescribed by law.

All data collected has been included in the research. The data transcripts have been generated with diligence after collection. Detailed records of the data have been kept for further consultation.

The research has not been sponsored or funded by any institution external to the University of KwaZulu-Natal.

4.5 Ethics considerations

All participants were informed about the objective of the study to allow individuals to understand the implications of participation and to reach a fully informed, considered and freely given decision about whether or not to do so, without the exercise of any pressure or intimidation. Participants briefed on personal data handling with confidentiality. The research adheres to the Protection of Personal Information Act, 2013. The language used was understandable to all and respectful.

The use of secondary data in the research has been focused on public available data that ensures replicability, transparency and integrity of the research procedures. No sensitive information has been disclosed and more important, re-identification of individuals.

The researcher has the intention of publishing the findings in the forms that will make them available to the public.

5 CASE STUDY

5.1 Definition of the case study

Durban represents a paradigm of the Southern African megacity: large population with high levels of inequality, dysfunctional service provision, lack of heritage and historical references, strategic location with geopolitical interest and a tightly imposed urban vision from the colonial era. Durban is at the same time a coastal city that is prone to natural disaster due to climate change (Hansen, 2019; Nsibande, 2019). Moreover, Durban is part of the 100 Resilient Cities project pioneered by the Rockefeller Foundation (The Rockefeller Foundation and UNDRR, 2016). Therefore, social and environmental challenges meet together to conform an interesting breeding ground for the development and testing of creative solutions that are forced to look at problems from a holistic perspective.

The Umgeni River is one of South Africa's largest river systems, with a catchment area of over 4,400 square kilometres (Raper, 2014). The Umgeni has also been described as one of South Africa's most polluted rivers. There are many bustling informal settlements located along its river banks, with a high concentration of people. In addition to the uncontrolled use of natural resources, the lack of service delivery in slums has a big impact on solid waste disposal and management. Almost half of the urban solid waste is not collected (Zandamela, 2016).

There is no formalised waste collection in these areas which has resulted in illegal dumping and burning of waste. During heavy rains these litter dumps are washed into the river. Additional waste makes its way into the river through storm water ducts and careless human activity. The river serves as a major conduit of plastic waste to the Indian Ocean (Carnie, 2013; Rall, 2019). The Umgeni River is also historically prone to flooding, a characteristic that has been heightened by climate change, leading to displacement within river-adjacent communities, and a sharp increase in the amount of plastic waste exiting the river mouth and accumulating on Durban's beaches with great impact on the local economy (Hansen, 2019; Nsibande, 2019).

Urban waste is identified as a paradoxical topic: it is considered of great importance in the Global North although it does not represent a big challenge due to long-term implemented planning in the sector. On the contrary, urban waste is typically undermined in the Global

South, which represents a great threat not only at environmental level but also social and economic.

The area is already the centre of several studies and has called the attention of a number of stakeholders including many civil societies, NGOs, government departments and academics. The SARCHI Chair in Waste and Climate, the Group of Marine Biology at UKZN; The Ocean Cleanup, a non-profit organization developing advanced technologies to rid the oceans of plastic through the development of specialized vessels; DGC, an NGO focus on sustainable solutions and plastic pollution alleviation, its potential use through circularity and community upliftment; the eThekwini Municipality and a coalition of national and international experts aiming at using this unique urban case study to attempt to address two major research gaps identified by the CSIR in the RDI Waste roadmap: "1. Quantifying the effect of climate change on the waste sector, while developing mitigation and adaptation strategies to transition the city from resilient, to smart, to wise, to sustainable; 2. Opportunity to study the retention of plastic in riverine and estuarine habitats including sediments and water columns and in conjunction with trapping systems such as the litter-booms".

Upstream the Dusi uMngeni Conservation Trust (DUCT) have a pollution maintenance, monitoring and education programme focused: on clearing sewer lines, eradicating invasive plants, monitoring sewer lines and reporting spillages, revealing neglected manholes and educating communities and schools about waste water and sanitation. Save Our Rivers are active along the length of the river with the ADReach team collecting waste at the mouth of the river and along the adjacent beaches. Durban Solid Waste (DSW) and Parks and Recreation also have teams operating to collect waste. In 2015, DUCT initiated the implementation of litterbooms in the Umgeni River, aimed at capturing surface waste before it could reach the ocean. They are now managed by a not for profit organisation, DGC. As of March 2020, DGC has four functioning litterbooms in the Umgeni and its contributing tributaries. However, there are inefficiencies in the design, placement and implementation of these booms. Another organisation, The Litterboom Project, also has a litterboom in the Umgeni. However, their interest is dedicated to litterboom implementation at a national level. Three of Durban Green Corridor's booms are located in the final 2.5kms of Umhlangane tributary, which joins the Umgeni 5km above the river mouth. This catchment is highly industrialised and has two informal settlements located along its riverbanks.

This scenario offers a unique opportunity to stress the research questions aforementioned and test the hypothesis of the study, taking into account smart solutions that apply to existing challenges that are important based on real conditions. This implies a bottom-up approach on the implementation of initiatives, further planning and policy making. Moreover, the complexity of the location and composition of the urban structure appears to be inviting to redefine the relationship between resilience and sustainability through the application of smart technologies that are relevant.

5.2 Territorial analysis of KwaZulu-Natal

5.2.1 Introduction

The case study is located in the province of KwaZulu-Natal. In order to contextualize the city of eThekwini, in the terms that have been described in this document, it is important to understand the territorial features of the surroundings. As a level of political power and policy making arena, the analysis of the province assists to the exercise of scaling down the initial sub-continental approach of this study to the final urban analysis of the case study.

This section presents the results of mapping the data available by Stats-SA related to urban and sustainability indicators for the province of Kwazulu-Natal. Other sources of data from public departments have been consulted. The indicators selected are included in fields such as levels of urbanization, access to communication technologies and household waste management.

5.2.1.1 Availability of data

The two censuses available by Stats-SA correspond to the years 2001 and 2011. It is to be expected that an update of the census will be published on 2021. This situation aligns to the already mentioned problem challenge of availability of reliable and updated data for the region.

In addition to the above, the municipal organization of the territory has gone through a modification on the 3rd August 2016, through which a few municipalities have merged to create new municipalities and others have been split and added to existing municipalities.

Ezingoleni and Hibiscus Coast have merged into Ray Nkonyeni Local Municipality; Emnambithi and Indaka have merged into Alfred Duma Local Municipality; Umtshezi and Imbabazane have merged into Inkosi Langalibalele Local Municipality; The Big 5 False Bay and Hlabisa have merged into Big Five Hlabisa Local Municipality; Ingwe and KwaSani have merged into Dr Nkosazana Dlamini Zuma Local Municipality; Ntambanana Local Municipality was disestablished and its municipal area merged into City of uMhlathuze Local Municipality, Mthonjaneni Local Municipality and uMfolozi Local Municipality.

Therefore, in order to map the province based on the current status for municipal divisions, calculations have been made with the data available from 2011 and allocated to the new municipalities. No data is available in the 2011 census for uMfolozi Local Municipality and the data related to City of uMhlathuze Local Municipality and Mthonjaneni Local Municipality does not consider the impact of the addition of Ntambanana Local Municipality. In this regard, the calculation has not been possible due the lack of information on the portions in which Ntambanana Local Municipality has been divided.

5.2.1.2 Natural environment in KwaZulu-Natal

KwaZulu-Natal represents a very interesting sample of territorial diversity. It is located on the East coast of South Africa, with an area of 94,361 km² and has three international borders with Mozambique, Lesotho and Eswatini. Domestically, it borders with three provinces: Eastern Cape, Free State and Mpumalanga

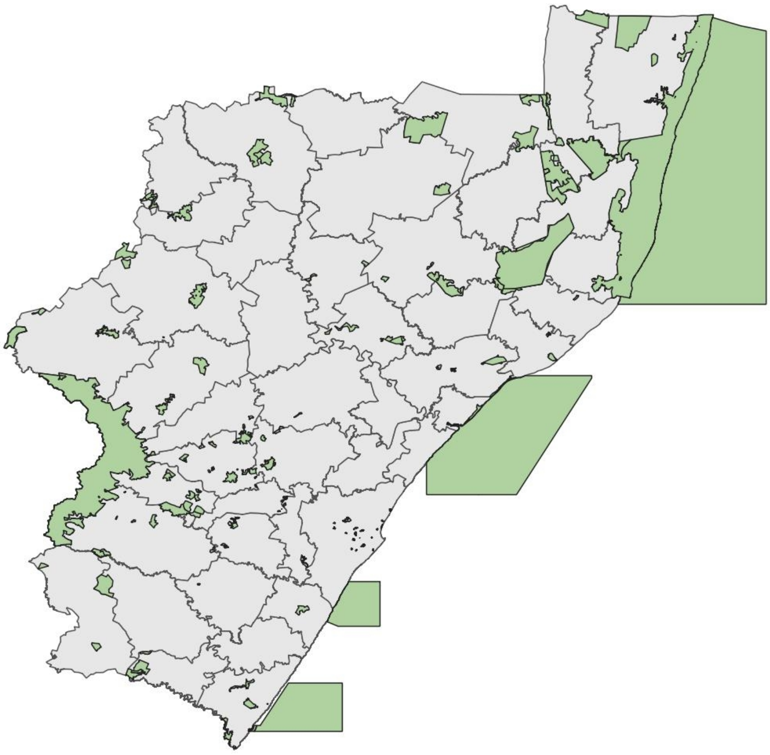


Figure 22. Natural parks and protected areas in KwaZulu-Natal

From the environmental perspective, KZN is home of two UNESCO World Heritage Sites: the iSimangaliso Wetland Park, included in the Ramsar Convention (UNESCO, 2021c), and the uKhahlamba Drakensberg Park (UNESCO, 2021d), with extraordinary biodiversity of a range of flora and fauna. The Tugela River is the largest in the area and flows west to east across the center of the province.

The geographic areas within the provinces fit into mountain, midland and lowland categories: two mountainous areas, the western Drakensberg Mountains, a 3,000 metes high basalt range conforms the natural border to Lesotho; and northern Lebombo Mountains, low granite parallel ranges from Hluhluwe to the south of Punda María. The central Midlands, a hilly plateau rising toward the Drakensberg on the west. The coast along the Indian Ocean is a flat strap, particularly narrow in the south, increasing the width towards the north of the province.

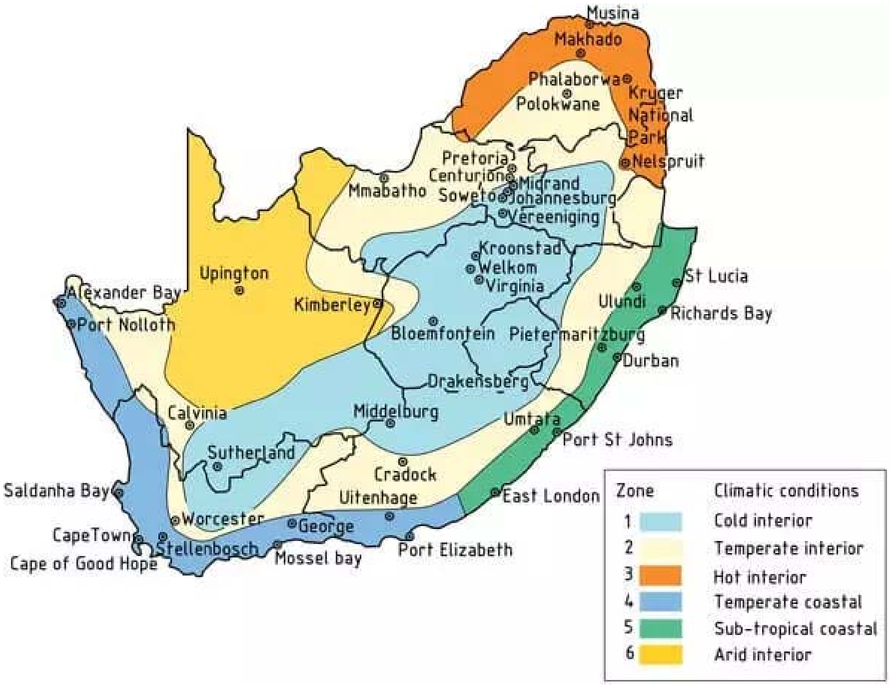


Figure 23. Climatic zone map SANS 204 (RSA, 2011)

The South African National Standards document SANS 204 (RSA, 2011) divides the province in three of the six climate zones present in the country: cold interior, temperate interior and Sub-tropical coastal (see Figure 23).

5.2.1.3 Main transport infrastructures

The mapping of the main transport infrastructure suggests a certain level of integration within the several modes of transportation present in the province. However, the spatial analysis contained in this section does not look at performance indicators in detail. Failure in such performance is mentioned in case of severe impact.

a) Roads

The road system in South Africa is organized in three levels: Primary, Secondary and Tertiary Roads. KwaZulu-Natal is crossed by two of the main national roads on South Africa: N2 and N3. The N2 runs East-West along the coast, connecting the Eastern Cape Province with the Eswatini border in Golela, and continuing further north to the Mpumalanga Province. The N3 on the other hand runs South- North across the province, connecting Durban with the Free State Province on the further way to Gauteng Province. The number of lanes in both roads varies between 4 and 3 in Durban to 2 in the rest of the sections within KZN. The condition of the road is good to very good in most of the section in the province (World Bank Group, 2021a).

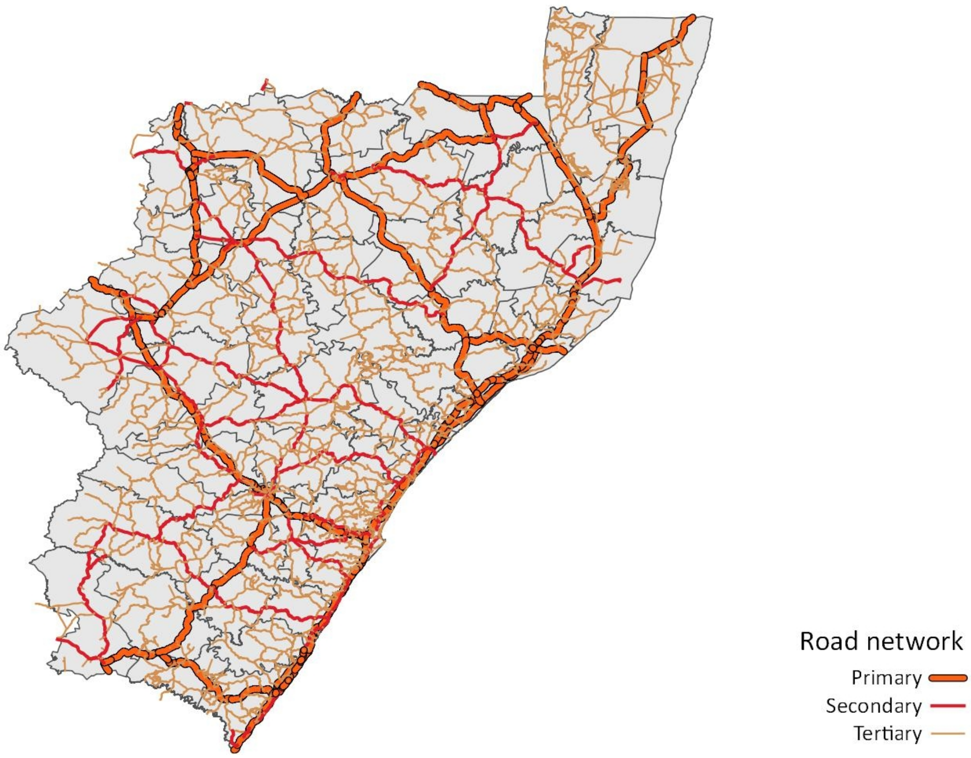


Figure 24. Road network of KwaZulu-Natal

Other primary roads connect the province both internally and internationally. In this way, the R22 starts from Richards Bay towards the northern border post with Mozambique in Kosi-Bay. The N11, R602 and R33 connect the N2 with the N3. The R34 starts from Richards Bay towards north to connect with R33 in Vryheit. In the south, the R56 starts from Pietermaritzburg connecting with the N2 near Kokstad. Despite the category as primary, the number of lanes in these roads is 2 and the condition is not always good.

The municipalities located in the interior of the province are seriously disconnected from the primary road network. This is not only coincident with the lowest levels of urban population but with the presence of nature reserves such as Hluhluwe-Imfolozi Park, the oldest proclaimed nature reserve in Africa and the World Heritage Site of iSimangaliso Wetland Park.

b) Airports

There are sixty-six airfields in KwaZulu-Natal and three airports of national importance: Pietermaritzburg Airport, Richards Bay Airport and Margate Airport; and one international airport: King Shaka International Airport. Airfields in the province serve for either non-commercial purposes, such as sport aviation and private flights, or fall into the category of license airports in support of the national network, including business and indirect hire-and-reward functions. Some airfields are reduced to landing airstrip in remote areas of the province while others offer charter and training services to light aircrafts.

National airports serve scheduled traffic and are comply with the Civil Aviation Act, 2009 and the National Airport Security Programme. International airports are designated port of entry that service intercontinental traffic and regional-international and domestic traffic. Such airports are also compliant with the aforementioned regulations. King Shaka International Airport is a strategic airport for domestic services throughout South Africa, included in the "Golden Triangle" connecting Cape Town International Airport, O. R. Tambo International Airport in Johannesburg. King Shaka International Airport is located 34 km north of Durban and has 2,818,611 departing passengers and 27,041 arriving air traffic movements. It also has a cargo terminal with a capacity of 150,000 metric tons. Recapturing local air freight traffic from Johannesburg is one of the strategic mandates for King Shaka (SouthAfrica.info, 2021). Estimates account about 25,000 metric tons (27,600 short tons) of air freight a year produce in KwaZulu-Natal, that is currently transported by road to Johannesburg (Inggs, 2009). King Shaka International Airport was awarded fifth place in the Best Airport ACI-ASQ Awards for Middle East and Africa.

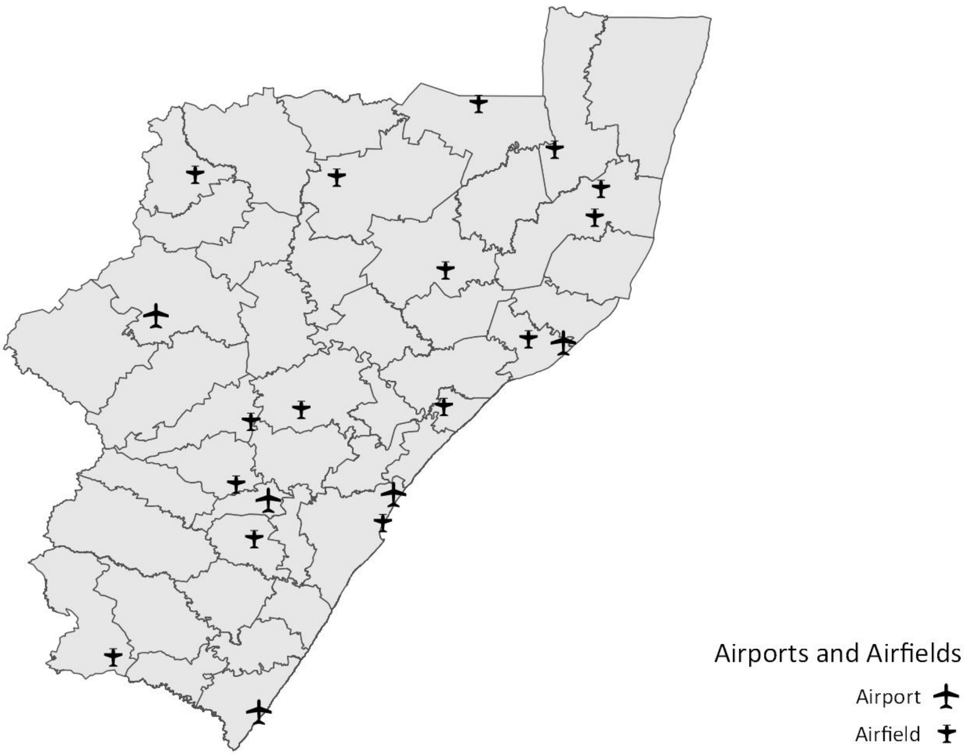


Figure 25. Main airports and airfields in KwaZulu-Natal

The level of connectivity of airfields with other transportation networks is very good. Most of the main airfields and all airports are located in connection with the primary road network and core rail network. The rest of the important airfields are connected with secondary roads and non-core rail network.

c) Ports

South Africa has eight commercial ports and approximately 96 % of the country’s exports are conveyed by sea. Two of these ports are located in KZN: Durban and Richards Bay.

The Port of Durban is the fourth largest container terminal in the Southern Hemisphere (Inggs, 2009), and the busiest shipping terminal in SSA (The Economist, 2016). Regarding the Port of Richards Bay, it is the South Africa's premier bulk port, originally built to handle coal exports. However, it handles a range of bulk goods nowadays.

Figure 26. Ports in KwaZulu-Natal

Together with the port of Maputo, Durban and Richards Bay are the 3 coal export ports in Southern Africa. Coal is the biggest mineral resource in sells volume in the country, which 70% is for domestic consumption and 30% dedicated to export (ICEX, 2019). Despite the world class rate of these two facilities, their productivity is severely constrained by terrestrial infrastructures such as roads and railways. Inadequate rail capacity is limiting exports to below-port capacity at all three aforementioned ports (Creamer, 2009).

d) Railways

The railway system in South Africa is the most developed in Africa (de Jong, 2002). However, no high-speed line is available in the country to date. Freight and commuters services are separately operated by two different public companies: Transnet Freight Rail and PRASA respectively. Transnet Freight Rail is the largest division of Transnet, a State Owned Company (SOC), wholly owned by the Government of the RSA and is the custodian of rail, ports and pipelines.

The commuters' network is structured into urban and long distance routes. Metrorail is present in KwaZulu-Natal as one of the only four urban commuter transport services in the country.

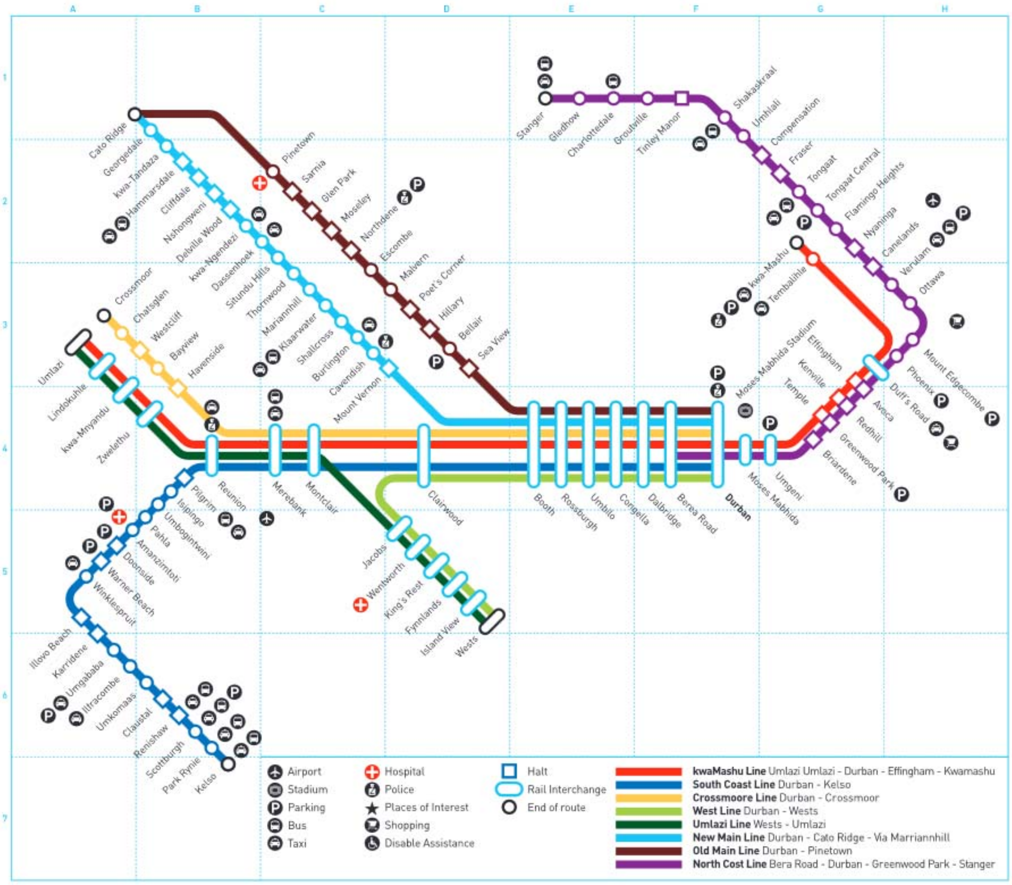


Figure 27. 2010 Local passenger rail routes of South Africa. KwaZulu-Natal. Durban (Metrorail, 2021).

Shosholoza Meyl operates long distances routes connecting the major metros in the country: Johannesburg, Cape Town, Durban, Port Elizabeth and East London on a weekly basis. Shosholoza Meyl offers tourist class and premier classe.

In comparison with other provinces, KZN is among the top priorities in the Development Plan by Transnet. The Natcor line, as part of the Gauteng - Durban corridor, is the largest by volume and growth potential (Transnet, 2016). Durban, Richards Bay and Port Shepstone are key stations in the rail network.

The railway network's layout overlaps with most of the primary road network. A number of main stations are distributed along the network. Moreover, the stations located in non-core lines connect with either primary or secondary roads, which allow enhancing a level of integration between different transportation systems. However, this layout has a similar effect on connectivity: the municipalities located in the interior of the province are seriously disconnected from the rail network. Moreover, some of the lines covering these interior municipalities are no longer operative.

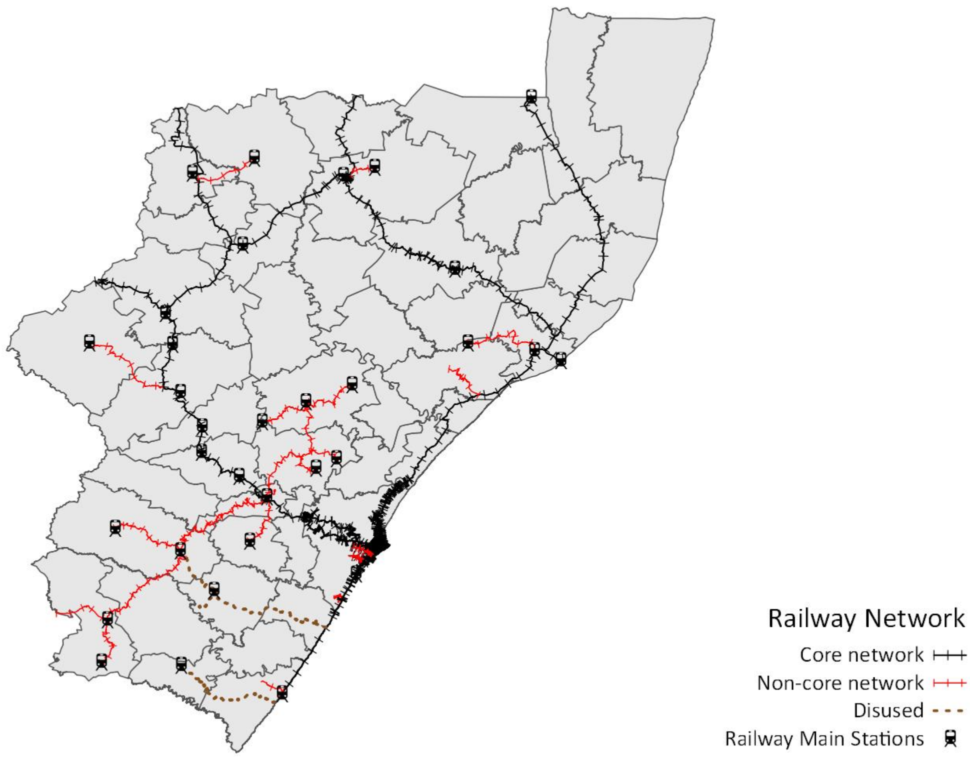


Figure 28. Railway network in KwaZulu-Natal

The two ports in the province are connected to the freight rail core network. Airports and airfields position is also coincident with the railway network.

5.2.1.4 Analysis of transport infrastructures in KwaZulu-Natal

The vast majority of the territory of KZN is covered by transport infrastructures, (see Figure 29) some of which are key components not only of national interest but also from a strategic perspective at international level. King Shaka International Airport, the ports of Durban and Richards Bay, the national roads N2 and N3, and the freight rail Richards Bay Coal Terminal play a relevant role in the development of the province. However, there is no indication of significant impact on the urban development of KZN. The route towards Gauteng through the N3 appears as the most urbanized area in the province. Nevertheless, a domino effect might be expected on municipalities that remain essentially rural despite being adjacent to more urbanized and infrastructure equipped municipalities. Such is the case of Mkhambathini and Dannhauser. The principal routes connecting Richards Bay with Mpumalanga and Eswatini, through the N2 and R34, reflect little impact on the level of urbanization of the municipalities.

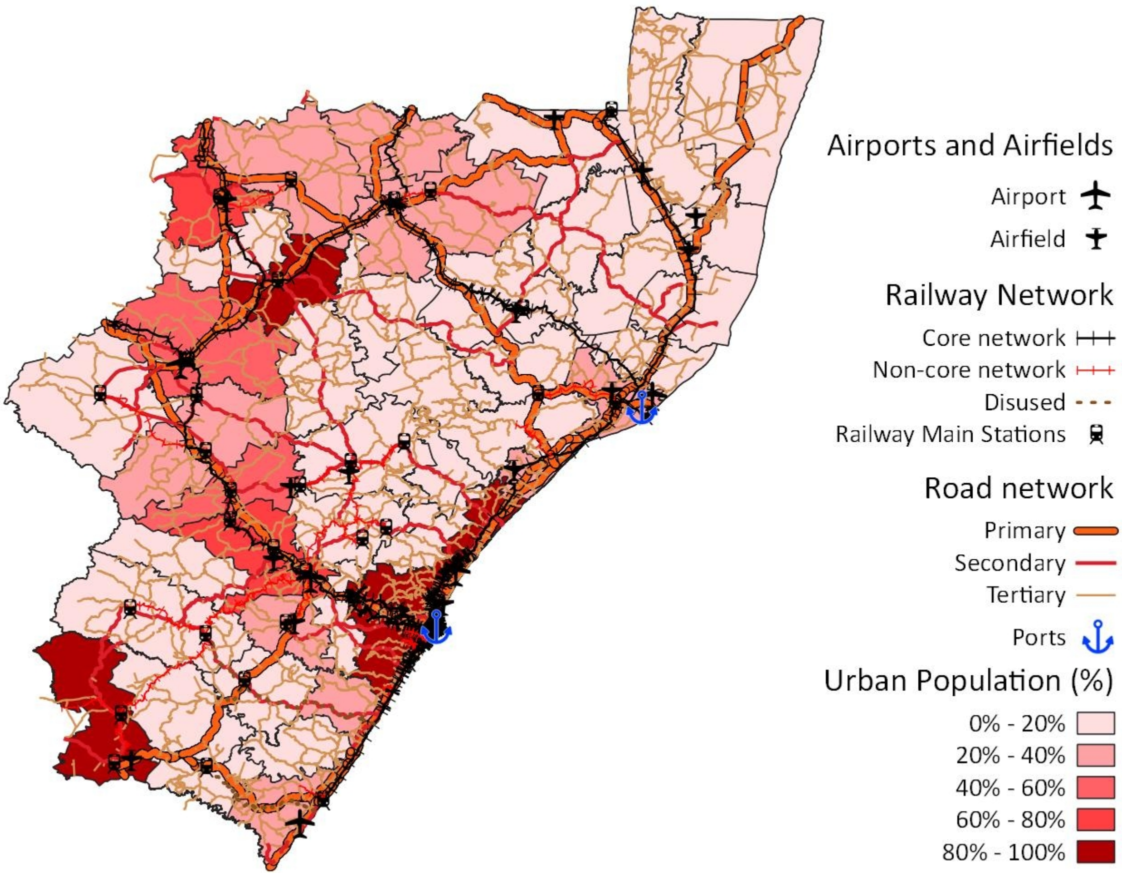


Figure 29. Transportation infrastructures in KwaZulu-Natal

The presence of such infrastructures appears as potential catalyst for the development of the province. An integrated approach to the infrastructures network that already exist (Figure 29 The location of road nodes, airfields and railway stations is coincident in many cases) might allow for a strategic regional development that would start with the identification of key municipalities suitable for fast and cost effective urban and economic growth, aiming to reduce the pressure on eThekwini Municipality by, firstly, attracting migrants that might find appealing not only moving closer to their origin but better quality of life and reducing the housing delivery backlogs that big metros in South Saharan Africa experience. Secondly, reduce the pressure on city management, with clotted department that are hardly capable to respond to a functional service delivery strategy. Thirdly, reducing the pressure on the urban infrastructures of eThekwini: water and sanitation, urban waste, electrical supply and mobility.

It is acknowledged the presence of natural ecosystems of enormous importance, being Hluluwe-Imfolosi Park, Isimangaliso Wetland Park and Ukhalamba-Drakensberg Park the most important in terms of area footprint, but also the category of World Heritage Site of the latest two. This might have an impact on the urban development of the municipalities affected. In fact, these protected areas are located in municipalities with an urban population lower than 20%. The interior of the province is also sprinkled with numerous protected areas although of smaller scale. In this case, their presence is not correlated with the level of urbanization of the municipalities.

5.2.2 Urban population in KwaZulu-Natal

This section analyses the level of urbanization of KZN and the connections between urban hubs in order to determine possible sources of dysfunctionality and infrastructures overloads in the existing urban areas, eThekwini in particular.

KZN ranks second in population in South Africa, with an estimate of 11.5 million inhabitants, it is home of the 19.3% of the people in the country. It also ranks second in density of population with 85.3 inhabitants per km², although distant from the number one in the ranking, the highly urbanized Gauteng, with 675.1 inhabitants per km².

5.2.2.1 Analysis of GIS

The data contained in the 2011 census produced by StatsSA has been analyzed based on the geographic location in order to determine spatial relationships between indicators.

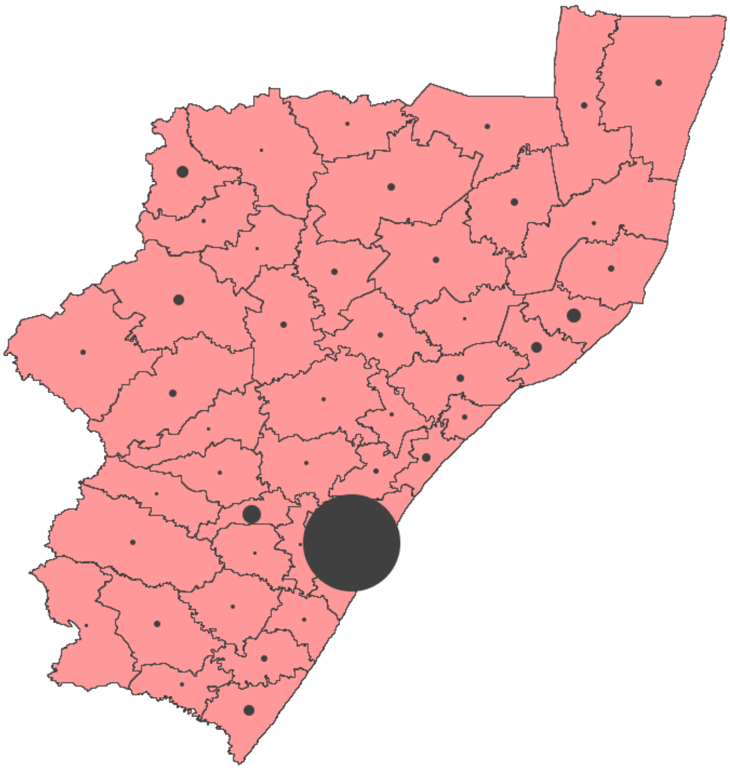


Figure 30. Population distribution in KwaZulu-Natal.

a) Population

KwaZulu-Natal contains one of the eight metropolitan municipalities of South Africa, eThekwini, the third most populated municipality in the country after the City of Johannesburg in first place and the City of Cape Town in the second. With a population of 3,442,361 inhabitants, it is almost 6 times bigger than the second most populated municipality and capital of the province, Msunduzi with 618,536, and 100 times bigger than the less populated municipality: Impendle. eThekwini is home for the 33% of the entire population of the province. 1 in 3 residents in KwaZulu-Natal lives in eThekwini.

The municipalities with higher population are identified to be located along the coast and the national road N3 (see Figure 30).

b) Population density

With 1347 inhabitants per Km², eThekwini represents the most densify municipality in the province followed by Msunduzi with 824 inhabitants per Km². The 75% of the municipalities in the province have a density rate lower than 100 inhabitants per Km². In correlation with the population trends, the municipalities with higher population density rate are indentified to be located along the coast and the national road N3.

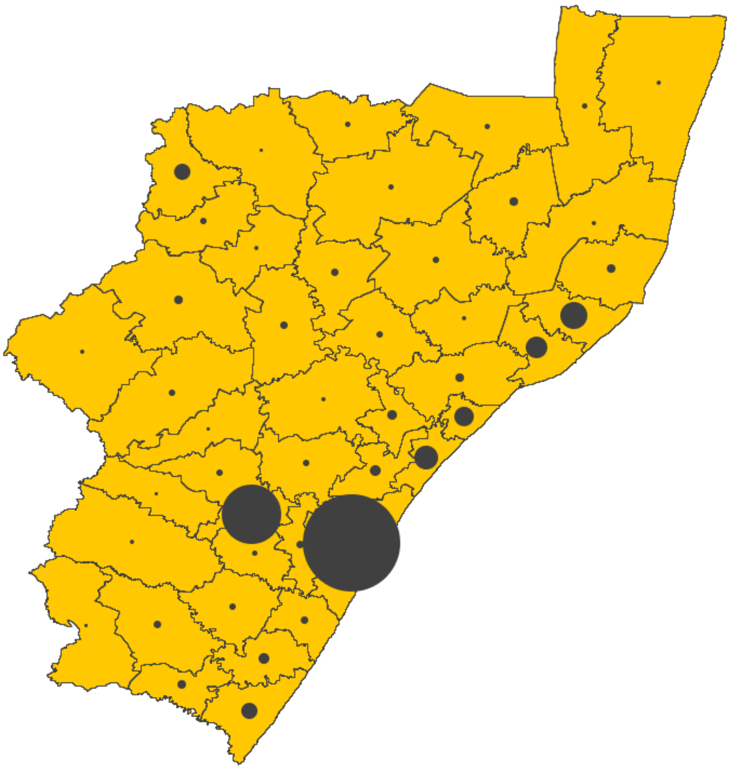


Figure 31. Population density in KwaZulu-Natal

c) Urban population

Within the 44 municipalities in KZN, the percentage of population living in urban condition is very low: less than 20% for 26 municipalities and less than 40% for 35 municipalities. Only 4 municipalities have between 80% and 85% of their population living in urban condition.

The location of municipalities with a higher rate of urban population is coincident with the presence of either transportation arteries such as national roads, rail core network, airports and ports, or strong economic hubs. Municipalities in the N2 and N3 route have an urban population rate higher than 40%. The non-core rail network does not have a correlation with the level of urban population (See Figure 29).

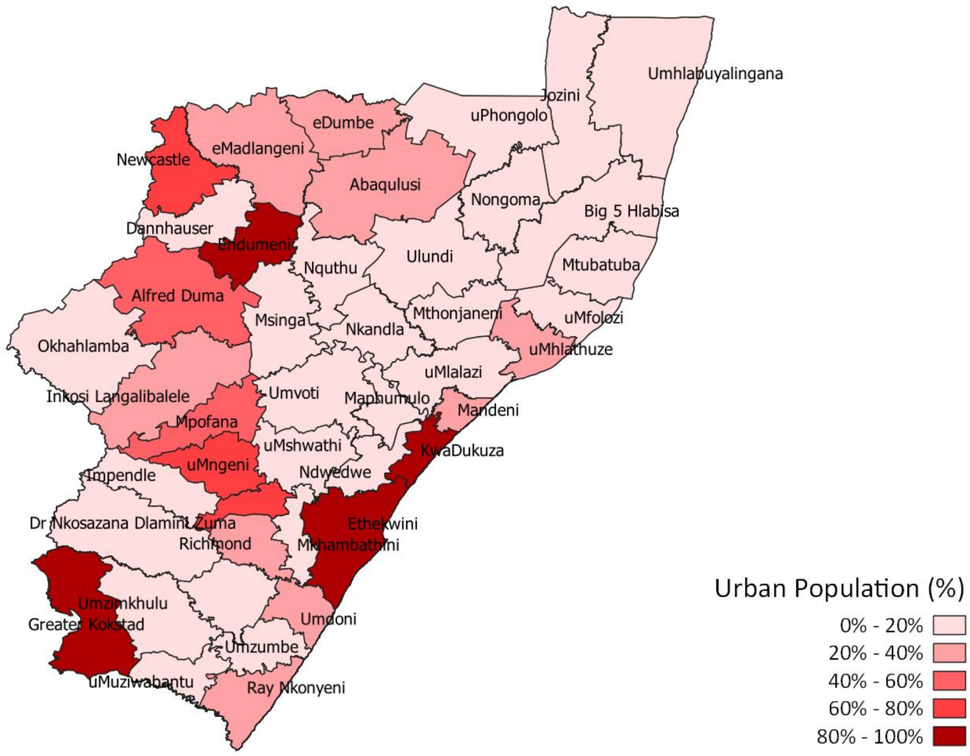


Figure 32. Urban population in KwaZulu-Natal by Municipality (%)

Coastal developments seem to have an impact on the rate of urban population only near eThekwini. Greater Kokstad represents a service centre and commercial hub for most of the nearby parts of the Eastern Cape and the city of Dundee in Endumeni, is a mining town very rich in coal deposits, with a large population living in Sibongile township.

The interior of KZN remains fundamentally rural. Natural parks and game reserves are located in this area. The international borders do not seem to represent any impact in terms of local trade and economic transactions that would translate into more developed urban hubs in the areas.

This indicator in conjunction with the population density give an idea of the level of residential sprawl present in the province, which translates in whether a big stress on conventional municipal service delivery and bulk infrastructures or an absolute lack of such urban commodities.

5.2.3 ICT connectivity in KwaZulu-Natal

ICT connectivity is the core of any smart initiative. Stressing the level of connectivity together with the preferred ICT present in the province becomes a key element in the analysis of potential applicable smart solutions, and moreover, the application to smart project towards the solution to the problem of plastic pollution, which is integrated in an overall strategy to achieve urban resilience.

5.2.3.1 Internet access in KwaZulu-Natal

The vast majority of households in KwaZulu-Natal have no access to internet. Three quarters of the municipalities present an access rate lower than 30%. The access rate of all municipalities is lower than 40%, with the exception of eThekwini and uMhlathuze which access rate is close to 50%.

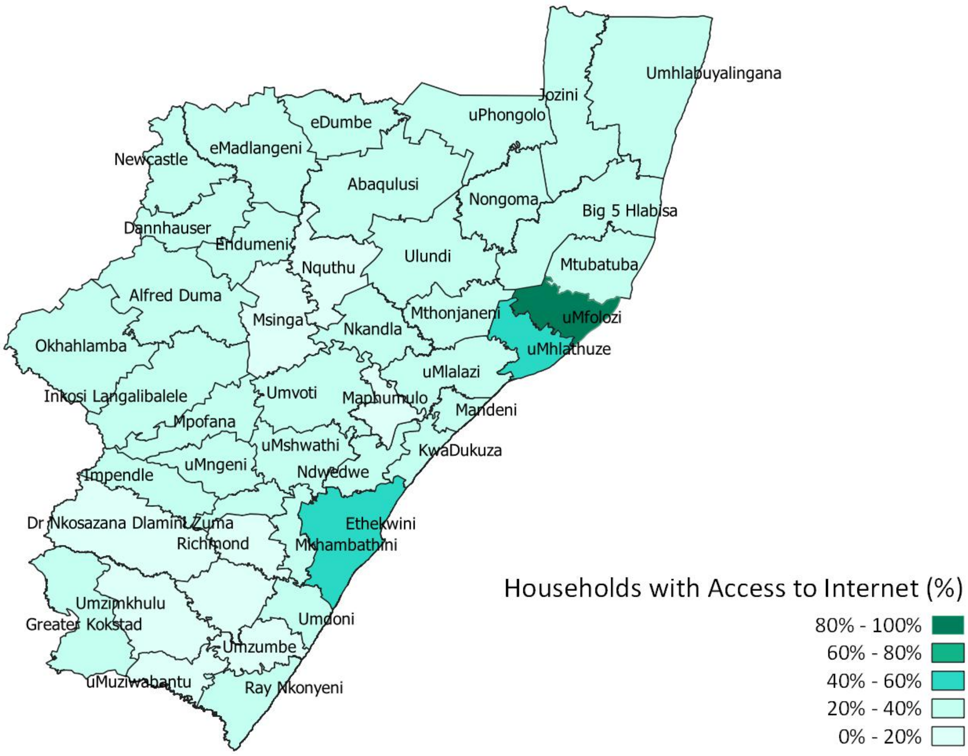


Figure 33. Households with access to internet in KwaZulu-Natal by municipality (%)

5.2.3.2 Internet access preferences in KwaZulu-Natal

The internet accessibility available for households considered in the mapping breaks down in three different categories of connection: cell phone, home landlines and elsewhere, which includes work places, internet cafes, hotspots and satellite. Cell phone is the prevalent mean of internet connection. Municipalities with low access rate show insignificant values for landlines and other means of connection. eThekwini and uMhlathuze, the two municipalities with higher internet access rate present a balance between the three categories.

The rate of internet access from home and elsewhere increases for municipalities with a higher level of urban population, whereas for those municipalities with an urban population rate lower than 20%, the use of cell phone is prevalent.

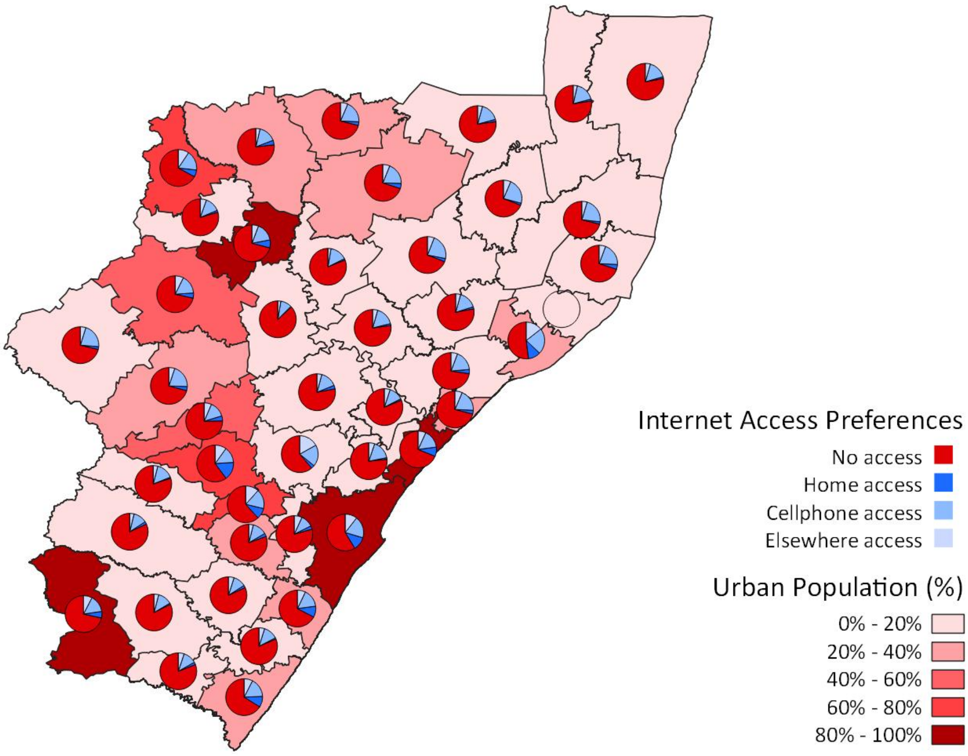


Figure 34. Internet access preferences in KwaZulu-Natal by municipality

5.2.3.3 Communication means available in KwaZulu-Natal

Basic means of communication other than internet are to be considered. Therefore, the mapping reflects the data related to household communication goods such as telephone landlines, cell phone, terrestrial television, satellite television, radio and computer. The findings reflect that telephone landlines, satellite television and computers are rare to be found as part of the households' goods inventory. The situation is consistent across the province: the presence of cell phone, terrestrial television and radio is overwhelmingly prevalent in comparison with the rest of the means indicated.

This trend is also persistent in eThekwini and municipalities with a higher rate of urban population. However, and substantial increase in the number of households with telephone landlines and computers can be notice in these areas.

The lack of telephone landline infrastructures represents a big challenge for the implementation of broadband internet infrastructures at a provincial level. Again, areas with a higher urban population show a higher use of landlines and are more likely to improve and update the existing infrastructures due to cost effectiveness.

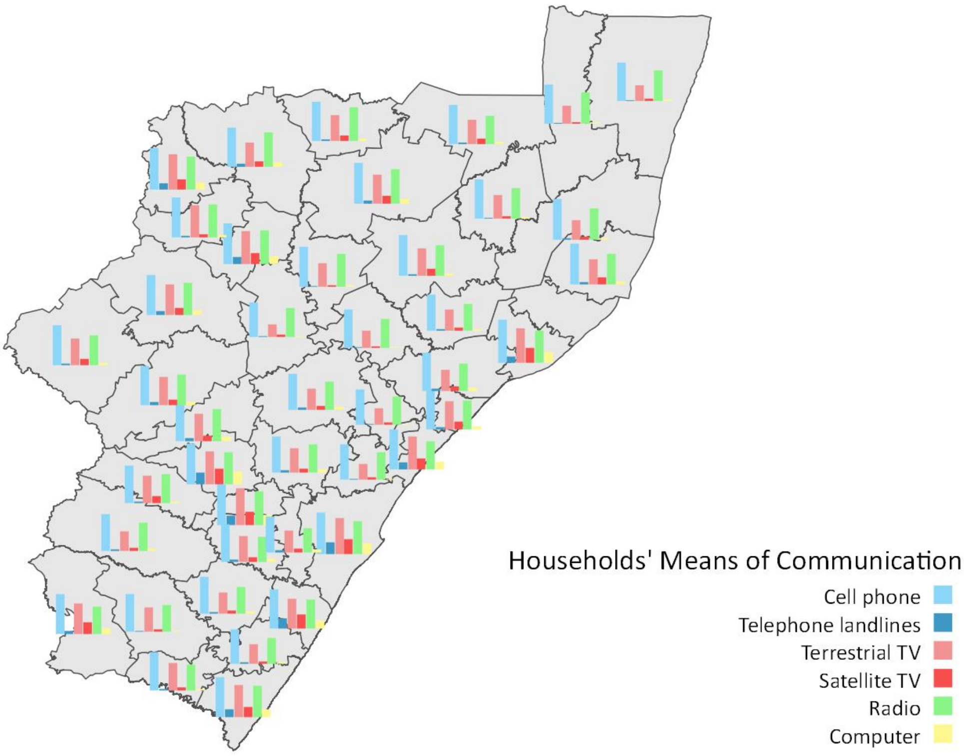


Figure 35. Households' means of communication in KwaZulu-Natal by municipality.

5.2.3.4 Opportunities for bottom-up smart initiatives: Prosumer citizen, internet penetration and digital literacy

The current scenario, mapped for the province of KwaZulu-Natal, represents a big challenge for the implementation of what is internationally claimed as smart initiatives (Finger, 2017). Top-down strategies lacking of the acknowledgement of the levels of connectivity of the population are likely to fail. The concept of prosumer citizen (Lang *et al.*, 2020) who contributes in the generation of data, which is the base of most of smart projects, becomes a daydream in an environment where the citizen is disconnected. The facilitation of internet penetration becomes the first step in the construction of a functional data network. A precedent in new technology penetration can be found in the recent mobile telephone infrastructure (Agyenim-boateng, Benson-Armer and Russo, 2015). In fact, the use of cell phones does not seem to be strange in the region but the access to the internet, based on the data. Lack of infrastructures but also high ISP tariffs in South Africa, the most expensive in the African continent excluding Ethiopia (Skhirtladze *et al.*, 2017) and limited digital literacy (Guillén and Suárez, 2005) are factors that contribute to this low level of connectivity. Therefore, reducing the gap of the digital divide is to be considered as well among the first steps for the achievement of functional smart solutions.

Based on the data previously presented, internet connection whether does not happen or it is through cell phone for the majority of the population. Community based cell phone applications appear as a good first step for the implementation of bottom-up solutions that are highly engaged with the communities. Public software that is data-free, such the case of COVID-19 apps, might be available for data collection of public interest. Engagement campaigns through forms of incentive are to be considered. However, the data risks to be biased by the use of devices limited to a fraction of the population. Multiple ways of communication should be considered: SMS messaging, interaction menu, multilanguage platforms, etc.

5.2.4 Solid refuse waste in KwaZulu-Natal

In order to identify potential sources of waste pollution, the data available from Stats SA has been mapped. This analysis does not consider industrial and commercial uses and their contribution to waste production.

5.2.4.1 Waste management models in KwaZulu-Natal

Five categories of households' waste management are considered in the mapping: municipal collection, communal dump site, individual dump site, no waste collection and other forms of waste management. Individual dump site is the prevalent waste management system for three quarters of the municipalities in the province. Almost 40% of the municipalities experience a number of households with no waste collection higher than 10%. The presence of communal dump sites in the province is minimal, lower than 3% for most municipalities and no higher than 5%.

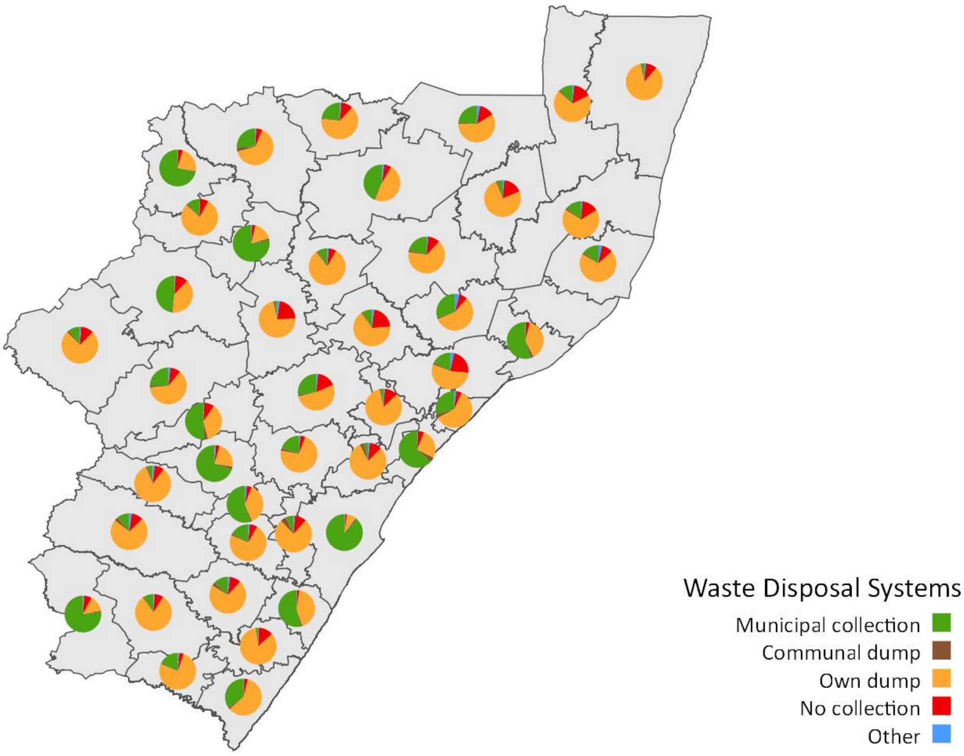


Figure 36. Waste disposal systems in KwaZulu-Natal by municipality

5.2.4.2 Municipal waste collection in KwaZulu-Natal

Only 5 municipalities: eThekwini, Endumeni, Greater Kokstad, Newcastle and Umgeni attend more than 70% of the households with regular municipal collection although the frequency is not higher than once per week (Bosch Munitech, 2016). These municipalities are among the group of higher rates of urban population. This section stresses the types of waste collection and does not analyze the efficiency of municipal waste management systems implemented in the province at municipal level. However, a correlation between the level of urbanization and the implementation waste management systems has been found. From a bottom-up perspective, based on these findings of a highly fragmented scenario, almost at individual level, a decentralized strategy seems to be appropriated for the less urbanized areas. Nevertheless, the implementation and enforcement of policies and installation of equipment might be challenging. On the contrary, highly urbanized areas follow a traditional model of waste collection which efficiency is to be analyzed yet.

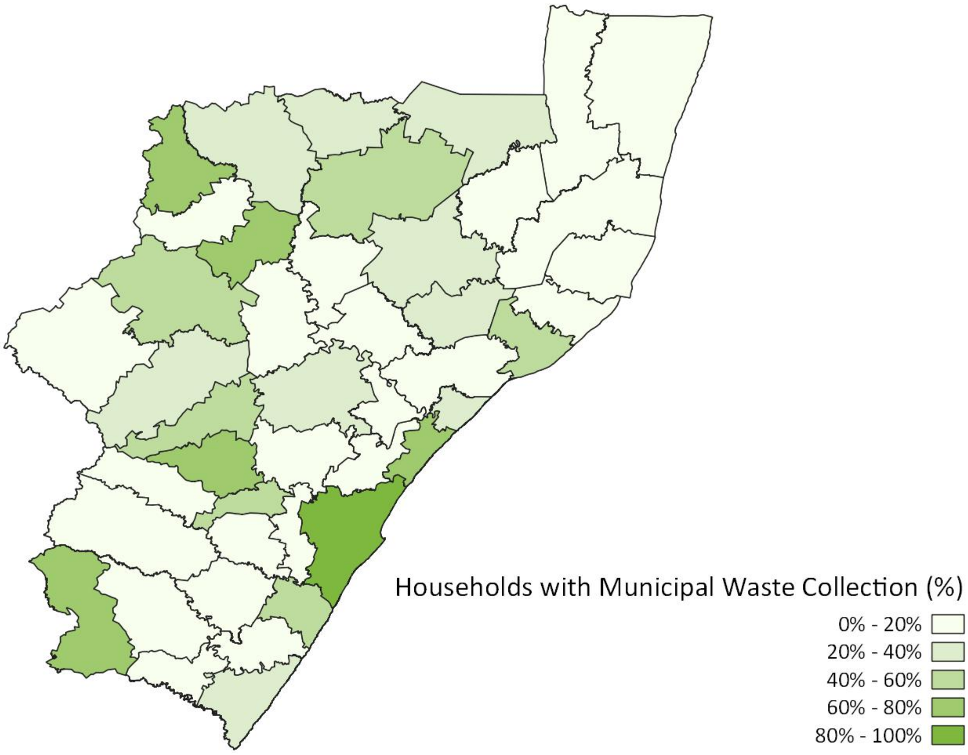


Figure 37. Household with municipal waste collection in KwaZulu-Natal (%)

5.3 Territorial analysis of the Umgeni catchment

Once the general parameters have been analyzed for the province, a closer look at the Umgeni catchment, focusing on the municipalities that contain part of the drainage basin of the river, seeks to isolate the former parameters in the scenario that directly affects the case study. Being the Umgeni River one of the most polluted rivers in South Africa (Carnie, 2013; Rall, 2019), reasons for such situation are to be found in this limited region.

The Umgeni river drainage basin intersects with 9 municipalities: Mpofana, Msunduzi, Umgeni, Impendle, uMshwathi, Richmond, Ndwedwe, Mkhambathini and finally eThekwini (see Figure 38 and Figure 39). The drainage systems contains, together with the tributaries to the Umgeni River, five dams: Albert Falls Dam, located in uMshwathi; Midmar Dam, located in Umgeni; Nagle Dam, located in Mkhambathini; Henley Dam, located in Msunduzi; and Inanda Dam, located in eThekwini.

The group of municipalities intersected by the Umgeni River catchment shows a noticeable diversity in terms of demographics, ICT and waste management patterns. As the provincial analysis highlighted previously, this is due to the coincidence of the Umgeni River catchment with the national road N3 crossing some of the municipalities and therefore, increasing the rate of urban population, ICT connectivity and municipal waste collection.

Figure 38. Umgeni River drainage basin

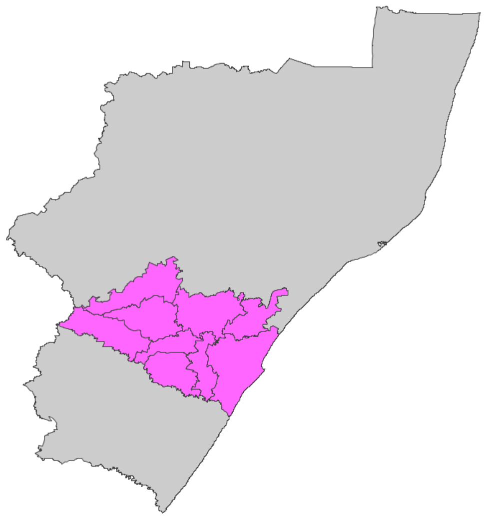


Figure 39. Municipalities affected by the Umgeni River drainage basin

The presence of eThekwini, which patterns are exceptional in comparison with the average in the province, brings the opportunity to address the effect of the phenomena of the African Megacity in topics of environmental concern, waste pollution in this case study.

5.3.1 Urban Population in the Umgeni catchment

Tackling the two extremes, Impendle, Ndwedwe and Mkhambathini have a rate of urban population lower than 6%, whereas for Msunduzi and Umgeni, the urban population exceeds the 75%. The highest rate corresponds to eThekwini, with 85% of residents living in urban conditions.

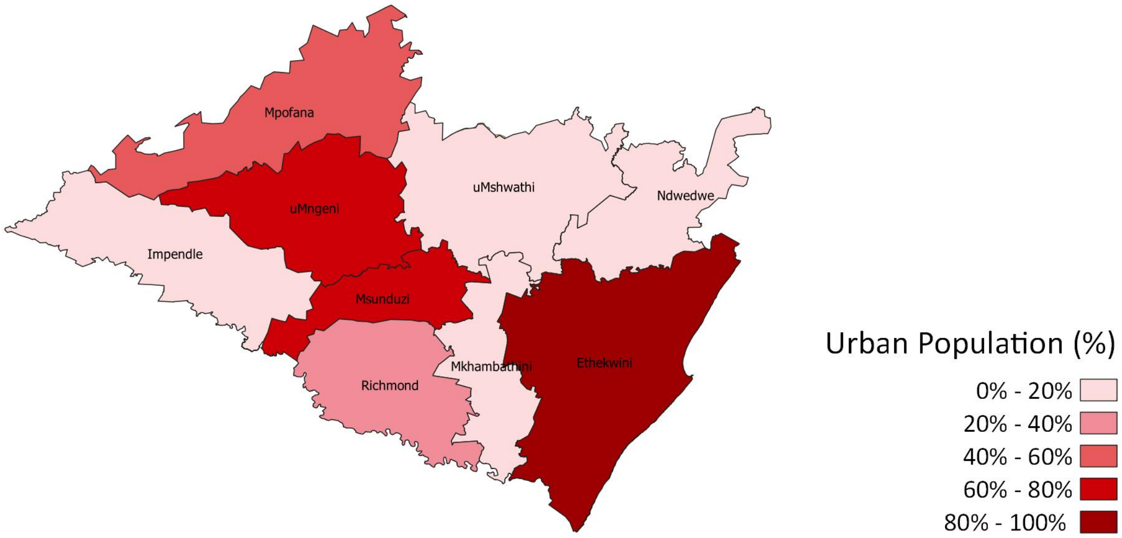


Figure 40. Urban population in the Umgeni River catchment by municipality (%)

5.3.2 ICT connectivity in the Umgeni catchment

In terms of access to ICT, the trend for the Ungeni River catchment is coincident with the patterns indicated for the province: municipalities with a higher urban population rate reveal a higher presence of ICT.

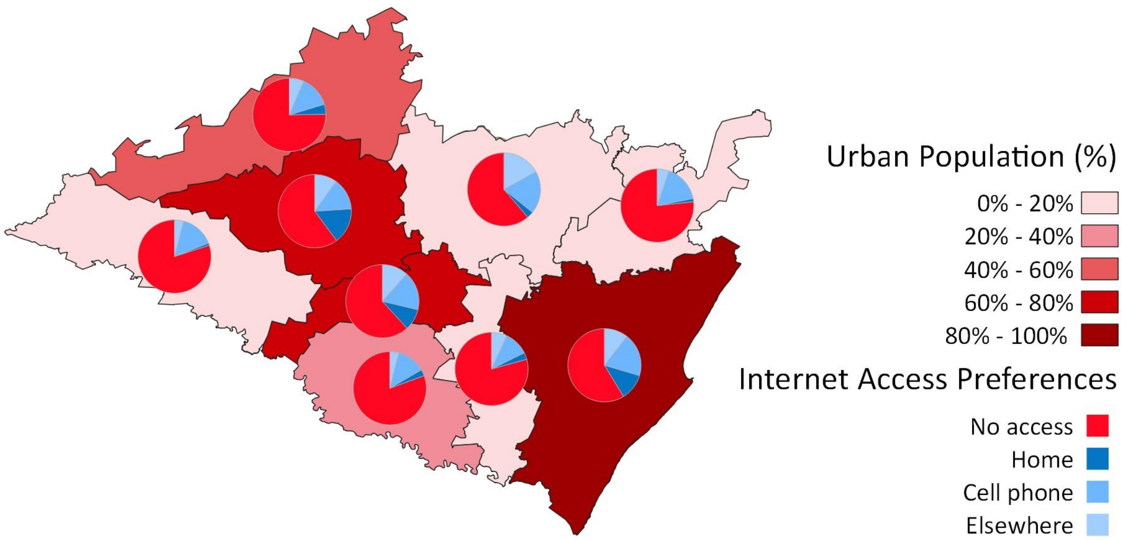


Figure 41. Internet access preferences in the Umgeni River catchment by municipality

Mpofana, Impendle, Richmond, Ndwedwe and Mkhambathini show the lowest ICT connectivity, below 25% of the households. For Msunduzi, Umgeni and however, although an increase of ICT connection and presence of home computers are noticed, it is not substantially higher, reaching a connectivity rate of 40%.

For eThekwini, against what could be expected based on the great difference in urban population rates respect of the rest of municipalities in the province, the numbers for ICT connectivity don't correlate such contrast and only 42% of households have internet connection.

5.3.3 Waste management in the Umgeni catchment

For the case of waste management, the situation in eThekwini is overwhelmingly different from the rest of municipalities in the Umgeni catchment area. 88% of the formal households are serviced with periodical municipal collection. 33% of the total population live in informal settlement (Marx and Charlton, 2003) with no collection service. After eThekwini, Umgeni shows a committed waste management rate with 70% of households attended by municipal waste collection and Mpofana and Msunduzi collect just over 50% of households waste.

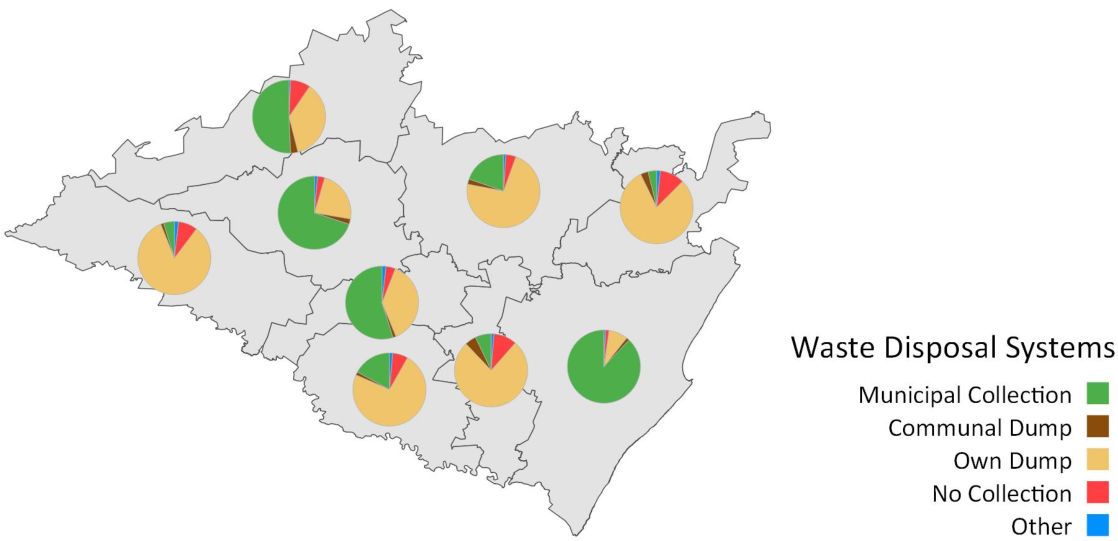


Figure 42. Waste disposal systems in the Umgeni river catchment by municipality

The numbers for the less urbanized municipalities indicate the opposite pattern. In Impendle, Richmond, Mkhambathini, Ndwedwe and uMshwathi over 70% of households have individual dump sites and municipal collection is lower than 23%, with extremely low rates of 3.4% in Ndwedwe and 4.8% in Impendle.

Logically, municipalities with higher municipal waste collection rates might appear as less polluting. This analysis opens the question of assessing the efficiency of municipal waste management systems put in place in the several municipalities of the area by overlapping the results of waste pollution rates. Therefore, although municipal plans are implemented to manage urban waste, they might not be efficient.

5.4 Mapping the Umgeni River mouth

Five major streams may carry as much as 1 340 tons alone towards the Indian Ocean in the Durban area. Among these is the Umgeni River (estimated 380 tons per year). This section discusses the paths of waste entry as well as the current collection and handling methods of The Ocean Cleanup (TOC), DSW, DGC, The Litterboom Project (TLP) and Save Our Rivers.

5.4.1 Waste entry

There are three possible paths for a piece of plastic to have reached a specific section in a river course: it has either entered the river previously and flown down the river, or; it has blown off the riverbed into the river at that waste entry point, or; it has entered through a storm water pipe outlet at that point. Both the selected case study and initial survey for case selection are bounded systems. The initial survey catchment is bounded 5km upstream of the Umgeni river mouth, and 3km upstream of the Umhlanagane tributary. In order to trace the waste entry points for the Umgeni and Umhlangane, these three contextualised pathways are examined.

5.4.1.1 River-originated waste

Plastic waste enters a river via stormwater pipe outlets and bank-based litter dumps along the entire course of the river. In order to create a bounded river system, all the waste that has entered the river before the boundary is referred to as river-originated waste. It is an enormous task to map every waste entry point along the entire Umgeni River, as well as each of its tributaries. Waste generated depends on the human activity as well as the level of waste management and collection implemented in the area. Figure 43 shows a zoning layer together with informal settlements upstream.

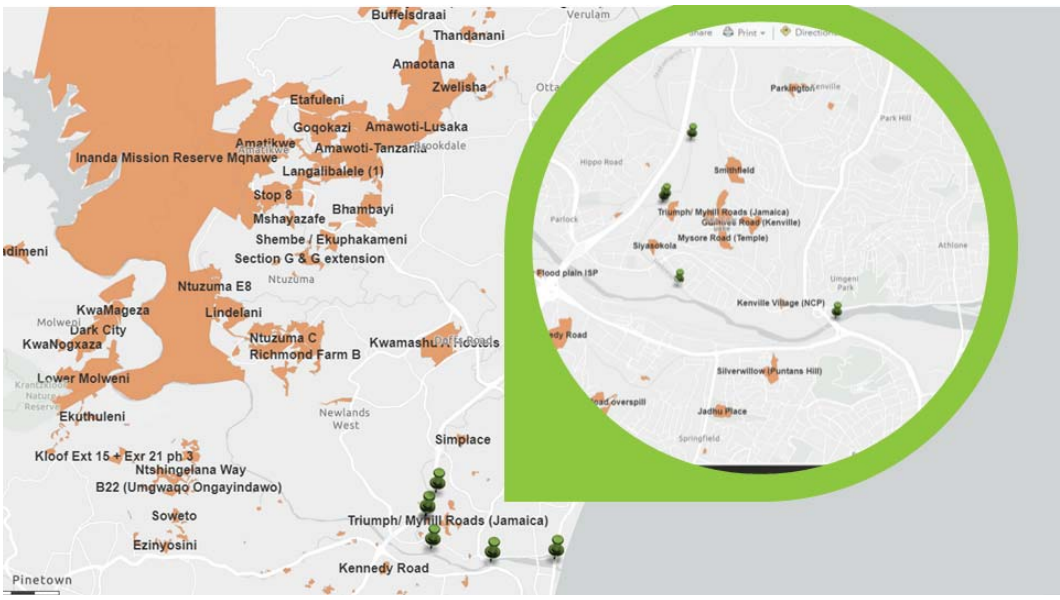


Figure 43. Informal settlements upstream

One notices that there is a large concentration of informal settlements along the Umgeni river below the Inanda Dam. There are also several settlements along the Umhlangane, with 5 located within 3km of the confluence of the Umgeni and Umhlangane. As waste management in informal areas is limited, the informal settlements upstream were also mapped.

5.4.1.2 Riparian zone-originated waste

The amount and type of litter located along the banks depends on the human activity in the area and the collection services provided. Figure 44 illustrates the land use adjacent to the section of the catchment subjected to study and Figure 45 shows images of the activity located along the riverbanks. It is to be noticed that industrial parks, residential housing, informal settlements and dedicated parks line the selected catchment. Different types of waste are generated in each zone. The park near the mouth is often strewn with litter, which then blows into the river. This is a result of the bins being uncapped during heavy winds the contents of the bins is displaced over the park and subsequently swept into the river. There is also general littering derived from careless human activity. For example: the park is a fishing hotspot but none of the bins are located near the riverbed and so several fishermen discard their waste on the floor.

Figure 44. Land-use in the bounded catchment. Source: eThekwini GIS

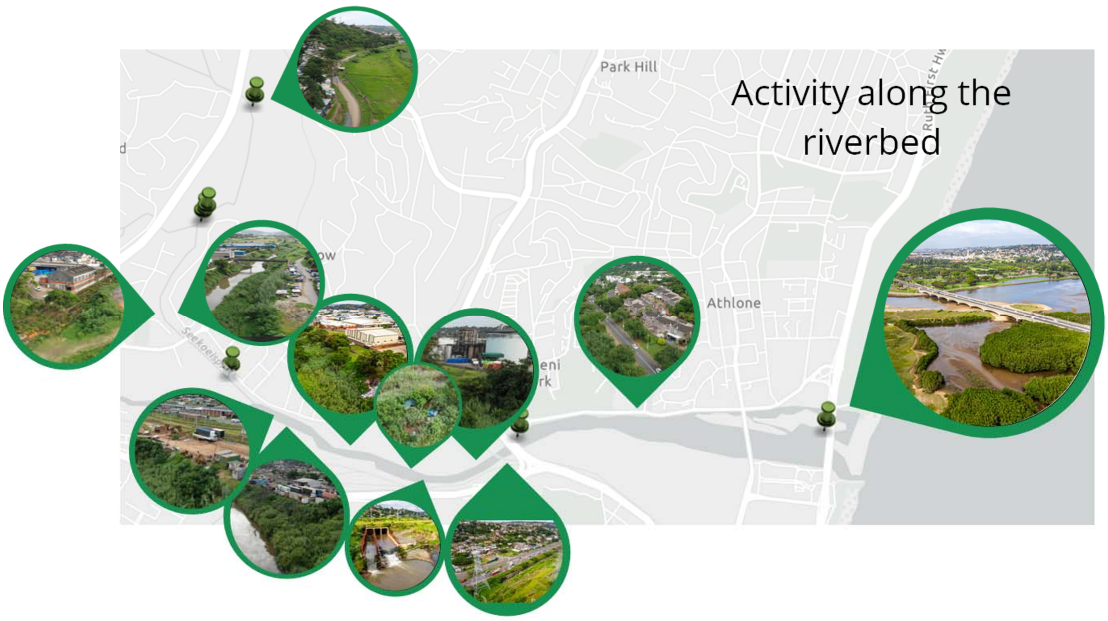


Figure 45. Activity along the river bank

The residential area on the northern banks is serviced regularly by DSW. As it is a middle income area, the residents have the means to store and manage their waste until it is collected. Therefore, this is not considered a high-priority waste area. Although the industrial areas are also serviced by DSW regularly, there appears to be a greater disregard for waste generation and several informal dumping spots lie between the factories and the river. The irregular servicing and lack of resources in the informal settlements has resulted in the formation of many informal dumping spots, illustrated in Figure 46. These dumping spots act as waste entry hotspots into the river because when it rains or there are heavy winds, the litter is swept into the river.

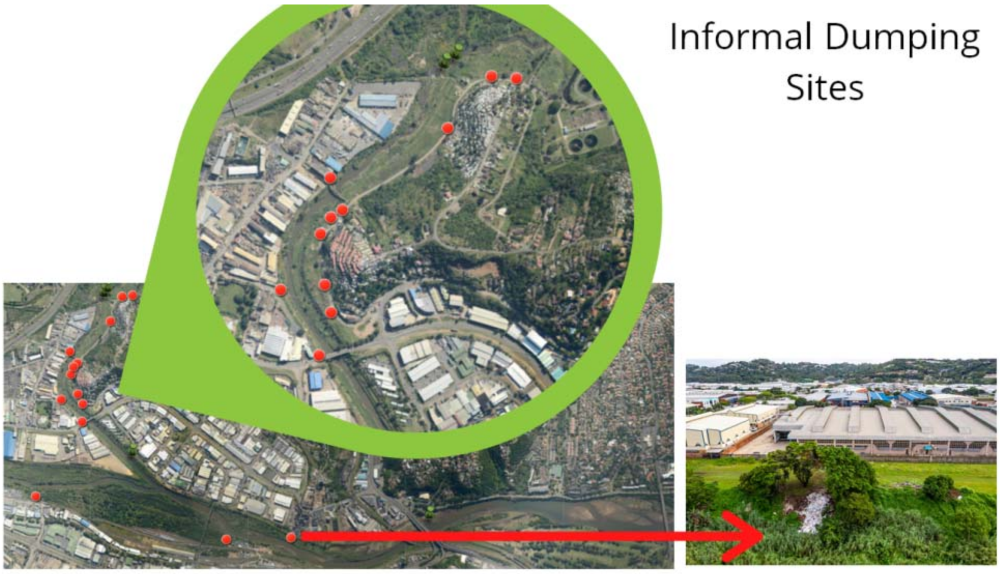


Figure 46. Informal dumping sites

5.4.1.3 Storm water waste

Litter that is scattered in the in-land in the greater catchment area enters the river via storm water pipes. Figure 47 illustrates all of the storm water pipe outlets into the Umgeni River and Umhlangane tributary. The amount of waste that exits these outlets is positively related to the area that the pipe services. The service area of each pipeline was determined by tracing the extend of the connected pipes, with a consideration of the fluvial flood lines and areas geomorphology. Each service area was then populated to determine the number of people that live in each area. It is hypothesized that the areas with the largest number of inhabitants (excluding industrial areas) will contribute the largest quantity of waste. Therefore these large pipe outlets are also considered to be waste entry hotspots.

Figure 47. Stormwater pipe service areas

5.4.2 Key stakeholders active in the Umgeni River mouth

A few stakeholders are currently active in the Umgeni River mouth area. These include academic research groups from the UKZN, municipal departments such as DSW and Economic Development, as well as a representation of the civil society in the form of several NPOs.

From the UKZN, the SARChI Chair in Waste and Climate Change (SCWCC) is actively involve for the past years in research related to plastic pollution, engaging with both the municipality and DGC. Recently, the SCWCC has signed a MOA with The Ocean Cleanup (TOC), an NPO specialized in plastic pollution in marine environments and development of advance technology. Other active NOPs in the area are Save our Rivers and The Litterboom Project (TLP).

As there is an overlapping influence in the area it is necessary to acknowledge the role that each organization plays. This section details the current system without making comment on it.

5.4.2.1 Partnership SARChI Waste and Climate Change and The Ocean Cleanup

The UKZN has signed MOA with TOC via the SCWCC with the purpose of researching the pathway of plastic pollution in the Umgeni River on its way to the Indian Ocean. The research project spans 3 years, staring in June 2021, with the main objective of to mapping plastic pollution hotspots and monitor plastic in the Umgeni River catchment and the coastline of Durban.

TOC is a NPO developing advanced technologies to clean the oceans of plastic. To accomplish this goal, they work with a dual approach: stopping the source and cleaning up what has already accumulated in the ocean. In April 2021, their research department published the paper "More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean" (Meijer *et al.*, 2021). The main finding of the study is that 1000 rivers, uniquely distributed around the world, are responsible for almost 80% of river plastic pollution.

This inequality is partially due to geography. In an archipelago like the Philippines, most of the population stay near the ocean, so the probabilities for a piece of disposal to make its way to the ocean are much higher than for a continental country like India or China. For this reason, the Philippines have a higher impact on ocean plastic pollution, even though the amount of mismanaged plastic generated in the latter two countries is much bigger. The main reason plastic pollution is unevenly distributed is the differences in quality of waste management policy and infrastructure around the world.

A pattern emerges when looking at the relationship between mismanaged waste and income. Low-income countries do not consume goods packed in plastic due to affordability. On the contrary, high-income countries consume the majority of plastic but have efficient waste collection and sanitation systems, preventing plastic from reaching the oceans. The result is that most of plastic pollution can be found in emerging economies with sufficient wealth to consume plastic but lack of adequate waste management systems.

TOC has undertaken the task of strategically select three of these rivers at a time and attempting their cleanup. On May 2021, t he University of KwaZulu-Natal and TOC signed an agreement to partner up in the exploration of mechanisms of plastic pollution in the Umgeni

River and its transportation through all seasons. This three-year research project defines a staged approach through mapping, trapping, collecting, processing, testing, modelling and social engaging. With the use of satellite imagery, airplanes and drones, river cameras, floating GPS trackers, "litter-boom" waste characterization, underwater sampling and beach litter characterization, the research is specifically seeking to find new insight into the seasonal dynamics of plastic waste transport through the Umgeni River system and provide a replicable model for cities in the West Indian Ocean (WIO) region.

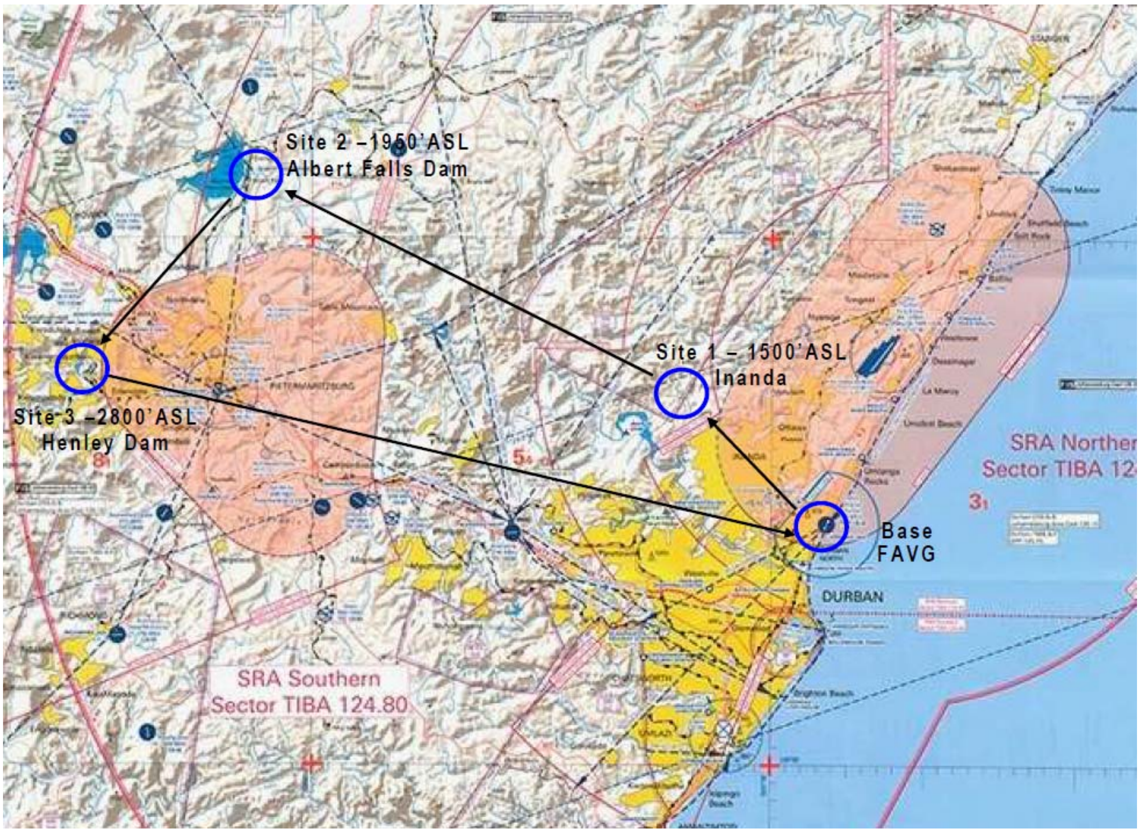


Figure 48. The Bateleurs flight plan.

The starting point of the research took place as a workshop was held between all involved stakeholders, including UKZN, TOC, the National Department of Science and Innovation (DSI) through the RDI Waste Roadmap, eThekwini municipality, The Bateleurs - a non-profit group of volunteer pilots who avail their aircraft for conservation causes - DGC and Sustainable Seas Trust (SEAS). The researcher, together with members from UKZN and The Ocean Cleanup, was assisted by The Bateleurs in a survey flight on the 27th of May 2021 (see Figure 48)

5.4.2.2 Durban Green Corridors

Durban Green Corridors (DGC) in a NGO that have operated 6 litterbooms (4 currently functioning) in the Umgeni. They work in conjunction with Power Rush, a waste preparation facility in KwaMashu, at a distance of 11 Km (see Figure 49).

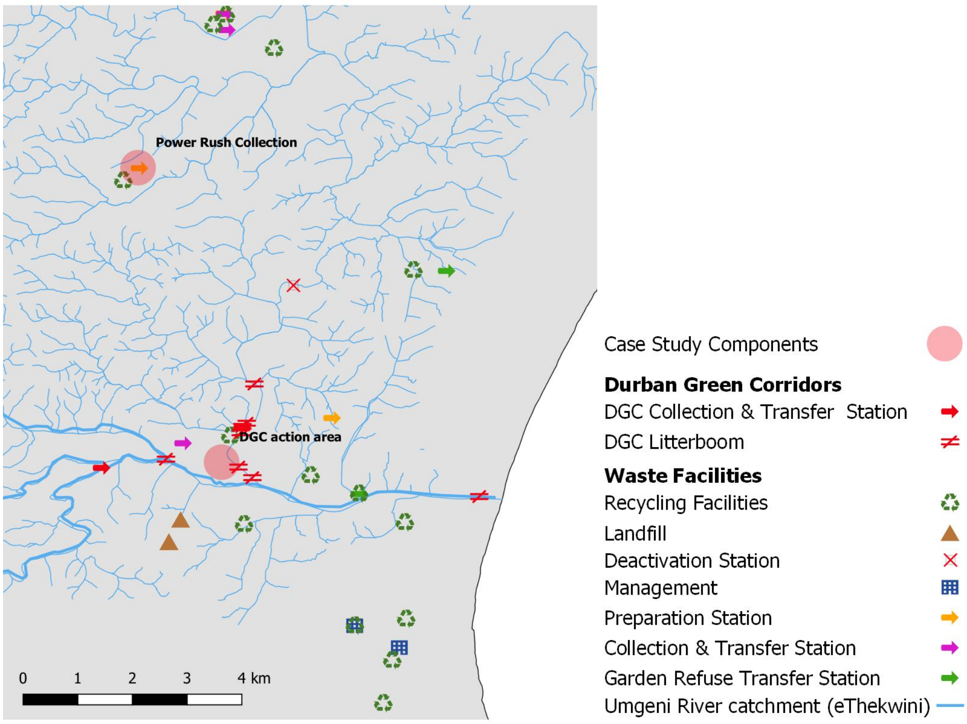


Figure 49. Durban Green Corridors operations

The location of these booms is illustrated in Figure 50. The booms are either made from 900mm PVC pipe or a line of 2l bottles secured with a meshing material. Both types are secured with nylon rope to an anchor.

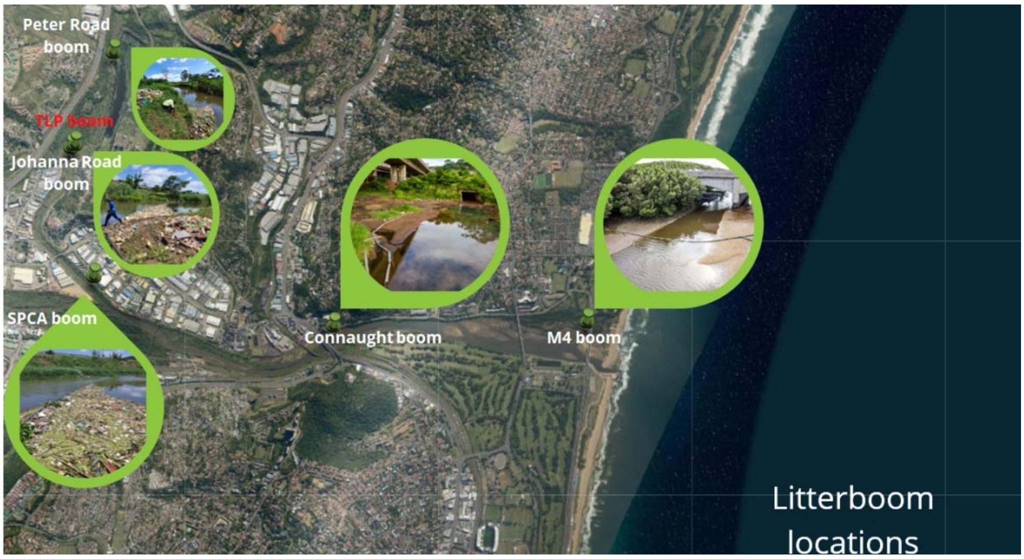


Figure 50. Litterboom locations

Figure 51 illustrates the distance along the riverbank between each boom.

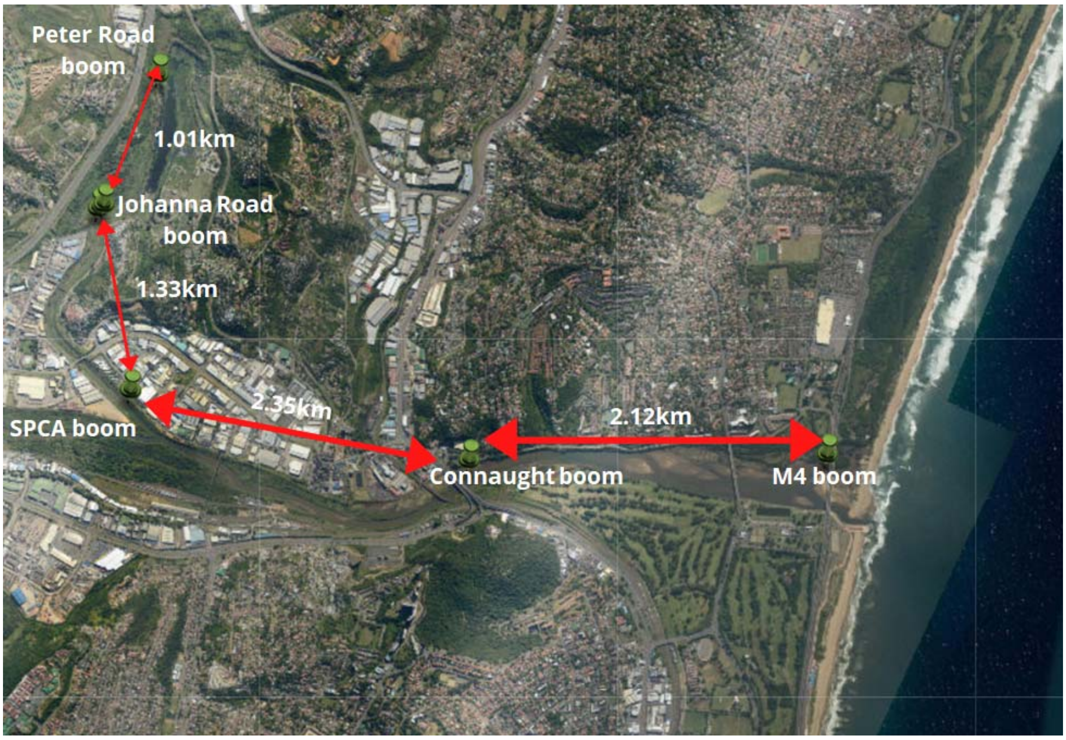


Figure 51. Distance between each litterboom

Table 14 provides the geo-location of each boom, material type and operation status.

Table 14. Durban Green Corridors litter booms

Name	Geo-location	Material	Operation status
M4	-29.8093278015, 31.0378286174	2l bottles and shade cloth	Functioning
Connaught	-29.809663329, 31.0161306399	2l bottles	Out of order
SPCA	-29.8059962147, 30.9954276275	PVC pipe	Functioning
Johanna Road	-29.7964609987, 30.9933533366	PVC pipe	Functioning
Peter Road	-29.7894471193, 30.9969009112	PVC pipe	Functioning
Quarry Road	n/a	n/a	Out of order

The means available for DGC are as follow:

- **Staff:** The team consists of one administrative project managed, one manager, two waste pickers and one waste collector.
- **Material resources:** 1 kayak, 1 paddle, 5 litter booms, 1 fishing net, 1 pickup truck, 1 smart phone app, 2 laptops and a few 1 m^3 polyethylene bags.
- **Booms:** The device consists of an anchor (a large, buried rock), a connection material (a weak nylon rope) and the boom (either a 900mm PVC pipe with two end caps or a series of 2l bottles). The booms are placed diagonally so that the current transports the litter to the bank (see Figure 52).

Figure 52. DGC litterboom at Johanna Road

The booms are placed either after informal settlements, at storm water outlets or where tributaries join the river. Accessibility is a key factor in determining the location of the booms. The Connaught, SPCA and Johanna Road booms can be easily reached with a car. The M4 and Peter Road Boom require approximately 100m of bush walking to reach. The booms are serviced every 2 weeks to ensure that they are fit for operation.

The Johanna Road boom is the oldest and was implemented in 2014, followed by the M4 boom (2015), SPCA boom, Connaught boom and then the Peters Road Boom. The Johanna Road, M4 and Connaugh booms are the main booms with the SPCA and Peters Road Booms in support of the Johanna Road Boom.

The collection procedure appears arduous: all of the booms need to be monitored manually. A team of waste collectors drive to the various booms to establish their status and determine their collection plan. The waste collectors use their hands and the pool net. The waste is thrown on to the river bank, where it accumulates. The boom is not necessarily fully emptied in one day. The waste from Connaught and Peter Road Booms are placed in large polyethylene bags and transported to Johanna Road (by kayak and car). The waste is then separated at Johanna Road (Connaught, Peter Road and Johanna Road Booms) and at the SPCA boom. The waste is separated into PET and plastics; tins; paper and cardboard; polystyrene; and general waste. The waste from the M4 boom is classified and placed into large bags and transported using a kayak to the DSW collection site on the Southern riverbank. The PET and plastics, tins, cardboard and paper are transported to Power Rush in KwaMashu (see Figure 55). At Power Rush the pickup truck loaded with waste is weighed. The waste is removed and the pickup truck is weighted again to establish the quantity of waste that has been delivered. Both of these readings are rounded to the nearest 10kg. DGC has an account with PowerRush and so no money physically passes hands.

Table 15 summarizes the rate for the different materials. The polystyrene is taken to another recycling unit in KwaMashu run by Jonathan Welch while the general waste is taken to the dumping zone for DSW to collect.

Table 15. DGC Rate for different materials

Material	PET	Plastic	Milk/mass bottles	Aluminium	Tin	Paper	Cardboard
Rate (R)	2.7	2	1	2	2	0.7	0.6

The standard week routine during the period of observation follows as below:

Monday: Johanna Road

Tuesday: Johanna Road

Wednesday: Peter Road, SPCA and Connaught

Thursday: SPCA

Records: Once a delivery has been made, the waste collector records the quantity of waste delivered on a smart phone app, with an attached photograph. The photograph feature was not working at the time of observation. Table 16 shows all of the entries to the end of field work.

Table 16. DGC litterboom collection records

Date	**Separation unit**	**Quantity(kg)**	**Quality**
3 Sept 2019	Quarry Road		
2 Oct 2019	Johanna Road	180	PET
9 Oct 2019	Johanna Road	30	PET
10 Oct 2019	Johanna Road	130	PET
14 Oct 2019	Johanna Road	90	PET
8 Nov 2019	Johanna Road	80	PET
12 Nov 2019	Johanna Road	60	PET
13 Nov 2019	M4	400	PET
19 Nov 2019	Green Hub	370	PET
12 Dec 2019	Johanna Road	80	PET
16 Jan 2020	Johanna Road	80	PET

Four full polyethylene bags can be loaded on the pickup truck at a time. This accounts to a weight of approximately 90kg per trip (see Figure 55).

5.4.2.3 Save our Rivers

Save our Rivers is a civil society championed by Janet Simpkins. The ADReach Team, sponsored by ADReach, comprises of 6 waste pickers that collect waste in the Beachwood Mangroves and on the beaches South and North of the Umgeni River Mouth. The team work from 8am-4pm from Monday to Thursday collecting waste. On a Friday they receive training/education from The Wildlife and Environment Society of South Africa (WESSA). The team was initiated in July 2019 and since then has collected 9,132 bags of litter. Table 17 shows the quantities collected each month. The team decides where to collect each week depending on where they feel it is needed. According to the team leader, the Beachwood Mangroves are a hotspot for waste. The bags are stockpiled near the collection point and when they have a large enough quantity they are loaded onto kayaks and transported to the DSW collection site on the Southern banks of the river. DSW then removes the waste.

Table 17. Quantity of bags of litter collected by the ADReach Team

Month	**Quantity of bags**
July 2019	1731
August 2019	1496
September 2019	803
October 2019	1126
November 2019	1326
December 2019	989
January 2020	1661

A large portion of this litter is fine pieces of polystyrene which are exceptionally difficult and time-consuming to collect. The perception of the waste n site can be misleading. The researcher witnessed a collection operation with the result of little progress despite the amount of waste collected. The rate for one hour of collection in an area of 2 m^2 was 400 litres (8 bags of 50 litres each).

5.4.2.4 Durban Solid Waste

Durban Solid Waste is the municipal department responsible for waste collection in Durban. They have a team that collects waste on the beaches on the Southern side of the river mouth as well as trucks which collect waste from various collection points.

DSW has implemented a pilot project related to the recycling of the plastic waste collected, with base in KwaMashu. The waste is classified and used as raw material for the manufacturing of pavers. The circular economy approach is at the core of the project which aims to ease the economic pressure on the municipal budget due to construction materials, paving in this case.

5.4.2.5 The Litterboom Project

The Litterboom Project (TLP), an NGO founded in 2017, aims to reduce the quantity of waste entering the sea by trapping it while it is still in the river system. TLP has a presence in 5 rivers in South Africa. The TLP has a boom located in a tributary that joins the Umgeni 4.5km before the mouth. This boom is located near the Johanna Road informal settlement, as illustrated in red on Figure 50. The boom is located between two of DGC's booms and was out of order during the site visit on 29th of January 2020. The TLP is staffed by Yes4Youth Employees and there are four employees responsible for each boom. The TLP also have a team that clear plastic between the M4 bridge and Connaught bridge.

5.4.3 Analysis of the litterboom system

This section analyses the waste management system discussed above to identify areas requiring improvement. The large quantity of litter collected by the ADReach team indicates that despite the presence of the litter traps, there is still a large quantity of litter reaching the river mouth. This can be attributed to the lack of litter booms in the main river, pollution generated near the river mouth and inefficiencies in the current litter trap system.

It has been decided to focus on the litterbooms that DGC have installed for the following reasons:

- They have more booms present in the catchment than TLP
- They have a boom on either side of the TLP boom. The presence of these booms is likely to affect the quantity of waste collected at the TLP boom.
- They have more readily available data

Currently the litterboom waste management system as well as the boom design is very rudimentary.

5.4.3.1 Litterboom Waste Management System

The waste collection process is extremely time consuming as only two bottles can be removed with the net at each fish (see Figure 53). The waste is then placed loose on the bank and so can easily fall back into the river if it rains or the wind blows. If the collectors are working at Peter Road boom, this waste then needs to be loaded into a packet, paddled down the river, unpacked, separated and then packed again. Essentially it is being handled five times, which is very time consuming. There is a need for a better method of waste collection and separation. As the entire boom is not emptied at once, there is a build-up of waste. When the wind blows lightly it picks up PET bottles and blows them past the boom. Bottle caps are not accepted at Power Rush and so many of these are scattered on the floor at the separation location (see Figure 54).

Figure 53. DGC waste collector

Figure 54. Collection point at Johanna Road

Figure 55. DGC loaded pickup truck at Power Rush KwaMashu facilities

Furthermore, the waste from Connaught, Peter Road and Johanna Road is mixed together before a recording of waste quantity is made. Therefore, there are no records for the quantity of waste collected at each location, making extremely difficult to determine the waste entry points. The quality of waste is also not currently documented- with only records of PET, which misleads to thinking that mostly PET is captured by the litterbooms. There is even a misconception at the administrative office that polystyrene and the likes are not collected.

In order to determine the efficiency of the boom and optimise its design, it is necessary to know what waste it catches and what it doesn't. Currently, there is no record of the relationship between the quantity of waste collected and rainfall- which is a contributing factor to waste entering riverine systems. Acquiring this data will help develop a waste flow chart. This could be utilised to predict the state of the litterbooms (how full they are) and develop a working timetable for the team. Currently, in order for the team to determine the state of each boom the waste collector has to drive there and take photographs. This is a time consuming and costly activity. However, as South Africa has a high unemployment rate, it is to be carefully consider the implementation of technology aided systems as this project is a good opportunity to create jobs. It is also worth considering whether the implementation of monitored system is in fact necessary.

5.4.3.2 Litterboom Design

Currently the litterboom design is very rudimentary and during heavy rains the booms are prone to breaking. The rope connections prove to be the weak point, coming undone. As a result the boom itself has not yet broken- which may be the purpose for this design. Figure 52 illustrates the rope connections at both the boom end and anchor.

The rope does not have enough slack and at low tides the boom hangs above the river, allowing litter to pass below it.

A positive aspect of the rudimentary design is that it is cost effective and easy to repair if the boom is broken. Moreover, he boom is not seen as something valuable and so it is unlikely to be stolen. However, the quart nightly litterboom checks are time consuming and so it is important to design a more stable boom that will not require these.

5.4.3.3 Litterboom Location

The boom locations have primarily been chosen based on accessibility for both, vehicles and kayaks. Consideration has also been given to the stormwater entry points, with the Connaught boom directly capturing waste from one such point. The project co-coordinator has also considered placing booms just before the confluence of tributaries to the Umgeni. Currently, there appears to be adequate consideration being given to boom locations. However, in order to determine whether the locations are optimal, a season of data acquisition at the booms will be necessary.

5.4.4 Plastic waste characterization in the Umgeni River Mouth

The waste characterization included in this study has been conducted under the umbrella of the SARChI Chair in Waste and Climate Change, by the master student Muhammad Khan, supervised by Prof. Cristina Trois. The researcher assisted in documenting the process.

The waste stream analysis has been carried out to characterise and quantify waste along the Umhlangane tributary entering the Umgeni River. The data collection took place during the second week of December 2020. For seven days, waste was collected from two litterbooms installed by DGC: SPCA and Johanna Road. Waste was then sorted into material types and quantified. The material types trapped in the litterbooms were cardboard and paper, glass, vegetative matter, metal, textile, rubber, PETE, HDPE, PVC, LDPE, PP and PS. Other materials and refuse were trapped and categorized as miscellaneous.

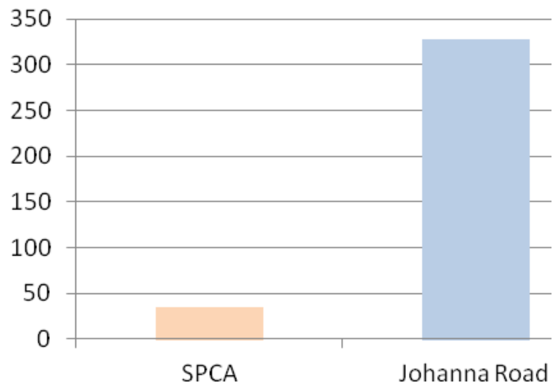


Figure 56. Quantity of waste trapped by the litterbooms (Kg)

The waste was directly collected from the water and therefore, the weights correspond to dirty and wet mass. A total of 361.30 kilograms of waste was trapped and analysed in both litterbooms: 34.16 Kg in SPCA and 327.14 in Johanna Road (see Figure 56). This comparison brings some questions regarding the location of the SPCA litterboom: the area covered might be not particularly conflicted in terms of plastic waste emission, the efficiency of the technology which the litterboom has been made of might be not particularly efficient or the river flow might be not particularly strong during these days.

Figure 57 shows the composition of the waste trapped by the litterbooms sorted by types of material. Of the total waste trapped in the litterbooms, almost 56% was plastic. The second larger group corresponded to vegetative matter (33.49%). This might be seen evident as litterbooms are mitigation means for floating debris. Plastic waste was later sorted in the several types found in the litterbooms.

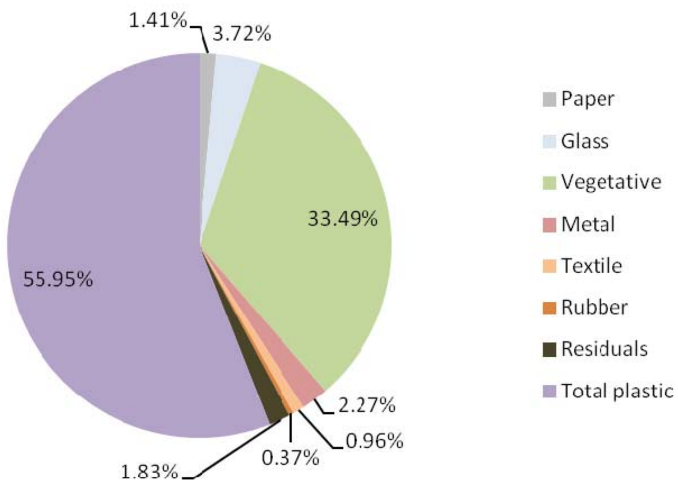


Figure 57. Composition of waste trapped by the litterbooms

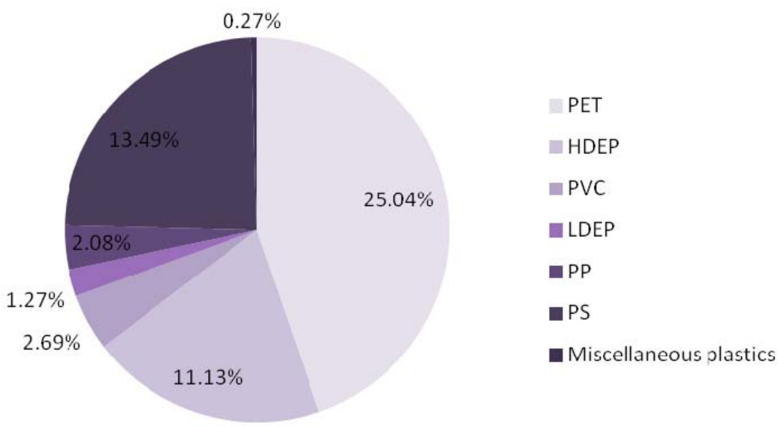


Figure 58. Composition of plastic fraction trapped by the litterbooms

The composition of plastic waste specifically is presented in Figure 58. Within the group of plastics, PET, HDEP and PS are the most common materials, representing almost 50% of the overall waste trapped. The uses found are mostly packaging and bottles in the case of HDEP.

5.4.5 River waste data collection strategies

It is important to define the problem to solve in order to specifically design a data collection strategy. The plastic pollution has three aspects to consider: 1. plastic pollution in the water, either floating or underwater, 2. polluted river banks, and 3. marine plastic pollution. All three problems would be sorted out if paths of waste entries are located, assessed and controlled. An integrated and efficient municipal waste management can reduce the amount of plastic entering the river streams. Due to limited resources and expertise, waste management strategies lack of consistency and efficiency. Testimonials from waste collectors point out that this inconsistent situation is exacerbated by the irregular behaviour of plastic movement within the river stream, associated to rainfall, flow speed and waste generation.

A river drainage basin scale strategy could determine the origin and quantity of plastic in the river by municipalities. Overlapping the results to both, territorial zoning of the basin and waste management strategies in the different areas can be a useful tool to approach the problem in an efficient manner. From exhaustive and resource demanding level to cost efficient and strategized methods, these are the type of data collection strategies that can be put in place:

a) A systematic assessment would advise for the location of litter booms in all 52 tributaries plus one in the river mouth, in order to gauge the amount of plastic contributed by each river and by extension, riverine area.
b) Grouping the tributaries by outlet tributaries in which they merge. This reduce the number of collection points to ten:

    - Umgeni Municipality: Umgeni River, Karkloof River
    - Msunduzi Municipality: uMsunduze River
    - uMshwathi Municipality: Mpolweni River, Umgeni River
    - Mkhambathini Municipality: uMsunduze River, Umgeni River
    - eThekwini Municipality: Mqeku River, Umgeni River, Palmet River

- This method helps to discard locations initially identified as potential plastic entry.

c) Analysis of the dams' outlet water and shores. There are five dams located in the Umgeni River catchment. Dams can slow down and divert the transit of plastic in the river. Part of the plastic will end up stranded on the shores. In this case, the analysis of the shores is an accessible task, unlike the analysis of river banks, and gives indications of the plastic entered upstream. However, dams group tributaries from several municipalities, and therefore it is a less accurate method to identify plastic entry points and put it in relationship with waste management strategies.

d) Analysis of the river mouth. This is the case of the current set up managed by the aforementioned associations. The main goal of this option is stopping marine plastic pollution. Data collected from this set up lacks of dimension in terms of origin and river banks pollution.

5.4.5.1 SARChI Chair data collection methodology

The SARChI Chair in Waste and Climate Change (SCWCC) and TOC have started their activities recently. However, despite the limited time, their presence has attracted the attention of all stakeholders currently assessing the problem of plastic pollution in the Umgeni River as well as the media. For the purpose of this research, their initial plan is to be taken into account and analyzed in conjunction with the rest of stakeholders.

SCWCC and TOC have structured their operations through a research-base approach structured in 4 pieces: source, deposition, cross sectional distribution water body and ocean emission. They have stratified the collection of quantitative data in seven layers: satellite imagery, Unmanned Aerial Vehicles (UAV) imagery, camera survey, surface/riverbank samples, GPS trackers, water column samples and riverbed samples.

The purpose for satellite imagery is indicated in Figure 59. Plastic accumulation, detection of entry points and hotspots and plastic debris on water surface are the tree main elements targeted with the satellite.

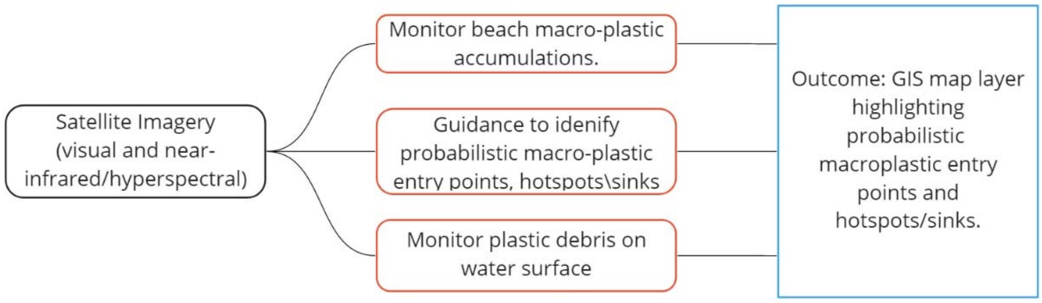


Figure 59. SCWCC satellite imagery data collection outcomes

After the workshop hosted by Prof. Cristina Trois (SCWCC) on 'Mapping Plastic Pollution in the uMgeni River' on the 24th of May 2021, satellite imagery was initially discarded. The presentation from Dr. Michael Gebreslasie raised concerns about the efficiency in the identification of data and the cost implication. The data processing of such imagery show the locations of deposits of debris, unable however to accurately identify amount and composition. Moreover, the use of satellite imagery in a regular basis might increase substantially the initial budget due to the average price rate of $1,500 per image. This decision has put the focus on aerial imagery, both piloted flights and UAV.

The next layer of data corresponds to UAV imagery. Figure 60 presents the purpose for a close up imagery: quality of hotspots and waste characterization, quantitative monitoring of hotspots and movement of hotspots on land.

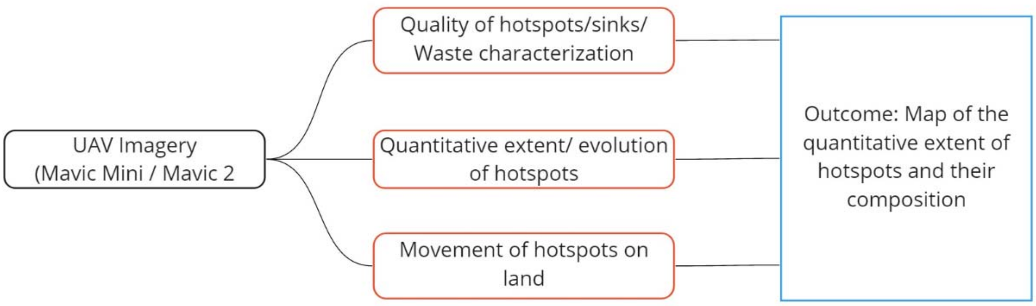


Figure 60. SCWCC UAV imagery data collection outcomes

The visual survey through fixed cameras presented in Figure 61. It aims to collect data related to fluxes of plastic on river transects and monitor flow speed. The data from the cameras is to be then displayed on an integrated mapping.

The discussion about the camera monitoring turns around challenges related to vandalism and stolen units. Unlike the GPS trackers, hidden inside waste looking artefacts and mostly inaccessible, cameras will be located in more accessible areas. The use of existing municipal cameras has been considered as a viable option.

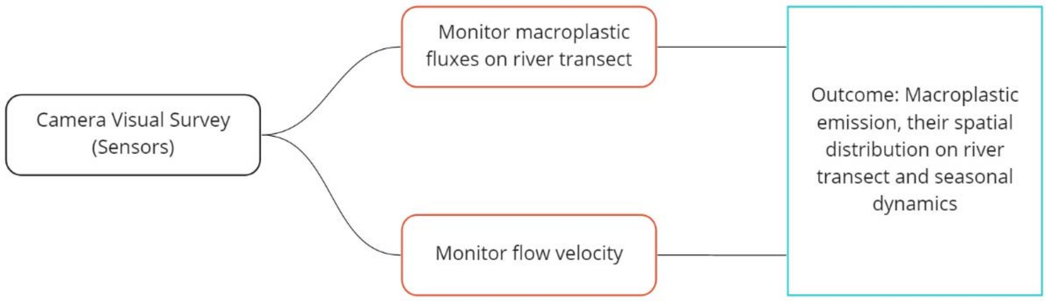


Figure 61. SCWCC camera visual survey data collection outcomes

Regarding waste characterization in both, riverbanks and ocean shores, the UKZN has committed the task to master students. A waste characterization of the DGC's litterboom located in Johanna Road has been finalized already.

In order to collect data on debris displacement, 100 GPS labelled trackers will be deployed repeatedly in different sections of the river and tributaries. Two trackers have been deployed as testing exercise. The results show little movement. This might be due to the low river stream flow during the dry season. No major rainfalls have been registered during the testing time. This exercise has strengthened the idea of tracking during different seasons and more important, the need of a substantial amount of trackers located in different places.

The ultimate outcome of SCWCC and TOC operations is to identify entry points and the behaviour of plastic in the river, and efficiently assist with the implementation of an integrated and multifaceted system to clean the Umgeni River from plastic, but most importantly, stop plastic from entering the ocean.

5.5 An overview of waste treatment facilities in eThekwini

eThekwini Municipality reaches most of homesteads and residents with a planned municipal collection services. 87.9% based on the data from Stats SA. The service is delivered by the municipal department DSW, with a frequency of once a week for most areas. A number of waste transfer stations and landfills are distributed within the municipal boundary. To date, no waste separation is implemented in the waste collection process at residential level. Waste separation depends on individual initiatives that make the effort to carry the refuses to dedicated collection stations.

The private sector is also present in the field of waste management. In this case, the facilities are oriented to both, preparation and transfer of specific types of waste: fundamentally paper, plastic, glass and metals; and a few processing plants undertaking recycling.

The informal sector is to be acknowledged as well. Informal waste pickers carry a first step in waste separation, either at source or once the refuse is in the landfill. Several civil society groups and NGO's are involved in improving the life condition of waste pickers (Mkhize, Dube and Quazi, 2014).

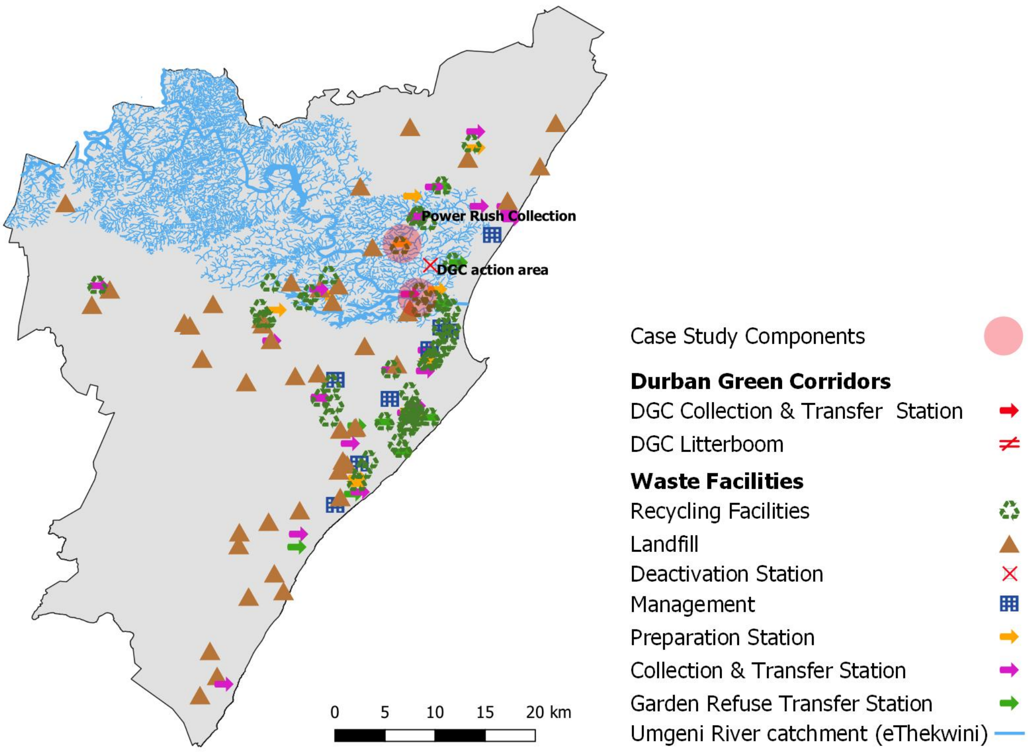


Figure 62. Waste treatment facilities in eThekwini

In recent years, some companies specialized in waste management have started activities in the city. They offer assistance with the implementation of waste optimization at different levels.

In order to foresee the potential of the definition of logistic corridors specialized in waste management that might facilitate relationships among the stakeholders on one hand, and the possibilities to improve the functionality of the case study, Figure 62 shows the location of the waste treatment facilities in eThekwini. The map is a combination of the information available by the eThekwini GIS service and a search in the Yellow Pages and Google Maps. Although this study has not examined the capacity of such facilities in terms of operations volume and management capacity, the map shows the presence of a diverse scenario when it comes to waste facilities. Therefore, further research is to be conducted in order to find out the reasons for a high number of informal dumping sites.

6 RESULTS AND DISCUSSION

6.1 Introduction

In this chapter, the data from the main sources used in the research is presented: GIS, literature and testimonials from the stakeholders involved in the case study. The analysis and results are presented through figures and tables with reference to the aim of the study. The meaning of a Southern African suitable sustainably resilience and Smart City has been stressed through the analysis of systems of measurement specific for sustainability, resilience and Smart City. The result is a hybrid matrix of relevant indicators which selection is based on the extensive literature review on Southern African cities.

The chapter analyses in detail the socio-political readiness for the implementation of smart initiatives in the province of KwaZulu-Natal and eThekwini Municipality based on basic requirements found in the literature which overlap with statistical data transferred to GIS models multiple scales. The importance of this analysis lays on the capacity to define the characteristics of the actual socio-technical fabric in which develop smart initiatives, with its weakness and strong points. Therefore, it represents a tool for decision making based on knowledge-based information.

Despite the study being framed within the engineering sector, the research design has intentionally avoided a straightforward methodology that might miss important aspects of the context in which engineering methods are applied. The research methodology of the study has paid considerable attention to the understanding of urban dynamics in the Southern Africa and find out what is already in place. A combination of academic literature and reports from reputable sources with opposite scopes such as NPOs and private consultants has helped to draw an overall picture of the state of the art of the southern African cities.

The length of the research process of almost 6 years has allowed for comparison of data during this time, especially for the work done based on the mentioned reports. However, official data from national statistics agencies have been considered only once due to the lapse of 10 years for the update of census. This highlights the differences in agility between public and private sector when it comes to the use of indicators and the importance of dealing with updated data.

In any case, the public sector has proved to be ineffective as is the case of eThekwini, which appoints external consultants to address data harvesting and analysis.

The accessibility of data has experienced changes during the research. For instance, the availability of GIS data on the internet experiences a high level of volatility. Some of the data initially available is now blocked or no longer included in the websites. A sample of this is the data once available from the SA Dept. of Health:

(https://sarva.saeon.ac.za/metadata/department-of-water-and-sanitation)

This situation raises questions on who controls the data. Partnership between public and private sector appears as a way to move forward regarding data harvesting although ownership of data and information leaks threaten the transparency and confidentiality expected from public agencies.

The case study gives the opportunity to study a multifaceted urban problem: It includes sustainable concerns, technical solutions to solve an environmental problem, municipal decision making and capacity, and engagement from the civil society. It has been detailed mapped and testimonials from the stakeholders, and presence of the case in the media, have been systematically catalogued and analysed.

The response and activities from several stakeholders involved in the case study have been documented and analysed. A remarkable concern on the effects on the environment and the population directly affected by the plastic pollution of the Umgeni River has been detected from all stakeholders. The problem has been tracked by the media, locally and internationally. This press has awakened awareness, leading to a number of agreements and plans implementation with the involvement of national and international agencies. The problem of the plastic pollution is unanimously acknowledged by the participants and the importance and urgency of bringing solutions has been stated by all stakeholders.

6.2 Common features in the Southern African city. Technological readiness and sustainable resilience.

Africa is considered by many as the last frontier of development. Many places in Southern Africa remain in pristine condition where wild animals roam unfenced. But this vision has a double side. On one hand, Africa has the potential to be the scenario in which applying lessons learnt from the past and skip the burden of mistakes correction: the famous leapfrogging. It is a blank canvas in which genuine uninterested good ideas might be applied seeking the wellbeing of the inhabitants. On the other hand, Africa is the place in which international lobbies have the last chance to continue doing what they know best: the unsustainable extraction of natural resources, the use of fossil energy and the exploitation of workers.

This polarity is the characteristic that has sparked the idea for this research, which starts with the hypothesis of specific urban features of the Southern African region being overlooked in the process of implementation of Smart City projects, and rather than allowing for a solid development of the African cities, is exacerbating the gap between Southern Africa and the so called “Global North”, increasing inequalities and subjugating, once more, the African population, exposed to environmental, social and economic threats. The implementation of foreign technological frameworks and the consequent superficial technology appropriation encounters a weak foundation lacking of accumulated knowledge, rendering the African urban context vulnerable to external actors.

In order to achieve a level of replicability in the research, applied to a geographical context with socio-cultural similarities, the study started with the search for common features in the Southern African cities. The foundation of the current cities in the region was not undertaken by natives, yet by foreigners with economic purposes. This is not an isolated event in the history of human settlements. Phoenicians, indigenous from present-day Syria, founded trading cities all over the Mediterranean shores from 1,500 B.C. to 300 B.C. Samples of these are Carthage and Gades (present-day Tunisia, Tunisia and Cádiz, Spain). In Southern Africa, the remains of ancient structures indicate the existence of human settlements with a sophisticated level of social organization. Such is the case of Great Zimbabwe in Zimbabwe, Mapungubwe in Limpopo, South Africa, both from the 11th century, or the recently discovered city of Kweneng, in Gauteng, South Africa, from the 15th Century. Despite these locations were centers for governance and social organization, the features of the settlements remain fundamentally rural.

The lifestyle of these communities is associated to the land, unlike urban centers in other regions of the world, in which new groups of individuals have emancipated from the linkage to the land, conforming new social categories. The aforementioned settlements were abandoned in the 19th centuries due to tribal wars and the pressure from colonial forces.

The current urban landscape is derived from the urban conceptualization and the cities founded by Portuguese, Dutch and English. Except for Luanda and Cape Town, all capitals and major cities in Southern Africa are founded in the 19th and early 20th centuries. These foreign conceptualizations of human settlement brought along equally foreign technologies. There is a Zulu term for city: *esilungwini*. It means “the place of the white man” or “where the white man resides”. It pictures very clearly the origin of the relationship of indigenous African people with the western concept of polis inherited from Greece, which still relates to the nowadays concept of city. In Southern Africa, the urban experience requires cultural adaptation. In contrast with other regions in the world in which small urban centers for governance and service provision can be found in rural areas, in Southern Africa, rural areas are enormous extensions of residential sprawl based on economies of subsistence, with no reference to urbanization. Moreover, the integration within the urban arena has been ruled by segregation, impeding rural migrants to fully submerge in the urban landscape. The apprehension of a complete urban experience has been capped for the majority of the inhabitants of the city. This situation has resulted in fragmented cities with large scars in the form of infrastructures, mainly railways and highways, that rather than linking, separate areas of the city.

The footprint of colonialism can be perceived by the status of territorial planning in the region: a few large and dominant cities are strategically located for governance and international connectivity where the colonial elite settled. These cities host ports and airports together with the majority of urban population, whereas the rest of the country remains rural and underdeveloped. These cities have become the economic hubs of the countries. The post-colonial transfer of power allowed for free movement of people who perceived cities as a kind of panacea to solve their struggles. This migration intensity together with lack of municipal capacity has derived in unprecedented pressure on urban services and resulted in a dysfunctional urban performance. The South African province of KwaZulu-Natal has been analysed, mapping demographic data from a territorial perspective in section 5.2. The results reflect this historical trend with absolute accuracy. With a total of 11.5 million inhabitants, one in every three inhabitants of the province lives in Durban (3,442,361), which is also the municipality with higher a density in the province. The ambitions of modernity that once shaped Durban, with a world class CBD and very low density suburbs, seems to have been sustained by the Group Areas Act. At the moment of this discriminatory law being repealed and free movement of all South Africans allowed, the city is perceived a destination to overcome poverty and achieve prosperity, attracting migrants although Durban has proved to be unable to welcome migration as could be expected, with an increasing population dwelling in informal settlement up to 35% today.

This situation exacerbates the problems related to the embedded case study of the Umgeni River. Even though the Umgeni river drainage basin intersects with 9 municipalities, only eThekwini and Msunduzi are potentially able to address the problem of plastic waste entering the river stream and finally the Indian Ocean. While it is true that only Msunduzi might substantially contribute to the problem upstream, based on the level of urbanization, other municipalities that are prominently rural not only lack of waste management plans but 75% of homestead manage their own waste with individual dumpsites. Despite the lack of data, those settlements close to the river are assumed to contribute at some level.

The urban competitive approach that most city managers adopt seeking for external investment has an impact in both, the inhabitants and the environment. Prioritization of economic targets clashes with sustainable policies overlooking potential hazards. Solving problems related to human capital, labour skills and poverty overnight convenes old formulas that are applied either seeking for quick results or allowing for the appointment of outdated service providers. Despite this narrative, inequality rates grow exponentially. The political agendas are far from echoing the priorities of the mass. High unemployment rates, low productivity labour and lack of appropriate service delivery exert tremendous pressure on the citizens to keep the pace of developmental plans that leave them aside. In addition, the case of urban growth in the Southern African region is particularly sensible due to the proximity to wilderness areas. The more highways are built, the faster the urban sprawl and uncontrolled growth happen, with great impact on the ecosystems.

This inequality also reflects in the use of ICT. In eThekwini, not even 50% of the population has access to internet. The potential level of digital divide in the province has been addressed in section 5.2.3. For most municipalities, the number of households with access to internet is lower than 20%. However, other means of communication such as cell phone and radio have a solid presence across the region and obviously across social classes.

The absence of public state and lack of political leadership have pushed many citizens to live outside the norms which does not necessary mean crime: informal dwelling, informal economy, informal tenure, informal ways of exercise power or even informal infrastructures as it is the case of the taxi industry in Southern Africa, which capitalize urban commuting, are more presents in developing countries than other developed regions in the world, in which informality is considered an anomaly. However, as it seen in many political discourses, narratives from the first world are paraphrased word by word aiming to create a welcoming atmosphere to foreign investment, not acknowledging informality at its core.

This paradox perpetuates the problem: the scale of informality in Southern Africa cannot be addressed as if it were an anomaly, and moreover, attempts to solve the problem with planning tools or infrastructure design that only look at urban features doesn’t work either. The approach to informality should be holistic. In fact, sociologist are more likely to be effective than urban planners and engineers. In the case of the Umgeni catchment, the section within eThekwini boundaries, few informal settlements are blamed as the main contributors of plastic entering the river stream. It is true that informal settlements might contribute to this problem more than formal areas. The reasons can be grouped in two categories: one is the level of awareness of environmental hazards among the population living in the informal settlements and the other is the absolute lack of service provision by the municipality in these areas, being urban waste collection the one with the higher impact on this problem for obvious reasons. Little is noticed about the industrial zones in the area which waste is not as visible as residential waste, as the waste characterization in section 5.4.4 shows.

Cities are intrinsically resilient systems. Ancient cities are still inhabited despite multiple processes of colonization and migration. At the same time, cities evolve as technology is developed. However, it is in the last few decades that great concern about sustainable development has emerged based on the exponential stress that cities put the environment under. Southern African cities are closer to corporate facilities than the traditional idea of a city. Founded by foreigners with economic purposes, inhabitants of these cities usually lack of the sense of belonging as can be seen in other parts of the world such as Rome, Cairo or Seville. Levels of pride and participation in the public life are low. In the case of South Africa, the levels of economic inequality and cultural diversity draw an even more conflicted scenario than the rest of the region. The economic elites of these cities could be categorized as seasonal. In fact, a number of wealthy people migrated after 1994, when apartheid ended. Other groups don't even reside in the city. This situation questions if whether Southern African cities have any chance to become resilient cities over the next couple of centuries, especially considering their high level of dysfunctionality.

This close look at the readiness of the Southern African context has detected on one hand, a misleading narrative from the private sector to speed up agendas related to the implementation of technologies without the solid infrastructural foundation and therefore a lack of efficient use of resources that engages with the actual social capacity to absorb such technology. On the other hand, the denial narrative from the public administration unable to recognize the collapse of the capacity within the public sector. A reflexion on leapfrogging becomes relevant. It is seen by many an appealing option for later technology adopters. Technology may not provide the expected results. Countries of the global south hope that similar benefits to those seen in developed countries will be achieved quickly. However, the availability of resources makes especially sensitive the definition of strategies and areas in which invest. Unlike the global north, unicorn approaches are not be affordable. This situation affects data collection strategies as well. Resource constrains make imperative to have clarity about the reasons for data collection campaigns and whether the data will be significant.

One of the key contributions of the research is the comprehensive synthesis of the features of the Southern African city and the challenges for sustainable development. New technologies are inevitable to be implemented in the future growth of cities, and urban management and planning will be assisted with sophisticated tools which might have a considerable impact in the quality of life of the inhabitants. The international agreement on the implementation of sustainable strategies for urban development cannot be denied to the region.

6.3 Relevant indicators of urban performance for Southern Africa

In this section, the researcher presents the process of identification of specific indicators for the Southern African context, starting from the selected international measurement systems discussed in chapter 3. A group of indicators that might be relevant for the Southern African urban context in line with the three main topics of the research: urban resilience, Smart City and urban sustainability. The final selection of relevant indicators for the region is the result of a process of rearrangement and purge of repeated and misplaced indicators in the selected systems, as well as based on the literature review. New indicators have been added to the final matrix in order to acknowledge urban features that are present in Southern Africa but not considered in other developed regions in the world.

The selection of indicators contained in this section is based on the literature review and it is extracted from the revision of measurement systems in section 3.3. Indicators related to national policies have been discarded as the study is centred in the city. An adaptation of the Smart City Wheel by B. Cohen (2012) has been proposed for the Southern African context (see Figure 65), which identifies the urban domains that need to be prioritized in order to implement the transition from resilient to sustainably resilient.

The main challenge to measure the performance of cities in Southern Africa is the lack and reliability of data. Measurement systems are based on arrays of indicators. As can be seen in section 3.3, there is not a fixed formula and many implications shape the final measurement system. The 6-key fields of performance developed by TU Vien is a good example of an overarching systems focused on the Smart City concept. This system has become the base for later systems applied to specific cities.

Given the literature on indicators of performance, this research has considered a large quantity of both, qualitative and quantitative indicators. The final cut contained in section 6.3 establishes a framework that is tailored for Southern Africa but it is not a ready-to-go model to be directly applied. Instead, it formulates a context in which measurement systems applied to Southern Africa can be developed from. The main challenge once again is the collection of updated and reliable data.

6.3.1 Rearrangement and purge of repeated indicators

After the analysis of all measurement systems selected for this study (see annexure 2), each system group the indicators within categories. Different systems have different names although overarching concepts can be recurrent in all systems. In order to approach all systems with a level of standardization, a set of categories can be identify to summarize equal concepts with different names. This initial set of categories represents a first step on understanding how a certain main topic, i.e. urban resilience, will put the accent on certain categories rather than others by allocating either a higher number of indicators or not even including some indicators that are important for other topics.

The initial set of categories is composed by 10 items: Economy, People, Governance, Infrastructures, Environment, Living, Energy (Infrastructure + Environment), Social (People + Living), Description and Miscellaneous. The set is applied across measurement systems from different topics.

Initially, the process of rearrangement and purge of repeated indicators has been defined by main topic separately: resilience, smartness and sustainability. In order to establish a consistent number of categories across measurement systems, all indicators have been classified according to the 10 aforementioned new categories. For instance, the ARUP + Rockefeller Foundation's City Resilience Framework establishes a category named *"Health and well-being"* that contains 14 indicators. This category fits into the definition of the category *"Living"* in the *Fields of Performance of the City* by TU Vien (Fertner *et al.*, 2007), which includes healthcare. However, these indicators cannot be automatically allocated to the new category defined in this study, also named "Living". Some indicators deal with economic matters: *"Supportive financing mechanisms"*, others deal with concepts aligned to governance and city management such as *"Effective emergency response services"*.

After rearranging and purging of indicators by separate topic (Urban Resilience, Smart City and Urban Sustainability) the number of indicators has been reduced from the initial 1,458 to 1,098. Despite the reduction of resulting indicators, some categories have increased their number. Social and miscellaneous indicators are relocated within other categories.

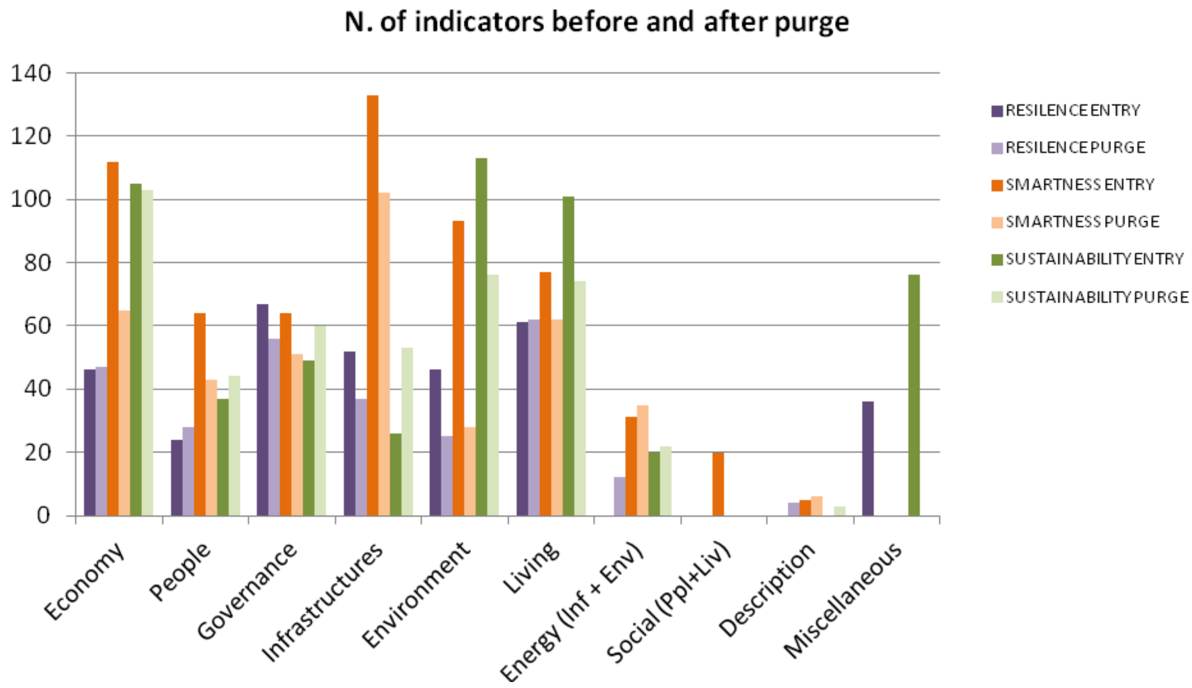


Figure 63. N. of indicators before and after the purge

Figure 63 shows the result of the rearrangement and purge of repeated indicators, classified by new categories, for each of the main topic (Urban Resilience, Smart City and Urban Sustainability). There is a reasonable reduction of indicators in the 'after purge' group. However, in the case of Urban Resilience, the categories of 'economy', 'people' and 'living' experience an increase due the rearrangement. Something similar happens to Sustainability in the category of 'governance'.

Indicators classified as miscellaneous before the rearrangement have been relocated in corresponding categories in order to avoid 'leaks' of valid data allocated in irrelevant categories. As seen in section 6.3.2, the categories 'miscellaneous' and 'description' will be removed from the final group of proposed categories for the Southern Africa.

6.3.2 Merging urban resilience + Smart City + urban sustainability

The next step in the process of extracting a relevant matrix of indicators for the Southern African context consists on merging all three systems of measurement and remove repeated indicators again. Some indicators are repeated within very similar terms. In other cases, some indicators are included in more complex indicators and therefore removed as well. After merging the systems, the result is a collection of 868 indicators related to specific issues. This implies that almost 40% of indicators are repeated either within the group of systems tackling the same topic or any system of measurement regardless the topic.

Economy appears as the category with the higher number of indicators, followed by Infrastructures and Living. Indicators previously included in the categories social and miscellaneous have been relocated in other categories in which they can add more value to the final assessment.

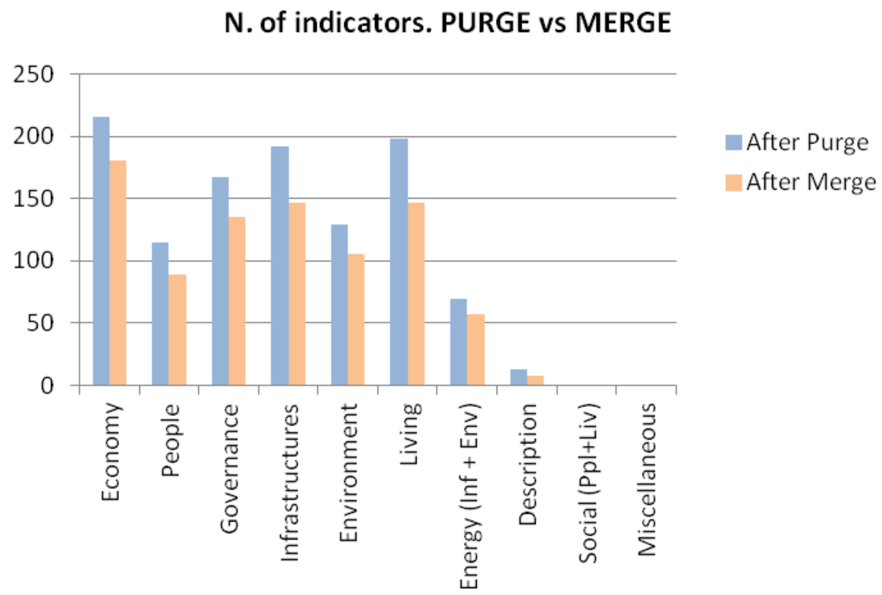


Figure 64. N. of indicators after merging topics

6.3.3 Proposed categories and subcategories for the Southern African sustainable city

The proposed group of categories includes: Economy, People, Governance, Environment, Infrastructures and Living. These categories breakdown in subcategories based on the selected indicators that are relevant for the region, detailed in Table 18.

The definition of this set of categories starts from concepts that are clearly independent from each other. This does not deny the existence of feedback loops that set relations between them. However, the intention is to set a clear process in the evaluation and assessment of the city that will ultimately aid city managers and policy makers on their tasks. For instance, *ISO/37122-2019. Sustainable cities and communities. Indicators for smart cities* bring two related concepts to the level of categories: *Solid waste* and *Water waste*. Although these will have specific features on their own, they will likely be managed by the same departments.

Other systems bring forward certain sectors of infrastructures as categories. *Ranking of European medium-sized cities* includes *Mobility*, *ITU-T Y.4901-L.1601. Key performance indicators related to the use of information and communication technology in smart sustainable cities* does the same with *ICT*. This situation has been avoided in the proposal of categories. Further on, these concepts are included as subcategories. However, highly specified concepts as the ones mentioned before regarding waste, are included in a subcategory, in this case waste.

Table 18. Proposed categories and subcategories

PROPOSED CATEGORIES AND SUBCATEGORIES					
Economy	**People**	**Governance**	**Environment**	**Infrastructures**	**Living**
Employment-Labour market	Education	Representation	Air quality	Energy	Housing
Informality	Equality	City management	Water bodies	Mobility	Health
Innovation	Inclusivity	Public perception	Vegetation	Water	Safety
Productivity-Economic performance	Open-mindedness	Civil society	Conservation	Waste	Culture
Development	Social cohesion	Accessibility	Natural hazards	ICT	Recreation
Entrepreneurship	Social diversity	Planning	Exploitation	Management	Tourism
Prosperity	Human capital	Policy	Other pollutants		
International presence			Environmental attractiveness		
Financial security					
Equality					
Attractiveness					

Figure 65. Proposed categories and subcategories of indicators for Southern Africa

6.3.4 Selection of indicators for the Southern African sustainable city

The final selection of relevant indicators for the region is the result of an initial process of rearrangement and purge of repeated and misplaced indicators in the studied systems, as well as a selection based on the literature review. Moreover, some indicators have been discarded for not being relevant to urban contexts as explained in this section.

Specific indicators have been preferred for the selection in the final set proposed in this research. In order to avoid biases, the selection includes indicators related to traditionally considered minor problems, generally affecting a major powerless sectors of the society in the area. These are generally eclipsed by big scale urban features. Samples of these indicators are *acknowledgement of local lifestyle*, *payment preferences*, or *average time for building permit approval* to mention a few.

Indicators related to environmental features out of urban boundaries have been discarded. Marine protected areas or species loss not related to urban activities, to mention a couple, are included in some of the measurement systems, however, these topics are beyond not only urban territory but city management and usually belong to the real of national and international policies, for instance, SDG's indicator 15.8.1 'Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species'.

Indicators related to national policies regarding labour, human rights or legal accessibility have been discarded unless are included in urban contexts. In this regard, the *SDG's* contain a vast number of indicators that are not necessary urban related issues although they affect to national development and indirectly, cities.

Table 19. Category economy - Proposed core indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Attractiveness	Importance as decision-making centre (HQ, etc.)	Qualitative	Core	Smartness
	Number of commercial bank branches per 100,000 adults and number of automated teller machines (ATMs) per 100,000 adults	Quantitative	Core	Sustainability
	Foreign direct investments (FDI), official development assistance and South-South Cooperation as a proportion of total domestic budget	Quantitative	Core	Sustainability
	Financial Soundness Indicators	Qualitative	Core	Sustainability
	Financial incentives for improved climate resilient initiatives	Qualitative	Core	Resilience
Development	Plant & equipment expenditure	Quantitative	Core	Smartness
	Aid for Trade commitments and disbursements	Quantitative	Core	Sustainability
	Development, adoption or implementation of policy instruments aimed at supporting the shift to sustainable consumption and production	Quantitative	Core	Sustainability
	Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies	Quantitative	Core	Sustainability
	Policies/by laws protect the labour force and adapted to conditions of work under climate change	Qualitative	Core	Resilience
Employment	Percentage of people unemployed for more than six months who have access to a programme that is intended to improve their employment chances	Quantitative	Core	Resilience
	Self-employment rate	Quantitative	Core	Smartness
	Labour productivity	Quantitative	Core	Smartness

	Proportion of youth (aged 15-24 years) not in education, employment or training	Quantitative	Core	Sustainability
	Employment % change since base year	Quantitative	Core	Sustainability
	Employment creation in high productivity sectors	Quantitative	Core	NEW
	Reliable employment data	Qualitative	Core	NEW
	International Labour Organization employment records	Qualitative	Core	NEW
	Presence of active and independent workers' unions	Qualitative	Core	NEW
	Employment breakdown by sectors (primary, secondary and tertiary)	Quantitative	Core	NEW
	New businesses are created in secondary economic hubs/nodes to promote decentralisation	Quantitative	Core	Resilience
Entrepreneurship	Number of new businesses registered within the city in the past year, per 100,000 population	Quantitative	Core	Resilience
	Share of income supplement business	Quantitative	Core	NEW
	Administration hurdles on starting a business	Qualitative	Core	NEW
	Labour share of GDP	Quantitative	Core	Sustainability
Equality	Concentration of turnover in the top 4 companies	Quantitative	Core	Resilience
	Diversity of business	Qualitative	Core	Resilience
	Average hourly earnings of female and male employees, by occupation, age and persons with disabilities	Quantitative	Core	Sustainability
	Proportion of small-scale industries in total industry value added	Quantitative	Core	Sustainability
	Level of insurance cover	Qualitative	Core	Resilience
Financial security	Number of cities major economic drivers/commodities at risk	Qualitative	Core	Resilience
	Supportive financing mechanisms	Qualitative	Core	Resilience
	Proportion of small-scale industries with a loan or line of credit	Quantitative	Core	Sustainability
	Proportion of informal employment in total employment, by sector and sex	Qualitative	Core	Sustainability
Informality	Contribution of the informal sector to the GDP	Quantitative	Core	NEW
	Patent applications per million inhabitants	Quantitative	Core	Resilience
Innovation	Share of tertiary education across the labour force	Quantitative	Core	Resilience
	Employment rate in knowledge-intensive sectors	Quantitative	Core	Smartness
	Innovation hubs in the city	Qualitative	Core	Smartness
	Accessibility of open data sets	Qualitative	Core	Smartness
	Application of computing platforms	Qualitative	Core	Smartness
	Improvement of industry productivity through ICT	Qualitative	Core	Smartness
	Investments in ICT innovation	Quantitative	Core	Smartness
	Green Market Development	Qualitative	Core	Sustainability
	Research and development expenditure as a proportion of GDP	Quantitative	Core	Sustainability
	Proportion of medium and high-tech industry value added in total value added	Quantitative	Core	Sustainability
	e-Service provision either public or private	Qualitative	Core	NEW
	Strong integration with regional and global economies	Qualitative	Core	Resilience
International presence	Air transport of freight	Quantitative	Core	Smartness
	International trademarks	Quantitative	Core	Smartness
	Enterprises with foreign origin of capital	Quantitative	Core	Smartness
	GDP per capita	Quantitative	Core	Resilience
Productivity	Economic structure and profile	Qualitative	Core	Resilience

	Survival rate of new businesses per 100,000 population	Quantitative	Core	Smartness
	Direct disaster economic loss in relation to global gross domestic product (GDP)	Quantitative	Core	Sustainability
	Material footprint, material footprint per capita, and material footprint per GDP	Quantitative	Core	Sustainability
	Proportion of domestic budget funded by domestic taxes	Quantitative	Core	Sustainability
	% of country's GDP	Quantitative	Core	Sustainability
	Own-source revenue as % of total revenues	Quantitative	Core	Sustainability
	Payment preferences	Qualitative	Core	NEW
	GDP share of activities dependent on natural resources	Quantitative	Core	NEW
	Percentage of people earning less than the mean per capita income	Quantitative	Core	Resilience
Prosperity	Equalised disposable household income	Qualitative	Core	Resilience
	Poverty rate	Quantitative	Core	Resilience
	Food security	Qualitative	Core	Resilience
	Volume of remittances as a proportion of total GDP ($)	Quantitative	Core	Sustainability
	Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider	Quantitative	Core	Sustainability
	Annual inflation rate (avg. of last 5 years) (%)	Quantitative	Core	Sustainability
	Income distribution (GINI Coefficient)	Quantitative	Core	Sustainability
	Correlation urbanization-minimum income	Qualitative	Core	NEW
	Urban poverty growth	Quantitative	Core	NEW
	Middle class purchasing power	Quantitative	Core	NEW

Table 20. Category economy - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Attractiveness	Companies with HQ in the city quoted on national stock market	Quantitative	Supporting	Smartness
	Investment share in GDP	Quantitative	Supporting	Sustainability
	Tourism direct GDP as a proportion of total GDP and in growth rate	Quantitative	Supporting	Sustainability
Development	Debt service ratio (debt service expenditure as a percentage of a municipality's own-source revenue)	Quantitative	Supporting	Smartness
	Capital spending as a percentage of total expenditures	Quantitative	Supporting	Smartness
	Own-source revenue as a percentage of total revenues	Quantitative	Supporting	Smartness
	Targeted Industry Development	Qualitative	Supporting	Sustainability
	Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries	Quantitative	Supporting	Sustainability
	Amount in United States dollars committed to public-private partnerships for infrastructure	Quantitative	Supporting	Sustainability
Employment	Proportion in part-time employment	Quantitative	Supporting	Smartness
	Perception of getting a new job	Qualitative	Supporting	Smartness

	Proportion and number of children aged 5-17 years engaged in child labour, by sex and age	Quantitative	Supporting	Sustainability
	Fatal and non-fatal occupational injuries per 100,000 workers, by sex and migrant status	Quantitative	Supporting	Sustainability
Equality	Ratio of share in national income of highest to lowest quintile	Quantitative	Supporting	Sustainability
Financial security	Risk management	Qualitative	Supporting	Resilience
	Capital spending as a % of total expenditures	Quantitative	Supporting	Sustainability
	Debt service ratio (%)	Quantitative	Supporting	Sustainability
Innovation	Percentage of the labour force employed in occupations in the ICT sector	Quantitative	Supporting	Smartness
	Percentage of payments to the city that are paid electronically based on electronic invoices	Quantitative	Supporting	Smartness
	Share of Green Public Procurement	Quantitative	Supporting	Smartness
	Percentage of the ICT sector on GDP	Quantitative	Supporting	Smartness
	Share of people working in creative industries	Quantitative	Supporting	Smartness
	Percentage of buildings built or refurbished within the last 5 years in conformity with green building principles	Quantitative	Supporting	Smartness
	Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability	Qualitative	Supporting	Sustainability
International presence	Air transport of passengers	Quantitative	Supporting	Smartness
	Export intensity	Quantitative	Supporting	Smartness
	Number of companies whose business is a foreign language	Quantitative	Supporting	Smartness
Productivity	Commercial tax per capita	Quantitative	Supporting	Resilience
	Productivity and sufficiency	Qualitative	Supporting	Resilience
	Tax collected as a percentage of tax billed	Quantitative	Supporting	Smartness
	Freight movement	Quantitative	Supporting	Smartness
	Domestic material consumption	Quantitative	Supporting	Smartness
	Debt to GNI ratio	Quantitative	Supporting	Sustainability
	Capital spending as % of total expenditures	Quantitative	Supporting	Sustainability
	Current account deficit as percentage of GDP	Quantitative	Supporting	Sustainability
	Annual growth rate of real GDP per employed person	Quantitative	Supporting	Sustainability
	Commercial/Ind. assessment as % of total assess’t	Quantitative	Supporting	Sustainability
	Manufacturing value added as a proportion of GDP and per capita	Quantitative	Supporting	Sustainability
	Gross Operating Budget per capita ($)	Quantitative	Supporting	Sustainability
	Gross Capital Budget per capita ($)	Quantitative	Supporting	Sustainability
Prosperity	Fuel poverty	Qualitative	Supporting	Smartness
	Saving rate	Quantitative	Supporting	Smartness
	Jobs/housing ratio	Quantitative	Supporting	Smartness
	Perception on personal risk of poverty	Qualitative	Supporting	Smartness
	Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population	Quantitative	Supporting	Sustainability
	Redistributive impact of fiscal policy	Quantitative	Supporting	Sustainability
	Remittance costs as a percentage of the amount remitted	Quantitative	Supporting	Sustainability
	Cost of living ($)	Quantitative	Supporting	Sustainability

Table 21. Category people - Proposed core indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Education	Adequate education for all	Qualitative	Core	Resilience
	Number of research projects	Quantitative	Core	Resilience
	Participation in life-long-learning in %	Quantitative	Core	Smartness
	Percentage of students completing secondary education: survival rate	Quantitative	Core	Smartness
	Number of computers, laptops, tablets or other digital learning devices available per 1,000 students	Quantitative	Core	Smartness
	Environmental education	Qualitative	Core	Smartness
	Number of institutions of higher education	Quantitative	Core	Smartness
	Share of children in nurseries and kindergartens in the total number of children aged 0 to 6 in the city	Quantitative	Core	Smartness
	Adult literacy rate	Quantitative	Core	Sustainability
	Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and numeracy skills, by sex	Quantitative	Core	Sustainability
	Proportion of teachers with the minimum required qualifications, by education level	Quantitative	Core	Sustainability
	Percentage of teachers with fixed-term contract	Quantitative	Core	NEW
	Educational facilities with basic infrastructures	Quantitative	Core	NEW
Equality	Women as a percentage of total elected to city-level office	Quantitative	Core	Smartness
	Gender income equity	Qualitative	Core	Smartness
	Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict affected, as data become available) for all education indicators on this list that can be disaggregated	Quantitative	Core	Sustainability
Human capital	Population qualified at Levels 5-6 ISCED	Quantitative	Core	Smartness
	Number of science, technology, engineering and mathematics (STEM) higher education degrees per 100,000 population	Quantitative	Core	Smartness
	Digital literacy	Qualitative	Core	Smartness
	City's human capital index	Quantitative	Core	NEW
Inclusivity	Percentage of disabled persons employed	Quantitative	Core	Resilience
	Marginal society	Qualitative	Core	Resilience
	Knowledge about the EU	Qualitative	Core	Smartness
	Perception on social inclusion	Qualitative	Core	Smartness
	Equal resources for learners with disabilities	Qualitative	Core	NEW
Open-mindedness	Immigration-friendly environment (attitude towards immigration)	Qualitative	Core	Smartness
	Number of emigrated people	Quantitative	Core	Smartness
	Weight of customary law	Qualitative	Core	NEW
	Limitations to freedom of expression	Qualitative	Core	NEW
Social cohesion	Percentage of neighbourhoods with regular neighbourhood association meetings	Quantitative	Core	Resilience
	Perceived social network support (percentage people that replied "yes" to the question: If you were in trouble, do you have family and friends you can count on to help in case of need?	Qualitative	Core	Resilience
	Preservation of cultural heritage	Qualitative	Core	Smartness
	Compact & Complete Communities	Qualitative	Core	Sustainability

Social diversity	Number of civic, social advocacy or faith-based organisations per 10,000 people	Quantitative	Core	Resilience
	Share of foreigners	Quantitative	Core	Smartness

Table 22. Category people - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Education	Percentage of school children educated in disaster risk reduction	Quantitative	Supporting	Resilience
	Importance as knowledge centre (top research centres, top universities etc.)	Qualitative	Supporting	Smartness
	Percentage of students completing primary education: survival rate	Quantitative	Supporting	Smartness
	Satisfaction with quality of educational system	Qualitative	Supporting	Smartness
	Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex	Quantitative	Supporting	Sustainability
	Proportion of schools offering basic services, by type of service	Quantitative	Supporting	Sustainability
	Volume of official development assistance flows for scholarships by sector and type of study	Quantitative	Supporting	Sustainability
Equality	Percentage of women employed in the city government workforce	Quantitative	Supporting	Smartness
	Proportion of women aged 15-49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care	Quantitative	Supporting	Sustainability
Human capital	Foreign language skills	Qualitative	Supporting	Smartness
Inclusivity	Accessibility and distribution	Qualitative	Supporting	Resilience
	Perceived interpersonal local network support: % of people that replied 'yes' to the quest)on: If you were in trouble, do you have neighbours you can count on to help you whenever you need them?	Qualitative	Supporting	Resilience
	Application of services to support persons with specific needs	Qualitative	Supporting	Smartness
	Opportunities for people with special needs	Qualitative	Supporting	Smartness
Open-mindedness	History with extreme events	Qualitative	Supporting	Resilience
	Participation in language courses	Quantitative	Supporting	Smartness
	Tourism intensity	Qualitative	Supporting	Smartness
	Proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18	Quantitative	Supporting	Sustainability
Social cohesion	Participation in voluntary work	Qualitative	Supporting	Smartness
Social diversity	Foreign citizens who have applied for resident status	Quantitative	Supporting	Resilience
	Net migration	Quantitative	Supporting	Smartness

Table 23. Category governance - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Accessibility	Accessible criminal and civil justice	Qualitative	Core	Resilience
	Percentage of city services accessible and that can be requested online	Quantitative	Core	Smartness
City management	Comprehensive government emergency management	Qualitative	Core	Resilience
	Comprehensive city monitoring and data management	Qualitative	Core	Resilience
	Knowledge and enforcement of ecosystem management beyond city's administrative boundaries	Qualitative	Core	Resilience
	Level of decentralisation of management of resources	Qualitative	Core	Resilience
	Percentage of access to information requests processed within 90 days	Quantitative	Core	Resilience
	Effective emergency response services	Qualitative	Core	Resilience
	Number of natural disaster related deaths per 100,000 population	Quantitative	Core	Smartness
	Expenditures by the municipality for a transition towards a Smart City	Quantitative	Core	Smartness
	Human Services	Qualitative	Core	Sustainability
	Statistical capacity indicator for Sustainable Development Goal monitoring	Qualitative	Core	Sustainability
	Integrated municipal services	Qualitative	Core	NEW
	Anticipation	Qualitative	Core	NEW
	Conduction of local population and housing census	Qualitative	Core	NEW
Civil society	Proactive multi-stakeholder collaboration	Qualitative	Core	Resilience
	Effective mechanisms for communities to engage with government	Qualitative	Core	Resilience
	Partnerships for climate science are established and capacitate action	Quantitative	Core	Resilience
	Political activity of inhabitants	Qualitative	Core	Smartness
	Citizen participation	Qualitative	Core	Smartness
Planning	Inter-offices working group regarding risk, climate change and resilience	Quantitative	Core	Resilience
	Budget for Disaster Risk Reduction	Quantitative	Core	Resilience
	Budget for maintenance of infrastructure	Quantitative	Core	Resilience
	Land-use plans that have been developed with reference to local hazard risk assessment and that have been subjected to a formal consolation process	Quantitative	Core	Resilience
	Multi-hazard early-warning system	Qualitative	Core	Resilience
	Spatial segregation (Dissimilarity Index, or Spatial Ordinal Entropy Index at a 1,000-metre scale)	Quantitative	Core	Resilience
	Percentage of municipal budget allocated for the provision of mobility aids, devices and assistive technologies to citizens with special needs	Quantitative	Core	Smartness
	Climate resilience strategy	Qualitative	Core	Smartness
	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	Qualitative	Core	Sustainability
	Mix-use zoning planning	Quantitative	Core	NEW
	Acknowledgement of local lifestyle	Qualitative	Core	NEW
Policy	Capacity-development platforms (online portal, brochures, guides, toolkits)	Qualitative	Core	Resilience
	Smart City policy	Qualitative	Core	Smartness

	Existence of strategies. rules and regulations to enable ICT literacy among inhabitants	Qualitative	Core	Smartness
	Incentives for final users for low carbon measures	Qualitative	Core	Smartness
	Government investment in R&D (per capita)	Quantitative	Core	Sustainability
	Degree of sustainable public procurement policies and action plan implementation	Qualitative	Core	Sustainability
	Green land use policies	Qualitative	Core	Sustainability
Public perception	Satisfaction with transparency of bureaucracy	Qualitative	Core	Smartness
	Proportion of the population satisfied with their last experience of public services	Qualitative	Core	Sustainability
Representation	City representatives per resident	Qualitative	Core	Smartness
	Proportions of positions in national and local institutions, including (a) the legislatures; (b) the public service; and (c) the judiciary, compared to national distributions, by sex, age, persons with disabilities and population groups	Quantitative	Core	Sustainability
Transparency	City open data portal, including budget, organisational structure, plans and projects of different policy sectors	Quantitative	Core	Resilience
	Proactive corruption prevention	Qualitative	Core	Resilience
	Number of convictions for corruption and/or bribery by city officials per 100,000 population	Quantitative	Core	Smartness
	Percentage of population having paid bribes	Qualitative	Core	Sustainability
	Total value of inward and outward illicit financial flows ($)	Quantitative	Core	Sustainability
	Number of companies publishing sustainability reports	Quantitative	Core	Sustainability

Table 24. Governance - Proposed supporting indicators.

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Accessibility	Annual number of online visits to the municipal open data portal per 100,000 population	Quantitative	Supporting	Smartness
	Online support for new city inhabitants	Qualitative	Supporting	Smartness
	Percentage of the city population with access to real-time public alert systems for air and water quality advisories	Quantitative	Supporting	Smartness
City management	Local government revenue	Quantitative	Supporting	Resilience
	Roles and responsibility	Qualitative	Supporting	Resilience
	Leadership and administrative capabilities	Qualitative	Supporting	Resilience
	Number of fire-fighters per 100,000 population	Quantitative	Supporting	Smartness
	Number of fire related deaths per 100,000 population	Quantitative	Supporting	Smartness
	Average downtime of the city's IT infrastructure	Quantitative	Supporting	Smartness
	Average time for building permit approval (days)	Quantitative	Supporting	Smartness
	Environmental Justice	Qualitative	Supporting	Sustainability
	Green management	Qualitative	Supporting	Sustainability
	Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar)	Quantitative	Supporting	Sustainability
Civil society	Widespread community awareness and preparedness	Qualitative	Supporting	Resilience
	Civic associations	Quantitative	Supporting	Resilience

	Partnerships between cities and NGOs	Quantitative	Supporting	Resilience
	Number of volunteer and part-time fire-fighters per 100,000 population	Quantitative	Supporting	Smartness
	Civil & Human Rights	Qualitative	Supporting	Sustainability
	Public participation in green policy	Qualitative	Supporting	Sustainability
Planning	Robust planning approval process	Qualitative	Supporting	Resilience
	Fine scale projections of climate Risk & Vulnerability (R&V) assessments available to all	Qualitative	Supporting	Resilience
	Percentage per capita of food reserves within a city (including supermarket agreements) for 72 hours (percentage of the population which could be served)	Quantitative	Supporting	Resilience
	Adoption of a consistent planning approval process with respect to EMF	Qualitative	Supporting	Smartness
	Green action plan	Qualitative	Supporting	Sustainability
Policy	Price of water	Quantitative	Supporting	Resilience
	Existence of systems, rules and regulations to ensure Child Online Protection (COP)	Qualitative	Supporting	Smartness
	Existence of systems, rules and regulations to ensure privacy protection in public service	Qualitative	Supporting	Smartness
	Proportion of children under 5 years of age whose births have been registered with a civil authority, by age	Quantitative	Supporting	Sustainability
	Proportion of government recurrent and capital spending to sectors that disproportionately benefit women, the poor and vulnerable groups	Quantitative	Supporting	Sustainability
	Number of countries with mechanisms in place to enhance policy coherence of sustainable development	Qualitative	Supporting	Sustainability
Public perception	Perceptions of local government emergency support	Qualitative	Supporting	Resilience
	Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group	Qualitative	Supporting	Sustainability
Representation	Number of political parties per 1,000 inhabitants	Quantitative	Supporting	Smartness
Transparency	Satisfaction with fight against corruption	Qualitative	Supporting	Smartness
	Establishment within the administration	Qualitative	Supporting	Smartness
	Availability of EMF information	Qualitative	Supporting	Smartness
	Number of Parties to international multilateral environmental agreements on hazardous, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement	Quantitative	Supporting	Sustainability

Table 25. Category environment - Proposed core indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Air quality	Fatal chronic lower respiratory diseases per inhabitant	Quantitative	Core	Smartness
	Greenhouse gas emissions measured in tonnes per capita	Quantitative	Core	Smartness
	GHG intensity trend	Quantitative	Core	Sustainability
	Clean air policies	Qualitative	Core	Sustainability
	Ambient concentration of air pollutants in urban areas	Quantitative	Core	Sustainability
Conservation	Nature conservation and protection areas	Quantitative	Core	Resilience
	Effectively managed protective ecosystems	Qualitative	Core	Resilience

	Opinion on nature protection	Qualitative	Core	Smartness
	Species Habitat Index	Quantitative	Core	Sustainability
	Biodiversity Habitat Index	Quantitative	Core	Sustainability
	Natural Resource Protection	Qualitative	Core	Sustainability
	Official development assistance on conservation and sustainable use of biodiversity; and revenue generated and finance mobilized from biodiversity-relevant economic instruments	Qualitative	Core	Sustainability
Environmental attractiveness	Perception on environmental quality	Qualitative	Core	Smartness
	Terrestrial biomes	Quantitative	Core	Sustainability
Exploitation	Derelict industrial sites	Quantitative	Core	Resilience
	Local food production	Quantitative	Core	Smartness
	Brownfield use	Quantitative	Core	Smartness
	CO2 intensity	Quantitative	Core	Sustainability
	Ecological footprint of the town	Quantitative	Core	Sustainability
	Natural environmental resources consumption triggered by lack of services delivery	Quantitative	Core	NEW
Natural hazards	Degree of unsealed ground	Quantitative	Core	Resilience
	Property damage due to natural disasters	Quantitative	Core	Resilience
	Urban heat island effect	Qualitative	Core	Resilience
Other pollutants	Soil pollution avoidance	Qualitative	Core	Smartness
	Ambient Noise & Light	Qualitative	Core	Sustainability
Vegetation	Share of green and water spaces	Quantitative	Core	Smartness
	Tree cover loss	Quantitative	Core	Sustainability
	Proportion of land that is degraded over total land area	Quantitative	Core	Sustainability
Water bodies	Water consumption	Quantitative	Core	Resilience
	State of water bodies	Qualitative	Core	Resilience
	Water losses	Quantitative	Core	Smartness
	Access to improved water source	Quantitative	Core	Smartness
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	Quantitative	Core	Sustainability
	Index of coastal eutrophication; and plastic debris density	Quantitative	Core	Sustainability

Table 26. Category environment - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Air quality	Ventilation status	Qualitative	Supporting	Resilience
	Estimated average exposure to air pollution or PM10 concentration (ug/m3)	Quantitative	Supporting	Resilience
	O3 (Ozone) concentration	Quantitative	Supporting	Smartness
	Number of real-time remote air quality monitoring stations per square kilometre (km2)	Quantitative	Supporting	Smartness
	Black Carbon growth rate	Quantitative	Supporting	Sustainability
	CO2 from land cover	Quantitative	Supporting	Sustainability
	Sustainable Nitrogen Mgmt Index	Quantitative	Supporting	Sustainability

Conservation	Ecosystem health	Qualitative	Supporting	Resilience
	Individual efforts on protecting nature	Qualitative	Supporting	Smartness
	Percentage change in number of native species	Quantitative	Supporting	Smartness
	Species Protection Index	Quantitative	Supporting	Sustainability
	Grassland loss	Quantitative	Supporting	Sustainability
	Wetland loss	Quantitative	Supporting	Sustainability
	Invasive Species	Quantitative	Supporting	Sustainability
	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	Quantitative	Supporting	Sustainability
	Coverage by protected areas of important sites for mountain biodiversity	Quantitative	Supporting	Sustainability
Exploitation	Quality and utilization (nutrition)	Qualitative	Supporting	Resilience
	Working Lands	Quantitative	Supporting	Sustainability
	Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities	Quantitative	Supporting	Sustainability
Natural hazards	Existence of climate resilience hub	Qualitative	Supporting	Resilience
	Reported cases of climate change induced diseases	Quantitative	Supporting	Resilience
Other pollutants	Lead exposure	Quantitative	Supporting	Sustainability
Vegetation	Annual number of trees planted per 100,000 population (supporting indicator)	Quantitative	Supporting	Smartness
	Forest area as a proportion of total land area	Quantitative	Supporting	Sustainability
Water bodies	Number of springs	Quantitative	Supporting	Resilience
	Presence of faecal coliforms in freshwater	Quantitative	Supporting	Sustainability
	Proportion of transboundary basin area with an operational arrangement for water cooperation	Quantitative	Supporting	Sustainability

Table 27. Category Infrastructures - Proposed core indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Energy	Percentage of renewable energy capacity	Quantitative	Core	Resilience
	Number of critical facilities served by efficient distributed energy	Quantitative	Core	Resilience
	Average number of electrical interruptions per customer per year	Quantitative	Core	Resilience
	Number of different supply sources providing at least 5% of electricity generation capacity	Quantitative	Core	Resilience
	Adequate affordable energy supply	Qualitative	Core	Resilience
	Diversity of renewable energy	Qualitative	Core	Resilience
	Per capita energy consumption	Quantitative	Core	Resilience
	Percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources, as a share of the city's total energy mix for a given year	Quantitative	Core	Smartness
	Percentage of the city's electricity that is produced using decentralised electricity production systems	Quantitative	Core	Smartness
	Storage capacity of the city's energy grid per total city energy consumption	Quantitative	Core	Smartness
	Refurbished buildings improving energy performance	Quantitative	Core	Smartness

	Efficient use of electricity (use per GDP)	Qualitative	Core	Smartness
	Automatic energy management in buildings	Qualitative	Core	Smartness
	Resource Efficient Public Infrastructure	Qualitative	Core	Sustainability
	Proportion of population with access to electricity	Quantitative	Core	Sustainability
	Renewable energy share in the total final energy consumption	Quantitative	Core	Sustainability
	Energy-efficient buildings standards	Qualitative	Core	Sustainability
	Energy tariff rate minimum income wage relation	Quantitative	Core	NEW
ICT	Reliable communications technology	Qualitative	Core	Resilience
	Computers in households	Qualitative	Core	Smartness
	Percentage of city area under a white zone/dead spot/not covered by telecommunication connectivity	Qualitative	Core	Smartness
	Household ICT expenditures	Qualitative	Core	Smartness
	Adoption of ICT for disaster management	Qualitative	Core	Smartness
	Availability of ICT based safety systems	Qualitative	Core	Smartness
	Proportion of population covered by a mobile network, by technology	Quantitative	Core	Sustainability
	Fixed Internet broadband subscriptions per 100 inhabitants, by speed	Quantitative	Core	Sustainability
	Proportion of individuals using the Internet	Qualitative	Core	Sustainability
	Availability of broadband connection	Qualitative	Core	NEW
Management	Robust protective infrastructure	Qualitative	Core	Resilience
	Diligent maintenance and continuity	Qualitative	Core	Resilience
	Percentage of unplanned outages that are restored to supply within industry standard timeframes - outages duration	Quantitative	Core	Resilience
	Climate-smart infrastructure planning and the integration of green and grey infrastructure	Qualitative	Core	Resilience
	Integrated management in public buildings	Qualitative	Core	Smartness
	Recycling rate	Qualitative	Core	Smartness
Mobility	Diverse and affordable transport networks	Qualitative	Core	Resilience
	Travel time	Qualitative	Core	Resilience
	Household expenditure on transport per quintile	Qualitative	Core	Resilience
	NMT paths as a percentage of the total municipal road network length	Quantitative	Core	Resilience
	Public transport network per inhabitant	Quantitative	Core	Smartness
	Satisfaction with quality of public transport	Qualitative	Core	Smartness
	International accessibility	Qualitative	Core	Smartness
	Access to vehicle sharing solutions for city travel	Qualitative	Core	Smartness
	Percentage of city streets and thoroughfares covered by real-time online traffic alerts and information	Quantitative	Core	Smartness
	Percentage of vehicles registered in the city that are low-emission vehicles	Quantitative	Core	Smartness
	Percentage of the city's public transport services covered by a unified payment system	Quantitative	Core	Smartness
	Average modal split-passengers	Qualitative	Core	Smartness
	Average modal split vehicles	Qualitative	Core	Smartness
	Percentage of marked pedestrian crossings equipped with accessible pedestrian signals	Quantitative	Core	Smartness
	Size of non-car transport network	Quantitative	Core	Sustainability
	Green transport promotion	Qualitative	Core	Sustainability

	Death rate due to road traffic injuries	Quantitative	Core	Sustainability
	Proportion of the population that has convenient access to public transport, by sex, age and persons with disabilities	Qualitative	Core	Sustainability
	Share of commuters using informal means of transport	Qualitative	Core	NEW
	Walkable network	Quantitative	Core	NEW
	Roadworthy vehicles policy enforcement	Qualitative	Core	NEW
	Urban planning centered in walkability	Qualitative	Core	NEW
	ICT managed public parkings	Qualitative	Core	NEW
Waste	Percentage of city population with regular solid waste collection (residential) (core indicator)	Quantitative	Core	Smartness
	Total collected municipal solid waste per capita	Quantitative	Core	Smartness
	Percentage of the city's solid waste that is recycled	Quantitative	Core	Smartness
	Mixed municipal waste	Quantitative	Core	Smartness
	Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities	Quantitative	Core	Sustainability
	Waste Minimization	Qualitative	Core	Sustainability
Water	Number of different supply sources providing at least 5% of water supply capacity	Quantitative	Core	Resilience
	Percentage of households without connection having access to a source of water less than 200m from the dwelling	Quantitative	Core	Resilience
	Percentage of city population served by wastewater collection	Quantitative	Core	Smartness
	Percentage of the city's wastewater that has received no treatment	Quantitative	Core	Smartness
	Average annual hours of water service interruption per household	Quantitative	Core	Smartness
	Percentage of drinking water tracked by real-time, water quality monitoring station	Quantitative	Core	Smartness
	Quality of drinking water	Qualitative	Core	Smartness
	Proportion of population using safely managed drinking water services	Qualitative	Core	Sustainability
	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	Qualitative	Core	Sustainability

Table 28. Category Infrastructures - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Energy	Agreements between municipality and private power producers for renewable energy	Qualitative	Supporting	Resilience
	Number of days that city fuel supplies could maintain essential household functions	Quantitative	Supporting	Resilience
	Share of households with inability to keep house warm	Qualitative	Supporting	Resilience
	Percentage of street lighting managed by a light performance management system	Quantitative	Supporting	Smartness
	Percentage of public buildings requiring renovation/refurbishment	Quantitative	Supporting	Smartness
	Percentage of buildings in the city with smart energy meters	Quantitative	Supporting	Smartness
	Local freight transport fuel mix	Quantitative	Supporting	Smartness
	Fossil fuelled four wheels vehicles per capita	Quantitative	Supporting	Smartness

	Fossil fuelled two wheels vehicles per capita	Quantitative	Supporting	Smartness
	Number of electric charging stations for electric vehicles	Quantitative	Supporting	Smartness
	Number of electric vehicles in the city	Quantitative	Supporting	Smartness
	Percentage of electric vehicles per sector (private, public and service)	Quantitative	Supporting	Smartness
	Proportion of population with primary reliance on clean fuels and technology	Quantitative	Supporting	Sustainability
	Household solid fuels	Qualitative	Supporting	Sustainability
	Amount of fossil-fuel subsidies per unit of GDP (production and consumption)	Quantitative	Supporting	Sustainability
	Energy-efficient buildings initiatives	Qualitative	Supporting	Sustainability
	Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials	Qualitative	Supporting	Sustainability
ICT	Number of landline phone connections per 100,000 population	Quantitative	Supporting	Smartness
	Percentage of the city area covered by municipally provided Internet connectivity	Quantitative	Supporting	Smartness
	Information security of public services and systems	Qualitative	Supporting	Smartness
	Investment intensity in ICT projects enabling SSC	Qualitative	Supporting	Smartness
	Application of ICT based noise monitoring	Qualitative	Supporting	Smartness
Management	Flexible infrastructure	Qualitative	Supporting	Resilience
	Retained spare capacity	Qualitative	Supporting	Resilience
	Availability of EMF information	Quantitative	Supporting	Smartness
Mobility	Effective transport operation & maintenance	Qualitative	Supporting	Resilience
	Percentage of households with at least one vehicle	Qualitative	Supporting	Resilience
	Use of economical cars	Qualitative	Supporting	Smartness
	Percentage of public transport lines equipped with a real-time system	Quantitative	Supporting	Smartness
	Kilometres of high capacity public transport system per 100,000 population	Quantitative	Supporting	Smartness
	Number of personal automobiles per capita	Quantitative	Supporting	Smartness
	Number of two-wheel motorized vehicles per capita	Quantitative	Supporting	Smartness
	Number of bicycles available through municipally provided bicycle-sharing services per 100,000 population	Quantitative	Supporting	Smartness
	Percentage of traffic lights that are intelligent/smart	Quantitative	Supporting	Smartness
	City area mapped by real-time interactive street maps as a percentage of the city's total land area	Quantitative	Supporting	Smartness
	Percentage of public transport routes with municipally provided and/or managed Internet connectivity for commuters	Quantitative	Supporting	Smartness
	Percentage of the city's bus fleet that is motor-driven	Quantitative	Supporting	Smartness
	Km2 restricted areas	Quantitative	Supporting	Smartness
	Flexibility in delivery services	Qualitative	Supporting	Smartness
	Congestion reduction policies	Qualitative	Supporting	Sustainability
Waste	Percentage of the city's solid waste that is disposed of in a sanitary landfill	Quantitative	Supporting	Smartness
	Percentage of the city's solid waste that is disposed of in an incinerator	Quantitative	Supporting	Smartness
	Percentage of the city's solid waste that is burned openly	Quantitative	Supporting	Smartness
	Percentage of the city's solid waste that is disposed of in an open dump	Quantitative	Supporting	Smartness

	Percentage of the city's solid waste that is disposed of by other means	Quantitative	Supporting	Smartness
	Hazardous Waste Generation per capita (tonnes)	Quantitative	Supporting	Smartness
	Percentage of the city's hazardous waste that is recycled	Quantitative	Supporting	Smartness
	Percentage of public garbage bins that are sensor-enabled public garbage bins	Quantitative	Supporting	Smartness
Water	Adapted sewer system	Qualitative	Supporting	Resilience
	Frequency of sewer blockages	Quantitative	Supporting	Resilience
	Percentage of the city's wastewater receiving primary treatment	Quantitative	Supporting	Smartness
	Percentage of the city's wastewater receiving secondary treatment	Quantitative	Supporting	Smartness
	Percentage of the city's wastewater receiving tertiary treatment	Quantitative	Supporting	Smartness
	Percentage of city population with sustainable access to an improved water source	Qualitative	Supporting	Smartness
	Percentage of waste drop-off centres (containers) equipped with telemetering	Quantitative	Supporting	Smartness
	Percentage of the wastewater pipeline network monitored by a real-time data-tracking sensor system	Quantitative	Supporting	Smartness
	Number of real-time environmental water quality monitoring stations per 100,000 population	Quantitative	Supporting	Smartness
	Percentage of buildings in the city with smart water meters	Quantitative	Supporting	Smartness
	Degree of integrated water resources management	Qualitative	Supporting	Sustainability
	Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management	Quantitative	Supporting	Sustainability
	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH)	Quantitative	Supporting	Sustainability

Table 29. Category living - Proposed core indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Culture	Strong city-wide identity and culture	Qualitative	Core	Resilience
	Percentage of the city's cultural records that have been digitised	Quantitative	Core	Smartness
	Percentage of city population that are active public library users	Quantitative	Core	Smartness
	Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	Quantitative	Core	Sustainability
	Cultural facilities attendance per inhabitant	Quantitative	Core	NEW
Health	Average quality of life (satisfaction)	Qualitative	Core	Resilience
	Number of hospital beds per 100,000 people	Quantitative	Core	Resilience
	Mortality: all causes	Quantitative	Core	Resilience
	Existence of a city health education programme	Qualitative	Core	Resilience
	Availability of primary health care services in foreign languages	Quantitative	Core	Resilience
	Consultations in health centres per capita	Quantitative	Core	Resilience

	Number of public health care facilities per capita	Quantitative	Core	Resilience
	Life expectancy	Quantitative	Core	Smartness
	Satisfaction with quality of health system	Qualitative	Core	Smartness
	Sharing of medical resources and information among hospitals, pharmacies and other health care providers	Qualitative	Core	Smartness
	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis	Quantitative	Core	Sustainability
	Coverage of essential health services	Qualitative	Core	Sustainability
	Mortality rate attributed to household and ambient air pollution	Quantitative	Core	Sustainability
	Proportion of the target population covered by all vaccines included in their national programme	Quantitative	Core	Sustainability
	Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis	Quantitative	Core	Sustainability
	Health worker density and distribution	Quantitative	Core	Sustainability
	International Health Regulations (IHR) capacity and health emergency preparedness	Qualitative	Core	Sustainability
	Prevalence of undernourishment	Quantitative	Core	Sustainability
	Universal health coverage	Qualitative	Core	NEW
Housing	Safe and affordable housing	Qualitative	Core	Resilience
	Housing deprivation: percentage of population living in dwelling considered overcrowded, while: 1) leaking roof or damp walls, floors, foundations or rot in window frames and floor; 2) no bath or shower; or 3) too dark	Quantitative	Core	Resilience
	Percentage of houses which have passed local building code inspections	Quantitative	Core	Resilience
	Houses in hazardous locations	Quantitative	Core	Resilience
	Percentage of newly subsidised housing units in brownfield development	Quantitative	Core	Resilience
	Percentage of city population living in slums	Qualitative	Core	Smartness
	Areal size of informal settlements as a percentage of city area	Quantitative	Core	Smartness
	Proportion of population living in households with access to basic services	Quantitative	Core	Sustainability
	Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure	Quantitative	Core	Sustainability
	Customary land management systems	Qualitative	Core	NEW
Recreation	Percentage of public recreation services that can be booked online	Quantitative	Core	Smartness
	Access to public amenities	Qualitative	Core	Smartness
	Square metres of public indoor recreation facility space per capita	Quantitative	Core	Sustainability
	Square metres of public outdoor recreation facility space per capita	Quantitative	Core	Sustainability
Safety	Diverse protection of livelihoods following a shock	Qualitative	Core	Resilience
	Percentage of population that could be served by city's access to stock of emergency shelter for 72 hours	Quantitative	Core	Resilience
	Secure technology networks	Qualitative	Core	Resilience
	Effective systems to deter crime	Qualitative	Core	Resilience
	Crime rate	Quantitative	Core	Smartness
	Number of police officers per 100,000 population	Quantitative	Core	Smartness
	Data privacy	Qualitative	Core	Smartness
	Number of deaths, missing persons and directly	Quantitative	Core	Sustainability

	affected persons attributed to disasters per 100,000 population			
	Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work injury victims, and the poor and the vulnerable	Quantitative	Core	Sustainability
	Pension security coverage (%)	Quantitative	Core	Sustainability
	Proportion of people that feel safe walking alone around the area they live	Qualitative	Core	Sustainability
	Number of victims of intentional homicide per 100,000 population, by sex and age	Quantitative	Core	Sustainability
	Proportion of population subjected to (a) physical violence, (b) psychological violence and (c) sexual violence in the previous 12 months	Qualitative	Core	Sustainability
	Proportion of young women and men aged 18-29 years who experienced sexual violence by age 18	Qualitative	Core	Sustainability
Tourism	Overnights per year per resident	Quantitative	Core	Smartness
	International Events Hold	Quantitative	Core	Smartness
	Engagement of tourism with local communities	Qualitative	Core	NEW
	Share of domestic tourism	Quantitative	Core	NEW

Table 30. Category living - Proposed supporting indicators

SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Culture	Number of online bookings for cultural facilities per 100,000 population	Quantitative	Supporting	Smartness
	Connected libraries	Quantitative	Supporting	Smartness
	Share of employees in cultural industries	Quantitative	Supporting	Smartness
Health	Emergency medical care	Qualitative	Supporting	Resilience
	Self-perception of health % population > 15 years who report “good” or better health to the question “How is your health in general?” with response scale “It is very good/good/fair/bad/very bad”	Quantitative	Supporting	Resilience
	Percentage of hospitals that have carried out disaster preparedness drills in the last year	Quantitative	Supporting	Resilience
	Low birth weight	Quantitative	Supporting	Resilience
	Number of health related questions examined by the city council every year	Quantitative	Supporting	Resilience
	Abortion rate in relation to total number of live births	Quantitative	Supporting	Resilience
	Fertility rate	Quantitative	Supporting	Resilience
	Aging index	Quantitative	Supporting	Resilience
	Percentage of the city’s population with an online unified health file accessible to health care providers	Quantitative	Supporting	Smartness
	Adoption of telemedicine	Qualitative	Supporting	Smartness
	Adoption of telemedicine	Qualitative	Supporting	Smartness
	Encouraging a healthy lifestyle	Qualitative	Supporting	Smartness
	Indoor Air Quality	Quantitative	Supporting	Sustainability
	Maternal mortality ratio	Quantitative	Supporting	Sustainability
	Proportion of births attended by skilled health personnel	Quantitative	Supporting	Sustainability

	Number of people requiring interventions against neglected tropical diseases	Quantitative	Supporting	Sustainability
	Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders	Quantitative	Supporting	Sustainability
	Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol	Quantitative	Supporting	Sustainability
	Proportion of women of reproductive age (aged 15-49) who have their need for family planning satisfied with modern methods	Quantitative	Supporting	Sustainability
	Adolescent birth rate (aged 10-14 year; aged 15- 19 years) per 1,000 women in that age group	Quantitative	Supporting	Sustainability
	Proportion of population with large household expenditures on health as a share of total household expenditure or income	Qualitative	Supporting	Sustainability
	Age-standardized prevalence of current tobacco use among persons aged 15 years and older	Qualitative	Supporting	Sustainability
	Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (%)	Quantitative	Supporting	Sustainability
Housing	Percentage of household income spent on housing by the poorest 20% of the population	Quantitative	Supporting	Resilience
	Percentage of housing units exposed to a high level of hazard that have been designed or retrofitted to withstand the force of the hazard	Quantitative	Supporting	Resilience
	Ownership with burdens	Qualitative	Supporting	Resilience
	Average living area per inhabitant	Quantitative	Supporting	Smartness
	Satisfaction with personal housing situation	Qualitative	Supporting	Smartness
	Diversity of housing types	Qualitative	Supporting	Smartness
Recreation	Availability of sporting facilities	Qualitative	Supporting	Smartness
Safety	Dependency ratio	Qualitative	Supporting	Resilience
	Safe hazard shelter vs. expected public demand	Qualitative	Supporting	Resilience
	Percentage of neighbourhoods with emergency groups (e.g. local Red Cross groups, voluntary fire fighting associations, etc)	Qualitative	Supporting	Resilience
	Percentage of buildings with insurance cover for high-risk hazards relevant to the city (UN-Habitat)	Quantitative	Supporting	Resilience
	Satisfaction with personal safety	Qualitative	Supporting	Smartness
	Percentage of the city area covered by digital surveillance cameras	Quantitative	Supporting	Smartness
	Number of victims of human trafficking per 100,000 population, by sex, age group and form of exploitation	Quantitative	Supporting	Sustainability
	Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms	Quantitative	Supporting	Sustainability
	Unsentenced detainees as a proportion of overall prison population	Quantitative	Supporting	Sustainability
	Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months	Quantitative	Supporting	Sustainability

The selection of indicators contained in this research does not intend to be simultaneously implemented in the assessment of Southern African cities. It aims to define a guideline through an open framework with 312 indicators that might be tailored for different urban scenarios within the region. In this sense, city managers might make their own selection from this pool of indicators in order to assess and strength specific areas within the city. Section 6.4.4

contains a tailored selection of indicators regarding the case study included in this research, plastic pollution in the Umgeni River. Further research should look at how to measure such indicators in the context of the eThekwini.

6.4 Findings from the case of the Umgeni River in Durban

6.4.1 Challenges on data collection and decision machining

In the first half of the year 2021, the problem of plastic pollution in the Umgeni River has gained notoriety. The partnership between the UKZN and the NPO The Ocean Cleanup has been celebrated and attracted the attention from the civil society and the Municipality. TOC is based in the Netherlands with a high-tech approach in their operations. Despite the positive impact of this partnership, not only at research level but also the positive results that their presence in the area might bring for the next few years, it means, once again, foreign actors bringing the solution to Southern Africa. TOC has presented a data collection strategy that will require the assistance of the UKZN. Efforts have been made by the eThekwini municipality and UKZN to make them knowledgeable of the local whereabouts. Ideally, the picture should have been the other way around, initiatives and research carried by the UKZN and local actors for years, with solid implemented strategies might required the assistance of the technology brought by TOC. The reality is that the problem of the plastic pollution in the Umgeni River has been addressed by a few members from civil society, academia and municipality in the recent years. Lack of coordination and ignorance of what has been done by who, has dropped the level of effectiveness of their actions. The addition to the equation of a mediatic agent can set the spotlight on the problem and bring together efforts from different stakeholders.

When it comes to addressing plastic pollution in particular, the following gaps have emerged after the analysis of the system: There is a necessity to design and implement a more efficient waste collection and handling system to ensure an accurate stream of data that can be utilised to predict the status of booms; The absence of efficient recycling channels that might highlight the benefits of the waste collected; The relationship between rainfall and quantity of waste needs to be established; The design of the litterboom requires optimisation to ensure that it is sturdy enough to capture waste and debris during flooding. Further studies for the optimization and new designs might be the subject of research project.

The analysis of census data from KZN through GIS has allowed the identification of trends at territorial level that are typically overseen and decontextualized.

Regarding the case study, the findings confirm sufficient technical knowledge and capacity at the time of approaching plastic pollution entering the ocean in urban environments. The contribution of the UKZN to study the problem sets the foundation for a solid strategy to move forward. Moreover, the presence of specialized companies in the waste sector allows for the development of waste stream corridors that could make appealing the collection of stranded plastic waste with profitable outputs. Unfortunately, this clashes with budget priorities from the public sector.

6.4.2 Umgeni River plastic pollution in the media

As an important component in the Smart City, ICT in particular, as well as urban resilience, mass media plays a relevant role in understanding the perception of urban issues by the public. The research design explained in section 4.2, mentions the restrictions to social interactions due to COVID-19 that have forced a change of direction in the collection related to qualitative data. Therefore, the analysis of the Umgeni River plastic pollution in the media becomes an alternative to overcome the challenge and avoiding missing out an important part in the validity of the study through triangulation.

The topic has been tracked since 2014, year in which this research started, to April 2021. An extensive pool of samples has been collected. Local and international sources have been considered. The research has included all items initially found in order to avoid bias and work within a diversified framework. The presence of the topic in international news highlights the important scale of the problem.

Taking into account the fact that most media are profitable companies, an overlap of the presence on the topic with the rainfall historic records has been conducted in order to measure sensationalism. The results show a level of correlation which intensifies in the year 2019, after the floods in March and December (see Figure 66). The aim of this exercise is to determine if whether this is a dormant problem for the public, who is only aware when overwhelming events run out of control and make it to the press, or on the contrary, constant awareness and a continuous assessment and measurement of the problem is conducted in a regular basis.

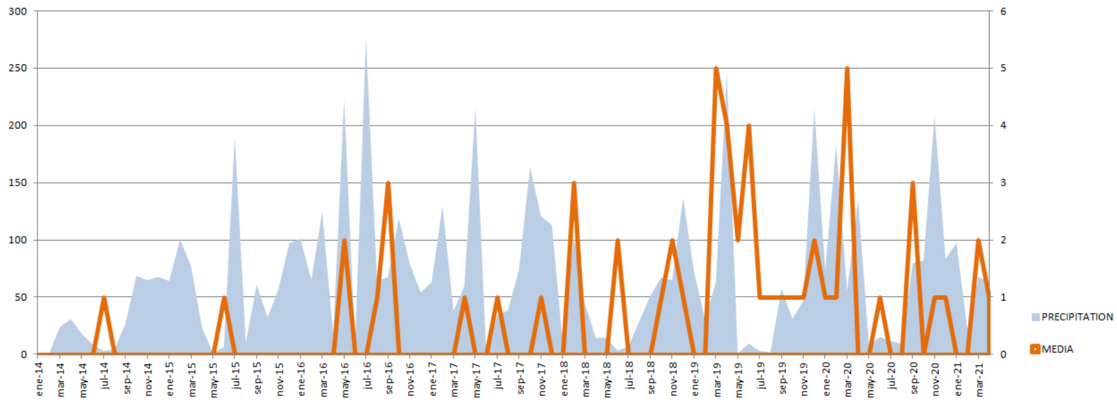


Figure 66. Rainfall records in Durban vs. media intensity

The mass media echoes the doubtful honour held by the Umgeni River of being one of the most polluted rivers in South Africa, highlighting not only environmental but health hazards and death risk. The media is sprinkled with news about hazardous waste reaching the river stream and the coast. A wave of over 1,000 fish deaths at the north of the Umgeni estuary in 2013, in autumn 2016, the beaches were closed due to medical waste washed ashore. In 2019, two major rainfall events took place in March and December, covering with plastic the coast near the estuary. Also in 2019, Chemical spill in the Umgeni below its point of confluence with the Msunduzi River were detected in August 2019.

The content of the news can be grouped in three categories: individual events, public service backlogs and mitigation initiatives. These three groups are not always necessarily related. As mentioned, chemical spill and fish death for instance, are dealt in isolation of the bigger picture. The media highlights public service backlogs and public educational challenges as main causes of the problem. Waste filtration into the sewage systems and manholes discharging untreated waste are common faults. Residents report a poor disposal collection in the best case scenario. In some areas it is non-existing. The sewage system is also reported to be vandalised by some residents. Illegal dumpling is pointed as one of the major contributors to plastic pollutions from a behavioural perspective.

Educational and social awareness interventions have been published during 2019. Such is the case of the Neptune Project, the creative brainchild of Professor Cristina Trois, South African

Research Chair (SARChI) in Waste and Climate Change at UKZN. The Neptune Project's main goal is to highlight the problem of plastic pollution in the oceans, and help find inventive ways to fight against this plague through recycling plastic into art.

Mitigation initiatives such as DGC, DUCT and TLP are very present in the media. Insight of their activities and call for cleanups appear regularly in the press. Moreover, signing of agreements between different stakeholders to sum efforts in the fight against plastic pollution fits into this mitigation group. The Durban Partnership against Plastic Pollution and the African Marine Waste Conference in 2017 are examples of this. From the plastic industry, the support to the reduction of use and banning on plastic use product made a few headlines. Plastics SA, the umbrella organization representing the South African Plastics Industry, was one of the first signatories of the Declaration of the Global Plastics Associations for Solutions on Marine Litter, whereby 74 plastics associations from around the world have committed themselves to fight marine litter.

In July 2019, the South African Department of Environment, Forestry and Fisheries was expected to implement a 2-year project to clean up five rivers in Durban (IOL, June 2019). Little was known about the progress of the project until September 2020, when a press release from the UN Environment Programme was published, announcing again the intention of starting the same project.

In December 2019, after heavy rains and massive flooding events, the YouTube video 'Durban South Africa, Umgeni River Plastic Pollution' (Redman, 2019) became viral. The problem gained international attention. Some media highlighted the paradoxical situation in which Durban, having been awarded as the greenest city in the world (to be precise, among only 155 cities in 60 countries members of the HUGSI Index) a few days before, had the beaches buried under a blanket of plastic.

The search of international news has been conducted in 3 languages together with English: Spanish, Italian and German. These are languages spoken by the researcher, who is capable to determine the relevance and content of the articles. For the same reason, the use of other well spread languages, such as Mandarin Chinese or French, has been discarded, as it is impossible for the researcher to understand the content of the articles.

The following is a list of keywords used in the search:

English:	*Durban Umgeni river plastic pollution*
	Durban Umgeni river plastic pollution news
Spanish:	*Inundación plástico en Durban*
Italian:	*Fiume plastica Durban*
German:	*Fluss Plastik Verschmutzung Durban*
	Plastik Verschmutzung Durban

Most of the content found at international level corresponds with the rainfall of December 2019. In most cases, the articles make reference to the aforementioned viral video. Despite the high number of publications found, the treatment of the event is superficial, limited to a description without a deeper analysis of the problem.

The media pressure that came after the December 2019 floods seems to have sparked a series of project and initiatives to look at the future in a constructive way. Alternatives to the waste collected such as DSW pavers manufacturing in 2020 and the partnership with the SARCHI Chair in Waste and Climate Change made their way to the news, creating an optimistic synergy. Moreover, the South African Department of Environment, Forestry and Fisheries has implemented an integrated program that includes social engagement, cleanup project and recycling potential of the waste collected that will tackle plastic pollution in 5 rivers: Umgeni, uMlazi, uMbilo, uMhlatuzana, and aManzimnyama rivers.

The Ocean Cleanup joined the fight against plastic pollution in the Umgeni River in May 2021. The NPO, with a large international footprint, had a catalyst effect and the agreement signed with the UKZN for a 3-year research project was covered internationally.

No political use of the crisis has been detected in the analyzed media samples. It is clear the critic to public services performance but no particular mention to political parties in government has been found.

6.4.3 Positions of the stakeholders on the plastic pollution in the Umgeni River

During the period in which the research has been conducted, the researcher has attended a number of meetings and workshops together with the most relevant stakeholders related to the problem of plastic pollution in the Umgeni River mouth. This section presents their experiences and visions.

eThekwini officials, UKZN, DGC, TOC, Durbanites Against Plastic Pollution (DAPP), DUCT and Umgeni Estuary Conservation have taken part in several meetings and workshops, presenting their vision and involvement in relationship with the riverine waste situation at the Umgeni River mouth. Members of the ADReach and Litterboom teams were consulted to determine where they believed to be hotspots for waste entry, what they perceived to be the largest waste fraction and how the booms function. Answers were recorded by note-taking, and two task team events were recorded with consent in Zoom.

The position of eThekwini Municipality can be summarized in two opposite situations: availability to collaborate and little budget to solve the problem from the perspective of public intervention. Poor municipal waste management has been indicated repeatedly in this research. In the best case scenario, planned collection happens once a week. Informal settlements, residential alternative for 33% of the population in the city, have no waste collection. eThekwini officials have made themselves available to collaborate and share data with UKZN (non strategic in most cases), although response times have been generally long. The engagement of UKZN and TOC seems to have sparked the interest of the municipality in solving the problem in a solid manner. Visits to critical areas and the Waste Beneficiation Centre in KwaMashu have been guided by the city officials.

To date, the approach to solve the problem from eThekwini Municipality has been more aligned to cure rather than preventing. DSW workers are regularly deployed after flooding events, for massive cleanups. However, the municipality seems to be overwhelmed to solve the problem at origin.

The UKZN has taken the Umgeni River plastic pollution problem as case study for a number of research topics. Directed by Prof. Cristina Trois (SCWCC), postgraduate and PhD research thesis have focussed on this particular problem. UKZN has played a role of connection between stakeholders also, facilitating engagement between them and endorsing sustainable initiatives proposed by organizations from the civil society, such as DGC and TOC. Alternative vision from students and the use of new technologies have brought new approaches to solve the problem.

The project on the plastic pollution in the Umgeni River is part of the one of the focus area of the SCWCC, which has identified 7 layers of action: mapping, testing, trapping, collecting, processing, modelling and engaging. The final goal is to develop a replicable model for the adaptation to climate change of the waste sector. The study will be carried out in two phases: in phase I, the focus will be on macro- and micro-plastics, while phase II will revolve around the optimisation of waste minimisation systems like the litterbooms or the Waste Resource Optimisation & Scenario Evaluation (WROSE) model, including a final science engagement part for the dissemination of the new knowledge.

DUCT initiated the litterboom installation in 2015, which DGC took over later. DUCT is highly involved in beach cleanups and they express their frustration about the scale of the problem and the little progress in solving the waste entry to the river. They aim for “progressive, combined and sustained actions by government and civil society to address and solve the problem”. On their own words, “DUCT’s vision is an ecologically healthy and biologically diverse uMngeni-uMsunduzi river system that provides sustained ecological goods and services for the communities that depend on them for their survival”. They assume that communities acquire a basic understanding of rivers ecosystems and will engage and acknowledge the rivers as source of natural resources and therefore preserve their functions: riparian zones, quantity and quality of water are maintained at adequate levels, allowing for biological diversity to be preserve. For this, cooperation between public and private sector together with academia and civil society is key to efficiently sustain the rivers systems

DGC is championing the fight against plastic pollution at the moment. With little resources, they have battling plastic waste since 2015. Their director has stated several times their frustration at facing such overwhelming problem. However, since the beginning of the research, they have increased the number of litterboom and optimized their system within their own limitations. DGC wants to develop more capacity and plans to involve SMEs and people from townships. They have made themselves available to collaborate with research project from the UKZN and the relationship with the SCWCC is close and they also collaborate with the Department of Science and Innovation. eThekwini Municipality has secured funding to conduct an Environmental Impact Assessments related to the location of the litterbooms.

DGC together with Assignment Earth NPC led DAPP, an education programme directed by qualified non government partners based in Durban. DAPP have effectively produced business and product life cycle plans, business plans and implemented, river care field work, litter boom operations, informal collector support, recycling systems strengthening, clean-up events and community based education and awareness campaigns. Their programme is setup to be delivered through a holistic package of initiatives across the waste management sector.

The Umgeni Estuary Conservancy is a body of individuals focused on catalysing interest and active engagement in the public to preserve and restore the Umgeni River and its riparian zones; and its indigenous fauna and flora from Connaught to the estuarine area at the Beachwood Mangroves. They engage with the public through a number of activities to awake awareness about environmental issues. Moreover, they organize monthly cleanups of the Blue Lagoon, at the Umgeni River mouth.

The latest stakeholder to arrive is TOC. The study on the Umgeni River is part of a bigger project from TOC, which aims to investigate 3 rivers in 3 years across the globe (Ozama River in the Dominican Republic and Chao Phraya River in Thailand are the other two). These rivers were chosen according to 6 parameters: discharge, annual rainfall, basin size, basin population, MPW, ME plastic emission. The research has 4 main focuses (sources, deposition/remobilisation, cross sectional distribution, ocean emissions), which will be investigated on 7 layers (satellite imagery, UAV imagery, camera/visual survey, surface/riverbank samples, GPS trackers, water column samples, riverbed samples). The study aims to quantify and qualify the role of entry points, quantify and qualify macro-plastic fluxes on the water surface and investigate the pathways of macro-plastic debris.

6.4.4 Application of the framework to measurement of plastic pollution in urban environments. The case of eThekwini

The definition of the case study as an environmental problem within the urban context in a city like Durban, paradigm of Southern African megacity, offers a great opportunity to stress the framework developed in section 6.3, in which urban resilience is understood only if is achieved under the parameters of sustainability. Moreover, the addition of a digital layer through smart projects complete the vision of transformation of African urban scenarios within current principles accepted worldwide although generated locally.

The case study focuses on the Umgeni River due its multifaceted character as urban feature. It represents a micro-city, with multiple actors converging. This section is an example of adaptation of the open framework in section 6.3, scaled down to a particular urban reality: plastic pollution in arterial urban systems. The resulting Table 31 has been informed by the quantitative and qualitative analysis of the case study. In this case, supporting indicators allow assessing in detail realities that might be overseen at urban scale.

A dedicated selection of indicators, which values may assist to propose solutions that could gain traction fast, given the acknowledgement and assessment of the specific features of a critical sector within KwaZulu-Natal. This is a tailored toolkit that fits within a bigger urban framework composed by the matrix of indicators in section 6.3.4.

Table 31. Proposed indicators for the measurement of plastic pollution in urban environments

	SUBCATEGORY	INDICATOR	TYPE	LEVEL	TOPIC OF ORIGIN
Economy	Development	Financial incentives for improved climate resilient initiatives	Qualitative	Core	Resilience
		Plant & equipment expenditure	Quantitative	Core	Smartness
	Innovation	Improvement of industry productivity through ICT	Qualitative	Core	Smartness
		Green Market Development	Qualitative	Core	Sustainability
		Research and development expenditure as a proportion of GDP	Quantitative	Core	Sustainability
People	Education	Number of research projects	Quantitative	Core	Resilience
		Environmental education	Qualitative	Core	Smartness
	Human capital	Population qualified at Levels 5-6 ISCED	Quantitative	Core	Smartness
		Number of science, technology, engineering and mathematics (STEM) higher education degrees per 100,000 population	Quantitative	Core	Smartness
	Social cohesion	Percentage of neighbourhoods with regular neighbourhood association meetings	Quantitative	Core	Resilience
		Number of civic, social advocacy or faith-based organisations per 10,000 people	Quantitative	Core	Resilience
Gove	Accessibility	Percentage of city services accessible and that can be requested online	Quantitative	Core	Smartness

	City management	Comprehensive government emergency management	Qualitative	Core	Resilience
		Comprehensive city monitoring and data management	Qualitative	Core	Resilience
		Effective emergency response services	Qualitative	Core	Resilience
		Number of natural disaster related deaths per 100,000 population	Quantitative	Core	Smartness
		Integrated municipal services	Qualitative	Core	NEW
		Anticipation	Qualitative	Core	NEW
	Civil society	Effective mechanisms for communities to engage with government	Qualitative	Core	Resilience
		Partnerships for climate science are established and capacitate action	Quantitative	Core	Resilience
		Citizen participation	Qualitative	Core	Smartness
	Planning	Inter-offices working group regarding risk, climate change and resilience	Quantitative	Core	Resilience
		Budget for Disaster Risk Reduction	Quantitative	Core	Resilience
		Budget for maintenance of infrastructure	Quantitative	Core	Resilience
		Land-use plans that have been developed with reference to local hazard risk assessment and that have been subjected to a formal consultation process	Quantitative	Core	Resilience
		Multi-hazard early-warning system	Qualitative	Core	Resilience
		Climate resilience strategy	Qualitative	Core	Smartness
		Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	Qualitative	Core	Sustainability
	Policy	Capacity-development platforms (online portal, brochures, guides, toolkits)	Qualitative	Core	Resilience
		Degree of sustainable public procurement policies and action plan implementation	Qualitative	Core	Sustainability
		Green land use policies	Qualitative	Core	Sustainability
Environment	Conservation	Nature conservation and protection areas	Quantitative	Core	Resilience
		Effectively managed protective ecosystems	Qualitative	Core	Resilience
		Opinion on nature protection	Qualitative	Core	Smartness
		Natural Resource Protection	Qualitative	Core	Sustainability
	Environmental attractiveness	Perception on environmental quality	Qualitative	Core	Smartness
	Exploitation	Derelict industrial sites	Quantitative	Core	Resilience
		Brownfield use	Quantitative	Core	Smartness
		Ecological footprint of the town	Quantitative	Core	Sustainability
	Natural hazards	Degree of unsealed ground	Quantitative	Core	Resilience
		Existence of climate resilience hub	Qualitative	Supporting	Resilience
		Property damage due to natural disasters	Quantitative	Core	Resilience
		Reported cases of climate change induced	Quantitative	Supporting	Resilience

		diseases			
		Urban heat island effect	Qualitative	Core	Resilience
	Other pollutants	Soil pollution avoidance	Qualitative	Core	Smartness
	Water bodies	State of water bodies	Qualitative	Core	Resilience
		(a) Index of coastal eutrophication; and (b) plastic debris density	Quantitative	Core	Sustainability
Infrastructures	ICT	Adoption of ICT for disaster management	Qualitative	Core	Smartness
		Availability of ICT based safety systems	Qualitative	Core	Smartness
		Proportion of population covered by a mobile network, by technology	Quantitative	Core	Sustainability
	Management	Robust protective infrastructure	Qualitative	Core	Resilience
		Climate-smart infrastructure planning and the integration of green and grey infrastructure	Qualitative	Core	Resilience
		Recycling rate	Qualitative	Core	Smartness
	Waste	Percentage of city population with regular solid waste collection (residential)	Quantitative	Core	Smartness
		Total collected municipal solid waste per capita	Quantitative	Core	Smartness
		Percentage of the city's solid waste that is recycled	Quantitative	Core	Smartness
		Percentage of the city's solid waste that is disposed of in a sanitary landfill	Quantitative	Supporting	Smartness
		Percentage of the city's solid waste that is disposed of in an incinerator	Quantitative	Supporting	Smartness
		Percentage of the city's solid waste that is burned openly	Quantitative	Supporting	Smartness
		Percentage of the city's solid waste that is disposed of in an open dump	Quantitative	Supporting	Smartness
		Percentage of the city's solid waste that is disposed of by other means	Quantitative	Supporting	Smartness
		Hazardous Waste Generation per capita (tonnes)	Quantitative	Supporting	Smartness
		Percentage of the city's hazardous waste that is recycled	Quantitative	Supporting	Smartness
		Percentage of public garbage bins that are sensor-enabled public garbage bins	Quantitative	Supporting	Smartness
		Mixed municipal waste	Quantitative	Core	Smartness
		Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities	Quantitative	Core	Sustainability
		Waste Minimization	Qualitative	Core	Sustainability
	Water	Adapted sewer system	Qualitative	Supporting	Resilience
		Percentage of drinking water tracked by real-time, water quality monitoring station	Quantitative	Core	Smartness

		Number of real-time environmental water quality monitoring stations per 100,000 population	Quantitative	Supporting	Smartness
		Quality of drinking water	Qualitative	Core	Smartness
		Proportion of population using safely managed drinking water services	Qualitative	Core	Sustainability
		Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)	Quantitative	Supporting	Sustainability
Living	Culture	Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)	Quantitative	Core	Sustainability
	Health	Mortality: all causes	Quantitative	Core	Resilience
		Existence of a city health education programme	Qualitative	Core	Resilience
		Consultations in health centres per capita	Quantitative	Core	Resilience
		Life expectancy	Quantitative	Core	Smartness
	Housing	Houses in hazardous locations	Quantitative	Core	Resilience
		Percentage of city population living in slums	Qualitative	Core	Smartness
		Proportion of population living in households with access to basic services	Quantitative	Core	Sustainability

In this particular case, the categories governance and infrastructures contain the bigger number of indicators. As mentioned before, the pool of indicators is not a closed selection and new indicators can be added to tackle specific assessments. For instance, in the category economy, new indicators can gauge circular economy as well as the presence of economic activities related to collection and treatment of plastic waste. The level of awareness of the impact of plastic waste in the environment or the attitude of the population towards the use of highly polluting plastic items can also be assessed with new specific indicators.

For obvious reasons, indicators related to infrastructures of waste have a prevalent number in the systems, but in this particular case, it might help to compare the case to international standardized benchmarks. The results could be used to highlights areas that are performing as per the specific state of art. However, these indicators in combination with the rest of the matrix should determine the way to move forward within a local perspective.

Indicators related to research and STEM education are considered important, particularly at initial stages. It is essential to take into account that at early stages, the approach is that one of find solutions to an overwhelming situation that not only has to do with environmental issues but social and economical matters. Rendering riverine waste as a resource would spark the interest of the private sector to engage. Economic indicators related to green markets are therefore imperative.

The Umgeni estuary is the subject of multiple conservation initiative. Some of them are responsive to the problem of plastic pollution. Others recognize the enormous environmental value of the area, which is home of great biodiversity and a popular spot for recreation. Indicators in this regards would highlight the disastrous consequences of the perpetuation of the problem. But also, once the problem is solved, these indicators will gauge stability and performance of the solutions.

Through Table 31, the researcher highlights the importance of acknowledging feed-back loops and interconnected elements that might be initially seen as unrelated. It is significant the level of integration that urban matters require in order to be solved. The table indirectly exposes the need for interdepartmental collaboration and a holistic approach.

This specific framework might be perceived as ambitious. The eThekwini municipality recognized to have failed in the assessment of urban waste due to lack of data (eThekwini Municipality, 2020b). However, the framework may help to understand the complexity of the problem and approach with a broader vision what seems to be perceived as a straight forward specialized technical problem. The framework includes elements on which eThekwini can start working even without the need of any data, particularly to articulate an integrated plan. Further research should look at how to measure such indicators in the context of the eThekwini.

7 CONCLUSIONS AND RECOMMENDATIONS

When African cities are to be portrayed as appealing places, they are referred to as vibrant, and one cannot help but thinking of the story of the jiggling atoms by Nobel Prize laureate Richard Feynman. The jiggling atoms bounce and produce heat that is then spread by contact to finally cool down and achieve balance. Is this urban vibration the result of an unbalanced status? Is this tension due to the combination of opposite realities what sparks the urban synergies present in the African context? The high levels of inequality; major climate change vulnerability; the low rate of qualified skilled labour and technological literacy when the 4IR is about to wipe out the job market as we know it; modern constitutional frameworks that clash with traditional indigenous ruling and tribalism; and incapable governance to address problems directly related to the quality of life of the mass, namely healthcare, education and security. With the exception of South Africa in some cases, Southern African countries rate the lowest in most studies addressing performance for development on a regular basis.

In this scenario, Africa lays in a vulnerable position: despite the chances for leapfrogging and catch up in the race of development though the implementation of new technology, the lack of capacity might perpetuate the presence of questioned trends: the unsustainable extraction of natural resources, the use of fossil energy and the exploitation of workers. Therefore, it seems important to identify the genuine urban features of the Southern African region for a successful implementation of Smart City projects, understanding for successful initiatives those that bring solutions to the major problems in the areas instead of only benefitting economic elites. A progressive reduction between the gap between Southern Africa and the so called "Global North" should be a core drive for these projects, to finally achieve similar levels of development.

In a globalized world, cities are expected to perform under common benchmarks. The African population is relatively new to urban habitats. The current urban landscape in Africa is inherited from urban conceptualizations by European colonial powers. Except for Luanda and Cape Town, all capitals and major cities in Southern Africa are founded in the 19th and early 20th centuries. These foreign formulation of human settlement brought along equally foreign technologies. There is a Zulu term for city: *esilungwini*. It means "the place of the white man" or "where the white man resides". In Southern Africa, the urban experience requires cultural adaptation. Moreover, the African population has been historically deprived from the integration within the urban arena due to segregation, impeding Africans to fully submerge in the urban landscape and resulting in an extreme lack of the sense of belonging. The apprehension of a complete urban experience has been capped for the majority of the inhabitants of the city. This situation becomes evident in the territorial planning at national levels: a few large and dominant cities are strategically located for governance and international connectivity where the colonial elite settled. The post-colonial transition has resulted in massive migrations, turning these hubs into the most populated areas. This migration intensity together with lack of municipal capacity derived in unprecedented pressure on urban services and resulted in a dysfunctional urban performance.

A revision of territorial planning might help to ease the pressure on African megacities. Given the fact that transport infrastructures are put in place, mostly for freight transport which extractive economies are based on, a national strategy would allow for growth of second row cities well connected to the dominant one. On one hand, it would reduce migration and therefore overpopulation of cities and on the other, could increase the rates of urban population across the province. Moreover, it would split political power, now in hands of the council of the mega-city, and allow for efficient political accountability and social engagement. City managers wouldn’t be seen as distant unapproachable figures and migrants from close origins might have a stronger sense of belonging and enrol in public life. In addition to this, service provision, especially those that require centralization, would be less costly and more efficient as there are planned for a smaller scale. At the same time, these growing second row cities could represent the scenario for the implementation of new technologies from scratch, avoiding the expenses on services retrofitting.

The analysis of case study has proven shortage of capacity to deal with territorial problems that affect more than one municipality, particularly in those with predominant rural conditions. A diversified urban planning within the province could allow for multiple initiatives to take traction, which could result in a domino effect. Instead, the concentration of urban features within only one megacity acts as a bottleneck for progress in the area.

The agenda to address social conflicts is typically put aside in favour of economic performance far from echoing the priorities of the mass, with the consequent impact in both, the inhabitants and the environment. A way to approach social equity might be based on looking at the city in terms of compensation of lacks. A strong walkability in cities can have an impact in many aspects related to efficiency, sustainability, economy and equality among others. Therefore, relocating non car owners closer to work has a polyphonic impact, affecting not only monthly expense in transport but also the carbon footprint of the city, and increasing at the same time the diversity within the city. This inequality also reflects in the use of ICT, where other means of communication such as cell phone and radio have a solid presence across the region and obviously across social classes. Even though it is to be expected that internet users have access to cell phones and radios, their social interaction and source of information might happen predominantly via Smartphone. For the success of smart initiatives involving the population, this particularity should be acknowledged.

Informality is one of the fundamental features that differentiate Africa from the 'Global North'. The absence of public state and lack of political leadership have pushed many citizens to live outside the norms which does not necessary mean crime: informal dwelling, informal economy, informal tenure, informal ways of exercise power or even informal infrastructures. The straight implementation of solutions developed in the 'Global North' are proven to be inefficient and attempts to solve the problem with planning tools or infrastructure design that only look at urban physical features doesn't work either. The approach to informality should be holistic. In fact, sociologist are more likely to be effective than urban planners and engineers. Multidisciplinary teams and perseverant engagement with informal communities should be on the agenda of any municipal manager at any department. The implementation of cross-departmental offices would assist to enhance integration within local governments. A multidimensional approach might be needed, focussing on the political economies of exclusion, that proposes an alternative vision of Southern African cities but also acknowledges informality and supports survival efforts of the urban poor rather than impeding them. In link with the aforementioned suggestions on regional planning, data from informal dwellers would allow for the identification of hotspots in terms of rural migration and disadvantaged areas in the country, which development would ease the pressure on the megacities.

Informed citizens are more likely to be active in the public life and are prone to participate. For efficient ways to engage with communities in order to approach an urban challenge such of the case study, limitations are to be acknowledged. Further research is needed to determine the accurate scale of the contribution of plastic waste to the Umgeni River pollution; however, the scenario seems ready to test information strategies that might involve sms and radio communications, and coordinated actions from civil society organizations in order to engage with the communities and awake awareness of the consequences of waste mismanagement. The use of more sophisticated technologies might be not effective based on the findings from section 5.3.2. The way in which technology responds sets in the social structure at all levels: individuals, groups and institutions. No previous experience with computers means lack of relevance at social level. Despite this might make easier the introduction of new technologies as there is no old values to change, at least the selected technology is to be contextualized. New rules must be learnt and accepted. In addition to this, it is important to carefully identify both, social and technical considerations in order to ensure that technology is not embraced to the disadvantage of the social. Therefore, technological dissemination should be focused on the local user rather than technology appropriation.

The term "urban resilience" is a truism. Cities are intrinsically resilient systems. Otherwise, how do we explain the existence of cities founded thousands of years ago, still inhabited nowadays? Such is the case of Jericho in Palestine, from 9,000 B.C.; Athens in Greece, from 5,000 B.C.; or Faiyum in Egypt, from 7,200 B.C. to name a few. In fact, cities have experienced changes of culture, religion, or even race. Migrations and colonization have changed dramatically the social landscape of cities over the years. Cities have evolved with the consequent technological progress and still been able to keep the idiosyncrasy of the place. But it is in the latest decades when the concerns about the use of limited resources, and development resulting in a poisoned environment, point out that resilience cannot be achieved whatever it takes: resilience and development should evolve within sustainable principles.

New technologies might help to coordinate and put in place initiatives with common aims and therefore, overturn the situation depicted above. Information technologies break cultural and racial barriers. They help to disseminate different values rooted in cultural principle and make them more accessible to other ethnic groups, which reduces the fear to the unknown. ICT could help to make more cohesive societies in multiethnic scenarios and bring people together in the search for common goals. At the same time, information campaigns are more efficient when the message gets directly delivered to the recipient. One of the great concerns by academics and city managers is the lack of awareness in the public about basic environmental knowledge linked to everyday life behaviour and its impact on the ecosystem. Information on sustainable and environmental matters can be made accessible to the citizens by the strategic use of ICT. It is important to remark that smart initiatives are not necessary associated with expensive infrastructures and an elitist use of technology. A basic use of the technology that is available to the public nowadays can make a great impact.

The tailor made Southern African sustainable city wheel in Figure 65 summarizes the domains that need to be prioritized in order to implement the transition from resilient to sustainably resilient. However, the resulting matrix of indicators is not a ‘ready-to-go’ model to be directly applied. Instead, it formulates a context in which measurement systems applied to Southern Africa can be developed from. The main challenge once again is the collection of updated and reliable data. To better understand the implications of these results, future studies could address social engagement via ICT for specific areas and institutional structures for the process and analysis of data typically affected by lack of political coordination among different levels of administration.

It is important to take into account that the average number of indicators considered in the measurement systems is about 100-150. These indicators will express either qualitative or quantitative data. In the case of the 6-key fields of performance developed by TU Vien, it is clear that a high education institution has directed the design of the system based on data from public agencies, international organizations and own research. These reliable sources legitimize the results when the system is applied. In the case of Southern Africa in general, and based on the closer look at eThekwini in particular, it seems convenient that the lack of reliability in the data should be offset with a strong partnership with high education institutions that might produce unbiased and transparent data based on academic research and speed up the development of innovative approaches and assessment for process of implementation and ensure supervision of the activities of private commercial partners. Private agencies which base their activities on strong work ethics principles and research oriented methodologies might also play an important role in the definition of measurement systems and contribute to accelerate the build up of efficient data centred decision tools. The use of internationally recognized quality certifications for private agencies could bring credibility to a new innovative ecosystem. As Perboli et al (2014) indicate, most of the Smart City projects (85%) are initiated, managed and financed by public sector, skilled officers are to be on board of public institutions.

As discussed in the literature review, South Africa enjoys a solid international footprint when it comes to research, alliances with international academic institutions and registration of patents. This situation might indicate a level of feasibility in the creation of urban labs appointed with the scope of researching and generating reliable urban data that is to be update in a regular basis. Public agencies on the contrary are underfunded and understaffed. For instance, Statistics SA, the public agency for statistics, publishes the national census every 10 years. Although a regularly updated national census can be ambitious, periodical updates for the larger cities could help with the implementation of reliable measurement systems. There is therefore room for suggestions, based on the current resources, to enhance initiatives that would be effective in the design of such systems.

The Umgeni area within eThekwini boundaries represents a small scale city model. The catchment overlaps a diverse range of urban zones: residential, industrial, commercial, rural and informal. It also falls under the duties of several municipal and regional departments. Therefore, it is a good scenario to test integrated initiatives. The problem of plastic pollution might play an important role as pilot project. Although it limits the boundaries of the problem to environmental issues and sustainable management, the lessons learnt could be extrapolated to other urban areas. Further research is needed to understand the relationships at urban level and the contribution of each actor involved both, consciously and unconsciously.

The lack of municipal capacity could be addressed by strengthening the role social actors: residents (which includes business owners and services users) and civil society. A top-down model that lays all responsibilities on municipal management will require a large investment in infrastructures, equipment and development of human capital. This is unlikely to take place at short term. Taking into account the diversity in the profile of residents, further studies could address the capacity of enrolment and contribution of each group, either actively or passive.

Smart initiatives in the context of strengthening the sustainable resilience of the city could start by selecting a few specific areas that urge to be improved. Small scale pilot project strategically located might create innovative environments that could influence adjacent areas. It is to take into account that digitization of citizen services is considered an essential component of the Smart City. In the case of Southern Africa where the citizen is disconnected from mainstream ICT modes, the risk of exacerbating inequalities through digital divide becomes a very important aspect to consider in this specific regional context.

In the context of Southern Africa, soft infrastructure oriented strategies appear as most suitable to address the transition towards Smart City models. The city and spatial planning in particular should be conceived as drivers for socio-economic prosperity. However, further research should be conducted in order to gauge the challenges in terms of capacity development at all levels, from city managers and policy makers, professionals and engineers, to citizens.

The case study has proven a rather disconnected city as disconnected the citizens are. An integrated range of urban mobility models could boost opportunities for circular economy together with mitigating the problem of housing. Spatial allowances are to be introduced in the town planning strategies. This might concede opportunities for testing new technologies that mean one, an upgrade of existing infrastructure that are already familiar and two, opportunities for public-private engagement, not only local but could attract international partners willing to share the technological knowhow. Physical planning becomes the carpet of the smart dimension of the city. Nevertheless, companies must survey local needs and preferences and then adapt their offers in order to make their products suitable for a mass acceptance. Moreover, companies can not only learn but partner with home-grown businesses that have acquired a knowhow on local preferences over the years.

The analysis of census data from KZN through GIS has allowed the identification of trends at territorial level that are typically overseen and decontextualized. As mentioned already, a revision of planning strategies at regional scale are imperative for the transition to urban sustainability through smart initiatives. Disconnection, digital illiteracy and absence of urban references characterize the province together with overwhelming differences between eThekwini and the rest of municipalities.

The progressive downscaling of the methodology, starting at sub-continental level to zoom into the city of eThekwini for the analysis of a case study has been challenging but helpful. The literature review compiles a solid body of knowledge from diverse sources specific to the region. This strategy might allow for the replicability of the methodology in other cities with similar characteristics as Durban. The findings confirm existing concerns about the current capacity to follow the pace for development that new technologies are setting but at the same time, the potential for a genuine self-made sustainable future.

8 REFERENCES

Abdychev, A. *et al.* (2018) *The Future of Work in Sub-Saharan Africa*, *Departmental Papers / Policy Papers*. doi: 10.5089/9781484383094.087.

Abernethy, K., Maisels, F. and White, L. J. T. (2016) 'Environmental Issues in Central Africa', *Annual Review of Environment and Resources*, 41, pp. 1–33. doi: 10.1146/annurev-environ-110615-085415.

AfDB (2011) *Africa's Middle Class Triples to more than 310m over Past 30 Years Due to Economic Growth and Rising Job Culture*. African Development Bank. Available at: https://www.afdb.org/fr/news-and-events/africas-middle-class-triples-to-more-than-310m-over-past-30-years-due-to-economic-growth-and-rising-job-culture-reports-afdb-7986.

AfDB (2013) *An Integrated Approach to Infrastructure Provision in Africa*, *African Development Bank*. Tunis.

AfDB, OECD and UNDP (2016) *African economic outlook 2016*. Available at: https://www.oecd-ilibrary.org/development/african-economic-outlook-2016_aeo-2016-en%0Ahttp://www.oecd.org/countries/namibia/1826046.pdf.

AfDB and World Bank Group (2011) *Africa Infrastructure Knowledge Program*.

AFRETEP (2016) *African Renewable Energy Technology Platform. Processed GIS data*. European Union. Available at: https://europa.eu/capacity4dev/afretep/wiki/processed-gis-data.

African Union (2015) *Agenda 2063. The Africa We Want. Popular version. Second edition*. Addis Ababa: African Union.

Agyenim-boateng, Y., Benson-Armer, R. and Russo, B. (2015) 'Winning in Africa's consumer market', *McKinsey and Company(Consumer Packaged Goods)*, pp. 1–7.

Aichison, J. (2003) *Adult literacy and basic education: A SADC perspective.*, *Adult Education and Development*.

Aitchison, J. (2004) 'Lifelong learning in South Africa: Dreams and delusions', *International Journal of Lifelong Education*, 23(6), pp. 517–544. doi: 10.1080/026037042000311451.

Alawadhi, S. *et al.* (2012) 'Building understanding of smart city initiatives', *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 7443 LNCS, pp. 40–53. doi: 10.1007/978-3-642-33489-4_4.

Albino, V., Berardi, U. and Dangelico, R. M. (2015) 'Smart cities: Definitions, dimensions, performance, and initiatives', *Journal of Urban Technology*, 22(1), pp. 3–21. doi: 10.1080/10630732.2014.942092.

Alcántara Vasconcellos, E. (2001) *Urban transport, environment and equity: The case for developing countries*. London: Routledge.

Alesina, A. *et al.* (2002) 'Fractionalization. Discussion Paper Number 1959', *Harvard Institute of Economic Research*, (1959). Available at: http://post.economics.harvard.edu/hier/2002papers/2002list.html.

Alphamers (2020) *Floating trash barrier*. Available at: https://alphamers.blog/2020/06/28/the_ocean_cleanup/.

Amirtahmasebi, R. *et al.* (2016) 'Johannesburg: Aligning Diverse Prophecies for Revitalizing a Declining Inner City', in *Regenerating Urban Land: A Practitioner's Guide to Leveraging Private Investment*, pp. 385–420. doi: 10.1596/978-1-4648-0473-1_ch11.

Amoako, K. Y. (1998a) 'Opening Statement at the Global Connectivity for Africa Conference', in. Addis Ababa.

Amoako, K. Y. (1998b) 'Opening Statement at the Global Connectivity for Africa Conference'.

Amusa, K., Monkam, N. and Viegi, N. (2016) 'Foreign aid and Foreign direct investment in Sub-Saharan Africa: A panel data analysis', *ERSA working paper*, (June), pp. 1–23.

Anderson, P. L. *et al.* (2013) *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities. A Global Assessment (Regional assessment of Africa Urbanization).* Edited by T. Elmqvist et al. Springer. doi: 10.1007/978-94-007-7088-1.

Andrady, A. L. (2003) *Plastics and the environment*. John Wiley and Sons.

Andrady, A. L. (2011) ‘Microplastics in the marine environment’, *Marine Pollution Bulletin*, 62(8), pp. 1596–1605. doi: 10.1016/j.marpolbul.2011.05.030.

Angelidou, M. (2014) ‘Smart city policies: A spatial approach’, *Cities*, 41, pp. S3–S11. doi: 10.1016/j.cities.2014.06.007.

Angelidou, M. (2015) ‘Smart cities: A conjuncture of four forces’, *Cities*, 47, pp. 95–106. doi: 10.1016/j.cities.2015.05.004.

Anguelovski, I., Chu, E. and Carmin, J. A. (2014) ‘Variations in approaches to urban climate adaptation: Experiences and experimentation from the global South’, *Global Environmental Change*, 27(1), pp. 156–167. doi: 10.1016/j.gloenvcha.2014.05.010.

Antonelli, C. (1991) *The diffusion of advanced telecommunications in developing countries*. Paris: OECD. doi: 10.1016/0048-7333(94)90056-6.

APP (2015) *Africa Progress Report 2015*, *Africa Progress Panel (APP)*. Geneva.

Aurigi, A. (2005) ‘Competing urban visions and the shaping of the digital city’, *Knowledge, Technology & Policy*, 18(1), pp. 12–26. doi: 10.1007/s12130-005-1013-z.

Aurik, J. C. (2017a) ‘How to fix the future skills gap’, January.

Aurik, J. C. (2017b) ‘Making the Case for the Fourth Industrial Revolution in Africa’, May.

Babayemi, J. O. *et al.* (2019) ‘Ensuring sustainability in plastics use in Africa: consumption, waste generation, and projections’, *Environmental Sciences Europe*, 31(1). doi: 10.1186/s12302-019-0254-5.

Ballas, D. (2013) ‘What makes a “happy city”?’, *Cities*, 32(1), pp. S39–S50. Available at: https://doi.org/10.1016/j.cities.2013.04.009.

Bandalong (2021a) *Bandalong Litter Trap*. Available at: https://www.bandalong.com.au/bandalong-litter-trap.html (Accessed: 1 July 2021).

Bandalong (2021b) *The proven solution for floatables control*. Available at: https://stormwatersystems.com/bandalong-litter-trap/ (Accessed: 1 July 2021).

Banerjee, S. *et al.* (2008) ‘Access, affordability, and alternatives: Modern infrastructure services in Africa’, in *Africa infrastructure country diagnostic*. Washington, DC: World Bank Group. Available at: www.worldbank.org.

Barne, D. and Wadhwa, D. (2018) *Year in Review: 2018 in 14 Charts*. World Bank Group. Available at: https://www.worldbank.org/en/news/feature/2018/12/21/year-in-review-2018-in-14-charts.

Barnett, C. and Parnell, S. (2018) ‘Spatial rationalities and the possibilities for planning in the New Urban Agenda for Sustainable Development’, *The Routledge Companion to Planning in the Global South*, pp. 25–36. doi: 10.4324/9781317392842-2.

Battersby, J. (2014) ‘Cities, planning and urban food poverty in Africa’, in Bhan, G., Srinivas, S., and Watson, V. (eds) *The Routledge Companion to Planning in the Global South*. Taylor and Francis Ltd., pp. 204–214.

Batty, M. *et al.* (2012) ‘Smart cities of the future’, *European Physical Journal: Special Topics*, 214(1), pp. 481–518.

Batty, M. (2013) ‘Big data, smart cities and city planning’, *Dialogues in Human Geography*, 3(3), pp. 274–279. doi: 10.1177/2043820613513390.

Beavon, K. S. O. (1992) ‘The post-apartheid city: hopes, possibilities, and harsh realities’, in Smith, D. M. (ed.) *The Apartheid City and Beyond*. London: Routledge, pp. 232–243.

Benton, M. J. (1995) ‘Diversification and extinction in the history of life’, *Science*, 268(5207), pp. 52–58. doi: 10.1126/science.7701342.

Berardi, U. (2013) ‘Clarifying the new interpretations of the concept of sustainable building’, *Sustainable Cities and Society*, 8, pp. 72–78. doi: 10.1016/j.scs.2013.01.008.

Best, J. (2019) ‘Anthropogenic stresses on the world’s big rivers’, *Nature Geoscience*, 12(1), pp. 7–21. doi: 10.1038/s41561-018-0262-x.

Bhan, G., Goswami, A. and Revi, A. (2017) ‘The intent to reside. Residence in the auto-constructed city', in Bhan, G., Srinivas, S., and Watson, V. (eds) *The Routledge Companion to Planning in the Global South*. London: Routledge, pp. 255–263. doi: 10.4324/9781317392842.

Bhorat, H., Naidoo, K. and Ewinyu, A. (2017) 'The tipping point: The youth bulge and the sub-Saharan African labor market', in *Increasing Employment Opportunities: Navigating Africa's complex job market*. Brookings, pp. 29–44.

BluePhin Technologies (2021) *Meet BluePhin*. Available at: https://bluephin.io/.

Boaden, B. and Taylor, R. (1992) 'Informal settlement: theory versus practice in KwaZulu-Natal a Zulu-Natal', in Smith, D. M. (ed.) *The Apartheid City and Beyond*. London: Routledge, pp. 148–158. doi: 10.4324/9780203417362.

Bonner, C. *et al.* (2017) 'Linking global with local advocacy Taylor and Francis', in Bhan, G., Srinivas, S., and Watson, V. (eds) *The Routledge Companion to Planning in the Global South*. London: Routledge, pp. 275–286. doi: 10.4324/9781317392842.

Borie, M. *et al.* (2019) 'Mapping narratives of urban resilience in the global south', *Global Environmental Change*, 54(August 2018), pp. 203–213. doi: 10.1016/j.gloenvcha.2019.01.001.

Bosch Munitech (2016) *eThekwini Municipality integrated waste management plan 2016-2021*. Durban.

Brestovansky, M. (2019) 'Cleaning up microplastics: Machine to be tested on isle beaches next month', *Hawaii News*, 5 January. Available at: https://www.hawaiitribune-herald.com/2019/01/05/hawaii-news/cleaning-up-microplastics-machine-to-be-tested-on-isle-beaches-next-month.

Bria, F. (2012) 'New governance models towards a open Internet ecosystem for smart connected European cities and regions', *Open innovation, directorate- general for the information society and media, European commission*, pp. 62–71.

Bridges.org (2002) *Supporting Entrepreneurship in Developing Countries : Survey of the Field and Inventory of Initiatives*. UN ICT Task Force.

Britannica enciylopedia (2021) 'Roman Republic', in *Britannica enciylopedia*. Available at: https://www.britannica.com/place/Roman-Republic.

Brooks, T. M. *et al.* (2016) 'Analysing biodiversity and conservation knowledge products to support regional environmental assessments', *Scientific Data*, 3. doi: 10.1038/sdata.2016.7.

Browne, M. A., Galloway, T. S. and Thompson, R. C. (2010) 'Spatial patterns of plastic debris along estuarine shorelines', *Environmental Science and Technology*, 44(9), pp. 3404–3409. doi: 10.1021/es903784e.

Bruge, A. *et al.* (2018) 'Monitoring litter inputs from the Adour river (southwest France) to the marine environment', *Journal of Marine Science and Engineering*, 6(1). doi: 10.3390/jmse6010024.

Bryceson, D. F. (2010) 'Africa at work: transforming occupational identity and morality', in *How Africa Works: Occupational Change, Identity and Morality, Rugby*. Practical Action Publishers, pp. 3–26. doi: 10.3362/9781780440248.001.

Bulkeley, H. (2010) 'Cities and the governing of climate change', *Annual Review of Environment and Resources*, 35, pp. 229–253. doi: 10.1146/annurev-environ-072809-101747.

Burzynski, E. S. (2012) *Exploring ' difference ' in place-making The case of bad buildings and residential regeneration in the inner city of Johannesburg , South Africa*. 146. London.

Byrne, M. (1996) 'Ports and Shipping', in McNeil, I. (ed.) *An Encyclopedia of the History of Technology*. Routledge, pp. 529–564. doi: 10.4324/9780203192115-19.

Calderwood, L. U. and Soshkin, M. (2019) *Travel and tourism at a tipping point*, *The travel & tourism competitiveness report 2019*. Geneva: World Economic Forum.

Carnie, T. (2013) 'Umgeni River "one of dirtiest" in SA', *IOL News*, June. Available at: https://www.iol.co.za/news/Umgeni-river-one-of-dirtiest-in-sa-1529000.

Carruthers, R., Krishnamani, R. R. and Murray, S. (2008)

'Improving Connectivity: Investing in Transport Infrastructure in Sub-Saharan Africa', *Africa infrastructure country diagnostic*. World Bank Group.

Carson, H. S. *et al.* (2013) 'Tracking the sources and sinks of local marine debris in Hawai'i', *Marine Environmental Research*, 84, pp. 76–83. doi: 10.1016/j.marenvres.2012.12.002.

Carter, P., Rojas, B. and Sahni, M. (2011) 'Delivering Next-Generation Citizen Services: Assessing the Environmental, Social and Economic Impact of Intelligent X on Future Cities and Communities', (June), pp. 1–14.

Cawthra, H. C. *et al.* (2012) 'Sedimentation on the narrow (8km wide), oceanic current-influenced continental shelf off Durban, Kwazulu-Natal, South Africa', *Marine Geology*, 323–325, pp. 107–122. doi: 10.1016/j.margeo.2012.08.001.

Center on Governance (2003) *SmartCapital Evaluation Guidelines Report: Performance Measurement and Assessment of SmartCapital*. Ottawa: University of Ottawa. Available at: http://www.christopherwilson.ca/papers/Guidelines_report_Feb2003.pdf.

Chen, M. and Skinner, C. (2014) 'The urban informal economy: enhanced knowledge, appropriate policies and effective organization', in Parnell, S. and Oldfieldl, S. (eds) *Routledge Handbook of Cities of the Global South*. New York: Routledge, pp. 219–235.

Chen, Y., Farinelli, U. and Johansson, T. B. (2004) 'Technological leapfrogging–a strategic pathway to modernization of the Chinese iron and steel industry', *Energy for Sustainable Development*, VIII(2), pp. 18–26.

Chisenga, J. (2000) 'Global Information and libraries in sub-Saharan Africa', *Library Management*, 21(4), pp. 178–187. doi: 10.1108/01435120010693997.

Clark, J. R. *et al.* (2016) 'Marine microplastic debris: a targeted plan for understanding and quantifying interactions with marine life', *Frontiers in Ecology and the Environment*, 14(6), pp. 317–324. doi: 10.1002/fee.1297.

Clark, P. and Crous, W. (2002) 'Public transport in metropolitan Cape Town: Past, present and future', *Transport Reviews*, 22(1), pp. 77–101. doi: 10.1080/01441640110052092.

Clear Blue Sea (2021) *Meet Fred: Floating Robot for Eliminating Debrisi*. Available at: https://www.clearbluesea.org/meet-fred/.

Clos, J. (2016) 'Meetings on Architecture', in *Biennale Architettura*. Venice. Available at: https://www.youtube.com/watch?v=Kpj8XsoySJ0.

Cochrane, A. (2007) 'Competitiveness, the market, and urban entrepreneurialism', in Publishing, B. (ed.) *Understanding Urban Policy: A Critical Approach*. Malden, pp. 85 – 103.

Cohen, B. (2012) 'Smart City Wheel', in *What Exactly Is A Smart City?* Fast Company. Available at: https://www.fastcompany.com/1680538/what-exactly-is-a-smart-city.

Craglia, M. *et al.* (2004) 'Towards the development of quality of life indicators in the "digital" city', *Environment and Planning B: Planning and Design*, 31(1), pp. 51–64. doi: 10.1068/b12918.

Creamer, M. (2009) *All three SA coal-export ports rail-constrained - Wood Mackenzie*, *Mining Weekly*. Johannesburg: Creamer media. Available at: https://www.miningweekly.com/article/all-three-sa-coal-export-ports-rail-constrained---wood-mackenzie-2009-03-11/rep_id:3650.

Creswell, J. W. (2007) *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications.

Cyrus, D. P. and Forbes, A. T. (1996) 'Preliminary results on the role of KwaZulu-Natal harbours as nursery grounds for juveniles of selected marine organisms which utilize estuaries', *African Journal of Wildlife Research*, 26(1), pp. 26–32.

Davies, G. and Burgess, J. (2004) 'Challenging the "view from nowhere": Citizen reflections on specialist expertise in a deliberative process', *Health and Place*, 10(4), pp. 349–361. doi: 10.1016/j.healthplace.2004.08.005.

Davies, M. (2007) *Doing a Successful Research Project*. New York: Palgrave Macmillan.

Davies, M. and Schiller, T. (2018) *Deloitte Africa Automotive Insights Navigating the African Automotive Sector: Ethiopia,* *Kenya and Nigeria*. Deloite. Available at: https://www2.deloitte.com/content/dam/Deloitte/za/Documents/manufacturing/za_Africa-Auto-2016-Report-28-May-2018.pdf.

Davison, R. *et al.* (2013) 'Technology Leapfrogging in Developing Countries: An Inevitable Luxury?', *Journal of Chemical Information and Modeling*, 53(9), pp. 1689–1699.

DEA (2009) *National Environmental Management: Waste Act 59 of 2008*, *Gazette*.

DEA (2012) *National waste information baseline report*. Department of Environmental Affairs. Republic of South Africa. Available at: http://sawic.environment.gov.za/documents/1880.pdf.

DEAT (1999) *National Waste Management Strategy, Version D*. Pretoria: Department of environmental affairs and tourism.

Deloitte & Touche (2014) 'Africa is ready to leapfrog the competition Through Smart Cities Technology Introduction'. Available at: http://www2.deloitte.com/content/dam/Deloitte/za/Documents/public-sector/ZA_SmartCities_12052014.pdf.

Demirguc-Kunt, A. *et al.* (2014) *Global Findex Database 2014: Measuring Financial Inclusion around the World*. Geneva: World Bank Group.

Demirgüç-Kunt, A. and Klapper, L. (2012) *Financial Inclusion and Innovation in Africa: An Overview*. Edited by Finance and Private Sector Development Team. World Bank Group.

Denzin, N. K. and Lincoln, Y. S. (1998) *Collecting and Interpreting Qualitative Materials*. Edited by N. K. Denzin and Y. V. Lincoln. London: Sage Publications.

Department of Transport and Public Works (2011) *Cape Town central city regeneration programme. Strategic framework*. Cape Town: Provincial Ggovernment of the Western Cape.

Derraik, J. G. B. (2002) 'The pollution of the marine environment by plastic debris: a review', *Marine Pollution Bulletin*, 44(9), pp. 842–852. Available at: http://www.sciencedirect.com/science/article/pii/S0025326X02002205.

Diaz Olvera, L., Plat, D. and Pochet, P. (2008) 'Household transport expenditure in Sub-Saharan African cities: measurement and analysis', *Journal of Transport Geography*, 16(1), pp. 1–13. doi: 10.1016/j.jtrangeo.2007.04.001.

Diaz Olvera, L., Plat, D. and Pochet, P. (2013) 'The puzzle of mobility and access to the city in Sub-Saharan Africa', *Journal of Transport Geography*, 32, pp. 56–64. doi: 10.1016/j.jtrangeo.2013.08.009.

Didier, S., Peyroux, E. and Morange, M. (2012) 'The Spreading of the City Improvement District Model in Johannesburg and Cape Town: Urban Regeneration and the Neoliberal Agenda in South Africa', *International Journal of Urban and Regional Research*, 36(5), pp. 915–935. doi: 10.1111/j.1468-2427.2012.01136.x.

Diebold, W. and Jacobs, J. (1984) *Cities and the Wealth of Nations*, *Foreign Affairs*. doi: 10.2307/20042112.

Dimitriou, H. T. and Gakenheimer, R. (2011) 'Conclusions: emergent crucial theme', in Dimitriou, H. T. and Gakenheimer, R. (eds) *Urban Transport in the Developing World. A Handbook of Policy and Practice*. Cheltenham-Northampton, pp. 589–603.

Dirks, S., Gurdgiev, C. and Keeling, M. (2010) *Smarter Cities for Smarter Growth: How Cities Can Optimize Their Systems for the Talent-Based Economy*, *IBM Global Business Services*. Available at: https://www-05.ibm.com/se/smartercities/pdf/GBE03348USEN.PDF.

Dirks, S. and Keeling, M. (2009) 'A vision of smarter cities', *New York: IBM Global Services*, p. 18. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:A+vision+of+smarter+cities#1.

Donner, J. (2008) 'Research approaches to mobile use in the developing world: A review of the literature', *Information Society*, 24(3), pp. 140–159. doi: 10.1080/01972240802019970.

Doong, D. J. *et al.* (2011) 'Quantity, distribution, and impacts of coastal driftwood triggered by a typhoon', *Marine Pollution Bulletin*, 62(7), pp. 1446–1454. doi: 10.1016/j.marpolbul.2011.04.021.

Dovey, K. and Ristic, M. (2017) 'Mapping urban assemblages: the production of spatial knowledge', *Journal of Urbanism*, 10(1), pp. 15–28. doi:

10.1080/17549175.2015.1112298.

Dumont, M., Stojanovska, N. and Cuyvers, L. (2011) 'World inequality, globalisation, technology and labour market institutions', *International Journal of Manpower*, 32(3), pp. 257–272. doi: 10.1108/01437721111136750.

Dyllick, T. and Hockerts, K. (2002) 'Beyond the business case for corporate sustainability', *Business Strategy and the Environment*, 11(2), pp. 130–141. doi: 10.1002/bse.323.

Easterly, W. and Levine, R. (1997) *Africa's Growth Tragedy*, *The Quarterly Journal of Economics*. Policies and Ethnic Divisions.

Economist Intelligence Unit (2009) *European Green City Index: Assessing the environmental impact of Europe's major cities*. Munich: Siemens.

EDF (2016) *Implementation of the Support to the Transport Sector Development Programme. Transport Policy Framework (White Paper)*. Addis Ababa: European Development Fund.

Edvinsson, L. E. (2006) 'Aspects on the city as a knowledge tool', *Journal of Knowledge Management*, 10(5), pp. 6–13. doi: 10.1108/13673270610691134.

Elkington, J. (1999) *Cannibals with forks: the triple bottom line of 21st century business*. New Society Publishers: New Society Publishers.

Ellis, G. (2018) *How Autonomous Cleaning Drones Could Save The Ocean*. Available at: https://blog.v-hr.com/blog/how-autonomous-cleaning-drones-could-save-the-ocean.

van Emmerik, T. *et al.* (2019) 'Seasonality of riverine macroplastic transport', *Scientific Reports*, 9(1), pp. 1–9. doi: 10.1038/s41598-019-50096-1.

van Emmerik, T. and Schwarz, A. (2020) 'Plastic debris in rivers', *Wiley Interdisciplinary Reviews: Water*, 7(1), pp. 1–24. doi: 10.1002/wat2.1398.

Ensley, L. (2005) 'Information and communications technological leapfrogging in developing countries of the world'.

Epstein, E. L. and Kole, R. (1998) *The Language of African Literature*, *Africa World Press*. Africa World Press.

eThekwini Corporate GIS (2021) *eThekwini Municipality GIS*. Durban: eThekwini Municipality. Available at: http://gis.durban.gov.za/gis_Website/internetsite/#top.

eThekwini Municipality (2019) *Durban climate action plan 2019*. Durban: eThekwini Municipality. Available at: http://www.durban.gov.za/City_Services/development_planning_management/environmental_planning_climate_protection/CAP/Pages/default.aspx.

eThekwini Municipality (2020a) *eThekwini municipal spatial development framework 2020-2021*. Durban.

eThekwini Municipality (2020b) *Strategic Environmental Assessment 2020/2021*. Durban: eThekwini Municipality. Available at: http://www.durban.gov.za/City_Services/development_planning_management/environmental_planning_climate_protection/SEA/Documents/Durban SEA Phase 1_Final Environmental Status Quo Report_17 09 2020.pdf.

European Parliement (2015) *Understanding waste streams*. Available at: https://www.europarl.europa.eu/EPRS/EPRS-Briefing-564398-Understanding-waste-streams-FINAL.pdf.

Ezemvelo KwaZulu-Natal Wildlife (2014) *Annual Integrated Report 2013/2014*.

Farmer, T. *et al.* (2006) 'Developing and implementing a triangulation protocol for qualitative health research', *Qualitative Health Research*, 16(3), pp. 377–394. doi: 10.1177/1049732305285708.

Faure, F. *et al.* (2012) 'Pollution due to plastics and microplastics in lake Geneva and in the Mediterranean sea', *Archives des Sciences*, 65(1–2), pp. 157–164. doi: 10.5169/seals-738358.

Feenstra, R. (1998) 'Comment on Robert Feenstra: Technology and Trade: A Threat to Low-Skilled Workers?', *Swedish Economic Policy Review*, 5, pp. 137–160.

Fergusson, W. C. (1974) 'Summary', in Staudinger, J. J. P. (ed.) *Plastics and the Environment*. London: Hutchinson and Co, p. 2.

Fertner, C. *et al.* (2007) *Smart cities Ranking of European medium-sized cities*. Available at: www.srf.tuwien.ac.at.

Figueiredo, L., Honiden, T. and Schumann, A. (2018) 'Indicators for Resilient Cities', *OECD Regional Development*

Working Papers. doi: 10.1787/6f1f6065-en.

Finger, M. (2017) 'Smart Cities: Management of Smart Urban Infrastructures [MOOC]'. Coursera.

Florida, R. (2002) *The rise of the creative class; and how it's transforming work, leisure, community and everyday life*. New York: Basic Books.

Florida, R. (2003) 'Cities and the creative class', *City and community*, 2(1).

Fong, M. W. L. (2011) 'Technology Leapfrogging for Developing Countries', *Encyclopedia of Information Science and Technology, Second Edition*, pp. 3707–3713. doi: 10.4018/978-1-60566-026-4.ch591.

Forbes, A. T. and Demetriades, N. T. (2008) 'Estuaries of Durban, KwaZulu-Natal, South Africa', in *Report prepared for the Environmental Management Department, eThekwini Municipality. Marine & Estuarine Research, Durban.*

Forbes, A. T., Demetriades, N. T. and Cyrus, D. P. (1996) 'Biological significance of harbours as coastal habitats in KwaZulu-Natal, South Africa', *Aquatic Conservation: Marine and Freshwater Ecosystems*, 6(4), pp. 331–341. doi: 10.1002/(sici)1099-0755(199612)6:4<331::aid-aqc198>3.3.co;2-3.

Foster, V. (2009) *Africa infrastructure country diagnostic. Air transport. Challenges to growth*, *World Bank Group*.

Foster, V. *et al.* (2009) 'Building Bridges : China's Growing Role as Infrastructure Financier for Sub-Saharan Africa', *Accounting*. doi: 10.1596/978-0-8213-7554-9.

Freduah, G. (2007) 'Problems of Solid Waste Management in Nima, Accra', *Undergraduate Research Journal for the Human* …. Available at: http://www.kon.org/urc/v6/george.html#.UntXPNDFm_8. mendeley%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Problems+of+Solid+Waste+Management+in+Nima,+Accra#0.

Freedom House (2020) *Freedom in the World 2020*. Available at: www.freedomhouse.org.

Gasperi, J. *et al.* (2014) 'Assessment of floating plastic debris in surface water along the Seine River', *Environmental pollution (Barking, Essex : 1987)*, 195, pp. 163–166. doi: 10.1016/j.envpol.2014.09.001.

Gathii, J. T. *et al.* (2017) 'The Continental Free Trade Area (CFTA) in Africa – A Human Rights Perspective', pp. 1–167. Available at: http://www.fes-globalization.org/geneva/documents/2017/2017_07_CFTA_HRIA_Publication.pdf.

George, H. (1881) *'Progress and poverty'*. Cambridge: Cambridge University Press. doi: https://doi.org/10.1017/CBO9780511693687.

Georgiadou, M. C. *et al.* (2020) 'Towards sustainable informal settlements: a toolkit for community-led upgrading in Durban', *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, 174(2), pp. 83–93. Available at: https://doi.org/10.1680/jensu.20.00040.

Giffinger, R. and Haindl, G. (2007) 'Smart Cities Ranking: an Effective Instrument for the Positioning of Cities?', pp. 703–714. Available at: https://upcommons.upc.edu/bitstream/handle/2099/11933/05_PROCEEDINGS_M5_01_0014.pdf.

Gilderbloom, J. I., Riggs, W. W. and Meares, W. L. (2015) 'Does walkability matter? An examination of walkability's impact on housing values, foreclosures and crime', *Cities*, 42(PA), pp. 13–24. doi: 10.1016/j.cities.2014.08.001.

Glaeser, E. L. and Berry, C. R. (2006) 'Why Are Smart Places Getting Smarter?', *Policy Briefs*, (617), pp. 1–4. Available at: http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers-programs/centers/taubman/brief_divergence.pdf.

Godard, X. (2011) 'Poverty and urban mobility: Diagnosis toward a new understanding', *Urban Transport in the Developing World: A Handbook of Policy and Practice*, pp. 232–261. doi: 10.4337/9781849808392.00018.

Godfrey, L., Scott, D. and Trois, C. (2013) 'Caught between the global economy and local bureaucracy: The barriers to good waste management practice in South Africa', *Waste Management and Research*, 31(3), pp. 295–305. doi: 10.1177/0734242X12470204.

González, J. A. A. and Rossi, A. (2012) *New trends for smart cities*, *OPEN INNOVATION mechanisms in smart cities*. European Commission within the ICT Policy Support Programme.

Gorman, M. (1993) *Environmental Hazards. Marine*

Pollution. Santa Barbara: ABCCLIO Inc.

Gounden, A. and Nkhumeleni, T. (2012) *The rise and rise of the African middle class*, *Deloitte on Africa Collection*. Johannesburg: Deloitte & Touche. Available at: http://www2.deloitte.com/content/dam/Deloitte/au/Documents/international-specialist/deloitte-au-aas-rise-african-middle-class-12.pdf.

Graham, M. (2014) 'Inequitable Distributions in Internet Geographies: The Global South Is Gaining Access, but Lags in Local Content', *Innovations: Technology, Governance, Globalization*, 9(3–4), pp. 3–19. doi: 10.1162/inov_a_00212.

Green, E. (2012) 'Explaining African Ethnic Diversity', *International Political Science Review*.

Greenfield, A. (2006) *Everyware: the dawning age of ubiquitous computing*. Boston: New Riders.

Greenfield, A. (2013) *Against the smart city*. Do projects.

GSMA (2021) 'State of the Industry Report on Mobile Money', *Gsma*, pp. 1–75. Available at: www.gsma.com/mobilemoney.

Guillén, M. F. and Suárez, S. L. (2005) 'Explaining the global digital divide: Economic, political and sociological drivers of cross-national internet use', *Social Forces*, 84(2), pp. 681–708. doi: 10.1353/sof.2006.0015.

Güneralp, B. *et al.* (2018) 'Urbanization in Africa: Challenges and opportunities for conservation', *Environmental Research Letters*, 13(1), pp. 2–7. doi: 10.1088/1748-9326/aa94fe.

Gutiérrez Rubí, A. (2016) 'El peligro de ciudades demasiado inteligentes', *Planeta futuro*, April. Available at: https://elpais.com/elpais/2016/04/13/planeta_futuro/1460545060_075298.html.

Haapio, A. (2012) 'Towards sustainable urban communities', *Environmental Impact Assessment Review*, 32(1), pp. 165–169. doi: 10.1016/j.eiar.2011.08.002.

Hai, H. (2016) 'Made in Africa: a practical initiative to jumpstart African manufacturing'. Available at: http://set.odi.org/helen-hai-made-in-africa-a-practical-initiative-to-jumpstart-africanmanufacturing/.

Hancke, G. P. and de Silva, B. de C. (2013) 'The role of advanced sensing in smart cities', *Sensors (Switzerland)*, 13(1), pp. 393–425. doi: 10.3390/s130100393.

Hanna, N. K. (1991) 'The information technology revolution and economic development', *World Bank Discussion Papers*, 120.

Hansen, D. (2019) 'WATCH: Trees Was Past Swan Boat as Umgeni River Floods'. Claxton Press. Available at: https://northglennews.co.za/150791/watch-trees-wash-past-swan-boat-Umgeni-river-floods/.

Haq, G. and Schwela, D. (eds) (2012) *Transport and Environment in Sub-Saharan Africa*. doi: 10.13140/RG.2.1.1030.3848.

Haque, U. (2012) 'Surely there's a smarter approach to smart cities?', *Wired UK*.

Harrison, C. *et al.* (2010) 'Foundations for Smarter Cities.', *IBM Journal of Research and Development*, 54(4), pp. 1–16.

Harrison, T. D. (2004) 'Physico-chemical characteristics of South African estuaries in relation to the zoogeography of the region', *Estuarine, Coastal and Shelf Science*, 61(1), pp. 73–87. doi: 10.1016/j.ecss.2004.04.005.

Hart, G. (2002) *Disabling Globalization: Places of Power in Post-Apartheid South Africa*. Pietermaritzburg: University of Natal Press. doi: 10.1017/S0010417504240294.

Hart, G. (2004) *Disabling Globalization: Places of Power in Post-Apartheid South Africa*, *Comparative Studies in Society and History*. Pietermaritzburg: University of Natal Press. doi: 10.1017/S0010417504240294.

Hart, S. L., Milstein, M. B. and Caggiano, J. (2003) 'Creating sustainable value', *Academy of Management Executive*, 17(2), pp. 56–69. doi: 10.5465/ame.2003.10025194.

Harvey, D. (2012) 'The Urban Roots Of Financial Crisis: Reclaiming The City For Anti-capitalist Struggle', *Socialist Register*, 48, pp. 1–35. Available at: http://newleftproject.org/Harvey_final.pdf.

Harvey, R. (2017) 'The "fourth industrial revolution": potential and risks for Africa', *SAIIA*, 21 March. Available at: http:i/www.sai ia.org.zafopi nion-anal ysis/the-fourth-industrial-revol ution-potential-and-risks-for-afri ca.

Hattingh, D. *et al.* (2012) *Rise of the African consumer*. Johannesburg: McKinsey and Company.

He, D. *et al.* (2018) 'Microplastics in soils: Analytical methods, pollution characteristics and ecological risks', *TrAC - Trends in Analytical Chemistry*, 109, pp. 163–172. doi: 10.1016/j.trac.2018.10.006.

Hellsten, S. K. (2016) 'Deconstructing the myth of the African middle class', in Melber, H. (ed.) *The rise of Africa's middle class: myths, realities and critical engagements*. Uppsala: Nordiska Afrikainsitute, pp. 95–109.

Herfindahl, E. and Treat, A. (2009) *Sub-Saharan Africa: Effects of Infrastructure Conditions on Export Competitiveness, Third Annual Report*. Washington, DC.

Heritier, A. (2007) 'Explaining Institutional Change in Europe', *Explaining Institutional Change in Europe*, pp. 1–288. doi: 10.1093/acprof:oso/9780199298129.001.0001.

Hillier, B. (2012) 'The city as a socio-technical system: A spatial reformulation in the light of the levels problem and the parallel problem', *Communications in Computer and Information Science*, 242 CCIS, pp. 24–48. doi: 10.1007/978-3-642-29758-8_3.

Hoffman, J. (1995) *Linking Economic Research and Policy-Making: The Role of AERC.*, *Papers*. African Economic Research Consortium.

Hollands, R. G. (2008) 'Will the real smart city please stand up?', *City*, 12(3), pp. 303–320. doi: 10.1080/13604810802479126.

Holling, C. S. (1973) 'Resilience and stability of ecological systems', *Annual Review of Ecology and Systematics*, 4, pp. 1–23.

Hoola One (2021) *Plastic removal device*. Available at: https://hoolaone.com/home/.

Hove, M., Ngwerume, E. T. and Muchemwa, C. (2013) 'The urban crisis in Sub-Saharan Africa: A threat to human security and sustainable development', *Stability*, 2(1), pp. 1–14. doi: 10.5334/sta.ap.

Huchzermeyer, M. (2004) *Unlawful Occupation: Informal Settlements and Urban Policy in South Africa and Brazil*. Trenton: Africa World Press.

Huchzermeyer, M., Karam, A. and Maina, M. (2018) 'Informal settlements', *Changing Space, Changing City*, 2015(May), pp. 154–175. doi: 10.18772/22014107656.12.

Huovila, A., Bosch, P. and Airaksinen, M. (2019) 'Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when?', *Cities*, 89(June), pp. 141–153. doi: 10.1016/j.cities.2019.01.029.

Husqvarna Group AI Lab and 20tree.ai (2019) 'Husqvarna Urban Green Space Index', pp. 1–16. Available at: www.hugsi.green.

ICAO (2018) *2017 Air Transport Statistical Results*, *Annual Reports of the Council*. International Civil Aviation Organization.

ICEX (2019) *Informe económico y comercial: Sudáfrica*. Johannesburg.

IEA (2002) *World Energy Outlook 2002*. Paris: International Energy Agency.

IEA (2008) *World Energy Outlook 2008 Edition*. Paris: International Energy Agency. Available at: https://www.iea.org/reports/world-energy-outlook-2008.

ILO (2020) *World Employment And Social Outlook: Trends 2020*, *International Labour Organization*.

Inggs, M. (2009) *Dube TradePort cargo terminal nearing completion*, *Engineering news*. Edited by M. Zhuwakinyu. Johannesburg: Creamer media. Available at: https://www.engineeringnews.co.za/article/dube-tradeport-2009-09-11/rep_id:4136.

Institute for Security Sudies (2016) *Crime quarterly*. Edited by C. Gould. Pretoria: Institute for Security Studies,. Available at: http://www.issafrica.org/publications/south-african-crime-quarterly.

IOC (2021) *African Marine Atlas*. Intergovernmental Oceanographic Commission. Available at: http://omap.africanmarineatlas.org/index.htm.

Ishida, T. (2002) 'Digital city Kyoto', *Communications of the ACM*, 45(7), pp. 76–81. doi: 10.1145/514236.514238.

ISO (2008) *ISO 15392:2008. Sustainability in building construction - General principles*. Geneva: International

Organization for Standardization. Available at: https://www.iso.org/standard/40432.html.

ISO (2011) *ISO 21929:2011. Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings*. Geneva: International Organization for Standardization. Available at: https://www.iso.org/standard/46599.html.

ISO (2018) *ISO 37120:2018. Sustainable cities and communities - Indicators for city services and quality of life*. International Organization for Standardization. Available at: https://www.iso.org/standard/68498.html.

ISWA (2009) 'Waste and Climate Change. ISWA white paper', in. Vienna: International Solid Waste Association.

ITU (1998) 'A Special ITU Development Initiative', *ITU News*, 3(98).

ITU (2000) *ITU at a glance*. Geneva: International Telecommunication Union.

ITU (2005) *The internet of things*. Geneva: International Telecommunications Union. Available at: www.itu.int/osg/spu/publications/internetofthings/InternetofThings_summary.pdf.

Jambeck, J. R. *et al.* (2015) 'Plastic waste inputs from land into the ocean', *Science*, 347(6223), pp. 764–768. Available at: http://www.sciencemag.org/cgi/doi/10.1126/science.1260879.

James, P. (2014) *Urban Sustainability in Theory and Practice. Circles of sustainability*. Routledge.

Jolliffe, D. and Lugo, M. A. (2018) *Piecing Together the Poverty Puzzle*. Washington DC: World Bank Group. doi: 10.1596/978-1-4648-1330-6.

de Jong, R. C. (2002) 'Railway Heritage at Risk'.

de Jong, S. *et al.* (2017) *The Geopolitical Impact of Climate Mitigation Policies*. The Hague: The Hague Centre for Strategic Studies.

Kamete, A. Y. (2013) 'Missing the point? Urban planning and the normalisation of "pathological" spaces in southern Africa', *Transactions of the Institute of British Geographers*, 38(4), pp. 639–651. doi: 10.1111/j.1475-5661.2012.00552.x.

Kanbur, R. *et al.* (2000) *World development report 2000/2001 : attacking poverty (English)*, *World Bank Group*. Washington, D.C. Available at: http://documents.worldbank.org/curated/en/230351468332946759/World-development-report-2000-2001-attacking-poverty.

Kanter, R. M. and Litow, S. S. (2009) 'Informed and Interconnected: A Manifesto for Smarter Cities', *Harvard Business School General Management Unit Working Paper*, pp. 09–141. Available at: https://hbswk.hbs.edu/item/informed-and-interconnected-a-manifesto-for-smarter-cities.

Kaplinsky, R. (2013) *Globalization, poverty and inequality: Between a rock and a hard place*. Hoboken: John Wiley & Sons.

Keating, M. (1993) *The Earth Summit's agenda for change : a plain language version of Agenda 21 and the other Rio Agreements*. Geneva: Centre for Our Common Future.

Kent, P. and Fox, A. (2004) *The broad economic impact of port inefficiency: a comparative study of two ports*. U.S. Agency for International Development. Available at: http://pdf.usaid.gov/pdf_docs/PNADC612.pdf.

Klapper, L. *et al.* (2019) *Sub-Saharan Africa Series : Mobile Money and Digital Financial Inclusion*, *Development Research Group*. Washington, D.C.

Klein, C. and Kaefer, G. (2008) 'From Smart Homes to Smart Cities: Opportunities and Challenges from an Industrial Perspective', *Next Generation Teletraffic and Wired/Wireless Advanced Networking*, pp. 260–260. doi: 10.1007/978-3-540-85500-2_24.

Knoth, G. (2015) '6 ways energy poverty impacts health', *ONE*, June. Available at: https://www.one.org/us/blog/six-ways-energy-poverty-threatens-health-care-for-the-poorest/.

Knowledge@Wharton (2017) 'Breeding unicorns in Africa: is this the first of many?', *World Economic Forum*, 28 April.

Komninos, N. (2009) 'Intelligent Cities: Towards Interactive and Global Innovation Environments', *International Journal* *of Innovation and Regional Development*, 1, pp. 337–355.

Kühn, S., Bravo Rebolledo, E. L. and Van Franeker, J. A. (2015) 'Deleterious effects of litter on marine life', in *Marine anthropogenic litter*. Springer, pp. 75–116.

Kumar, A. and Barrett, F. (2008) 'Stuck in traffic: Urban transport in Africa', in *Africa infrastructure country diagnostic*. World Bank Group.

KZN Transport (2021a) *GIS Data Documents*. Department of transport. Province of KwaZulu-Natal. Available at: http://gis.kzntransport.gov.za/downloads_data.aspx.

KZN Transport (2021b) *KZN provincial viewer*. Department of transport. Province of KwaZulu-Natal. Available at: https://gis1.kzntransport.gov.za/DOTProv/.

Laist, D. W. (1987) 'Overview of the biological effects of lost and discarded plastic debris in the marine environment', *Marine Pollution Bulletin*, 18(6 SUPPL. B), pp. 319–326. doi: 10.1016/S0025-326X(87)80019-X.

Lall, S. V., Henderson, J. V. and Venables, A. J. (2017) 'Africa's Cities: Opening Doors to the World', *Africa's Cities: Opening Doors to the World*. doi: 10.1596/978-1-4648-1044-2.

Lamprecht, A. (2013) 'The abundance, distribution and accumulation of plastic debris in Table Bay, Cape Town, South Africa', *MSc Thesis*, pp. 1–52. Available at: https://open.uct.ac.za/bitstream/handle/11427/6633/thesis_sci_2013_lamprecht_annemarie.pdf?sequence=1&isAllowed=y.

Landman, K. (2012) 'Gated communities in South Africa: tensions between the planning ideal and practice', *Stads- en Streeksbeplanning = Town and Regional Planning*, 2012(61), pp. 1–9.

Lane, J. (2003) 'Uses of microdata: keynote speech', in *In Statistical confidentiality and access to microdata: proceedings of the Seminar Session of the 2003 Conference of European Statisticians*. Geneva: United Nations Economic Commission for Europe.

Lang, B. *et al.* (2020) 'Prosumers in times of crisis: definition, archetypes and implications', *Journal of Service Management*, ahead-of-p(ahead-of-print). doi: https://doi.org/10.1108/JOSM-05-2020-0155.

Langa, Z., Conradie, P. and Roberts, B. (2006) 'Slipping through the net: Digital and other communication divides within South Africa', *South African social attitudes. Changing times, diverse voices*, pp. 131–149.

Lebreton, L. and Andrady, A. (2019) 'Future scenarios of global plastic waste generation and disposal', *Palgrave Communications*, 5(1). doi: 10.1057/s41599-018-0212-7.

Lechner, A. *et al.* (2014) 'The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river', *Environmental Pollution*, 188, pp. 177–181. doi: 10.1016/j.envpol.2014.02.006.

Leck, H. and Simon, D. (2013) 'Fostering Multiscalar Collaboration and Co-operation for Effective Governance of Climate Change Adaptation', *Urban Studies*, 50(6), pp. 1221–1238. doi: 10.1177/0042098012461675.

Lee, J. P., Hancock, M. G. and Hu, M.-C. (2014) 'Toward a framework for building Smart Cities: Lessons from Seoul and San Francisco', *Technological Forecasting and Social Change*, (89), pp. 80–99. doi: 10.1016/j.techfore.2013.08.033.

Leedy, P. D. and Ormrod, J. E. (2000) *Practical Research: Planning and Design*. Pearson.

Lemanski, C. (2004) 'A new Apartheid? urban spatiality, (fear of) crime, and segregation in Cape Town, South Africa', *Environment and Urbanization*, 16(2), pp. 101–111.

Leon, P. de (2020) 'Cleantech Startup BluePhin Technologies Is On A Mission To Battle The Global Problem Of Water Pollution'. Available at: https://www.entrepreneur.com/article/347691.

Leopold, A. (1949) *A Sand County Almanac*.

Li, C. *et al.* (2020) 'Evaluation system: Evaluation of smart city shareable framework and its applications in China', *Sustainability (Switzerland)*, 12(7), pp. 1–16. doi: 10.3390/su12072957.

Lincoln, Y. S. and Guba, E. G. (1985) *Naturalistic Inquiry*. Beverly Hills: Sage.

Lopes, C. (2015) 'How can Africa profit from its creative industries?', *World Economic Forum*. Available at: https://www.weforum.org/agenda/2015/09/how-can-africa-profit-from-its-creative-industries/.

López Moreno, E. and Oyeyinka, O. (2010) *State of The World's Cities: Bridging the Urban Divide*. Nairobi: UN-Habitat. Available at: https://unhabitat.org/state-of-the-worlds-cities-20102011-cities-for-all-bridging-the-urban-divide.

Lovejoy, T. E. (1997) 'Biodiversity: what is it?', in Wilson, E. O., Wilson, D. E., and Reaka-Kudla, M. L. (eds) *Biodiversity II : understanding and protecting our biological resources*. Washington DC: Joseph Henry Press, pp. 7–14.

Lucas, K. (2011) 'Making the connections between transport disadvantage and the social exclusion of low income populations in the Tshwane Region of South Africa', *Journal of Transport Geography*, 19(6), pp. 1320–1334. doi: 10.1016/j.jtrangeo.2011.02.007.

Luppi, B., Parisi, F. and Rajagopalan, S. (2012) 'The rise and fall of the polluter-pays principle in developing countries', *International Review of Law and Economics*, 32(1), pp. 135–144. doi: 10.1016/j.irle.2011.10.002.

Majgaard, K. and Mingat, A. (2012) *Education in Sub-Saharan Africa. A comparative analysis*. Washington DC: World Bank Group. doi: 10.1596/978-0-8213-8889-1.

Makgae, M. (2011) 'Key Areas in Waste Management: A South African Perspective', *Integrated Waste Management - Volume II*. doi: 10.5772/18023.

Maldonado, T. (1972) *Design, Nature, and Revolution: Toward a Critical Ecology*. University of Minnesota Press.

Malombe, J. M. (1993) 'Sanitation and solid waste disposal in Malindi', *Water, Sanitation, Environment and Development: Proceedings of the 19th WEDC Conference*, pp. 134–136.

Mamdani, M. (1996) *Citizen and Subject: Contemporary Africa and the legacy of late colonialism*. Princeton Academic Press.

Mandani, M. (1996) *Citizen and Subject: Contemporary Africa and the legacy of late colonialism*. Princeton Academic Press. doi: 10.4324/9781912281602.

Manson, K. (2015) 'Nestlé cuts Africa workforce as middle class growth disappoints', *Financial Times*, June. Available at: https://www.ft.com/content/de2aa98e-1360-11e5-ad26-00144feabdc0.

Manwa, H. (2007) *Is Zimbabwe ready to venture into the cultural tourism market?*, *Development Southern Africa*. Cité du Djoué. doi: 10.1080/03768350701445558.

Manyika, J. *et al.* (2011) *Big Data: The next frontier for innovation, competition and productivity*. London: McKinsey Global Institute. Available at: https://www.mckinsey.com/~/media/mckinsey/business functions/mckinsey digital/our insights/big data the next frontier for innovation/mgi_big_data_full_report.pdf.

Margolin, V. (2015) 'The Good City: Design for Sustainability', *She Ji*, 1(1), pp. 34–43. doi: 10.1016/j.sheji.2015.07.001.

Martin, R. and Sunley, P. (2003) 'Deconstructing clusters: Chaotic concept or policy panacea?', *Journal of Economic Geography*, 3(1), pp. 5–35. doi: 10.1093/jeg/3.1.5.

Marx, C. and Charlton, S. (2003) 'The case of Durban, South Africa', in Development Planning Unit (DPU) (ed.) *Understanding Slums: Case Studies for the Global Report 2003*. London: UN-Habitat.

Matete, N. and Trois, C. (2008) 'Towards Zero Waste in emerging countries - A South African experience', *Waste Management*, 28(8), pp. 1480–1492. doi: 10.1016/j.wasman.2007.06.006.

Mayors Adapt (2014) 'Mayors Adapt. The Covenant of Mayors Initiative on Adaptation to Climate Change', 2014(16 10). Available at: http://mayors-adapt.eu/.

Mbara, T. C. (2002) 'Transport: How Have African Cities Managed the Sector? What are the Possible Options?', *Urban & City Management Course for Africa*, 2(5), pp. 1–13. Available at: ???

Mbeki, M. (2005) 'Underdevelopment in sub-Saharan Africa: the role of the private sector and political elites', in *Foreign Policy Briefing No. 85*. Washington, DC: Cato Institute.

Mcgranahan, G. and Satterthwaite, D. (2014) 'Urbanisation concepts and trends', *International Institute for Environment and Development*, (June), pp. 1–27.

MEA (2004) *Ecosystem Services in Southern Africa: A Regional Assessment*. Scholes, R, *Southern African Millennium Ecosystem Assessment*. Scholes, R. Pretoria:

Millennium Ecosystem Assessment.

Meads, D. and Africa, C. (2019) 'Here ' s how Africa can take advantage of the Fourth Industrial Revolution', *World Economic Forum*, 2 May, pp. 2017–2020.

Meerow, S., Newell, J. P. and Stults, M. (2016) 'Defining urban resilience: A review', *Landscape and Urban Planning*, 147(March), pp. 38–49. doi: 10.1016/j.landurbplan.2015.11.011.

Meijer, L. J. J. *et al.* (2021) 'More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean', *Science Advances*, 7(18), pp. 1–14. doi: 10.1126/sciadv.aaz5803.

Mellander, C. and Florida, R. (2007) 'The Creative Class or Human Capital? Explaining regional development in Sweden', *CESIS Electronic Working Paper Series*, Paper No.(December), pp. 1–38. Available at: http://www.infra.kth.se/cesis/documents/WP79.pdf.

Mercy Corps (2018) *Urban Resilience Measurement: An Approach Guide and Training Curriculum*. Edited by S. Alexander, D. Nicholson, and J. Kurtz. Portland: USAID.

Metrorail (2021) 'KwaZulu-Natal Rail Map'. Durban: PRASA. Available at: http://www.metrorail.co.za/maps/DBN_RailMap.pdf.

Mevel, S. and Karingi, S. (2013) 'Towards a Continental Free Trade Area in Africa: A CGE Modelling Assessment with a focus on Agriculture', in Cheong, D., Jansen, M., and Peters, R. (eds) *Shared Harvests: Agriculture, Trade, and Employment*. Geneva: UNCTAD and ILO, pp. 281–324.

Miliute-Plepiene, J. *et al.* (2018) 'Overview of available methods to monitor marine plastic litter. Incl. method for riverine litter monitoring developed within BLASTIC', pp. 1–47. Available at: https://www.sei.org/wp-content/uploads/2017/12/blastic-overview-of-available-monitoring-methods-final.pdf.

Mittermeier, R. A. *et al.* (2011) 'Hotspots Revisited: Earth?s Biologically Richest and Most Endangered Ecoregions', p. 390pp. Available at: https://databasin.org/datasets/23fb5da1586141109fa6f8d45de0a260.

Mkhize, S., Dube, G. and Quazi, T. (2014) *Informal Economy Monitoring Study: Waste Pickers in Durban, South Africa*. Available at: https://www.wiego.org/sites/default/files/publications/files/Mkhize-IEMS-Durban-City-Report-Waste-Pickers.pdf.

Monfaredzadeh, T. and Berardi, U. (2014) 'How can cities lead the way towards a sustainable, competitive and smart future?', *WIT Transactions on Ecology and the Environment*, 191, pp. 1063–1074. doi: 10.2495/SC140902.

Monfaredzadeh, T. and Berardi, U. (2015) 'Beneath the smart city: Dichotomy between sustainability and competitiveness', *International Journal of Sustainable Building Technology and Urban Development*, 6(3), pp. 140–156. doi: 10.1080/2093761X.2015.1057875.

Moore, C. J., Lattin, G. L. and Zellers, A. F. (2011) 'Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California', *Revista de Gestão Costeira Integrada*, 11(1), pp. 65–73. doi: 10.5894/rgci194.

Mori, K. and Christodoulou, A. (2012) 'Review of sustainability indices and indicators: Towards a new City Sustainability Index (CSI)', *Environmental Impact Assessment Review*, 32(1), pp. 94–106. doi: 10.1016/j.eiar.2011.06.001.

Morritt, D. *et al.* (2014) 'Plastic in the Thames: A river runs through it', *Marine Pollution Bulletin*, 78(1–2), pp. 196–200. doi: 10.1016/j.marpolbul.2013.10.035.

Mosco, V. (2009) *The Political Economy of Communication*. 2nd edn. Sage Publications. doi: 10.4135/9781446279946.

Muneer, F. *et al.* (2021) 'Remediation of Water Pollution by Plastics', *Water Pollution and Remediation: Organic Pollutants*, pp. 89–117. doi: 10.1007/978-3-030-52395-4_3.

Mutai, J. (2020) *Citywide public space inventory and assessment toolkit. A guide to community-led digital inventory and assessment of public spaces.* Edited by UN-Habitat. Nairobi. Available at: https://unhabitat.org/sites/default/files/2020/07/city-wide_public_space_assessment_guide_0.pdf.

Nahman, A. and Godfrey, L. (2010) 'Economic instruments for solid waste management in South Africa: Opportunities and constraints', *Resources, Conservation and Recycling*, 54(8), pp. 521–531. doi: 10.1016/j.resconrec.2009.10.009.

Nam, T. and Pardo, T. A. (2011) 'Conceptualizing smart city with dimensions of technology, people, and institutions', *ACM International Conference Proceeding Series*, pp. 282–291. doi: 10.1145/2037556.2037602.

Napper, I. E. *et al.* (2015) 'Characterisation, quantity and sorptive properties of microplastics extracted from cosmetics', *Marine Pollution Bulletin*, 99(1–2), pp. 178–185. doi: 10.1016/j.marpolbul.2015.07.029.

Nash, R. (1967) *Wilderness and the American mind*. London: Yale University Press.

Nathan, M. (2008) 'The Wrong Stuff? Creative class theory and economic performance in UK cities', *Creative Urban Regions: Harnessing Urban Technologies to Support Knowledge City Initiatives*, (29486), pp. 80–93. doi: 10.4018/978-1-59904-838-3.ch005.

National Coordinating Agency for Population and Development *et al.* (2011) 'Kenya Service Provision Assessment Survey 2010', *Kenya Service Provision Assessment Survey*, pp. 1–695. Available at: https://esaro.unfpa.org/sites/default/files/pub-pdf/Kenya Service Provision Assessment Survey 2010.pdf%0Ahttp://dhsprogram.com/pubs/pdf/SPA17/SPA 17.pdf.

Navigant Research (2011) 'Smart cities: intelligent information and communications technology infrastructure in the government, buildings, transport, and utility domains (research report)'. Available at: http://www.navigantresearch.com/research/smartcities.

NCAR (2005) *A continent split by climate change: new study projects in Southern Africa, Rain in Sahel*. Boulder, CO.

Ncube, M., Lufumpa, C. L. and Kayizzi-Mugerwa, S. (2011) 'The middle of the Pyramid: Dynamics of the Middle Class in Africa', *African Development Bank Market Brief*, p. 24.

Neirotti, P. *et al.* (2014) 'Current trends in smart city initiatives: Some stylised facts', *Cities*, 38, pp. 25–36. doi: 10.1016/j.cities.2013.12.010.

Nel, E., Hill, T. and Maharaj, B. (2018) 'Durban's pursuit of economic development in the post-apartheid era', *Local Economic Development in the Changing World: The Experience of Southern Africa*, pp. 211–230. doi: 10.1007/s12132-003-0012-y.

Nelms, S. E. *et al.* (2018) 'Investigating microplastic trophic transfer in marine top predators', *Environmental Pollution*, 238, pp. 999–1007. doi: 10.1016/j.envpol.2018.02.016.

Norberg-Hodge, H. and Goering, P. (1992) *The Future of Progress: Reflections on Environment and Development*, *The International Society for Ecology and Culture*. Berkeley.

Nsibande, M. (2019) 'Plastic Nightmare at Durban Beach'. Claxton Press. Available at: https://risingsunoverport.co.za/71003/plastic-nightmare-durban-beach/.

Nulens, G. and Van Audenhove, L. (1999) 'An information society in Africa?: An Analysis of the Information Society Policy of the World Bank, ITU and ECA', *Gazette*, 61(6), pp. 451–471. doi: 10.1177/0016549299061006001.

Ochieng, R. O. (2000) 'Global information flows. Library Management Journal', *Library Management Journal*, 21(4), pp. 215-216.

Odendaal, N. (2003) 'Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies', *Computers, Environment and Urban Systems*, 27(6), pp. 585–607. doi: 10.1016/S0198-9715(03)00016-4.

Odendaal, N. (2016) 'Smart City: Neoliberal Discourse or Urban Development Tool?', in Grugel, J. and Hammett, D. (eds) *The Palgrave Handbook of International Development*. doi: 0.1057/978-1-137-42724-3_34.

Odendaal, N., Duminy, J. and Saunders, P. (2008) 'Is digital technology urban? Understanding inter-metropolitan digital divides in South Africa', *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat, OZCHI'08*, (September 2016), pp. 97–103. doi: 10.1145/1517744.1517774.

OECD (2016) *Economic outlook 2016*. doi: 10.1787/eco_outlook-v2016-1-en.

Olowu, D. (2017) 'African urbanisation and democratisation. Public policy, planning and public administration dilemmas', in Bhan, G., Srinivas, S., and Watson, V. (eds) *The Routledge Companion to Planning in the Global South*. London: Routledge, pp. 59–69. doi: 10.4324/9781317392842.

OMPI (2019) *World Intellectual Property Indicators 2019*.

oneworld radio (2006) 'How radio, cell phones, wireless web are empowering developing nations'.

openAFRICA (2021) *Open Africa datasets*. Available at: https://africaopendata.org/group/south-africa?tags=gis.

Opportunity Peterborough (no date) *Peterborough DNA: Future cities programme*. Available at: https://www.opportunitypeterborough.co.uk/projects/test-3/.

OSM (2021) *A valuable source of free geographic information*. OpenStreetMap. Available at: https://esri-southafrica.blog/2015/09/16/osm-openstreetmap/.

Oyekunle, O. A. (2019) 'Creative Industries in South Africa: An Engine for Urban Regeneration', *Urbanet*, February.

Page, J. (2016) 'Commodities, industry, and the African Growth Miracle', *Africa in focus*, April.

Papatheodorou, G. *et al.* (1999) 'Marine debris on the seafloor of the Mediterranean Sea: examples from two enclosed gulfs in western Greece', *Marine Pollution Bulletin*, 38(5), p. 389. Available at: https://login.wwwproxy1.library.unsw.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eih&AN=8346001&site=ehost-live&scope=site.

Parnell, S. and Pieterse, E. (2014) *Africa's Urban Revolution*, *Africa's Urban Revolution*. doi: 10.5040/9781350218246.

Parnell, S. and Pieterse, E. (2016) 'Translational Global Praxis: Rethinking Methods and Modes of African Urban Research', *International Journal of Urban and Regional Research*, 40(1), pp. 236–246. doi: 10.1111/1468-2427.12278.

Parnell, S. and Pieterse, E. (2019) '"The 'right to the city': institutional imperatives of a developmental state"', *The Globalizing Cities Reader*, pp. 264–269. doi: 10.4324/9781315684871-37.

Payne, G. (2004) 'Land tenure and property rights: An introduction', *Habitat International*, 28(2), pp. 167–179. doi: 10.1016/S0197-3975(03)00066-3.

Peck, J. (2005) 'Struggling with the creative class', *International Journal of Urban and Regional Research*, 29(4), pp. 740–770. doi: 10.1111/j.1468-2427.2005.00620.x.

Perboli, G. *et al.* (2014) 'A new taxonomy of smart city projects', *Transportation Research Procedia*, 3(July), pp. 470–478. doi: 10.1016/j.trpro.2014.10.028.

Peters, A. (2019) 'This giant vacuum is designed to suck up plastic from the beach'. Available at: https://www.fastcompany.com/90366838/this-giant-vacuum-is-designed-to-suck-up-plastic-from-the-beach.

Pieterse, E. (2019) *The Potential for Sustainable Urbanisation in Africa*.

Pieterse, E., Parnell, S. and Haysom, G. (2018) 'African dreams: locating urban infrastructure in the 2030 sustainable developmental agenda', *Area Development and Policy*, 3(2), pp. 149–169. doi: 10.1080/23792949.2018.1428111.

Pirie, G. (2014) 'Transport pressures in urban Africa: practices, policies, perspectives', in Parnell, S. and Pieterse, E. (eds) *Africa's Urban Revolution*. London: Zed Books, pp. 133–147. doi: 10.5040/9781350218246.ch-007.

Pitelis, C. (2005) 'Institutional diversity and governance for sustainable competitiveness', in British Academy of Management Annual Conference (ed.) *British Academy of Management*. Oxford.

Pitelis, C. (2010) *Institutional Diversity, Agency and Governance for Sustainable Value. Dynamic Regions in a Knowledge-Driven Global Economy Lessons and Policy Implications for the EU, working paper 39*.

Plastics SA (2018) *Plastic SA Annual review*. Available at: https://www.plasticsinfo.co.za/media-room/annual-reports/.

Plastics SA (2019) *The future of plastic waste management in South Africa*. Available at: https://www.plasticsinfo.co.za/2019/08/27/the-future-of-plastic-waste-management-in-south-africa/.

PlasticsEurope and Epro (2018) 'Plastics: The facts 2018. An analysis of European plastics production, demand and waste data', p. 60.

Pongrácz, E. and Pohjola, V. J. (2004) 'Re-defining waste, the concept of ownership and the role of waste management', *Resources, conservation and Recycling*, (40), pp. 141–153.

Porta, D. della (2008) 'Comparative analysis : case-oriented versus variable-oriented research', *Approaches and methodologies in the social sciences: a pluralist perspective*, pp. 198–222.

Porter, M. (1990) 'The competitive advantage of nations', *Harvard business review*, (March-April 1990).

Porter, M. (1995) 'Towards a new conception of the environment competitiveness relationship', *Journal of Economic Perspectives*, 9(4), pp. 97–119.

Preece, J. (2013) 'Africa and international policy making for lifelong learning: Textual revelations', *International Journal of Educational Development*, 33(1), pp. 98–105. doi: 10.1016/j.ijedudev.2012.02.007.

Pruter, A. T. (1987) 'Sources, quantities and distribution of persistent plastics in the marine environment', *Marine Pollution Bulletin*, 18(6 SUPPL. B), pp. 305–310. doi: 10.1016/S0025-326X(87)80016-4.

Purnomo, F., Meyliana and Prabowo, H. (2016) 'Smart city indicators: A systematic literature review', *Journal of Telecommunication, Electronic and Computer Engineering*, 8(3), pp. 161–164.

Putnam, R. (1993) '"The prosperous community: Social capital and public life"', *The american prospect*, 4(13), pp. 35–42.

Qureshi, Z. (2018) *Globalization technology and inequality: It's the policies, stupid*. Brookings. Available at: https://www.brookings.edu/blog/up-front/2018/02/16/globalization-technology-and-inequality-its-the-policies-stupid/.

Rådberg, J. (1996) 'Towards a Theory of Sustainability and Urban Quality: a New Method for Typolgical Urban Classification', *IAPS 14 Book of Proceedings*, pp. 384–392.

Radebe, J. (2005) 'The State of Transport in Africa', in *International Transport Convention 2005*.

Rall, S.-A. (2019) 'Call to Curb Pollution in Umgeni River', *IOL News*, 14 March. Available at: https://www.iol.co.za/mercury/news/call-to-curb-pollution-in-Umgeni-river-19878736.

Raper, P. E. (2014) *New diccionary of South African places*. Jonathan Ball Publishers.

Reddy, J. (2017) 'Further Development of WROSE, a waste management decision-making tool for KZN municipalities', (November).

Redman, J. (2019) *Durban South Africa, Umgeni River Plastic Pollution*. Durban: Youtube. Available at: https://www.youtube.com/watch?v=fcU7Q_-g3Dc.

RiverNetwork (2020) *Waste in our waters: A community toolkit for aquatic litter removal*. Boulder, CO. Available at: https://www.rivernetwork.org/wp-content/uploads/2020/06/waste-in-our-waters-community-toolkit-for-aquatic-litter-removal.pdf.

Roberts, D. (2008) 'Thinking globally, acting locally-institutionalizing climate change at the local government level in Durban, South Africa', *Environment and Urbanization*, 20(2), pp. 521–537.

Roberts, D. (2012) 'Thinking globally, acting locally: Institutionalizing climate change at the local government level in Durban, South Africa', *Adapting Cities to Climate Change: Understanding and Addressing the Development Challenges*, pp. 253–270. doi: 10.4324/9781849770361.

Robinson, J. (2008) 'Continuities and Discontinuities in South African Local Government', in van Donk, M. et al. (eds) *Consolidating Developmental Local Government: Lessons from the South African Experience*. Cape Town: Juta Academic, pp. 27–49.

Robinson, J. (2019) '"Global and world cities: a view from off the map"', *The Globalizing Cities Reader*, pp. 60–66. doi: 10.4324/9781315684871-9.

Rogerson, C. M. (1992) 'The absorptive capacity of the informal sector in the South African city', in Smith, D. M. (ed.) *The Apartheid City and Beyond*. London: Routledge, pp. 161–172. doi: 10.4324/9780203417362.

Roy, A. (2009) 'Why India cannot plan its cities: Informality, insurgence and the idiom of urbanization', *Planning Theory*, 8(1), pp. 76–87. doi: 10.1177/1473095208099299.

Royuela, V., Moreno, R. and Vayá, E. (2010) 'Influence of quality of life on urban growth: A case study of Barcelona, Spain', *Regional Studies*, 44(5), pp. 551–567. doi:

10.1080/00343400802662682.

RSA (1996) 'Constitution of the Republic of South Africa (Act 108 of 1996)', *Government Gazette*, 25799.

RSA (2004) *The Presidency, Social cohesion and social justice in South Africa*. Pretoria: (Republic of South Africa. Policy Co-ordination, Advisory Services.

RSA (2011) *SANS 204: Energy efficiency in buildings*. Pretoria: SABS Standards Division.

RSA (2020) *GIS Data Downloads*. Department of forestry, fisheries and the environment. Available at: https://egis.environment.gov.za/data_egis/data_download/current.

Ruhiiga, T. M. (2014) 'Urbanisation in South Africa: A critical review of policy, Planning and practice', *Etude de la Population Africaine*, 28(1), pp. 610–622. doi: 10.11564/28-0-519.

Ryan, P. G. (1988) 'Intraspecific Variation in Plastic Ingestion by Seabirds and the Flux of Plastic Through Seabird Populations', *The Condor*, 90(2), pp. 446–452. doi: 10.2307/1368572.

Ryan, P. G. *et al.* (2012) 'Long-term decreases in persistent organic pollutants in South African coastal waters detected from beached polyethylene pellets', *Marine Pollution Bulletin*, 64(12), pp. 2756–2760. doi: 10.1016/j.marpolbul.2012.09.013.

Ryan, P. G. and Moloney, C. L. (1990) 'Plastic and other artefacts on South African beaches: Temporal trends in abundance and composition.', *South African Journal of Science*, 86(7), pp. 450–452. Available at: https://www.researchgate.net/publication/283507743_plastic_and_other_artefacts_on_South_African_beaches_temporal_trends_in_abundance_and_composition.

Saarinen, J. (1998) 'Wilderness, tourism development, and sustainability: Wilderness attitudes and place ethics', *{USDA} Forest Service Proceedings {RMRS-P}*, 4, pp. 29–34. Available at: http://www.fs.fed.us/rm/pubs/rmrs_p004/rmrs_p004_029_034.pdf.

Saarinen, J. and Rogerson, C. M. (2015) 'Cultural tourism in Southern Africa', *Nordic Journal of African Studies*, 24(3&4), pp. 207–220.

SACN (2011a) *State of the Cities Report*. Cape Town.

SACN (2011b) *State of the Cities Report*. Cape Town: South African Cities Network.

SADC (2010) *Southern Africa Sub-Regional Framework on Climate Change Programmes Report, 1st draft Working Document*.

Sadri, S. S. and Thompson, R. C. (2014) 'On the quantity and composition of floating plastic debris entering and leaving the Tamar Estuary, Southwest England', *Marine Pollution Bulletin*, 81(1), pp. 55–60. doi: 10.1016/j.marpolbul.2014.02.020.

Salazar Ferro, P., Behrens, R. and Wilkinson, P. (2013) 'Hybrid urban transport systems in developing countries: Portents and prospects', *Research in Transportation Economics*, 39(1), pp. 121–132. doi: 10.1016/j.retrec.2012.06.004.

Sampson, R. J., Raudenbush, S. W. and Earls, F. (1997) 'Neighborhoods and violent crime: A multilevel study of collective efficacy', *Science*, 227, pp. 918–924.

SAWIC (2015) *Waste sources and types*. Department of Environmental Affairs. Available at: http://sawic.environment.gov.za/.

Schalekamp, H. and Behrens, R. (2010) 'Engaging paratransit on public transport reform initiatives in South Africa: A critique of policy and an investigation of appropriate engagement approaches', *Research in Transportation Economics*, 29(1), pp. 371–378. doi: 10.1016/j.retrec.2010.07.047.

Schmaltz, E. *et al.* (2020) 'Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution', *Environment International*, 144. doi: 10.1016/j.envint.2020.106067.

Schneidman, W. (2014) 'Hearing on "Will There be an African Economic Community?"', January. Available at: https://www.brookings.edu/testimonies/hearing-on-will-there-be-an-african-economic-community-2/.

Schultz, T. P. (2003) 'Human capital, schooling and health', *Economics and Human Biology*, 1(2), pp. 207–221. doi: 10.1016/S1570-677X(03)00035-2.

Schwab, K. (2016) 'The Fourth Industrial Revolution: what it means and how to respond', *World Economic Forum*.

Schwab, K. (2017) *Global Human Capital Report 2017*, *World Economic Forum*. Available at: https://www.weforum.org/reports/the-global-human-capital-report-2017.

Scott, D. and Oelofse, C. (2009) 'The politics of waiting: environmental governance in South Africa', in *Association of American Geographers' Annual Conference 22 – 27 March*. Las Vegas.

Seekings, J. (2000) 'Introduction: Urban Studies in South Africa after Apartheid', *International Journal of Urban and Regional Research*, 24(4), pp. 832–840. doi: 10.1111/1468-2427.00281.

Shah, R. and Jaisinghani, P. (2014) 'Towards an Inclusive Digital Economy', *Innovations: Technology, Governance, Globalisation*, (Special Issue: Digital Inclusion), pp. 3–5.

Sharma, S. and Chatterjee, S. (2017) 'Microplastic pollution, a threat to marine ecosystem and human health: a short review', *Environmental Science and Pollution Research*, 24(27), pp. 21530–21547. doi: 10.1007/s11356-017-9910-8.

Shleifer, A. and Vishny, R. (1993) 'Corruption', *Quarterly Journal of Economics*, CVIII, p. 599—617.

Sietchiping, R., Permezel, M. J. and Ngomsi, C. (2012) 'Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements', *Cities*, 29(3), pp. 183–189. doi: 10.1016/j.cities.2011.11.005.

Silva, C. N. (2015) *Urban planning in sub-saharan Africa: Colonial and post-colonial planning cultures*, *Urban Planning in Sub-Saharan Africa: Colonial and Post-Colonial Planning Cultures*. Routledge. doi: 10.4324/9781315797311.

Simone, A. M. (1999) 'Thinking about African Urban Management in an Era of Globalisation', *African Sociological Review / Revue Africaine de Sociologie*, 3(2). doi: 10.4314/asr.v3i2.23166.

Skhirtladze, R. *et al.* (2017) *ICT Prices 2017*. Edited by ICT Data and Statistics Division and Telecommunication Development Bureau of ITU. Geneva: International Telecommunication Union.

Skinner, C. and Watson, V. (2019) 'The Informal Economy in Cities of the Global South: Challenges to the Planning Lexicon', *Urban Planning International*, 34(2), pp. 23–30. doi: 10.22217/upi.2018.548.

SouthAfrica.info (2021) *King Shaka International Airport*. Available at: https://web.archive.org/web/20100510153608/http://www.southafrica.info/travel/advice/durbanairport.htm (Accessed: 1 July 2021).

Spaargaren, L. (2018) *The Bubble Barrier*. Delft University of Technology.

Spring, A., Rolfe, R. and Odera, L. (2013) *Sub-Saharan Africa business environment report: 2012-13. Business information at a ready glance*. Available at: http://warrington.ufl.edu/centers/ciber/docs/SABER_2012-2013.pdf.

Srinivas, S. (2017) 'No global South in economic development', in *The Routledge Companion to Planning in the Global South*. Taylor and Francis Ltd., pp. 127–139. doi: 10.4324/9781317392842-11.

Sriram, V. and Mersha, T. (2006) 'Facilitating entrepreneurship in Sub-Saharan Africa: what governments can do', *Journal for International Business and Entrepreneurship Development*, 3(1/2), p. 136. doi: 10.1504/jibed.2006.011956.

Stake, R. E. (1994) 'Case Studies : Case Studies ':, in Denzin, N. K. and Lincoln, Y. S. (eds) *A handbook of qualitative research*. London: Thousand Oaks, pp. 236–247.

Star, S. A. and Hughes, H. M. (1950) 'Report on an Educational Campaign: The Cincinnati Plan for the United Nations', *American Journal of Sociology*, 55(4), pp. 389–400. doi: 10.1086/220562.

Stats SA (2011) *Census 2011*. Statistics South Africa.

Stats SA (2012) *Census 2011. Statistical Release (Revised)*. Pretoria: Statistics South Africa.

Stats SA (2016) *Community survey 2016 in Brief. Report 03-01-06*. Pretoria: Statistics South Africa.

Stelfox, M., Hudgins, J. and Sweet, M. (2016) 'A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs', *Marine Pollution Bulletin*, 111(1–2), pp. 6–17. doi: 10.1016/j.marpolbul.2016.06.034.

Stern, N. (2007) *The economics of climate change: the Stern review*. Cambridge University Press.

Streit-bianchi, M., Cimadevila, M. and Trettnak, W. (2020) *Mare Plasticum-the Plastic Sea: Combatting Plastic Pollution Through Science and Art*. Springer Nature.

Swilling, M. (2011) 'Reconceptualising urbanism, ecology and networked infrastructures', *Social Dynamics*, 37(1), pp. 78–95. doi: 10.1080/02533952.2011.569997.

Tacoli, C., McGranahan, G. and Satterthwaite, D. (2015) *Urbanisation, rural–urban migration and urban poverty, Background Paper for World Migration Report 2015 Migrants and Cities: New Urban Partnerships to Manage Mobility*. Available at: http://pubs.iied.org/10725IIED.

Tancott, G. (2014) 'Transportation and Logistics in sub-Saharan Africa', *Infrastructure news*, March. Available at: https://infrastructurenews.co.za.

Teravaninthorn, S. and Raballand, G. (2008) 'Transport Prices and Costs in Africa : A Review of the International Corridors', in. Washington, DC: World Bank Group. Available at: https://openknowledge.worldbank.org/handle/10986/6610.

The Economist (2002) 'The road to hell is unpaved', *The Economist*, December.

The Economist (2016) 'The bottleneck'. Available at: https://www.economist.com/middle-east-and-africa/2016/03/19/the-bottleneck.

The LitterBoom Project (2021) *About*. Available at: https://www.thelitterboomproject.com/about (Accessed: 1 July 2021).

The Nation (2019) '"Litter trap" a success blocking trash from the sea', *The Nation Thailand*.

The Rockefeller Foundation and ARUP (2015) *City Resilience Index*. Edited by J. da Silva. London.

The Rockefeller Foundation and UNDRR (2016) '100 Resilient Cities'. Available at: https://resilientcitiesnetwork.org/.

Thlabela, K. *et al.* (2006) *Mapping ICT Access in South Africa*. Cape Town: HSRC Press.

Thomson, A. (2019) 'Turning the tide on plastic pollution: 5 green innovators you should check out in 2019', *The socialble*, February.

Thuzar, M. (2011) 'Urbanization in Southeast Asia: Developing Smart Cities for the Future?', *Regional Outlook*, pp. 96–100. doi: 10.1355/9789814311694-022.

Todes, A. (2012) 'Urban growth and strategic spatial planning in Johannesburg, South Africa', *Cities*, 29(3), pp. 158–165. doi: 10.1016/j.cities.2011.08.004.

Townsend, A. M. (2013) *Smart cities: big data, civic hackers, and the quest for a new utopia*. New York: W.W. Norton and Company.

Trainer, T. (1986) *Abandon Affluence!* London: Zed Books.

Tramoy, R. *et al.* (2019) 'Assessment of the plastic inputs from the Seine basin to the sea using statistical and field approaches', *Frontiers in Marine Science*, 6(APR). doi: 10.3389/fmars.2019.00151.

Transnet (2016) 'Chapter 3', in *Rail development plan*. Johannesburg. Available at: https://www.transnet.net/BusinessWithUs/LTPF 2017/LTPF Chapter 3 Rail Development Plan.pdf.

Transparency International (2020) 'Corruption perception index'. Available at: https://www.transparency.org/en/cpi/2020/index/tza.

Trois, C. et al. (2021) 'RDI Waste Road Map Research Proposal 2020: Capturing (Plastic) Waste "Streams'.

Trois, C. and Jagath, R. (2011) 'Sustained Carbon Emissions Reductions through Zero Waste Strategies for South African Municipalities', in *Waste Management*. INTECH Publications.

Trois, C. and Kissoon, S. (2018) 'Advancement of the Waste Resource Optimization and Scenario Evaluation (WROSE) model to include socio-economic and institutional indicators', in *Wastecon 2018*. Johannesburg.

Tsheleza, V. *et al.* (2019) 'Vulnerability of growing cities to solid waste-related environmental hazards: The case of Mthatha, South Africa', *Jàmbá: Journal of Disaster Risk Studies*, 11(1). doi: 10.4102/jamba.v11i1.632.

Turok, I. (2016) 'Getting urbanization to work in Africa: the role of the urban land-infrastructure-finance nexus', *Area Development and Policy*, 1(1), pp. 30–47. doi: 10.1080/23792949.2016.1166444.

U.S. Embassy Port Louis (2008) *USITC Study on Sub-Saharan Africa*. U.S. Department of State.

UN-Habitat (1996) *An urbanizing world. Global report on human settlements 1996*. Oxford University Press.

UN-Habitat (2006) 'The Locus of poverty is shifting to cities'. Available at: mirror.unhabitat.org/documents/media_centre/APMC/THE BAD NEWS.pdf.

UN-Habitat (2009) *Global Urban Indicators. Monitoring the Habitat Agenda and the Millennium Development Goals*. UN-Habitat.

UN-Habitat (2010) *Sustainable Mobility in African Cities*. Nairobi: UN-Habitat.

UN-Habitat (2012) *United Nations Human Settlement Programme. Annual report 2012*. Nairobi: UN-HABITAT. Available at: file:///C:/Users/ADMINI~1/AppData/Local/Temp/3459_alt.pdf.

UN-Habitat (2015) '15 - Urban Resilience', *Habitat III Issue Papers*, (May).

UN-Habitat (2016) *Africa Urban Agenda Programme*. Available at: https://unhabitat.org/africa-urban-agenda-programme.

UN-Habitat (2018) 'The state of African cities 2018: the geography of African investment', *The state of African cities 2018: The geography of African investment*. Available at: https://unhabitat.org/books/the-state-of-african-cities-2018-the-geography-of-african-investment/ [2020, December 3].

UN. Secretary-General (2000) *Report of the meeting of the high-level panel of experts on information and communication technology.*, *New York*. United Nations General Assembly and Economic and Social Council. Available at: www.unites.org/pdf/advdoc02..pdf.

UN (1972) *Conference on Environment and Development*. Stockholm.

UN (1987) *Our common future: World Commission on Environment and Development*. Oxford University Press.

UN (2012) 'Realizing the future we want for all', *Report to the Secretary General*, (June), pp. 1–28.

UN (2014) *The State of African Cities 2014 – UN-Habitat*, *United Nations Human Settlements Programme (UN-Habitat)*. Available at: http://unhabitat.org/the-state-of-african-cities-2014/.

UN (2015a) *Paris agreement*. Paris: United Nations Framework Convention on Climate Change. Available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

UN (2015b) 'Transforming our world: the 2030 Agenda for Sustainable Development'. Available at: https://sdgs.un.org/2030agenda.

UN (2015c) *United Nations Millenium Goals*. Available at: https://www.un.org/millenniumgoals/.

UN (2017) 'United Nations collaboration delivers new expert guidance to stimulate transition to Smart Sustainable Cities', 15 September. Available at: https://www.itu.int/en/mediacentre/Pages/2017-PR45.aspx.

UN (2021) *Growth rates of urban agglomerations by size class*. Available at: https://population.un.org/wup/Maps/ (Accessed: 21 June 2021).

UNCTAD (1999) *Foreign direct investment in Africa: performance and potential*. Geneva: United Nations Conference on Trade and Development. Available at: http://www.unctad.org.

UNCTAD (2006) *Review of Maritime Transport 2006*. Geneva: United Nations Conference on Trade and Development. Available at: https://unctad.org/system/files/official-document/rmt2006_en.pdf.

UNCTAD (2016) 'Cultural and Creative Industries in Africa', *African Politics and Policy*, 2(2).

UNCTAD (2021) *Technology and innovation report 2021*. New York: United Nations Conference on Trade and Development. Available at: https://unctad.org/webflyer/technology-and-innovation-report-2021.

UNDESA (2010) *World Urbanization Prospects: The 2009 Revision, Highlights*. United Nations, Department of Economic and Social Affairs, Population Division.

UNDESA (2018) *World Urbanization Prospects : The 2018 Revision*, *World Urbanization Prospects: The 2018 Revision*. Available at: https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf.

UNDESA (2019) *World Population Prospects 2019: Data Booklet [PDF]. Date of access: 12 December 2019, retrieved from: https://population.un.org/wpp/Publications/Files/WPP2019_DataBooklet.pdf*, *Department of Economic and Social Affairs Population Division*. United Nations Department of Economic Affairs. Available at: https://population.un.org/wpp/Publications/Files/WPP2019_DataBooklet.pdf.

UNDRR (2008) *Africa: Disaster Statistics*, *PreventionWeb*. New York: United Nations Office for Disaster Risk Reduction. Available at: https://www.preventionweb.net/english/countries/statistics/index_region.php?rid=1.

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

UNEP (2014) *Climate Finance for Cities and Buildings: A Handbook for Local Governments*. United Nations Environment Programme. Available at: www.unep.org/publications.

UNESCO (2015a) *Adult and youth literacy*. UNESCO Institute for Statistics.

UNESCO (2015b) *Education 2030 Framework for Action*. Available at: https://www.sdg4education2030.org/education-2030-framework-action-unesco-2015.

UNESCO (2015c) 'UNESCO science report: towards 2030', p. 794.

UNESCO (2017a) '2030 Agenda for Sustainable Development', *The United Nations Educational, Scientific and Cultural Organization*, p. 22.

UNESCO (2017b) *Accountability in education: Meeting our commitments*. Second, *Global education monitoring report 2017/8*. Second. Paris: UNESCO.

UNESCO (2017c) *Global education monitoring report 2017/18*. Paris.

UNESCO (2021a) *Cinema infrastructure*. Available at: http://data.uis.unesco.org/index.aspx?queryid=55.

UNESCO (2021b) *Education in Africa*. Available at: http://uis.unesco.org/en/topic/education-africa.

UNESCO (2021c) *iSimangaliso Wetland Park*. Available at: https://whc.unesco.org/en/list/914/ (Accessed: 1 July 2021).

UNESCO (2021d) *Maloti-Drakensberg Park*. Available at: https://whc.unesco.org/en/list/985/ (Accessed: 1 July 2021).

UNSTATS (2016) *The Sustainable Development Goals Report 2016.* New York: United Nations, Department of Economic and Social Affairs, Statistics Division.

Uys, F. M. and Jessa, F. (2019) *A public value approach to collaborative governance implementation in South African municipalities*. Stellenbosch: Stellenbosch University.

Vanderschuren, M. (2008) 'Safety improvements through Intelligent Transport Systems: A South African case study based on microscopic simulation modelling', *Accident Analysis and Prevention*, 40(2), pp. 807–817. doi: 10.1016/j.aap.2007.09.025.

Vanolo, A. (2016) 'Is there anybody out there? The place and role of citizens in tomorrow's smart cities', *Futures*, 82, pp. 26–36. doi: 10.1016/j.futures.2016.05.010.

te Velde, D. W. (2016) 'Why African manufacturing is doing better than you think'. Overseas Development Institute (ODI). Available at: https://www.odi.org/comment/10382-why-african-manufacturing-doing-better-you-think.

Vergara, S. E., Damgaard, A. and Gomez, D. (2016) 'The Efficiency of Informality: Quantifying Greenhouse Gas Reductions from Informal Recycling in Bogotá, Colombia', *Journal of Industrial Ecology*, 20(1), pp. 107–119. doi: 10.1111/jiec.12257.

Verster, C. and Bouwman, H. (2020) 'Land-based sources and pathways of marine plastics in a South African context', *South African Journal of Science*, 116(5–6). doi: 10.17159/sajs.2020/7700.

Vodafone (2005) *Many factors affect the spread of mobile phones (Key findings of SIM research)*.

De Vreyer, P. and Roubaud, F. (2013) *Urban Labor Markets in Sub-Saharan Africa*. The World Bank. doi: 10.1596/978-0-8213-9781-7.

De Vries, L. and Kotze, N. (2016) 'The revitalisation of parks and open spaces in downtown Johannesburg', *Urbani Izziv*, 27(1), pp. 123–131. doi: 10.5379/urbani-izziv-en-2016-27-01-003.

Wabnitz, C. and Nichols, W. J. (2020) 'Plastic Pollution : An Ocean Emergency Editorial : Plastic Pollution', *Marine Turtle Newsletter*, 1.

Wachsmuth, D., Aldana Cohen, D. and Angelo, H. (2016) 'Expand the frontiers of urban sustainability', *Nature*, 536, pp. 391–393. doi: https://doi.org/10.1038/536391a.

Washburn, D., et al (2010) 'Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO.', *Cambridge, MA: Forrester Research, Inc.*, p. http://public.dhe.ibm.com/partnerworld/pub/smb/sma.

Watson, V. (2014) 'African urban fantasies: Dreams or nightmares?', *Environment and Urbanization*, 26(1), pp. 215–231. doi: 10.1177/0956247813513705.

Webber, S. (2008) 'Visual Images in Research', in *Handbook of the Arts in Qualitative Research: Perspectives, Methodologies, Examples, and Issues*, pp. 42–54. doi: 10.4135/9781452226545.n4.

WHO (2012) 'Health Systems in Africa: Community Perceptions and Perspectives', p. 77.

WHO (2016) *Atlas of African Health Statistics 2016. Health situation analysis of the African Region*, *WHO African Health Observatory and Knowledge Management*.

WHO (2019) *World health statistics 2019: Monitoring health for the SDGs, sustainable development goals*. Geneva: World Health Organization.

Wolfram, M. (2012) 'Deconstructing smart cities: An intertextual reaing of concepts and practices for integrated urban and ICT development', *Real Corp 2012*, 0(May), pp. 171–181. Available at: http://www.corp.at/archive/CORP2012_192.pdf.

Wong, C. *et al.* (2005) *Connecting poverty and ecosystem services. Focus on Mozambique*. Nairobi: UNEP.

Woods, E. (2013) 'Smart Cities. Infrastructure, Information, and Communication Technologies for Energy, Transportation, Buildings, and Government', in *City and Supplier Profiles, Market Analysis, and Forecasts*. Pike Research.

Woolf, S. *et al.* (2016) 'Towards measurable resilience: A novel framework tool for the assessment of resilience levels in slums', *International Journal of Disaster Risk Reduction*, 19, pp. 280–302. doi: 10.1016/j.ijdrr.2016.08.003.

Woolfrey, L. (2013) 'Leveraging data in African countries: curating government microdata for research', (22).

Woolfrey, L. (2014) *An open African data approach to improving data quality*. World Bank Group.

World Bank Group (2010) *World Development Indicators*. Available at: https://datacatalog.worldbank.org/dataset/world-development-indicators.

World Bank Group (2015) *Stocktaking of the Housing Sector in Sub-Saharan Africa. Summary Report*, *The International Bank for Reconstruction and Development / The World Bank Group*. Washington DC. Available at: www.worldbank.org.

World Bank Group (2021a) *South African Road shapefile*. World Bank Group. Available at: https://datacatalog.worldbank.org/dataset/roads-south-africa/resource/8a6f8c59-b435-4bd6-8db5-e515b717ba86.

World Bank Group (2021b) *World Development Indicators*. World Bank Group. Available at:

https://datacatalog.worldbank.org/dataset/world-development-indicators.

World Economic Forum (2017a) 'The Future of Jobs and Skills in Africa - Preparing the Region for the Fourth Industrial Revolution', *Geneva: World Economic Forum.*, (May), pp. 1–28. Available at: www.weforum.org.

World Economic Forum (2017b) *The Global Human Capital Report 2017. Preparing people for the future of work*. Geneva: World Economic Forum.

World Economic Forum (2019) *The Global Competitiveness Report*, *World Economic Forum*. Geneva. Available at: www.weforum.org.

Wouterse, F. *et al.* (2011) 'Foreign Direct Investment in Land in West Africa The Status Quo, Lessons from Other Regions, Implications for Research', *Africa*, (December), pp. 1–4.

WRI (2009) *Climate Analysis Indicators Tool (CAIT)*. World Resources Institute. Available at: http://cait.wri.org/.

Wright, S. L. *et al.* (2013) 'Microplastic ingestion decreases energy reserves in marine worms', *Current Biology*, 23(23). doi: 10.1016/j.cub.2013.10.068.

WWF (2018) 'Living in a plastic age'. Available at: https://www.wwf.org.za/?26021/plastic-file-01.

Yiftachel, O. (2009) 'Theoretical notes on "gray cities": The coming of urban apartheid?', *Planning Theory*, 8(1), pp. 88–100. doi: 10.1177/1473095208099300.

Yovanof, G. S. and Hazapis, G. N. (2009) 'An architectural framework and enabling wireless technologies for digital cities & Intelligent urban environments', *Wireless Personal Communications*, 49(3), pp. 445–463. doi: 10.1007/s11277-009-9693-4.

Zandamela, T. S. (2016) *An assessment of municipal solid waste management in informal settlements in eThekwini Municipality. A case study of Cato Crest Informal Settlement, Durban*. University of KwaZulu-Natal.

Zhang, M. and World Bank Group (2010) *Competitiveness and growth in Brazilian cities : local policies and actions for innovation*. Washington D.C: World Bank Publication.

Ziccardi, L. M. *et al.* (2016) 'Microplastics as vectors for bioaccumulation of hydrophobic organic chemicals in the marine environment: A state-of-the-science review', *Environmental Toxicology and Chemistry*, 35(7), pp. 1667–1676. doi: 10.1002/etc.3461.

Zielinski, D. P., Voller, V. and Hondzo, M. (2011) 'Bubble Barrier Technologies for Common Carp', *Civil Engineering*, MS(August 2011), p. 87. Available at: http://library.safl.umn.edu/docs/theses/Zielinski_Daniel_MS_March2011.pdf (internal).

9 ANNEXURE

Annexure 1. Narratives on Smart City, Urban sustainability and Urban Resilience

Annexure 1. Narratives on Smart City, Urban Sustainability and Urban Resilience

1. Narratives of the Smart City

a) Integrated city

This conception of the Smart City equally considers the interaction between efficient application of technology and the upgrade of human capital through development. This model promote the urban space as an environment for collaboration and knowledge exchange between business and urban inhabitants and boost this way knowledge and innovation economies. The aim is to bring together future visions of the city and knowledge oriented economies in a spatial configuration (Angelidou, 2015). Cities in which this narrative becomes predominant are Barcelona and London.

The physical space is therefore equipped with smart technology, not only limited to the creation of the physical space itself, but also the inhabitants of the space and activities within it, to be more functional. Now more than ever, citizens can be better informed and therefore participants due to smart strategies strengthening urban integration.

The cycle technology – engagement – informed citizen demands innovation from the industry. In principle, the aim of an integrated city through smart technology is to bring together the socio-economic realm and the physical space of the city. This interaction is of great concern to policy makers and scientist.

b) Intelligent city

Yovanof and Hazapis (2009) stressed the notion of the *'intelligent city'* which arises at overlapping of the *'knowledge society'* with the *'digital city'*. Komninos (2009), intelligent cities have made possible mindful efforts to use ICT to impact life and work. The 'tag' intelligent suggests the ability to support learning, innovation in cities, and technological development; according to this, not every digital city is automatically intelligent, but every intelligent city has digital mechanisms. In the intelligent city, the "people" component does not form part in the same way it does in a Smart City (Woods, 2013).

c) Knowledge city

The term “knowledge city” has appeared in many discussions regarding smart cities. It is a city that encourages development of knowledge (Edvinsson, 2006). This city focuses on the generation of an ecosystem that is based on education, culture, training, learning and knowledge in order to generate creative citizens. An educated proletariat has a direct correlation to speeding up growth in urban areas. (Glaeser and Berry, 2006). The notion of clever, skilful, smart, imaginative, networked, associated, and competitive become a fundamental components of knowledge-based urban development (Dirks, Gurdgiev and Keeling, 2010).

The idea of a Smart City encompasses the facilitating of an environment that is appropriate for the creative class (Florida, 2003). Difficulties at urban level can be resolved by creative proposals that emanate from the human capital of the city: in essence, “smart solutions”. The tag Smart City thus steer to creative people coming across with clever solutions (Nam and Pardo, 2011).

d) Social gain

The potential of the social gain that new technologies can bring to the urban arena is stressed with enthusiasm by sectors of the civil society. Technology at the service of society in order to overcome poverty, inequality, crime, unemployment and other social challenges. The uneven penetration of new technologies, especially ICT, brings new incarnations of inequality in the form of digital divide. At the same time, these very same technologies have an impact on efficient management of urban systems and infrastructures, rendering public services less expensive. The United Nations, through its UN Development Programme, actively promotes ICT4D as a means for social and economic development worldwide.

e) Quality of life

Congestion, environmental quality, criminality among other factors summarized the obstacles that affect urban development. The ultimate goal for any city is the one of improving and ensuring the quality of life of the citizens by providing good municipal services together with the maintenance of a healthy environment. The narrative of quality of life is embedded in most of the visions of the Smart City. Even economic-driven narratives acknowledge the positive impact on economic prosperity and expansion of trading spaces. Cities with a good level of quality of live are more likely to retain and attract human capital. Resolutions to displace residents from place to place are not always based on economic reasons. Physical and social environment can also impact the joy and collective well-being of citizens together with economic performance (Royuela, Moreno and Vayá, 2010).

f) Competitive city

The competitive city model is related to theoretical deliberations about the linkage between economic growth and urban governance. The welfare ideology present in many local governments in Western developed countries in the 80's, shifted to neoliberal policies (Cochrane, 2007). Economic growth was therefore aligned to easing business processes and less interventionist governance on the market. Urban problems where associated to lack of economic performance and urban governance turned to an entrepreneurial and competitive management style.

The concept of urban competitiveness is typically distinguishes inputs from outcomes. While inputs are the sources, outcomes are the ultimate factor of successful implementation of competitive planning, typically measured through the economic performance within the city, under the neoliberal 'growth-first' ideology (Monfaredzadeh and Berardi, 2015).

g) Sustainable development

In the pursuit of sustainable urbanisation, governments at all levels and international institutions are developing a number of frameworks with multiple indicators in order to assess opportunities to upgrade the sustainable performance of cities or even regions. This approach acknowledges the need for tailor-made solutions and environmental issues and city performance in terms of pollution and GHG emission through the analysis of a complex array of indicators, which data are enable for collection through a network of sensors.

h) e-Governance and public participation

In the early 2000's, the concept of e-governance was massively highlighted by researchers on public administration. The aspiration of a 24-hour city was finally possible by making available information online. Today, municipal transaction via internet is consider imperative in urban structures (Odendaal, 2003). Occasionally, particularly in the global North where Internet saturation is greater, another dimension has been developed to public participation and strengthening democracy through ICT. Utilization of the WWW for the definition of virtual forums for discussion and opinion are opening innovations (Aurigi, 2005). The practical restrictions to ensure e-governance have to do with the digital divide and resistant organizational cultures that refuse to go along with digitization, predominantly where Internet access is still relatively low.

i) **Neoliberal discourse**

The connection between technology and development is strongly associated to ideas of modernization (Odendaal, 2016). The productions of the economy, coupled with globalization have been greatly empowered by the digital revolution. The neoliberal approach to development is the one of emphasising the one of business-led development that will enable for prosperity and quality of life. The possible broadening of the knowledge economy is recognized as an increase of commerce and wealth to the previously disadvantaged due to being disconnected.

The message from tech corporations highlights the benefits of technology implementation by addressing all relevant challenges. The global array of technological products available worldwide will solve the GHG emissions and mobility clot in the developed world and with equal efficiency, enable upgraded quality of life, climate change vulnerability and the need for improved governance in developing countries (Odendaal, 2016).

Although it is not difficult to encounter echoes of these narratives in cities worldwide, most of the practical applications content a mixture of more than just one concept. The ‘smartness’ in smart development is addressed as a normative assertion and conceptual dimension in town planning. Being smarter requires strategic decisions. The concept of smartness is welcomed by public institutions to differentiate new strategies to achieve sound economic growth, improve the quality of life of the people and achieve sustainable development (Center on Governance, 2003).

2. Narratives of urban sustainability

a) **Environmental problems first**

This point of view points out that current development patterns are leading to ecological and social complications on a world-wide scale. In its modest formulation, concerns regarding global environmental impediments are expressed as “this is unsustainable” or “this can’t go on.” For instance, if non renewable resource use, human population, or greenhouse gas emissions continue to grow for an indefinite period, it is rather clear that this will result in disaster, one form or another. The good status of natural ecosystems is intertwined with the future of human wellbeing.

b) **Negative sustainability**

Negative without the sense of being bad, “negative sustainability” concentrates on just keeping a system or process successful through performances of negation, which are, mitigating the extreme development, pollution reduction, and maintaining law and order. Negative sustainability maintains things through reducing the bad effects of previous development.

c) **Positive sustainability**

In contrast, positive sustainability involves defining the terms and conditions of what are positively good. It requires projecting practices for achieving the lasting future of those conditions. James (2014) defines positive sustainability as “practices and meanings of human engagement that make for ‘lifeworlds’ that project the ongoing probability of natural and social flourishing, vibrancy, resilience, and adaptation”. The term ‘lifeworld’ is used to incorporate both the social/natural and local/global bases for human living. It stresses local situations with global associations. Hence, the focus here is on local urban settlements and community sustainability, continuously looking at the global context (James, 2014).

d) **Small planet**

A large part of the concern about global problems results from the view of the planet as a whole. A finite system whose boundaries are shrinking quickly. This perspective has stimulated most directly since the 1960s by space exploration, which for the first time showed people the entire planet in a single photographic frame. Other changes such as global travel, telecommunications, and cultural exchange have also helped. People come to an intuitive understanding of the global impact of local decisions.

e) **Holistic and dynamic view**

This conception of sustainability recognizes the need to move beyond narrow, single-issue approaches to consider instead the development of entire systems that are sustainable. It also requires an appreciation of the dynamic, evolving nature of the system overtime. A holistic approach to sustainable development means coordinating traditionally disparate disciplines.

f) **Balance between environment and economy**

The tension between environment and economy is viewed by many as being at the core of the sustainable development discussion. It is increasingly accepted the need of having both but at the same time, it has also become obvious that existing economic systems do not adequately make room for environmental and human well-being issues. The pursuit of solutions that look at reforming economics in a way that incorporate non-economic matters.

g) **Intergenerational solidarity**

The current short-term dynamics on economic and political decision- making is often seen as a hazard. Sustainability implies patterns of development that will produce a healthy world, from the social and ecological perspective, far into the future.

Propelled by sustainability, the triple bottom line is a concept on sustainability that was introduced by Elkington (1999). It makes available a framework for measuring the performance of a system utilizing three lines: economic, social, and environmental. The triple bottom line articulates the extension of the environmental agenda with the inclusion of the economic and social lines (Elkington, 1999).

An integrated model is a concept that tackles a larger number of ideas and amalgamate them into a holistic system which appears to be commonly accepted. A systemic method to numerous initiatives that will form the foundation of a new theory of sustainable urban planning. Such a theory would take into account aspects from all three lines which are previously mentioned: social, environmental and economic. Consequently, the production and distribution of food; recycling soft and hard waste, providing shelter and eradicating homelessness, microlending and stimulating cooperative businesses, and providing alternative energy emerge as drivers for a integrated sustainable urban design (Margolin, 2015). In the book design titled: Nature and revolution: toward a critical ecology, Tomás Maldonado paid attention on the human environment, which he considered as “one of the many subsystems that create the vast ecological system of nature”. He argued that among subsystems, “only ours owns today the virtual and real capacity of aggravating substantial – that is irreversible – turbulences in the stability of other subsystems”. Within this process, designers are complicit unless playing a vigorous role in a process of social change (Maldonado, 1972). He therefore gives capacity to the urban designer, to have influence towards a sustainable design.

There is no specific response to the question of what the ideal sustainable city would look like at this present moment. We have the promoters of the compact city, which suggests a strategy of condensing and increasing urban density, which leads to a saving in relation time and energy, as well as pollution reduction from vehicular traffic. Contrarily, we have promoters of the green city which involves a strategy of decompressing and spreading out, using the unbuilt land or greenfields for water infiltration and cultivation. Numerous environmental problems nowadays are triggered by the lack of local recycling. Fluid and solid waste created by the cities should not be flushed into the ocean, burnt or dumped on waste dump in the city. This waste should rather be recycled; more importantly the organic waste should to be returned to fertile soil. This implies that we must provide additional land, unbuilt land, for infiltration and recycling of waste water, also for planting and cultivating. The consequential strategy appears to point towards a less dense, over-spread, city structure as opposed to modern-day. This may be referred to as "the density paradox". Nevertheless, the compact city and the green city are stereotypes which do not exist. In practice, cities are not homogenous. The urban density is not consistent. The modern city is a collective of small fragments (Rådberg, 1996).

3. Narratives of urban resilience

a) Natural hazards

Readiness and responsive strategies to face natural hazards are the fundamental features of resilience. Tools to identify and monitor geo-hazards are essential for safety planning away from areas at risk of floods, liquefaction, and landslides. Natural hazards driven initiatives tend to lessen the understanding of risk, with no consideration on other aspects of resilience which concentrated on the wellbeing of people and planning concerns. This narrative has been criticized for not paying enough attention to social and economic consideration, focussing essentially on technology and infrastructure designing. Engineers are the ultimate responsible professionals for the achievement of urban resilience. Furthermore, geo-hazards maps are occasionally used by city managers as tools in a way to drive the eviction of poor communities, often blamed and criticized for contaminating the environment, and justify removal.

b) Social Cohesion

Normally endorsed by civil society, this narrative stresses that, more than safety, the resilience of communities and people is dependent on their capacity to put in place and strengthen social networks. What was of importance was to allow inhabitants to settle near their families and workplace. Government acknowledge the importance of putting local communities the front of planning as these communities are identified as a key component of resilience.

c) **Planning Ahead**

The ‘planning ahead’ narrative highlights the uneven distribution of resources in the city, typically prioritizing electoral term-length initiatives to the detriment of the anticipation in long term development planning to reduce risk. Integration and coordination of municipal departments becomes the key element for a long term systematic approach.

d) **Technocratic Resilience**

“The ultimate aspiration is to provide objective knowledge whose validity is universal true everywhere no matter the context” (Davies and Burgess, 2004). Technology is considered as a shortcut to directly engagement with citizens in participatory events. GIS substitutes field work, detaching officials from the sense of physically conditions. This affects a degree of denaturation as technology is used to support in theory, democratic but at the same time technocratic, top-down initiatives that disengages poor and digitally disconnected people from planning authorities. The use of GIS and mapping as a main driver for planning strengthen and increases existing divides and inequalities.

e) **Co-Producing Resilience**

Bringing together the multiple members of society at all levels through engaging strategies is the characteristic feature of this vision of resilience. Through participatory tools such as mapping, planning and qualitative data collection strategies, different stakeholders collaborate to create common knowledge (Borie *et al.*, 2019). The way information is gathered and mapped facilitates multiple interpretations. Some stakeholders would look at the location of the same elements from different perspectives that might be unnoticed by others, expanding the response scenario. The agreement of a common data repository, able to integrate datasets from several sources, is essential for the success of these strategies. Moreover, a clear and open data-sharing agreement is equally essential to avoid micro-politics on stakeholders’ responsibilities for contribution.

f) **Emancipation**

Driven by NGOs, urban activists, and researchers, this narrative reports the effects of mainstream application of resilience on sustaining social inequalities. Some even feel uncomfortable with the word 'resilience', adopted and somehow abused by power clusters. They point out the need to engage with communities for a better understanding of their needs and implementation of bottom-up initiatives (Parnell and Pieterse, 2019). Emancipation demands a scenario with predominant quantitative data and room for multiple conceptualizations of resilience, in opposition to mapping, which brings oversimplification, reductionism and decontextualization, barely capturing social networks and people's experiences (Dovey and Ristic, 2017).

g) **Full display**

Science and technology is applied as an uncapping strategy by organised civil society. Informal settlements are scarcely registered in official cartography. Household surveys, conducted by NGOs and urban activists, challenge official data and make visible the urban poor. The aim is to spark reactions from city managers to respond to the needs of the most vulnerable areas. Multiplatform toolsets: GIS mapping and social media, have proven to be very effective to engage with communities to generate participatory maps with a wider scope.

h) **Environmental feedback loops**

This narrative highlights the positive impact of parks, public spaces and a functional public transport network in public health and not only as a booster for economic growth. It represents a long term strategy and cost implications are considered in a holistic manner. Reduction of pollution levels implies less diabetes, respiratory diseases, and numerous indirect benefits in term of public health. An increase of cost in parks and recreation departments has a direct reduction of cost in health departments, when at the same time other areas of city management are equally benefitted by the expansion of green infrastructures (Mutai, 2020). Silo organization among public sector technocrats represents the biggest barrier for the implementation of this vision.

Addressing resilience is not limited to a holistic comprehension of risk and immediate effects of a shocking event. It is also fundamental to foresee consequences that these events might cause on communities, geographical borders and economy (UN-Habitat, 2015). Although some of these narratives are incompatible with each other, some would be able to coexist in different scenarios at physical or governmental level, complementing each other. The use of the term 'resilience' finds resistance on several groups as they consider it aligned to mainstream dominant powers and therefore holds a biased meaning (Borie *et al.*, 2019).

Interdependence is strongly associated to resilience. Urban systems cannot be functional independently and failures on one or more spheres of the organizational structure of the city will affect the others, whether is government corruption, social unrest, economic recession, health pandemics, lack of performance at individual level will weaken the entire system. Therefore, resilience strategies request for an understanding of this inherent association (UN-Habitat, 2015).

1.1 References

Angelidou, M. (2015) 'Smart cities: A conjuncture of four forces', *Cities*, 47, pp. 95–106. doi: 10.1016/j.cities.2015.05.004.

Aurigi, A. (2005) 'Competing urban visions and the shaping of the digital city', *Knowledge, Technology & Policy*, 18(1), pp. 12–26. doi: 10.1007/s12130-005-1013-z.

Borie, M. *et al.* (2019) 'Mapping narratives of urban resilience in the global south', *Global Environmental Change*, 54(August 2018), pp. 203–213. doi: 10.1016/j.gloenvcha.2019.01.001.

Center on Governance (2003) *SmartCapital Evaluation Guidelines Report: Performance Measurement and Assessment of SmartCapital*. Ottawa: University of Ottawa. Available at: http://www.christopherwilson.ca/papers/Guidelines_report_Feb2003.pdf.

Cochrane, A. (2007) 'Competitiveness, the market, and urban entrepreneurialism', in Publishing, B. (ed.) *Understanding Urban Policy: A Critical Approach*. Malden, pp. 85 – 103.

Davies, G. and Burgess, J. (2004) 'Challenging the "view from nowhere": Citizen reflections on specialist expertise in a deliberative process', *Health and Place*, 10(4), pp. 349–361. doi: 10.1016/j.healthplace.2004.08.005.

Dirks, S., Gurdgiev, C. and Keeling, M. (2010) *Smarter Cities for Smarter Growth: How Cities Can Optimize Their Systems for the Talent-Based Economy*, *IBM Global Business Services*. Available at: https://www-05.ibm.com/se/smartercities/pdf/GBE03348USEN.PDF.

Dovey, K. and Ristic, M. (2017) 'Mapping urban assemblages: the production of spatial knowledge', *Journal of Urbanism*, 10(1), pp. 15–28. doi: 10.1080/17549175.2015.1112298.

Edvinsson, L. E. (2006) 'Aspects on the city as a knowledge tool', *Journal of Knowledge Management*, 10(5), pp. 6–13. doi: 10.1108/13673270610691134.

Elkington, J. (1999) *Cannibals with forks: the triple bottom line of 21st century business*. New Society Publishers: New Society Publishers.

Florida, R. (2003) 'Cities and the creative class', *City and community*, 2(1).

Glaeser, E. L. and Berry, C. R. (2006) 'Why Are Smart Places Getting Smarter?', *Policy Briefs*, (617), pp. 1–4. Available at: http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers-programs/centers/taubman/brief_divergence.pdf.

James, P. (2014) *Urban Sustainability in Theory and Practice. Circles of sustainability*. Routledge.

Komninos, N. (2009) 'Intelligent Cities: Towards Interactive and Global Innovation Environments', *International Journal of Innovation and Regional Development*, 1, pp. 337–355.

Maldonado, T. (1972) *Design, Nature, and Revolution: Toward a Critical Ecology*. University of Minnesota Press.

Margolin, V. (2015) 'The Good City: Design for Sustainability', *She Ji*, 1(1), pp. 34–43. doi: 10.1016/j.sheji.2015.07.001.

Monfaredzadeh, T. and Berardi, U. (2015) 'Beneath the smart city: Dichotomy between sustainability and competitiveness', *International Journal of Sustainable Building Technology and Urban Development*, 6(3), pp. 140–156. doi: 10.1080/2093761X.2015.1057875.

Mutai, J. (2020) *Citywide public space inventory and assessment toolkit. A guide to community-led digital inventory and assessment of public spaces.* Edited by UN-Habitat. Nairobi. Available at: https://unhabitat.org/sites/default/files/2020/07/city-wide_public_space_assessment_guide_0.pdf.

Nam, T. and Pardo, T. A. (2011) 'Conceptualizing smart city with dimensions of technology, people, and institutions', *ACM International Conference Proceeding Series*, pp. 282–291. doi: 10.1145/2037556.2037602.

Odendaal, N. (2003) 'Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies', *Computers, Environment and Urban Systems*, 27(6), pp. 585–607. doi: 10.1016/S0198-9715(03)00016-4.

Odendaal, N. (2016) 'Smart City: Neoliberal Discourse or Urban Development Tool?', in Grugel, J. and Hammett, D. (eds) *The Palgrave Handbook of International Development*. doi: 0.1057/978-1-137-42724-3_34.

Parnell, S. and Pieterse, E. (2019) '"The 'right to the city': institutional imperatives of a developmental state"', *The Globalizing Cities Reader*, pp. 264–269. doi: 10.4324/9781315684871-37.

Rådberg, J. (1996) 'Towards a Theory of Sustainability and Urban Quality: a New Method for Typolgical Urban Classification', *IAPS 14 Book of Proceedings*, pp. 384–392.

Royuela, V., Moreno, R. and Vayá, E. (2010) 'Influence of quality of life on urban growth: A case study of Barcelona, Spain', *Regional Studies*, 44(5), pp. 551–567. doi: 10.1080/00343400802662682.

UN-Habitat (2015) '15 - Urban Resilience', *Habitat III Issue Papers*, (May).

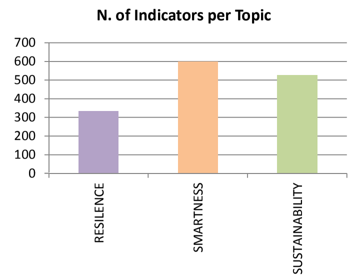
Woods, E. (2013) 'Smart Cities. Infrastructure, Information, and Communication Technologies for Energy, Transportation, Buildings, and Government', in *City and Supplier Profiles, Market Analysis, and Forecasts*. Pike Research.

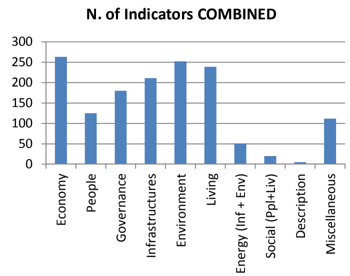
Yovanof, G. S. and Hazapis, G. N. (2009) 'An architectural framework and enabling wireless technologies for digital cities & Intelligent urban environments', *Wireless Personal Communications*, 49(3), pp. 445–463. doi: 10.1007/s11277-009-9693-4.

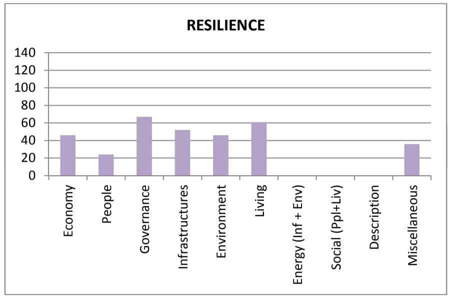
Annexure 2. Measurement systems of urban performance

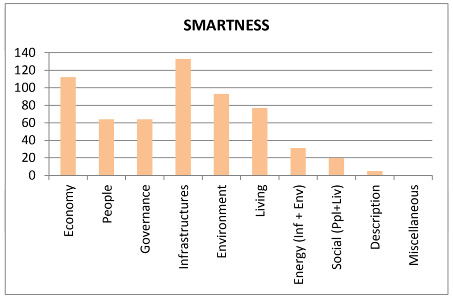
RESILENCE		SMARTNESS		SUSTAINABILITY	
SYSTEM	**CATEGORIES**	**SYSTEM**	**CATEGORIES**	**SYSTEM**	**CATEGORIES**
Arup	E0, P0, G12, I13, EV0, L14, EN0, PL0,	**TU Wien**	E12, P15, G9, I9, EV9, L20, EN0, PL0, d0, m0	**EPI**	E0, P0, G0, I2, EV30, L0, EN0, PL0, d0, m0
HABITAT	E3, P5, G3, I0, EV11, L8, EN0, PL0, d0	**Oman**	E0, P0, G0, I6, EV14, L6, EN0, PL0, d0, m0	**STAR**	E6, P0, G6, I0, EV6, L19, EN7, PL0, d0, m0
Latvia	E1, P4, G0, I5, EV1, L0, EN0, PL0, d0,	**ISO 37120-2018**	E11, P7, G16, I34, EV8, L17, EN7, PL0, d0, m0	**Global City Indicators**	E0, P0, G0, I0, EV0, L32, EN0, PL0, d0, m66
Evora	E4, P6, G3, I3, EV0, L0, EN0, PL0, d0,	**ISO 37122-2019**	E6, P7, G8, I32, EV3, L14, EN10, PL0, d0, m0	**European Common Indicators**	E0, P0, G0, I0, EV0, L0, EN0, PL0, d0, m10
MONARES	E3, P0, G5, I5, EV4, L0, EN0, PL0, d0,	**ETSI TS 103 463**	E22, P23, G10, I0, EV22, L0, EN0, PL0, d0, m0	**European Green City Index**	E0, P0, G3, I12, EV11, L0, EN4, PL0, d0, m0
ACCCRN	E8, P8, G9, I9, EV8, L7, EN0, PL0, d0,	**ITU-T Y.4901-L.1601**	E8, P0, G6, I24, EV3, L7, EN0, PL0, d0, m0	**UN**	E22, P6, G2, I0, EV13, L7, EN0, PL0, d0, m0
One World	E13, P0, G18, I17, EV0, L0, EN0, PL0,	**ITU-T Y.4902-L.1602**	E8, P0, G4, I6, EV10, L3, EN0, PL0, d0, m0	**Urban China Initiative**	E3, P5, G0, I0, EV10, L0, EN3, PL0, d0, m0
OECD	E6, P0, G17, I0, EV21, 22, EN0, PL0, d	**ITU-T Y.4903-L.1603**	E14, P0, G0, I0, EV19, L0, EN0, PL20, d0, m0	**SDG**	E80, P26, G52, I12, EV43, L43, EN6, PL0, d0, m0
WHO - Healthy Cities Project	E8, P0, G0, I0, EV13, L10, EN0, PL0, d	**Croatia**	E13, P7, G6, I3, EV5, L10, EN0, PL0, d0, m0		
		REPLICATE	E7, P5, G5, I19, EV0, L0, EN14, PL0, d5, m0		

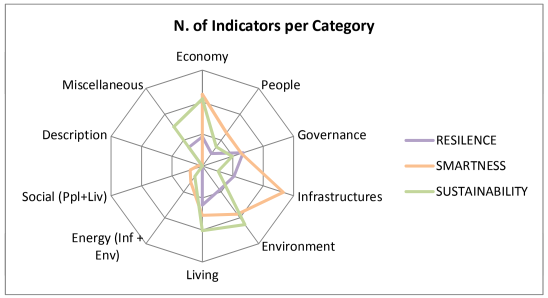
INITIAL ENTRY	N. of Indicators RESILENCE	N. of Indicators SMARTNESS	N. of Indicators SUSTAINABILITY	N. of Indicators TOTAL
Economy	46	112	105	263
People	24	64	37	125
Governance	67	64	49	180
Infrastructures	52	133	26	211
Environment	46	93	113	252
Living	61	77	101	239
Energy (Inf + Env)	0	31	20	51
Social (Ppl+Liv)	0	20	0	20
Description	0	5	0	5
Miscellaneous	36	0	76	112
TOTAL	332	599	527	1458

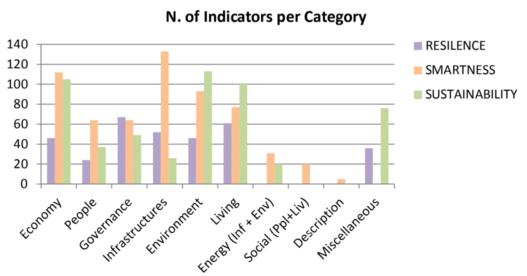


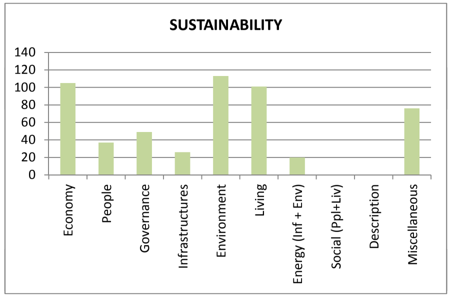




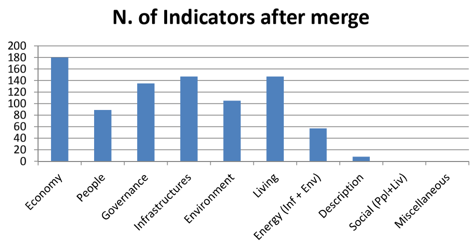


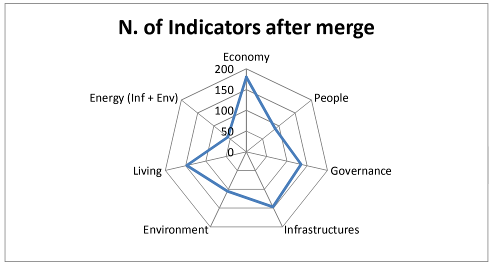




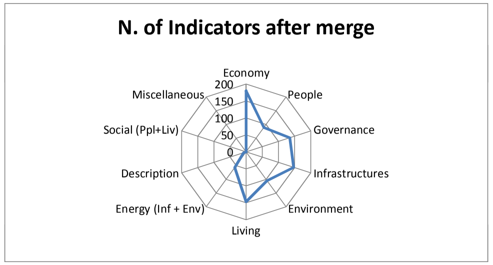


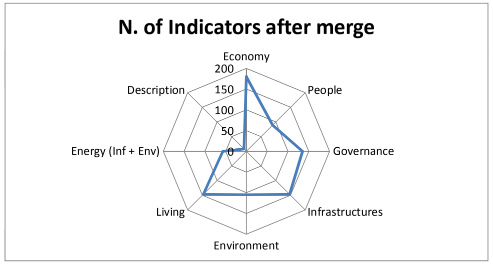
AFTER MERGE	N. of Indicators
Economy	180
People	89
Governance	135
Infrastructures	147
Environment	105
Living	147
Energy (Inf + Env)	57
Description	8
Social (Ppl+Liv)	0
Miscellaneous	0
TOTAL	868



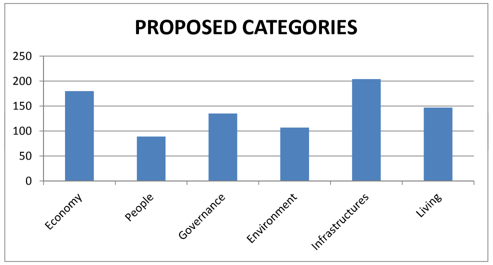


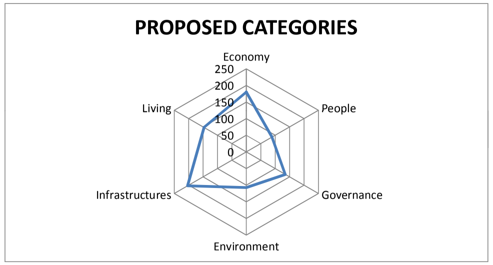
AFTER PURGE	N. of Indicators
Economy	215
People	115
Governance	167
Infrastructures	192
Environment	129
Living	198
Energy (Inf + Env)	69
Social (Ppl+Liv)	0
Description	13
Miscellaneous	0
TOTAL	1098



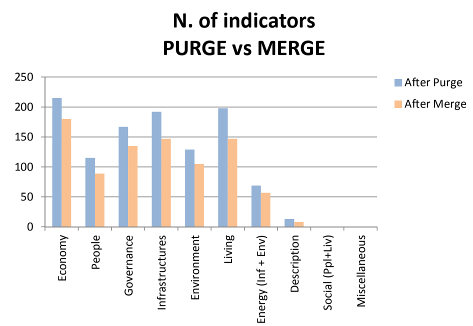


PROPOSED CATEGORIES	N. of Indicators
Economy	180
People	89
Governance	135
Environment	107
Infrastructures	204
Living	147
TOTAL	862



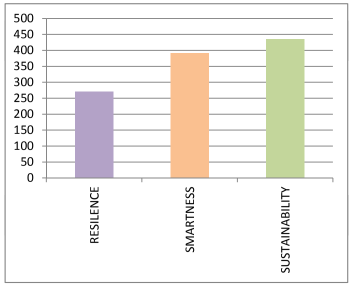


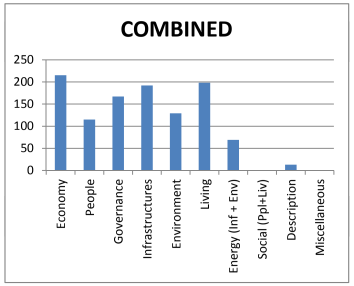
COMPARISSON PURGE vs MERGE	After Purge	After Merge
Economy	215	180
People	115	89
Governance	167	135
Infrastructures	192	147
Environment	129	105
Living	198	147
Energy (Inf + Env)	69	57
Description	13	8
Social (Ppl+Liv)	0	0
Miscellaneous	0	0

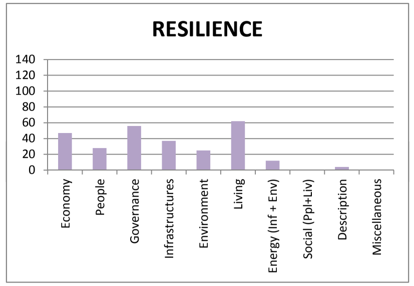


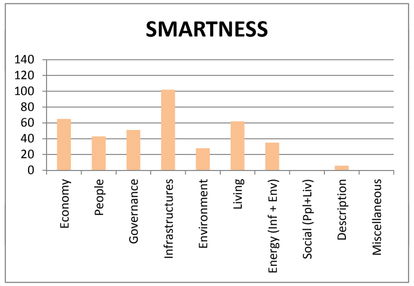
CHANGE %	N. of Indicators	N. of Indicators	N. of Indicators	N. of Indicators
TOTAL	RESILENCE	SMARTNESS	SUSTAINABILITY	TOTAL
Economy	102.2%	58.0%	98.1%	81.7%
People	116.7%	67.2%	118.9%	92.0%
Governance	83.6%	79.7%	122.4%	92.8%
Infrastructures	71.2%	76.7%	203.8%	91.0%
Environment	54.3%	30.1%	67.3%	51.2%
Living	101.6%	80.5%	73.3%	82.8%
Energy (Inf + Env)	#¡DIV/0!	112.9%	110.0%	135.3%
Social (Ppl+Liv)	#¡DIV/0!	0.0%	#¡DIV/0!	0.0%
Description	#¡DIV/0!	120.0%	#¡DIV/0!	260.0%
Miscellaneous	0.0%	#¡DIV/0!	0.0%	0.0%
TOTAL	81.6%	65.4%	82.5%	75.3%

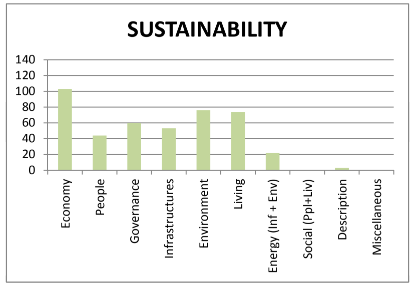
	N. of Indicators	N. of Indicators	N. of Indicators	N. of Indicators
AFTER PURGE	RESILENCE	SMARTNESS	SUSTAINABILITY	TOTAL
Economy	47	65	103	215
People	28	43	44	115
Governance	56	51	60	167
Infrastructures	37	102	53	192
Environment	25	28	76	129
Living	62	62	74	198
Energy (Inf + Env)	12	35	22	69
Social (Ppl+Liv)	0	0	0	0
Description	4	6	3	13
Miscellaneous	0	0	0	0
TOTAL	271	392	435	1098

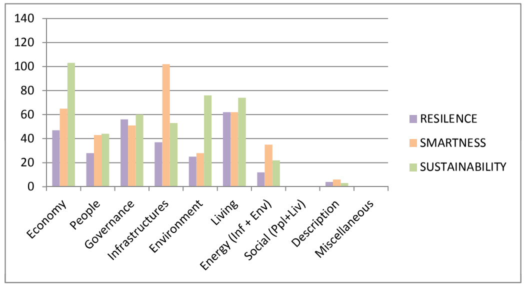


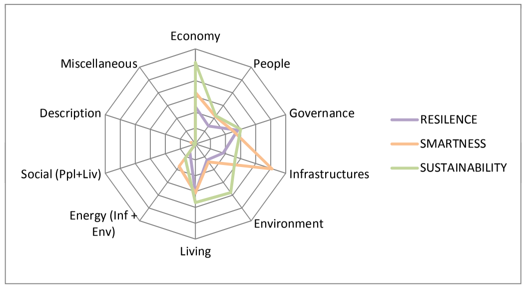






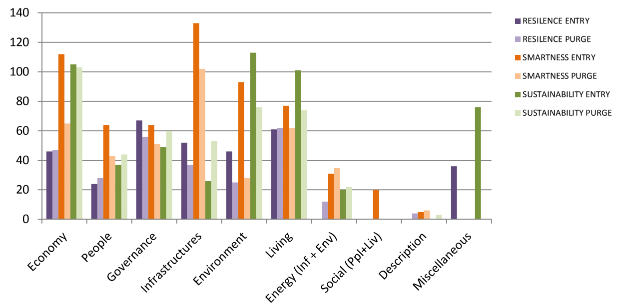




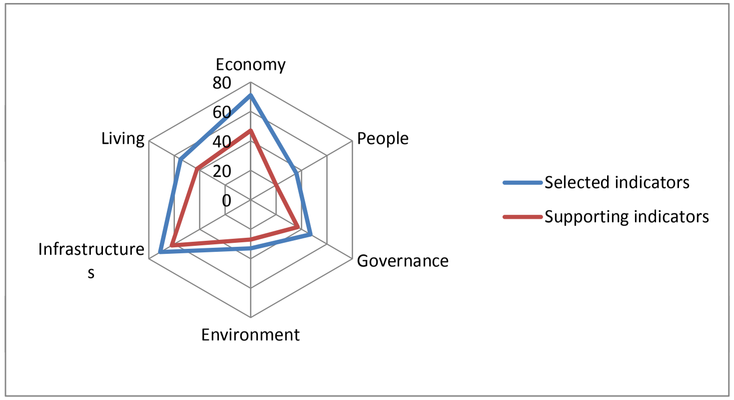


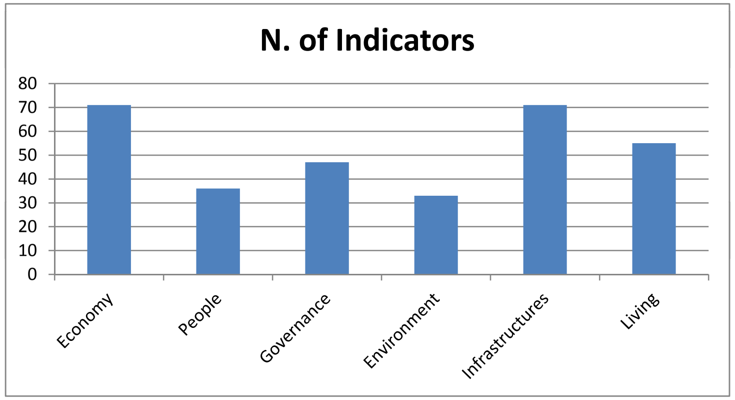
	N. of Indicators		N. of Indicators		N. of Indicators	
COMPARISON	RESILENCE ENTRY	RESILENCE PURGE	SMARTNESS ENTRY	SMARTNESS F	SUSTAINABILI	SUSTAINABILITY PURGE
Economy	46	47	112	65	105	103
People	24	28	64	43	37	44
Governance	67	56	64	51	49	60
Infrastructures	52	37	133	102	26	53
Environment	46	25	93	28	113	76
Living	61	62	77	62	101	74
Energy (Inf + Env)	0	12	31	35	20	22
Social (Ppl+Liv)	0	0	20	0	0	0
Description	0	4	5	6	0	3
Miscellaneous	36	0	0	0	76	0
TOTAL	332	271	599	435	527	435

N. of indicators before and after purge



PROPOSED CATEGORIES	Selected indicators	Supporting indicators
Economy	71	47
People	36	20
Governance	47	37
Environment	33	27
Infrastructures	71	62
Living	55	42
TOTAL	313	235





Asian Cities Climate Change Resilience Network

CATEGORIES	SUB-CATEGORIES	INDICATORS
Institutional	Structure and function	Knowledge and information
Institutional	Structure and function	Roles and responsibility
Institutional	Structure and function	Collaboration and partnership
Institutional	Planning and policy	Inclusivity
Institutional	Planning and policy	Assessment
Institutional	Planning and policy	Policy
Institutional	Emergency response	Emergency plan
Institutional	Emergency response	Early warning system
Institutional	Emergency response	Drill practice
Social	Demographics	Dependency ratio
Social	Demographics	Marginal society
Social	Demographics	Migration pattern
Social	Culture	Local tradition
Social	Culture	Religion and belief
Social	Social capital	Local organization
Social	Social capital	Community participation
Human	Health	Profile or health rate
Human	Health	Access and equity
Human	Health	Services
Human	Education	Formal education
Human	Education	Knowledge management
Human	Food and agriculture	Productivity and sufficiency
Human	Food and agriculture	Accessibility and distribution
Human	Food and agriculture	Quality and utilization (nutrition)
Economics	Profile	Local market
Economics	Profile	Business and enterprises
Economics	Profile	Economic structure and profile
Economics	Financing Mechanism	Risk management
Economics	Financing Mechanism	Budgeting
Economics	Livelihood	Diversity
Economics	Livelihood	Opportunity
Economics	Livelihood	Practice and policy
Physicial	Basic Services	Location and accesibiltiy
Physicial	Basic Services	Reliability and livability
Physicial	Basic Services	Equity and equality
Physicial	Critical Services	Shelter
Physicial	Critical Services	Evacuation route
Physicial	Critical Services	Emergency medical support
Physicial	Protective Services	Equality
Physicial	Protective Services	Standards
Physicial	Protective Services	Maintanance
Ecological	Stock and species	Biodiversity
Ecological	Stock and species	Connectivity
Ecological	Stock and species	Adaptability
Ecological	Environ ment	Quality and utilization (nutrition)
Ecological	Environ ment	Potential sources
Ecological	Landscape	Quality
Ecological	Landscape	Management
Ecological	Landscape	Services

WHO - Healthy Cities Project

CATEGORIES	SUB-CATEGORIES	INDICATORS
Health		Mortality: all causes
Health		Cause of death
Health		Low birth weight
Health services		Existence of a city health education programme
Health services		Percentage of children fully immunized
Health services		Number of inhabitants per practising primary health care practitioner
Health services		Number of inhabitants per nurse
Health services		Percentage of population covered by health insurance
Health services		Availability of primary health care services in foreign languages
Health services		Number of health related questions examined by the city council every year
Enviroiunental		Atmospheric pollution
Enviroiunental		Water quality
Enviroiunental		Percentage of water pollutants removed from total sewage produced
Enviroiunental		Household waste collection quality index
Enviroiunental		Household waste treatment quality index
Enviroiunental		Relative surface area of green spaces in the city
Enviroiunental		Public access to green space
Enviroiunental		Derelict industrial sites
Enviroiunental		Sport and leisure Pedestrian streets
Enviroiunental		Cycling in city
Enviroiunental		Public transport
Enviroiunental		Public transport network cover
Enviroiunental		Living space
Socio economic		Percentage of population living in substandard accommodation
Socio economic		Estimated number of homeless people
Socio economic		Unemployment rate
Socio economic		Percentage of people earning less than the mean per capita income
Socio economic		Percentage of child care places for pre-school children
Socio economic		Percentage of all live births to mothers
Socio economic		Abortion rate in relation to total nuniber of live births
Socio economic		Percentage of disabled persons employed

One World. GIZ project: Cities Resilience Programme: State of Preparedness of South African Cities in Addressing Climate Change Challenges and Building Climate Change Resilience

CATEGORIES	SUB-CATEGORIES	INDICATORS
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	River and wetlands health
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	Ecosystem health
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	Water resources availability
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	Ecosystem/vegetation type protection level
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	Percentage of biodiversity priority area
Climate-resilient infrastructure and ecosystems	Green infrastructure and resources	Percentage of renewable energy capacity
Climate-resilient infrastructure and ecosystems	Water infrastructure	Percentage of water reused
Climate-resilient infrastructure and ecosystems	Water infrastructure	Unaccounted for water/Percentage of non-revenue water
Climate-resilient infrastructure and ecosystems	Water infrastructure	Frequency of unplanned water service interruption
Climate-resilient infrastructure and ecosystems	Water infrastructure	Frequency of sewer blockages
Climate-resilient infrastructure and ecosystems	Water infrastructure	Water connections metered as a percentage of total connections
Climate-resilient infrastructure and ecosystems	Energy infrastructure	Percentage of renewable electricity available
Climate-resilient infrastructure and ecosystems	Energy infrastructure	Electricity interruptions per year (including load shedding) - outages frequency
Climate-resilient infrastructure and ecosystems	Energy infrastructure	Percentage of unplanned outages that are restored to supply within industry standard timeframes - outages duration
Climate-resilient infrastructure and ecosystems	Energy infrastructure	Number of critical facilities served by efficient distributed energy
Climate-resilient infrastructure and ecosystems	Waste management for adaptation to climate change	Percentage of households with, at least, basic refuse removal services
Climate-resilient infrastructure and ecosystems	Waste management for adaptation to climate change	Amount of solid waste send to landfill per capita
Integrated and enabling governance	Planning for climate risks	Fine scale projections of climate Risk & Vulnerability (R&V) assessments available to all
Integrated and enabling governance	Planning for climate risks	Data collection and promotion
Integrated and enabling governance	Climate resilient resource management	Knowledge and enforcement of ecosystem management beyond city's administrative boundaries
Integrated and enabling governance	Climate resilient resource management	Level of decentralisation of management of resources
Integrated and enabling governance	Climate resilient resource management	Urban density
Integrated and enabling governance	Climate resilient urban planning	Floodplain, flood-prone, exposed coastal zone are mapped and planned for
Integrated and enabling governance	Climate resilient urban planning	Urban planning informed by R&V assessments
Integrated and enabling governance	Climate resilient urban planning	Climate-smart infrastructure planning and the integration of green and grey infrastructure
Integrated and enabling governance	Budget for building climate resilience	Accessing climate financing and funding
Integrated and enabling governance	Budget for building climate resilience	Budget for Disaster Risk Reduction
Integrated and enabling governance	Budget for building climate resilience	Risk Financing
Integrated and enabling governance	Budget for building climate resilience	Budget for new climate resilient infrastructure

Integrated and enabling governance	Budget for building climate resilience	Budget for maintenance of infrastructure
Integrated and enabling governance	Budget for building climate resilience	Financial incentives for improved climate resilient initiatives
Integrated and enabling governance	Fit for purpose institutional arrangements	Partnerships for climate science are established and capacitate action
Integrated and enabling governance	Fit for purpose institutional arrangements	Partnerships between cities and NGOs
Integrated and enabling governance	Fit for purpose institutional arrangements	Collaborative and cross sectoral policy design, planning and review
Integrated and enabling governance	Fit for purpose institutional arrangements	Leadership and administrative capabilities
Climate resilient economy	Climate resilient urban planning	Policies/by laws protect the labour force and adapted to conditions of work under climate change
Climate resilient economy	Land management	Agricultural land at risk
Climate resilient economy	Climate resilient job creation	Amount of green jobs created
Climate resilient economy	Climate resilient job creation	Amount of green enterprises per sector
Climate resilient economy	Climate resilient job creation	Low unemployment rate
Climate resilient economy	Climate resilient job creation	Jobs created by EPWP, CWP and other ecological infrastructure programme at local level
Climate resilient economy	Climate resilient job creation	Sustainable livelihoods and a resilient informal sector
Climate resilient economy	Diversification of the economic base	New businesses are created in secondary economic hubs/nodes to promote decentralisation
Climate resilient economy	Diversification of the economic base	Agreements between municipality and private power producers for renewable energy
Climate resilient economy	Planning for climate risks	Level of insurance cover
Climate resilient economy	Planning for climate risks	Number of cities major economic drivers/commodities at risk
Climate resilient economy	Planning for climate risks	Climatic event management plan
Climate resilient economy	Planning for climate risks	Human settlement vulnerability
Climate adaptive social systems	Climate resilient resource management	Percentage of compliant water samples tested
Climate adaptive social systems	Climate resilient resource management	Air quality index level
Climate adaptive social systems	Climate resilient infrastructure	Existence of climate resilience hub
Climate adaptive social systems	Climate resilient infrastructure	Property damage due to natural disasters
Climate adaptive social systems	Climate resilient infrastructure	Civil unrest cases due to service delivery failure
Climate adaptive social systems	Access to water and sanitation	Water use in litres per capita
Climate adaptive social systems	Inclusivity	Percentage of households without connection having access to a source of water less than 200m from the dwelling
Climate adaptive social systems	Inclusivity	Percent of households with access to sanitation services
Climate adaptive social systems	Inclusivity	Food security
Climate adaptive social systems	Inclusivity	Number of public health care facilities per capita
Climate adaptive social systems	Inclusivity	Percentage of newly subsidised housing units in brownfield development
Climate adaptive social systems	Inclusivity	Percentage of households having access to adequate housing
Climate adaptive social systems	Inclusivity	Income distribution
Climate adaptive social systems	Inclusivity	Literacy levels within the city
Climate adaptive social systems	Inclusivity	Level of electricity consumption
Climate adaptive social systems	Inclusivity	Household expenditure on transport per quintile
Climate adaptive social systems	Inclusivity	Percentage of commuters (city-wide) using private motorised transport
Climate adaptive social systems	Inclusivity	NMT paths as a percentage of the total municipal road network length
Climate adaptive social systems	Health	Reported cases of climate change induced diseases
Climate adaptive social systems	Health	Efficacy of emergency facilities and services and efficacy of health care facilities and services in case of climatic disaster
Climate adaptive social systems	Health	Urban heat island effect
Climate adaptive social systems	Disaster response	Level of adequate shelter and food post disaster event

Climate adaptive social systems	Disaster response	Effective disaster response plans and communication systems during disasters

OECD - Indicators for Resilient Cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
Social	Income and inequality	Equalised disposable household income (OECD stat)
Social	Income and inequality	Poverty rate (OECD stat)
Social	Income and inequality	GINI Index (OECD stat)
Social	Income and inequality	Spatial segregation (Dissimilarity Index, or Spatial Ordinal Entropy Index at a 1 000-metre scale) (OECD stat)
Social	Income and inequality	Number of homeless people per 100 000 population (ISO 37120)
Social	Income and inequality	Percentage of jobs paying the city/national living wage (adapted from Arup, 2015)
Social	Social capital and social cohesion	Number of civic, social advocacy or faith-based organisations per 10 000 people (adapted from Cutter, Ash and Emrich, 2014)
Social	Social capital and social cohesion	Percentage of neighbourhoods with regular neighbourhood association meetings
Social	Social capital and social cohesion	Perceived social network support (percentage people that replied "yes" to the question: If you were in trouble, do you have family and friends you can count on to help in case of need? (OECD stat)
Social	Social capital and social cohesion	Perceived interpersonal local network support: % of people that replied 'yes' to the quest)on: If you were in trouble, do you have neighbours you can count on to help you whenever you need them? (adapted from OECD stat)
Social	Health and well-being	Percentage of population that has health insurance coverage, including both public and private or have access to "free" (at the point of delivery) healthcare (adapted from the University of Buffalo)
Social	Health and well-being	Self-perception of health % population > 15 years who report "good" or better health to the question "How is your health in general?" with response scale "It is very good/good/fair/bad/very bad" (WHO)
Social	Health and well-being	Average quality of life (satisfaction) (OECD stat)
Social	Medical capacity	Number of physicians per 100 000 people (ISO 37120)
Social	Medical capacity	Number of hospital beds per 100 000 people (ISO 37120)
Social	Medical capacity	Percentage of hospitals that have carried out disaster preparedness drills in the last year (adapted from UNISDR, 2008)
Social	Emergency response services	Average response time of fire response from initial call (ISO 37120)
Social	Emergency response services	Average emergency (police) callout response time last year (Amp, 2015)
Social	Emergency response services	Perceptions of local government emergency support (Oxfam)
Social	Communication	Number of telephone connections (landlines and cell phones) per 100 000 population (ISO 37120)
Social	Communication	Percentage of households with access to broadband Internet service (Cutter, Ash and Emrich, 2014)
Social	Communication	Percentage of population with language competency (or protlcency) (Cutter, Ash and Emrich, 2014)
Economic	Economic innovation	Number of new businesses registered within the city in the past year, per 100 000 population (Case Western Reserve University)
Economic	Economic innovation	Patent applications per million inhabitants (patent intensity, OECD stat)
Economic	Economic innovation	Share of tertiary education across the labour force (OECD stat)
Economic	Skills and employment	City's unemployment rate (percentage of working- age population) (OECD stat — Better Life Index)

Economic	Skills and employment	Percentage of secondary education completion rate (adapted from ISO) or educational attainment (OECD stat)
Economic	Skills and employment	Percentage of people unemployed for more than six months who have access to a programme that is intended to improve their employment chances (European Union, 2015, as quoted in CR1, 2016)
Environment	Housing	Housing deprivation: percentage of population living in dwelling considered overcrowded, while: 1) leaking roof or damp walls, floors, foundations or rot in window frames and floor; 2) no bath or shower; or 3) too dark (Eurostat)
Environment	Housing	Percentage of household income spent on housing by the poorest 20% of the population (University of Buffalo) (City Resilience Index, 2016)
Environment	Housing	Percentage of houses which have passed local building code inspections
Environment	Housing	Percentage of housing units exposed to a high level of hazard that have been designed or retrofitted to withstand the force of the hazard
Environment	Temporary accommodation needs	Percentage of population that could be served by city's access to stock of emergency shelter for 72 hours (Arup, 2015)
Environment	Temporary accommodation needs	Safe hazard shelter vs. expected public demand (Arup, 2015)
Environment	Temporary accommodation needs	Percentage per capita of food reserves within a city (including supermarket agreements) for 72 hours (percentage of the population which could be served) (UNISDR, 2014, as quoted in CR1, 2016)
Environment	Energy	Average number of electrical interruptions per customer per year (ISO 37120)
Environment	Energy	Number of different supply sources providing at least 5% of electricity generation capacity (World Bank)
Environment	Energy	Number of days that city fuel supplies could maintain essential household functions (UNISDR, 2014, as quoted in CR1, 2016)
Environment	Water	Proportion of population using safely managed drinking water services (SDG Indicator 6.1.1) (UN,2017b)
Environment	Water	Number of different supply sources providing at least 5% of water supply capacity (World Bank adapted from electricity)
Environment	Water	Percentage of population with access to improved sanitation coverage (ISO 37120)
Environment	Water	Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated (SDG Indicator 11.6.1) (UN, 2017b)
Environment	Sustainable urban development	Estimated average exposure to air pollution (OECD stat) or PM10 concentraon (ug/m3) (ISO 37120)
Environment	Sustainable urban development	Percentage of wefland loss
Environment	Sustainable urban development	Green area (hectares) per 100 000 population (ISO 37120) or average percentage of pervious surfaces
Environment	Access and transport	Proportion of population that has convenient access to public transport, by sex, age and persons with disabilWes (SDG Indicator 11.1.1) (UN, 2017b)
Environment	Access and transport	Percentage of households with at least one vehicle (Cutler, Ash and Emhch, 2014)
Environment	Access and transport	Number of arterial roads (km/km2) (Cutler, Ash and Emhch, 2014)
Environment	Access and transport	Death rated due to traffic road injunes (SDG Indicator 36i) (UN, 2017b)
Institutional	Risk-based planning	Risk assessment report

Institutional	City leadership that has sufficient capac	Land-use plans that have been developed with reference to local hazard risk assessment and that have been subjected to a formal consultaon process (Amp, 2015)
Institutional	City leadership that has sufficient capac	Hazard-mapping efforts, including energy facilities and industnal uses
Institutional	Awareness and alert	Multi-hazard early-warning system
Institutional	Awareness and alert	Percentage of population that has received training on first-aid and emergency response skills in past two years
Institutional	Awareness and alert	Percentage of school children educated in disaster risk reduction (UNISDR, 2008)
Institutional	Awareness and alert	Capacity-development platforms (online portal, brochures, guides, toolkits)
Institutional	Awareness and alert	Percentage of neighbourhoods with emergency groups (eg local Red Cross groups, voluntary firefighting associations, etc) (adapted from USAID)
Institutional	Awareness and alert	Level of trust in government
Institutional	Transparency and accountability	City open data portal, including budget, organisational structure, plans and projects of different policy sectors
Institutional	Transparency and accountability	Percentage of access to Information requests processed within 90 days
Institutional	Transparency and accountability	The country has mechanisms to ensure co-ordinaon across levels of government (OECD, 2017b)
Institutional	Transparency and accountability	The country has formal horizontal mechanisms/incentives between subnational governments (OECD, 201 lb)
Institutional	Funding availability	Percentage of buildings with insurance cover for high-risk hazards relevant to the city (UN-Habitat)
Institutional	Funding availability	Ten-year average per capita budget for mitigation projects (Cutter, Ash and Emrich, 2014)
Institutional	Funding availability	Percentage of municipal budget spent in fire, police and emergency services (Cutter, Ash and Emnch, 2014)
Institutional	Funding availability	Proportion of total government spending on essential services (education, health and social protection) (SDG Indicator 12.1) (UN, 2017b)

Feldmeyer - Indicators for Monitoring Urban Climate Change Resilience and Adaptation

CATEGORIES	SUB-CATEGORIES	INDICATORS
Environment	Soil and green spaces	Degree of unsealed ground
Environment	Water bodies	State of water bodies
Environment	Biodiversity	Nature conservation and protection areas
Environment	Air	Ventilation status
Infrastructure	Settlement structure	Building density
Infrastructure	Energy	Diversity of renewable energy
Infrastructure	Energy	Per capita energy consumption
Infrastructure	Water supply and wastewater treatment	Number of springs
Infrastructure	Water supply and wastewater treatment	Adapted sewer system
Economy	Innovation	Employees in research intensive companies
Economy	Business	Commercial tax per capita
Economy	Economic structure	Diversity of business
Society	Research	Number of research projects
Society	Knowledge and risk competence	History with extreme events
Society	Health care	Number of doctors
Society	Sociodemographic structure	Share of citizens ABV6/U65
Society	Civil society	Associations per 10000 capita
Society	Civil protection	Fire brigade volunteers
Governance	Participation	Number of participation processes
Governance	Municipal budget	Depth per citizen
Governance	Strategy, plans and environment	Risk and vulnerability analsysis
Governance	Strategy, plans and environment	Strategies against heavy rain and heat in plans
Governance	Administration	Inter-offices working group regarding risk, climate change and resilience

Feofilovs - Assessment of Urban Resilience to Natural Disasters with a System Dynamics Tool: Case study of Latvian Municipality

CATEGORIES	SUB-CATEGORIES	INDICATORS
Social dimension		Share of unemployed population
Social dimension		Youth dependency Elderly dependency
Social dimension		Share of population at poverty risk
Social dimension		Share of immigrants
Economic dimension		GDP per capita
Infrastructure dimension		Share of population experiencing housing deprivation
Infrastructure dimension		Share of population with electricity supply
Infrastructure dimension		Share of households with inability to keep house warm
Infrastructure dimension		Share of population with access to water supply
Infrastructure dimension		Share of population with wastewater treatment
Environmental dimension		Waste produced vs treated

Habitat Agenda - Urban Indicators Guidelines

CATEGORIES	SUB-CATEGORIES	INDICATORS
Shelter		Durable structures
Shelter		Overcrowding
Shelter		Secure tenure
Shelter		Housing finances
Shelter		Land prices
Shelter		Access to safe water
Shelter		Access to improved sanitation
Shelter		Connection to services
Social Development and eradication of poverty		Under-five mortality
Social Development and eradication of poverty		Homicides
Social Development and eradication of poverty		VIH prevalence
Social Development and eradication of poverty		Poor households
Social Development and eradication of poverty		Literacy rates School enrolment
Social Development and eradication of poverty		Women councillors
Environmental management		Urban population growth
Environmental management		Planned settlements
Environmental management		Price of water
Environmental management		Water consumption
Environmental management		Wastewater treated
Environmental management		Solid waste disposal
Environmental management		Regular solid waste collection
Environmental management		Houses in hazardous locations
Environmental management		Travel time
Environmental management		Transport modes
Economic development		Informal employment
Economic development		City product
Economic development		Unemployment
Governance		Local government revenue
Governance		Voters participation
Governance		Civic associations

GONALVES - Framework and Indicators to Measure Urban Resilience for Evora Municipality

CATEGORIES	SUB-CATEGORIES	INDICATORS
Economic Base	Productive structure diversity	Concentration of corporate headquarters in trade and construction
Economic Base		Concentration of turnover in the top 4 companies
Economic Base	Employment structure diversity	Workers in establishments with> 250 employees
Economic Base	Prodution structure vitality	Balance between the formation and dissolution of companies
Demografic Structure	Demografic vitality	Fertility rate
Demografic Structure	M ulti-etnicity	Aging index
Demografic Structure	Migration atractivity	Foreign citizens who have applied for resident status
Process of urbanization	Process of urbanization and urban form	Population that lives in places with more than 2000 inhabitants
Process of urbanization	Property ownership	Ownership with burdens
Process of urbanization	Built fabric transformabily	Proportion of reconstructions in face of new buildings constructed
Social coesion	Services acessibility	Consultations in health centers per capita
Social coesion	Social integration efforts	People receiving RMG and RSI (minimum income for survival)
Social coesion	Social support dependency	Unemployment rate
Human capital		Workers as employed persons with qualifications higher than the secondary
Human capital		Renewal of the active population index
Human capital	Higher education weight	Proportion of residents with higher education

ARUP + Rockefeller Foundation - City Resilience Framework

CATEGORIES	SUB-CATEGORIES	INDICATORS
Health and well-being	Minimal human vulnerability	Safe and affordable housing
Health and well-being	Minimal human vulnerability	Adequate affordable energy supply
Health and well-being	Minimal human vulnerability	Inclusive access to safe drinking water
Health and well-being	Minimal human vulnerability	Effective Sanitation
Health and well-being	Minimal human vulnerability	Sufficient affordable food supply
Health and well-being	Diverse livelihoods and employment	Inclusive labour policies
Health and well-being	Diverse livelihoods and employment	Relevant skills and training
Health and well-being	Diverse livelihoods and employment	Local business development and innovation
Health and well-being	Diverse livelihoods and employment	Supportive financing mechanisms
Health and well-being	Diverse livelihoods and employment	Diverse protection of livelihoods following a shock
Health and well-being	Effective safeguards to human health and life	Robust public health systems
Health and well-being	Effective safeguards to human health and life	Adequate access to quality healthcare
Health and well-being	Effective safeguards to human health and life	Emergency medical care
Health and well-being	Effective safeguards to human health and life	Effective emergency response services
Economy and society	Collective identity and community support	Local Community Support
Economy and society	Collective identity and community support	Cohesive communities
Economy and society	Collective identity and community support	Strong city-wide identity and culture
Economy and society	Collective identity and community support	Actively engaged citizens
Economy and society	Comprehensive security and rule of law	Effective systems to deter crime
Economy and society	Comprehensive security and rule of law	Proactive corruption prevention
Economy and society	Comprehensive security and rule of law	Competent policing
Economy and society	Comprehensive security and rule of law	Accessible criminal and civil justice
Economy and society	Sustainable economy	Well-managed public finances
Economy and society	Sustainable economy	Comprehensive business continuity planning
Economy and society	Sustainable economy	Diverse economic base
Economy and society	Sustainable economy	Attractive business environment
Economy and society	Sustainable economy	Strong integration with regional and global economies
Infrastructure and ecosystems	Reduced exposure & fragility	Comprehensive hazard and exposure mapping
Infrastructure and ecosystems	Reduced exposure & fragility	Appropriate codes, standards and enforcement
Infrastructure and ecosystems	Reduced exposure & fragility	Effectively managed protective ecosystems
Infrastructure and ecosystems	Reduced exposure & fragility	Robust protective infrastructure
Infrastructure and ecosystems	Effective provision of critical services	Effective stewardship of ecosystems
Infrastructure and ecosystems	Effective provision of critical services	Flexible infrastructure
Infrastructure and ecosystems	Effective provision of critical services	Retained spare capacity
Infrastructure and ecosystems	Effective provision of critical services	Diligent maintenance and continuity
Infrastructure and ecosystems	Effective provision of critical services	Adequate continuity for critical assets and services
Infrastructure and ecosystems	Reliable mobility and communications	Diverse and affordable transport networks
Infrastructure and ecosystems	Reliable mobility and communications	Effective transport operation & maintenance
Infrastructure and ecosystems	Reliable mobility and communications	Reliable communications technology
Infrastructure and ecosystems	Reliable mobility and communications	Secure technology networks
Leadership and strategy	Effective leadership and management	Appropriate government decision-making
Leadership and strategy	Effective leadership and management	Effective co-ordination with other government bodies
Leadership and strategy	Effective leadership and management	Proactive multi-stakeholder collaboration
Leadership and strategy	Effective leadership and management	Comprehensive hazard monitoring and risk assessment
Leadership and strategy	Effective leadership and management	Comprehensive government emergency management
Leadership and strategy	Empowered stakeholders	Adequate education for all
Leadership and strategy	Empowered stakeholders	Widespread community awareness and preparedness

Leadership and strategy	Empowered stakeholders	Effective mechanisms for communities to engage with government
Leadership and strategy	Integrated development planning	Comprehensive city monitoring and data management
Leadership and strategy	Integrated development planning	Consultative planning process
Leadership and strategy	Integrated development planning	Appropriate land use and zoning
Leadership and strategy	Integrated development planning	Robust planning approval process

Smart cities – Ranking of European medium-sized cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
Smart Economy	Innovative spirit	R&D expenditure in % of GDP
Smart Economy	Innovative spirit	Employment rate in knowledge-intensive sectors
Smart Economy	Innovative spirit	Patent applications per inhabitant
Smart Economy	Entrepreneurship	Self-employment rate
Smart Economy	Entrepreneurship	New businesses registered
Smart Economy	Economic image & trademarks	Importance as decision-making centre (HQ, etc.)
Smart Economy	Productivity	GDP per employed person
Smart Economy	Flexibility of labour market	Unemployment rate
Smart Economy	Flexibility of labour market	Proportion in part-time employment
Smart Economy	International, embeddedness	Companies with HQ in the city quoted on national stock
Smart Economy	International, embeddedness	Air transport of passengers
Smart Economy	International, embeddedness	Air transport of freight
Smart People	Level of qualification	Importance as knowledge centre (top research centres, top universities etc.)
Smart People	Level of qualification	Population qualified at Levels 5-6 ISCED
Smart People	Level of qualification	Foreign language skills
Smart People	Affinity to life long learning	Book loans per resident
Smart People	Affinity to life long learning	Participation in life-long-learning in %
Smart People	Affinity to life long learning	Participation in language courses
Smart People	Social and ethnic plurality	Share of foreigners
Smart People	Social and ethnic plurality	Share of nationals born abroad
Smart People	Flexibility	Perception of getting a new job
Smart People	Creativity	Share of people working in creative industries
Smart People	Cosmopolitanism/Open-mindedness	Voters turnout at European elections
Smart People	Cosmopolitanism/Open-mindedness	Immigration-friendly environment (attitude towards immigration)
Smart People	Cosmopolitanism/Open-mindedness	Knowledge about the EU
Smart People	Participation in public life	Voters turnout at city elections
Smart People	Participation in public life	Participation in voluntary work
Smart Governance	Participation in decision - making	City representatives per resident
Smart Governance	Participation in decision - making	Political activity of inhabitants
Smart Governance	Participation in decision - making	Importance of politics for inhabitants
Smart Governance	Participation in decision - making	Share of female city representatives
Smart Governance	Public and social services	Expenditure of the municipal per resident in PPS
Smart Governance	Public and social services	Share of children in day care
Smart Governance	Public and social services	Satisfaction with quality of schools
Smart Governance	Transparent governance	Satisfaction with transparency of bureaucracy
Smart Governance	Transparent governance	Satisfaction with fight against corruption
Smart Mobility	Local accessibility	Public transport network per inhabitant
Smart Mobility	Local accessibility	Satisfaction with access to public transport
Smart Mobility	Local accessibility	Satisfaction with quality of public transport
Smart Mobility	(Inter-) national accessibility	International accessibility
Smart Mobility	AvailabiLity of ICTinfrastructure	Computers in households
Smart Mobility	AvailabiLity of ICTinfrastructure	Broadband internet access in households
Smart Mobility	Sustainable, innovative and safe transport systems	Green mobility share (non-motorized individual traffic)
Smart Mobility	Sustainable, innovative and safe transport systems	Traffic safety
Smart Mobility	Sustainable, innovative and safe transport systems	Use of economical cars
Smart Environment	Attractivity of natural conditions	Sunshine hours
Smart Environment	Attractivity of natural conditions	Green space share
Smart Environment	Pollution	Summer smog (Ozon)
Smart Environment	Pollution	Particulate matter
Smart Environment	Pollution	Fatal chronic lower respiratory diseases per inhabitant
Smart Environment	Environmental protection	Individual efforts on protecting nature
Smart Environment	Environmental protection	Opinion on nature protection
Smart Environment	Sustainable resource management	Efficient use of water (use per GDP)

Smart Environment	Sustainable resource management	Efficient use of electricity (use per GDP)
Smart Living	Cultural facilities	Cinema attendance per inhabitant
Smart Living	Cultural facilities	Museums visits per inhabitant
Smart Living	Cultural facilities	Theatre attendance per inhabitant
Smart Living	Health conditions	Life expectancy
Smart Living	Health conditions	Hospital beds per inhabitant
Smart Living	Health conditions	Doctors per inhabitant
Smart Living	Health conditions	Satisfaction with quality of health system
Smart Living	Individual safety	Crime rate
Smart Living	Individual safety	Death rate by assault
Smart Living	Individual safety	Satisfaction with personal safety
Smart Living	Housing quality	Share of housing fulfilling minimal standards
Smart Living	Housing quality	Average living area per inhabitant
Smart Living	Housing quality	Satisfaction with personal housing situation
Smart Living	Education faciLities	Students per inhabitant
Smart Living	Education faciLities	Satisfaction with access to educational system
Smart Living	Education faciLities	Satisfaction with quality of educational system
Smart Living	Touristic attractivity	Importance as tourist location (overnights, sights)
Smart Living	Touristic attractivity	Overnights per year per resident
Smart Living	SociaL cohesion	Perception on personal risk of poverty
Smart Living	SociaL cohesion	Poverty rate

REPLICATE PROJECT. Renaissance of Places with Innovative Citizenship and Technology

CATEGORIES	SUB-CATEGORIES	INDICATORS
City description		Population increase rate
City description		Poputation of the city
City description		Tourism intensity
City description		Climate Koppen-Geiger classification
City description		Population density
Energy & environment	Emissions	CO2 emissions
Energy & environment	Air quality	PM10 concentration
Energy & environment	Air quality	Noise pollution
Energy & environment	Energy	Annual final energy consumption
Energy & environment	Renewable energy sources	Green electricity purchased
Energy & environment	Renewable energy sources	Renewable electricity generated within the city
Energy & environment	Renewable energy sources	Renewable heat generated within the city
Energy & environment	Energy efficiency	Smart energy meters
Energy & environment	Energy efficiency	Refurbished buildings improving energy performance
Energy & environment	Energy efficiency	N. of connections to a district heating network
Energy & environment	Services efficiency	Municipal solid waste per capita
Energy & environment	Services efficiency	Recycling rate
Energy & environment	Services efficiency	Liters of water used per capita
Energy & environment	Services efficiency	Water losses
Mobility	Access to Public Transport	Access to Public Transport
Mobility	PT use	Number of annual PT trips per capita
Mobility	Fossil fuelled four wheels vehicles per capita	Fossil fuelled four wheels vehicles per capita
Mobility	Fossil fuelled two wheels vehicles per capita	Fossil fuelled two wheels vehicles per capita
Mobility	Modal Split	Average modal split-passengers
Mobility	Modal Split	Average modal split vehicles
Mobility	Alternative Transport Infrastructure	Length of bike route network
Mobility	Alternative Transport Infrastructure	Number of electric charging stations for electric vehicles
Mobility	Alternative Transport Infrastructure	Number of electric vehicles in the city
Mobility	Alternative Transport Infrastructure	Percentage of electric vehicles per sector (private, public and service)
Mobility	Alternative Transport Infrastructure	Km2 restricted areas
Mobility	Alternative Transport Infrastructure	Access to vehicle sharing solutions
Mobility	Traffic Accidents	Traffic Accidents
Infrastructures for innovation	Internet connections	Internet connections per 100,000 population
Infrastructures for innovation	Internet connections	Access to public free WIFI
Infrastructures for innovation	Infomobility	Number of PT stops with realtime info
Infrastructures for innovation	Infomobility	e—ticketing
Infrastructures for innovation	Digitalisation	Numberof users of digital services
Infrastructures for innovation	Components with sensors	N. of infrastructure components with installed sensors
Governance		Climate resilience strategy
Governance		Existence of local sustainability plans
Governance		Existenc€ of Smart cities strategies
Governance		Existence of an Agenda 21
Governance		Signature and compliance of the Covenant of Mayors
Social		Population dependence ratio
Social		Number of high edu degrees per 100,000 population
Social		Affordability of housing
Social		Fuel poverty
Social		Open public participation
Economy & fiance		City’s unemployment rate

Economy & fiance		Expenditures by the municipality for the transition towards smart city
Economy & fiance		Incentives for final users for low carbon measures
Economy & fiance		Share of green public procurement
Economy & fiance		Gross Domestic Product
Economy & fiance		Percentage of the ICT sector on GDP
Economy & fiance		Median disposable income

Smart City Indicators for Smart City Pilot in Knowledge Oasis Muscat (KOM), Sultanate of Oman

CATEGORIES	SUB-CATEGORIES	INDICATORS
Environment	Air quality	Number of real-time remote air quality monitoring stations per square kilometre (km2)
Environment	Air quality	Percentage of public buildings equipped for monitoring indoor air quality
Environment	Smart energy management	Percentage of street lighting remotely managed by a light management system
Environment	Smart energy management	Percentage of street lighting that has been refurbished
Environment	Smart energy management	Percentage of buildings in the citywith smart energy meters
Environment	Smart energy management	Number of electric vehicle charging stations per registered electric vehicle
Environment	Smart energy management	Availability of smart electricity meters
Environment	Smart waste management	Percentage of waste drop-off centres (containers) equipped with telemetering
Environment	Smart waste management	Percentage of the city population that has a door-to-door garbage collection with an individual telemetering of household waste quantities
Environment	Smart waste management	Percentage of the wastewater pipeline network monitored by a real-time data tracking sensor system
Environment	Smart waste management	Resilience plans
Environment	Smart waste management	Percentage of the city’s water distribution network monitored by a smart water system
Environment	Smart waste management	Percentage of buildings in the city with smart water meters
Environment	Smart waste management	Percentage of the wastewater pipeline network monitored by a real-time data tracking sensor system
Quality of life	Safety and security	Percentage of the city area covered by digital surveillance cameras
Quality of life	Safety and security	Response time for emergency response services from initial call
Quality of life	Safety and security	Resilience plans
Quality of life	Safety and security	Emergency Service Response Time
Quality of life	Public transportation	Number of users of sharing economy transportation per 100,000 population
Quality of life	Public transportation	Percentage of public transport lines equipped with a real-time system
Quality of life	Public transportation	Percentage of public parking spaces equipped with real-time availability systems
Quality of life	Public transportation	Access to vehicle sharing solutions for city travel
Quality of life	Public transportation	Congestion
Quality of life	Public transportation	Road traffic efficiency
Quality of life	Public transportation	Real-time public transport information
Infrastructure	Urban mobility	Number of users of sharing economy transportation per 100,000 population
Infrastructure	Urban mobility	Percentage of public transport lines equipped with a real-time system
Infrastructure	Urban mobility	Access to vehicle sharing solutions for city travel
Infrastructure	Urban mobility	Congestion
Infrastructure	Urban mobility	Road traffic efficiency
Infrastructure	Urban mobility	Real-time public transport information

ITU-T Y.4903-L.1603. Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals

CATEGORIES	SUB-CATEGORIES	INDICATORS
Economy	ICT infrastructure	Internet access in households
Economy	ICT infrastructure	Household with a computer
Economy	Innovation	Research and development expenditure
Economy	Innovation	Patents
Economy	Employment	Employment rate
Economy	Trade	Trade
Economy	Productivity	Labour productivity
Economy	Physical infrastructure –Water Supply	Availability of smart water meters
Economy	Physical infrastructure –Electricity	Availability of smart electricity meters
Economy	Physical infrastructure –Electricity	Electricity system outrage frequency
Economy	Physical infrastructure –Electricity	Electricity system outrage time
Economy	Physical infrastructure –Transport	Public transport network
Economy	Physical infrastructure –Transport	Road traffic efficiency
Economy	Physical infrastructure –Transport	Real-time public transport information
Environment	Air quality	Air pollution
Environment	Air quality	GHG emissions
Environment	Water and sanitation	Quality of drinking water
Environment	Water and sanitation	Access to improved water source
Environment	Water and sanitation	Water consumption
Environment	Water and sanitation	Wastewater treated
Environment	Water and sanitation	Wastewater collection
Environment	Water and sanitation	Household sanitation
Environment	Noise	Exposure to noise
Environment	Environmental quality	Compliance with WHO endorsed exposure guidelines
Environment	Environmental quality	Adoption of a consistent planning approval process with respect to EMF
Environment	Environmental quality	Availability of EMF information
Environment	Environmental quality	Solid waste collection
Environment	Environmental quality	Solid waste treatment
Environment	Environmental quality	Green areas and public spaces
Environment	Biodiversity	Native species monitoring
Environment	Energy	Access to electricity
Environment	Energy	Renewable energy consumption
Environment	Energy	Electricity consumption
Sodety and culture	Education	Students ICT access
Sodety and culture	Education	Adult literacy
Sodety and culture	Education	School enrolment
Sodety and culture	Education	Higher education ratio
Sodety and culture	Health	Electronic health records
Sodety and culture	Health	Sharing of medical resources
Sodety and culture	Health	Life expectancy
Sodety and culture	Health	Maternal mortality
Sodety and culture	Health	Doctors
Sodety and culture	Safety - Disaster relief	Resilience plans
Sodety and culture	Safety - Emergency	Emergency Service Response Time
Sodety and culture	Safety - ICT	Information security and privacy protection
Sodety and culture	Housing	Housing expenditure
Sodety and culture	Housing	Informal settlements
Sodety and culture	Culture	Connected libraries
Sodety and culture	Culture	Cultural infrastructure
Sodety and culture	Culture	Cultural resources online
Sodety and culture	Social inclusion	Public participation
Sodety and culture	Social inclusion	Gender income equity
Sodety and culture	Social inclusion	Opportunities for people with special needs

ITU-T Y.4902-L.1602. Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
Environmental sustainability	Air quality	Air pollution intensity
Environmental sustainability	CO2 emissions	GHG emissions
Environmental sustainability	Energy	Use of alternative and renewable energy
Environmental sustainability	Energy	Energy saving in households
Environmental sustainability	Water. soil and noise	Quality of city water resources
Environmental sustainability	Water. soil and noise	Recycling of waste
Environmental sustainability	Water. soil and noise	Exposure to noise
Environmental sustainability	Water. soil and noise	Soil pollution avoidance
Environmental sustainability	Water. soil and noise	Green areas surface
Environmental sustainability	Water. soil and noise	Perception on environmental quality
Productivity	Capital investment	Improvement of industry productivity through ICT
Productivity	Employment	Service industry employment
Productivity	Inflation	Inflation rate
Productivity	Savings	Saving rate
Productivity	Export/import	Knowledge-intensive export/import
Productivity	Household income/consumption	Household ICT expenditures
Productivity	Innovation	Investments in ICT innovation
Productivity	Innovation	ICT related patents
Quality of life	Education	Students ICT availability
Quality of life	Health	Healthy life years (HLY)
Quality of life	Safety/security public place	Disaster and emergencies alert accuracy
Equity and social inclusion	Inequity of income/consumption (Gini coefficient)	Income distribution
Equity and social inclusion	Social and gender inequity of access to sen-ices and infrastructure	Gender income disparity
Equity and social inclusion	Openness and public participation	Use of online city services
Equity and social inclusion	Openness and public participation	Perception on social inclusion
Physical infrastructure	Infrastructure connection to services — piped water	Leakage in water supply system
Physical infrastructure	Infrastructure connection to services — sewage	Sewage system coverage
Physical infrastructure	Infrastructure connection to services — electricity	Reliability of electricity supply system
Physical infrastructure	Infrastructure connection to services — health infrastructure	Availability of sporting facilities
Physical infrastructure	Infrastructure connection to services — transport	Use of public transport
Physical infrastructure	Infrastructure connection to services — transport	Road traffic efficiency

ITU-T Y.4901-L.1601. Key performance indicators related to the use of information and communication technology in smart sustainable cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
Information and Communication Technology	Network and access	Availability of computers or similar devices
Information and Communication Technology	Network and access	Availability of Internet access in households
Information and Communication Technology	Network and access	Availability of fixed broadband subscriptions
Information and Communication Technology	Network and access	Availability of wireless broadband subscriptions
Information and Communication Technology	Services and Information platforms	Use of social media by the public sector
Information and Communication Technology	Information security and privacy	Information security of public services and systems
Information and Communication Technology	Information security and privacy	Existence of systems, rules and regulations to ensure Child Online Protection (COP)
Information and Communication Technology	Information security and privacy	Existence of systems, rules and regulations to ensure privacy protection in public service
Information and Communication Technology	Electromaanetic field	Compliance with WHO endorsed exposure guidelines
Information and Communication Technology	Electromaanetic field	Adoption of a consistent planning approval process with respect to EMF
Information and Communication Technology	Electromaanetic field	Availability of EMF information
Environmental sustainability	Air quality	Application of ICT based monitoring system for particles and toxic substances
Environmental sustainability	Water. soil and noise	Application of city water monitoring through ICT
Environmental sustainability	Water. soil and noise	Application of ICT based noise monitoring
Productivity	Capital investment	ICT related Research and Development expenditure
Productivity	Capital investment	Investment intensity in ICT projects enabling SSC
Productivity	Trade	Application of e-commerce transactions
Productivity	Innovation	Research and Development intensity in ICT
Productivity	Knowledge economy	Intangible investments as a proportion of GDP
Productivity	Knowledge economy	Employees belonging to ICT sector
Productivity	Knowledge economy	Companies providing e-services
Productivity	Knowledge economy	Application of computing platforms
Quality of life	Education	Use of e-learning system
Quality of life	Health	Use of electronic health records
Quality of life	Health	Use of electronic medical records
Quality of life	Health	Sharing of medical resources and information among hospitals, pharmacies and other health care providers
Quality of life	Health	Adoption of telemedicine
Quality of life	Safety/security public place	Adoption of ICT for disaster management
Quality of life	Safety/security public place	Availability of ICT based safety systems
Equity and social inclusion	Openness and public participation	Availability of online city information and feedback mechanisms
Equity and social inclusion	Openness and public participation	Online civic engagement
Equity and social inclusion	Openness and public participation	Online support for new city inhabitants
Equity and social inclusion	Openness and public participation	Existence of strategies. rules and regulations to enable ICT literacy among inhabitants
Equity and social inclusion	Governance	Provision of online systems for administering public services and facilities
Equity and social inclusion	Governance	Application of services to support persons with specific needs
Physical infrastructure	Infrastructure/ connection to services — piped water	Water supply system management using ICT

Physical infrastructure	Infrastructure/ connection to services — piped water	City fresh water sources monitored using ICT
Physical infrastructure	Infrastructure/ connection to services — piped water	Availability of smart water meters
Physical infrastructure	Infrastructure/ connection to services — sewage	Sewage system management using ICT
Physical infrastructure	Infrastructure/ connection to services — sewage	Drainage system management using ICT
Physical infrastructure	Infrastructure/ connection to services — electricity	Availability of smart electricity meters
Physical infrastructure	Infrastructure/ connection to services — road infrastructure	Availability of traffic monitoring using ICT
Physical infrastructure	Infrastructure/ connection to services — road infrastructure	Availability of parking guidance systems
Physical infrastructure	Infrastructure/ connection to services — road infrastructure	Availability of real-time traffic information
Physical infrastructure	Infrastructure/ connection to services — road infrastructure	Street lighting management using ICT
Physical infrastructure	Infrastructure/ connection to services — road infrastructure	Gas system management using ICT
Physical infrastructure	Building	Automatic energy management in buildings
Physical infrastructure	Building	Integrated management in public buildings

ISO/37122-2019. Sustainable cities and communities.
Indicators for smart cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
Economy		Percentage of service contracts providing city services which contain an open data policy
Economy		Survival rate of new businesses per 100,000 population
Economy		Percentage of the labour force employed in occupations in the information and communications technology (ICT) sector
Economy		Percentage of the labour force employed in occupations in the education and research and development sectors
Education		Percentage of city population with professional proficiency in more than one language
Education		Number of computers, laptops, tablets or other digital learning devices available per 1,000 students
Education		Number of science, technology, engineering and mathematics (STEM) higher education degrees per 100,000 population
Energy		Percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources, as a share of the city's total energy mix for a given year
Energy		Electrical and thermal energy (GJ) produced from wastewater treatment per capita per year
Energy		Electrical and thermal energy (GJ) produced from solid waste or other liquid waste treatment per capita per year
Energy		Percentage of the city's electricity that is produced using decentralised electricity production systems
Energy		Storage capacity of the city's energy grid per total city energy consumption
Energy		Percentage of street lighting managed by a light performance management system
Energy		Percentage of street lighting that has been refurbished and newly installed
Energy		Percentage of public buildings requiring renovation/refurbishment
Energy		Percentage of buildings in the city with smart energy meters
Energy		Number of electric vehicle charging stations per registered electric vehicle
Environment and climate change		Percentage of buildings built or refurbished within the last 5 years in conformity with green building principles
Environment and climate change		Number of real-time remote air quality monitoring stations per square kilometre (km2)
Environment and climate change		Percentage of public buildings equipped for monitoring indoor air quality
Finance		Annual amount of revenues collected from the sharing economy as a percentage of own-source revenue
Finance		Percentage of payments to the city that are paid electronically based on electronic invoices
Governance		Annual number of online visits to the municipal open data portal per 100,000 population
Governance		Percentage of city services accessible and that can be requested online
Governance		Average response time to inquiries made through the city's non-emergency inquiry system (days)
Governance		Average downtime of the city's IT infrastructure
Health		Percentage of the city's population with an online unified health file accessible to health care providers
Health		Annual number of medical appointments conducted remotely per 100,000 population
Health		Percentage of the city population with access to real-time public alert systems for air and water quality advisories
Housing		Percentage of households with smart energy meters
Housing		Percentage of households with smart water meters
Population and social conditions		Percentage of public buildings that are accessible by persons with special needs

Population and social conditions		Percentage of municipal budget allocated for the provision of mobility aids, devices and assistive technologies to citizens with special needs
Population and social conditions		Percentage of marked pedestrian crossings equipped with accessible pedestrian signals
Population and social conditions		Percentage of municipal budget allocated for provision of programmes designated for bridging the digital divide
Recreation		Percentage of public recreation services that can be booked online
Safety		Percentage of the city area covered by digital surveillance cameras
Solid waste		Percentage of waste drop-off centres (containers) equipped with telemetering
Solid waste		Percentage of the city population that has a door-to-door garbage collection with an individual monitoring of household waste quantities
Solid waste		Percentage of total amount of waste in the city that is used to generate energy
Solid waste		Percentage of total amount of plastic waste recycled in the city
Solid waste		Percentage of public garbage bins that are sensor-enabled public garbage bins
Solid waste		Percentage of the city’s electrical and electronic waste that is recycled
Sport and culture		Number of online bookings for cultural facilities per 100,000 population
Sport and culture		Percentage of the city’s cultural records that have been digitised
Sport and culture		Number of public library book and e-book titles per 100,000 population
Sport and culture		Percentage of city population that are active public library users
Telecommunication		Percentage of the city population with access to sufficiently fast broadband
Telecommunication		Percentage of city area under a white zone/dead spot/not covered by telecommunication connectivity
Telecommunication		Percentage of the city area covered by municipally provided Internet connectivity
Transportation		Percentage of city streets and thoroughfares covered by real-time online traffic alerts and information
Transportation		Number of users of sharing economy transportation per 100,000 population
Transportation		Percentage of vehicles registered in the city that are low-emission vehicles
Transportation		Number of bicycles available through municipally provided bicycle-sharing services per 100,000 population
Transportation		Percentage of public transport lines equipped with a publicly accessible real-time system
Transportation		Percentage of the city’s public transport services covered by a unified payment system
Transportation		Percentage of public parking spaces equipped with e-payment systems
Transportation		Percentage of public parking spaces equipped with real-time availability systems
Transportation		Percentage of traffic lights that are intelligent/smart
Transportation		City area mapped by real-time interactive street maps as a percentage of the city’s total land area
Transportation		Percentage of vehicles registered in the city that are autonomous vehicles
Transportation		Percentage of public transport routes with municipally provided and/or managed Internet connectivity for commuters
Transportation		Percentage of roads conforming with autonomous driving systems
Transportation		Percentage of the city’s bus fleet that is motor-driven
Urban/local agriculture and food security		Annual percentage of municipal budget spent on urban agriculture initiatives
Urban/local agriculture and food security		Annual total collected municipal food waste sent to a processing facility for composting per capita (in tonnes)
Urban/local agriculture and food security		Percentage of the city’s land area covered by an online food-supplier mapping system
Urban planning		Annual number of citizens engaged in the planning process per 100,000 population

Urban planning		Percentage of building permits submitted through an electronic submission system
Urban planning		Average time for building permit approval (days)
Urban planning		Percentage of the city population living in medium-to-high population densities
Wastewater		Percentage of treated wastewater being reused
Wastewater		Percentage of biosolids that are reused (dry matter mass)
Wastewater		Energy derived from wastewater as a percentage of total energy consumption of the city
Wastewater		Percentage of total amount of wastewater in the city that is used to generate energy
Wastewater		Percentage of the wastewater pipeline network monitored by a real-time data-tracking sensor system
Water		Percentage of drinking water tracked by real-time, water quality monitoring station
Water		Number of real-time environmental water quality monitoring stations per 100,000 population
Water		Percentage of the city's water distribution network monitored by a smart water system
Water		Percentage of buildings in the city with smart water meters

ISO/37120:2014 Sustainable development of communities.
Indicators for city services and quality of life

CATEGORIES	SUB-CATEGORIES	INDICATORS
Economy		City’s unemployment rate (core indicator)
Economy		Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties (core indicator)
Economy		Percentage of city population living in poverty (core indicator)
Economy		Percentage of persons in full-time employment (supporting indicator)
Economy		Youth unemployment rate (supporting indicator)
Economy		Number of businesses per 100,000 population (supporting indicator)
Economy		Number of new patents per 100,000 population per year (supporting indicator)
Education		Percentage of female school-aged population enrolled in schools (core indicator)
Education		Percentage of students completing primary education: survival rate (core indicator)
Education		Percentage of students completing secondary education: survival rate (core indicator)
Education		Primary education student/teacher ratio (core indicator)
Education		Percentage of male school-aged population enrolled in schools (supporting indicator)
Education		Percentage of school-aged population enrolled in schools (supporting indicator)
Education		Number of higher education degrees per 100,000 population (supporting indicator)
Energy		Total residential electrical energy use per capita (kWh/year) (core indicator)
Energy		Percentage of city population with authorized electrical service (core indicator)
Energy		Energy consumption of public buildings per year (kWh/rn2) (core indicator)
Energy		The percentage of total energy derived from renewable sources, as a share of the city’s total energy consumption (core indicator)
Energy		Total electrical energy use per capita (kWh/year) (supporting indicator)
Energy		Average number of electrical interruptions per customer per year (supporting indicator)
Energy		Average length of electrical interruptions (in hours) (supporting indicator)
Environment		Fine particulate matter (PM2.5) concentration (core indicator)
Environment		Particulate matter (PM10) concentration (core indicator)
Environment		Greenhouse gas emissions measured in tonnes per capita (core indicator)
Environment		NO2 (nitrogen dioxide) concentration (supporting indicator)
Environment		SO2 (sulphur dioxide) concentration (supporting indicator)
Environment		O3 (Ozone) concentration (supporting indicator)
Environment		Noise pollution (supporting indicator)
Environment		Percentage change in number of native species (supporting indicator)

Finance		Debt service ratio (debt service expenditure as a percentage of a municipality's own-source revenue) (core indicator)
Finance		Capital spending as a percentage of total expenditures (supporting indicator)
Finance		Own-source revenue as a percentage of total revenues (supporting indicator)
Finance		Tax collected as a percentage of tax billed (supporting indicator)
Fire and emergency response		Number of firefighters per 100,000 population (core indicator)
Fire and emergency response		Number of fire related deaths per 100,000 population (core indicator)
Fire and emergency response		Number of natural disaster related deaths per 100,000 population (core indicator)
Fire and emergency response		Number of volunteer and part-time firefighters per 100,000 population (supporting indicator)
Fire and emergency response		Response time for emergency response services from initial call (supporting indicator)
Fire and emergency response		Response time for fire department from initial call (supporting indicator)
Governance		Voter participation in last municipal election (as a percentage of eligible voters) (core indicator)
Governance		Women as a percentage of total elected to city-level office (core indicator)
Governance		Percentage of women employed in the city government workforce (supporting indicator)
Governance		Number of convictions for corruption and/or bribery by city officials per 100,000 population (supporting indicator)
Governance		Citizens' representation: number of local officials elected to office per 100,000 population (supporting indicator)
Governance		Number of registered voters as a percentage of the voting age population (supporting indicator)
Health		Average life expectancy (core indicator)
Health		Number of in-patient hospital beds per 100,000 population (core indicator)
Health		Number of physicians per 100,000 population (core indicator)
Health		Under age five mortality per 1,000 live births (core indicator)
Health		Number of nursing and midwifery personnel per 100,000 population (supporting indicator)
Health		Number of mental health practitioners per 100,000 population (supporting indicator)
Health		Suicide rate per 100,000 population (supporting indicator)
Recreation		Square meters of public indoor recreation space per capita (supporting indicator)
Recreation		Square meters of public outdoor recreation space per capita (supporting indicator)
Safety		Number of police officers per 100,000 population (core indicator)
Safety		Number of homicides per 100,000 population (core indicator)
Safety		Crimes against property per 100,000 (supporting indicator)
Safety		Response time for police department from initial call (supporting indicator)
Safety		Violent crime rate per 100,000 population (supporting indicator)

Shelter		Percentage of city population living in slums (core indicator)
Shelter		Number of homeless per 100,000 population (supporting indicator)
Shelter		Percentage of households that exist without registered legal titles (supporting indicator)
Solid waste		Percentage of city population with regular solid waste collection (residential) (core indicator)
Solid waste		Total collected municipal solid waste per capita (core indicator)
Solid waste		Percentage of the city's solid waste that is recycled (core indicator)
Solid waste		Percentage of the city's solid waste that is disposed of in a sanitary landfill (supporting indicator)
Solid waste		Percentage of the city's solid waste that is disposed of in an incinerator (supporting indicator)
Solid waste		Percentage of the city's solid waste that is burned openly (supporting indicator)
Solid waste		Percentage of the city's solid waste that is disposed of in an open dump (supporting indicator)
Solid waste		Percentage of the city's solid waste that is disposed of by other means (supporting indicator)
Solid waste		Hazardous Waste Generation per capita (tonnes) (supporting indicator)
Solid waste		Percentage of the cfty's hazardous waste that is recycled (supporting indicator)
Telecommunication and innovation		Number of internet connections per 100,000 population (core indicator)
Telecommunication and innovation		Number of cell phone connections per 100,000 population (core indicator)
Telecommunication and innovation		Number of landline phone connections per 100,000 population (supporting indicator)
Transportation		Kilometres of high capacity public transport system per 100,000 population (core indicator)
Transportation		Kilometres of light passenger public transport system per 100,000 population (core indicator)
Transportation		Annual number of public transport trips per capita (core indicator)
Transportation		Number of personal automobiles per capita (core indicator)
Transportation		Percentage of commuters using a travel mode to work other than a personal vehicle (supporting indicator)
Transportation		Number of two-wheel motorized vehicles per capita (supporting indicator)
Transportation		Kilometres of bicycle paths and lanes per 100,000 population (supporting indicator)
Transportation		Transportation fatalities per 100,000 population (supporting indicator)
Transportation		Commercial air connectivity (number of non-stop commercial air destinations) (supporting indicator)
Urban planning		Green area (hectares) per 100,000 population (core indicator)
Urban planning		Annual number of trees planted per 100,000 population (supporting indicator)
Urban planning		Areal size of informal settlements as a percentage of city area (supporting indicator)
Urban planning		Jobs/housing ratio (supporting indicator)
Wastewater		Percentage of city population served by wastewater collection (core indicator)
Wastewater		Percentage of the city's wastewater that has received no treatment (core indicator)
Wastewater		Percentage of the city's wastewater receiving primary treatment (core indicator)

Wastewater		Percentage of the city’s wastewater receiving secondary treatment (core indicator)
Wastewater		Percentage of the city’s wastewater receiving tertiary treatment (core indicator)
Water and sanitation		Percentage of city population with potable water supply service (core indicator)
Water and sanitation		Percentage of city population with sustainable access to an improved water source (core indicator)
Water and sanitation		Percentage of population with access to improved sanitation (core indicator)
Water and sanitation		Total domestic water consumption per capita (litres/day) (core indicator)
Water and sanitation		Total water consumption per capita (litres/day) (supporting indicator)
Water and sanitation		Average annual hours of water service interruption per household (supporting indicator)
Water and sanitation		Percentage of water loss (unaccounted for water) (supporting indicator)

ETSI TS 103 463. Key Performance Indicators for Sustainable Digital Multiservice Cities

CATEGORIES	SUB-CATEGORIES	INDICATORS
People	Health	Access to basic health care services
People	Health	Encouraging a healthy lifestyle
People	Safety	Traffic accidents
People	Safety	Crime rate
People	Safety	Cybersecurity
People	Safety	Data privacy
People	Access to (other) services	Access to public transport
People	Access to (other) services	Access to vehicle sharing solutions for
People	Access to (other) services	Length of bike route network
People	Access to (other) services	Access to public amenities
People	Access to (other) services	Access to commercial amenities
People	Access to (other) services	Access to high speed internet
People	Access to (other) services	Access to public free WiFi
People	Access to (other) services	Flexibility in delivery services
People	Education	Access to educational resources
People	Education	Environmental education
People	Education	Digital literacy
People	Diversity and social cohesion	No indicators identified at city level
People	Quality of housing and the built	Diversity of housing types
People	Quality of housing and the built	Preservation of cultural heritage
People	Quality of housing and the built	Ground floor usage
People	Quality of housing and the built	Public outdoor recreation space
People	Quality of housing and the built	Green space
Planet	Energy and mitigation	Annual final energy consumption
Planet	Energy and mitigation	Renewable energy generated within
Planet	Energy and mitigation	CO2 emissions
Planet	Energy and mitigation	Local freight transport fuel mix
Planet	Materials, water, land	Domestic material consumption
Planet	Materials, water, land	Water consumption
Planet	Materials, water, land	Grey and rain water use
Planet	Materials, water, land	Water Exploitation Index
Planet	Materials, water, land	Water losses
Planet	Materials, water, land	Population density
Planet	Materials, water, land	Local food production
Planet	Materials, water, land	Brownfield use
Planet	Climate resilience	Climate resilience strategy
Planet	Climate resilience	Urban Heat Island
Planet	Pollution and waste	Nitrogen dioxide emissions (NO2)
Planet	Pollution and waste	Fine particulate matter emissions (PM
Planet	Pollution and waste	Air quality index
Planet	Pollution and waste	Noise pollution
Planet	Pollution and waste	Recycling rate
Planet	Pollution and waste	Municipal solid waste
Planet	Ecosystem	Share of green and water spaces
Planet	Ecosystem	Native species
Prosperity	Employment	Unemployment rate
Prosperity	Employment	Youth unemployment rate
Prosperity	Equity	Fuel poverty
Prosperity	Equity	Affordability of housing
Prosperity	Green economy	Share of certified companies
Prosperity	Green economy	Share of Green Public Procurement
Prosperity	Green economy	Green jobs
Prosperity	Green economy	Freight movement
Prosperity	Economic performance	Gross Domestic Product
Prosperity	Economic performance	New business registered
Prosperity	Economic performance	Median disposable income
Prosperity	Innovation	Creative industry
Prosperity	Innovation	Innovation hubs in the city
Prosperity	Innovation	Accessibility of open data sets

Prosperity	Innovation	Research intensity
Prosperity	Innovation	Open data
Prosperity	Attractiveness and competitiveness	Congestion
Prosperity	Attractiveness and competitiveness	Public transport use
Prosperity	Attractiveness and competitiveness	Net migration
Prosperity	Attractiveness and competitiveness	Population Dependency Ratio
Prosperity	Attractiveness and competitiveness	International Events Hold
Prosperity	Attractiveness and competitiveness	Tourism intensity
Governance	Organization	Cross-departmental integration
Governance	Organization	Establishment within the
Governance	Organization	Monitoring and evaluation
Governance	Organization	Availability of government data
Governance	Community involvement	Citizen participation
Governance	Community involvement	Open public participation
Governance	Community involvement	Voter participation
Governance	Multilevel governance	Smart city policy
Governance	Multilevel governance	Expenditures by the municipality for a transition towards a smart city
Governance	Multilevel governance	Multilevel government

Smart cities. Croatian Large Cities Assessment

CATEGORIES	SUB-CATEGORIES	INDICATORS
Economy	R&D expenditure, plant and equipment	R&D expenditure
Economy	R&D expenditure, plant and equipment	Plant & equipment expenditure
Economy	Knowledge-intensive industries	Employment in knowledge-intensive industries
Economy	Patent applications	Patent applications
Economy	Entrepreneurship	Self-employment rate and flexibility of labor market
Economy	Entrepreneurship	Newly established enterprises
Economy	Trademarks	International trademarks
Economy	Productivity	Labor productivity
Economy	Productivity	Part-time employment
Economy	Employment and flexibility of labor market	Unemployment rate
Economy	Employment and flexibility of labor market	Employment intensity
Economy	International presence	Number of companies quoted on the Zagreb Stock Exchange
Economy	International presence	Export intensity
Economy	International presence	Enterprises with foreign origin of capital
Economy	International presence	Foreign direct investment
People	Students and universities	Number of institutions of higher education
People	Students and universities	Students enrolled in university studies
People	Foreign language eompanies	Number of companies whose business is a foreign language
People	Net migration	Number of emigrated people
People	People working in creative industries	Share of employees in cultural industries
People	Voter turnout at European elections	Voter turnout at European elections
People	Voter turnout at local elections	Voter turnout at local elections
Governance	Participation in decision making	Number of city council members per 1,000 inhabitants
Governance	Participation in decision making	Proportion of women council members to the total number of city council members
Governance	Participation in decision making	Number of political parties per 1,000 inhabitants
Governance	Public and social services and transparent governance	Share of children in nurseries and kindergartens in the total number of children aged 0 to 6 in the city
Governance	Public and social services and transparent governance	Total expenditures in city budget per capita
Governance	Public and social services and transparent governance	Budget transparency in 2017
Mobility	Local accessibility	Number of city bus lines
Mobility	Local accessibility	Number of bus stations in the city
Mobility	Local accessibility	Length of bicycle trails in the city, in kilometers
Environment	Sunshine hours	Sunshine hours
Environment	Green space	Share of green spaces
Environment	Mixed municipal waste	Mixed municipal waste
Environment	Use of water	Use of water
Environment	Use of electricity	Use of electricity
Living	Cultural facilities	Theatre attendance per inhabitant
Living	Cultural facilities	Cinema attendance per inhabitant
Living	Cultural facilities	Museum visitors per inhabitant
Living	Hospital beds	Hospital beds per 1,000 inhabitants
Living	Doctors	Doctors of medicine per 1,000 inhabitants
Living	At-risk-of-poverty rate	At-risk-of-poverty rate in 2011
Living	Housing quality	Residential area per capita in sqm
Living	Aging of population	Life expectancy
Living	Tourist attractivity	Number of tourists compared to the number of inhabitants in the city
Living	Tourist attractivity	Number of overnight stays in relation to the total number of inhabitants in the city

The UN Indicators of Sustainable Development

CATEGORIES	SUB-CATEGORIES	INDICATORS
Poverty	Income poverty	Proportion of population living below national poverty line
Poverty	Income inequality	Ratio of share in national income of highest to lowest quintile
Poverty	Sanitation	Proportion of population using an improved sanitation facility
Poverty	Drinking water	Proportion of population using an improved water source
Poverty	Access to energy	Share of households without electricity or other modern energy services
Poverty	Living conditions	Proportion of urban population living in slums
Governance	Corruption	Percentage of population having paid bribes
Governance	Crime	Number of intentional homicides per 100,000 population
Health	Mortality	Under-five mortality rate
Health	Mortality	Life expectancy at birth
Health	Health care delivery	Percent of population with access to primary health care facilities
Health	Health care delivery	Immunization against infectious childhood diseases
Health	Nutritional status	Nutritional status of children
Health	Health status and risks	Morbidity of major diseases such as HIV/AIDS, malaria, tuberculosis
Education	Education level	Gross intake ratio to last grade of primary education
Education	Education level	Net enrolment rate in primary education
Education	Education level	Adult secondary (tertiary) schooling attainment level
Education	Literacy	Adult literacy rate
Demographics	Population	Population growth rate
Demographics	Population	Dependency ratio
Natural hazards	Vulnerability to natural hazards	Percentage of population living in hazard prone areas
Atmosphere	Climate change	Carbon dioxide emissions
Atmosphere	Ozone layer depletion	Consumption of ozone depleting substances
Atmosphere	Air quality	Ambient concentration of air pollutants in urban areas
Land	Agriculture	Arable and permanent cropland area
Land	Forests	Proportion of land area covered by forests
Oceans, seas and coasts	Coastal zone	Percentage of total population living in coastal areas
Oceans, seas and coasts	Fisheries	Proportion of fish stocks within safe biological limits
Oceans, seas and coasts	Marine environment	Proportion of marine area protected
Freshwater	Water quantity	Proportion of total water resources used
Freshwater	Water quantity	Water use intensity by economic activity
Freshwater	Water quality	Presence of faecal coliforms in freshwater
Biodiversity	Ecosystem	Proportion of terrestrial area protected, total and by ecological region
Biodiversity	Species	Change in threat status of species
Economic development	Macroeconomic performance	Gross domestic product (GDP) per capita
Economic development	Macroeconomic performance	Investment share in GDP
Economic development	Sustainable public finance	Debt to GNI ratio
Economic development	Employment	Employment- population ratio
Economic development	Employment	Labor productivity and unit labor costs
Economic development	Employment	Share of women in wage employment in the non-agricultural sector
Economic development	Information and communication technologies	Internet users per 100 population
Economic development	Tourism	Tourism contribution to GDP
Global economic partnership	Trade	Current account deficit as percentage of GDP
Global economic partnership	External financing	Net Official Development Assistance (ODA) given or received as a percentage of GNI
Consumption and production patterns	Material consumption	Material intensity of the economy
Consumption and production patterns	Energy use	Annual energy consumption, total and by main user category

Consumption and production patterns	Energy use	Intensity of energy use, total and by economic activity
Consumption and production patterns	Waste generation and management	Generation of hazardous waste
Consumption and production patterns	Waste generation and management	Waste treatment and disposal
Consumption and production patterns	Transportation	Modal split of passenger transportation

Sustainability Tools for Assessing and Rating (STAR)

CATEGORIES	SUB-CATEGORY	INDICATORS
Built Environment		BE-i: Ambient Noise & Light
Built Environment		BE-2: Community Water Systems
Built Environment		BE-3: Compact & Complete Communities
Built Environment		BE-4: Housing Affordability
Built Environment		BE-5: Infill & Redevelopment
Built Environment		BE-6: Public Spaces
Built Environment		BE-7: Transportation Options
Climate & Energy		CE-1: Climate Adaptation
Climate & Energy		CE-2: Greenhouse Gas Mitigation
Climate & Energy		CE-3: Greening the Energy Supply
Climate & Energy		CE-4: Industrial Sector Resource Efficiency
Climate & Energy		CE-5: Resource Efficient Buildings
Climate & Energy		CE-6: Resource Efficient Public Infrastructure
Climate & Energy		CE-7: Waste Minimization
Economy & Jobs		EJ-1: Business Retention & Development
Economy & Jobs		EJ-2: Green Market Development
Economy & Jobs		EJ-3: Local Economy
Economy & Jobs		EJ-4: Quality Jobs & Living Wages
Economy & Jobs		EJ-5: Targeted Industry Development
Economy & Jobs		EJ-6: Workforce Readiness
Education, Arts & Culture		EAC-1: Arts & Culture
Education, Arts & Culture		EAC-2: Community Cohesion
Education, Arts & Culture		EAC-3: Education Opportunity & Attainment
Education, Arts & Culture		EAC-4: Historic Preservation
Education, Arts & Culture		EAC-5: Social & Cultural Diversity
Equity & Empowerment		EE-1: Civic Engagement
Equity & Empowerment		EE-2: Civil & Human Rights
Equity & Empowerment		EE-3: Environmental Justice
Equity & Empowerment		EE-4: Equitable Services & Access
Equity & Empowerment		EE-5: Human Services
Equity & Empowerment		EE-6: Poverty Prevention & Alleviation
Health & Safety		HS-1: Active Living
Health & Safety		HS-2: Community Health & Health System
Health & Safety		HS-3: Emergency Prevention & Response
Health & Safety		HS-4: Food Access & Nutrition
Health & Safety		HS-5: Indoor Air Quality
Health & Safety		HS-6: Natural & Human Hazards
Health & Safety		HS-7: Safe Communities
Natural Systems		NS-1: Green Infrastructure
Natural Systems		NS-2: Invasive Species
Natural Systems		NS-3: Natural Resource Protection
Natural Systems		NS-4: Outdoor Air Quality
Natural Systems		NS-5: Water in the Environment
Natural Systems		NS-6: Working Lands

UN Sustainable Development Goals (SDG's)

CATEGORIES	SUB-CATEGORY	INDICATORS
1. End poverty in all its forms everywhere		1.1.1 Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)
1. End poverty in all its forms everywhere		1.2.1 Proportion of population living below the national poverty line, by sex and age
1. End poverty in all its forms everywhere		1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
1. End poverty in all its forms everywhere		1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work injury victims, and the poor and the vulnerable
1. End poverty in all its forms everywhere		1.4.1 Proportion of population living in households with access to basic services
1. End poverty in all its forms everywhere		1.4.2 Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure
1. End poverty in all its forms everywhere		1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
1. End poverty in all its forms everywhere		1.5.2 Direct disaster economic loss in relation to global gross domestic product (GDP)
1. End poverty in all its forms everywhere		1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
1. End poverty in all its forms everywhere		1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
1. End poverty in all its forms everywhere		1.a.1 Total official development assistance grants from all donors that focus on poverty reduction as a share of the recipient country's gross national income
1. End poverty in all its forms everywhere		1.a.2 Proportion of total government spending on essential services (education, health and social protection)
1. End poverty in all its forms everywhere		1.b.1 Proportion of government recurrent and capital spending to sectors that disproportionately benefit women, the poor and vulnerable groups
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.1.1 Prevalence of undernourishment
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.2.3 Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage)
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.3.1 Volume of production per labour unit by classes of farming/pastoral/ forestry enterprise size

2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.3.2 Average income of small-scale food producers, by sex and indigenous status
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.4.1 Proportion of agricultural area under productive and sustainable agricultural practices
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.5.2 Proportion of local breeds classified as being at risk of extinction
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.a.1 The agriculture orientation index for government expenditures
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.b.1 Agricultural export subsidies
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.		2.c.1 Indicator of food price anomalies
3. Ensure healthy lives and promote well-being for all at all ages.		3.1.1 Maternal mortality ratio
3. Ensure healthy lives and promote well-being for all at all ages.		3.1.2 Proportion of births attended by skilled health personnel
3. Ensure healthy lives and promote well-being for all at all ages.		3.2.1 Under-five mortality rate
3. Ensure healthy lives and promote well-being for all at all ages.		3.2.2 Neonatal mortality rate
3. Ensure healthy lives and promote well-being for all at all ages.		3.3.1 Number of new HIV infections per 1,000 uninfected population by sex, age and key populations
3. Ensure healthy lives and promote well-being for all at all ages.		3.3.2 Tuberculosis incidence per 100,000 population
3. Ensure healthy lives and promote well-being for all at all ages.		3.3.3 Malaria incidence per 1,000 population
3. Ensure healthy lives and promote well-being for all at all ages.		3.3.4 Hepatitis B incidence per 100,000 population
3. Ensure healthy lives and promote well-being for all at all ages.		3.3.5 Number of people requiring interventions against neglected tropical diseases
3. Ensure healthy lives and promote well-being for all at all ages.		3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease

3. Ensure healthy lives and promote well-being for all at all ages.		3.4.2 Suicide mortality rate
3. Ensure healthy lives and promote well-being for all at all ages.		3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders
3. Ensure healthy lives and promote well-being for all at all ages.		3.5.2 Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol
3. Ensure healthy lives and promote well-being for all at all ages.		3.6.1 Death rate due to road traffic injuries
3. Ensure healthy lives and promote well-being for all at all ages.		3.7.1 Proportion of women of reproductive age (aged 15-49) who have their need for family planning satisfied with modern methods
3. Ensure healthy lives and promote well-being for all at all ages.		3.7.2 Adolescent birth rate (aged 10-14 year; aged 15- 19 years) per 1,000 women in that age group
3. Ensure healthy lives and promote well-being for all at all ages.		3.8.1 Coverage of essential health services
3. Ensure healthy lives and promote well-being for all at all ages.		3.8.2 Proportion of population with large household expenditures on health as a share of total household expenditure or income
3. Ensure healthy lives and promote well-being for all at all ages.		3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
3. Ensure healthy lives and promote well-being for all at all ages.		3.9.3 Mortality rate attributed to unintentional poisoning
3. Ensure healthy lives and promote well-being for all at all ages.		3.9.1 Mortality rate attributed to household and ambient air pollution
3. Ensure healthy lives and promote well-being for all at all ages.		3.a.1 Age-standardized prevalence of current tobacco use among persons aged 15 years and older
3. Ensure healthy lives and promote well-being for all at all ages.		3.b.1 Proportion of the target population covered by all vaccines included in their national programme
3. Ensure healthy lives and promote well-being for all at all ages.		3.b.2 Total net official development assistance to medical research and basic health sectors
3. Ensure healthy lives and promote well-being for all at all ages.		3.b.3 Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis
3. Ensure healthy lives and promote well-being for all at all ages.		3.c.1 Health worker density and distribution
3. Ensure healthy lives and promote well-being for all at all ages.		3.d.1 International Health Regulations (IHR) capacity and health emergency preparedness
3. Ensure healthy lives and promote well-being for all at all ages.		3.d.2 Percentage of bloodstream infections due to selected antimicrobial-resistant organisms
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.1.1 Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.1.2 Completion rate (primary education, lower secondary education, upper secondary education)

4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.2.1 Proportion of children aged 24-59 months who are developmentally on track in health, learning and psychosocial well-being, by sex
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.2.2 Participation rate in organized learning (one year before the official primary entry age), by sex
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict affected, as data become available) for all education indicators on this list that can be disaggregated
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.6.1 Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in: (a) national education policies, (b) curricula, (c) teacher education and (d) student assessment
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.a.1 Proportion of schools offering basic services, by type of service
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.b.1 Volume of official development assistance flows for scholarships by sector and type of study
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.		4.c.1 Proportion of teachers with the minimum required qualifications, by education level
5. Achieve gender equality and empower all women and girls		5.1.1 Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex
5. Achieve gender equality and empower all women and girls		5.2.1 Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age
5. Achieve gender equality and empower all women and girls		5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence
5. Achieve gender equality and empower all women and girls		5.3.1 Proportion of women aged 20-24 years who were married or in a union before age 15 and before age 18
5. Achieve gender equality and empower all women and girls		5.3.2 Proportion of girls and women aged 15-49 years who have undergone female genital mutilation/cutting, by age
5. Achieve gender equality and empower all women and girls		5.4.1 Proportion of time spent on unpaid domestic and care work, by sex, age and location
5. Achieve gender equality and empower all women and girls		5.5.1 Proportion of seats held by women in (a) national parliaments and (b) local governments
5. Achieve gender equality and empower all women and girls		5.5.2 Proportion of women in managerial positions
5. Achieve gender equality and empower all women and girls		5.6.1 Proportion of women aged 15-49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care

5. Achieve gender equality and empower all women and girls		5.6.2 Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education
5. Achieve gender equality and empower all women and girls		5.a.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control
5. Achieve gender equality and empower all women and girls		5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and b) share of women among owners or rights-bearers of agricultural land, by type of tenure
5. Achieve gender equality and empower all women and girls		5.b.1 Proportion of individuals who own a mobile telephone, by sex
5. Achieve gender equality and empower all women and girls		5.c.1 Proportion of countries with systems to track and make public allocations for gender equality and women’s empowerment
6. Ensure availability and sustainable management of water and sanitation for all.		6.1.1 Proportion of population using safely managed drinking water services
6. Ensure availability and sustainable management of water and sanitation for all.		6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
6. Ensure availability and sustainable management of water and sanitation for all.		6.3.1 Proportion of wastewater safely treated
6. Ensure availability and sustainable management of water and sanitation for all.		6.3.2 Proportion of bodies of water with good ambient water quality
6. Ensure availability and sustainable management of water and sanitation for all.		6.4.1 Change in water-use efficiency over time
6. Ensure availability and sustainable management of water and sanitation for all.		6.4.2 Level of water stress: freshwater witdrawal as a proportion of available freshwater resources
6. Ensure availability and sustainable management of water and sanitation for all.		6.5.1 Degree of integrated water resources management
6. Ensure availability and sustainable management of water and sanitation for all.		6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6. Ensure availability and sustainable management of water and sanitation for all.		6.6.1 Change in the extent of water-related ecosystems over time
6. Ensure availability and sustainable management of water and sanitation for all.		6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6. Ensure availability and sustainable management of water and sanitation for all.		6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management
7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.1.1 Proportion of population with access to electricity
7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.1.2 Proportion of population with primary reliance on clean fuels and technology
7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.2.1 Renewable energy share in the total final energy consumption
7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.3.1 Energy intensity measured in terms of primary energy and GDP
7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems

7. Ensure access to affordable, reliable, sustainable and modern energy for all.		7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.1.1 Annual growth rate of real GDP per capita
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.2.1 Annual growth rate of real GDP per employed person
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.3.1 Proportion of informal employment in total employment, by sector and sex
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.4.1 Material footprint, material footprint per capita, and material footprint per GDP
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.5.1 Average hourly earnings of female and male employees, by occupation, age and persons with disabilities
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.5.2 Unemployment rate, by sex, age and persons with disabilities
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.7.1 Proportion and number of children aged 5-17 years engaged in child labour, by sex and age
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.8.1 Fatal and non-fatal occupational injuries per 100,000 workers, by sex and migrant status
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.8.2 Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.9.1 Tourism direct GDP as a proportion of total GDP and in growth rate
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.10.1 (a) Number of commercial bank branches per 100,000 adults and (b) number of automated teller machines (ATMs) per 100,000 adults
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.10.2 Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.a.1 Aid for Trade commitments and disbursements

8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.		8.b.1 Existence of a developed and operationalized national strategy for youth employment, as a distinct strategy or as part of a national employment strategy
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.1.1 Proportion of the rural population who live within 2 km of an all-season road
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.1.2 Passenger and freight volumes, by mode of transport
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.2.1 Manufacturing value added as a proportion of GDP and per capita
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.2.2 Manufacturing employment as a proportion of total employment
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.3.1 Proportion of small-scale industries in total industry value added
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.3.2 Proportion of small-scale industries with a loan or line of credit
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.4.1 CO2 emission per unit of value added
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.5.2 Researchers (in full-time equivalent) per million inhabitants
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.5.1 Research and development expenditure as a proportion of GDP
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.b.1 Proportion of medium and high-tech industry value added in total value added
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.		9.c.1 Proportion of population covered by a mobile network, by technology
10. Reduce inequality within and among countries.		10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population
10. Reduce inequality within and among countries.		10.2.1 Proportion of people living below 50 per cent of median income, disaggregated by age, sex and persons with disabilities
10. Reduce inequality within and among countries.		10.3.1 Proportion of population reporting having personally felt discriminated against or harassed within the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
10. Reduce inequality within and among countries.		10.4.1 Labour share of GDP

10. Reduce inequality within and among countries.		10.4.2 Redistributive impact of fiscal policy
10. Reduce inequality within and among countries.		10.5.1 Financial Soundness Indicators
10. Reduce inequality within and among countries.		10.6.1 Proportion of members and voting rights of developing countries in international organizations
10. Reduce inequality within and among countries.		10.7.1 Recruitment cost borne by employee as a proportion of monthly income earned in country of destination
10. Reduce inequality within and among countries.		10.7.2 Number of countries with migration policies that facilitate orderly, safe, regular and responsible migration and mobility of people
10. Reduce inequality within and among countries.		10.7.3 Number of people who died or disappeared in the process of migration towards an international destination
10. Reduce inequality within and among countries.		10.7.4 Proportion of the population who are refugees, by country of origin
10. Reduce inequality within and among countries.		10.a.1 Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff
10. Reduce inequality within and among countries.		10.b.1 Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows)
10. Reduce inequality within and among countries.		10.c.1 Remittance costs as a percentage of the amount remitted
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.2.1 Proportion of the population that has convenient access to public transport, by sex, age and persons with disabilities
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.3.1 Ratio of land consumption rate to population growth rate
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.a.1 Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030

11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
11. Make cities and human settlements inclusive, safe, resilient and sustainable.		11.c.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials
12. Ensure sustainable consumption and production patterns.		12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production
12. Ensure sustainable consumption and production patterns.		12.2.1 Material footprint, material footprint per capita and material footprint per GDP
12. Ensure sustainable consumption and production patterns.		12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12. Ensure sustainable consumption and production patterns.		12.3.1 (a) Food loss index and (b) food waste index
12. Ensure sustainable consumption and production patterns.		12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12. Ensure sustainable consumption and production patterns.		12.4.1 Number of Parties to international multilateral environmental agreements on hazardous, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
12. Ensure sustainable consumption and production patterns.		12.5.1 National recycling rate, tons of material recycled
12. Ensure sustainable consumption and production patterns.		12.6.1 Number of companies publishing sustainability reports
12. Ensure sustainable consumption and production patterns.		12.7.1 Degree of sustainable public procurement policies and action plan implementation
12. Ensure sustainable consumption and production patterns.		12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
12. Ensure sustainable consumption and production patterns.		12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
12. Ensure sustainable consumption and production patterns.		12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability
12. Ensure sustainable consumption and production patterns.		12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption)
13. Take urgent action to combat climate change and its impacts.		13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
13. Take urgent action to combat climate change and its impacts.		13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
13. Take urgent action to combat climate change and its impacts.		13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
13. Take urgent action to combat climate change and its impacts.		13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
13. Take urgent action to combat climate change and its impacts.		13.2.2 Total greenhouse gas emissions per year

13. Take urgent action to combat climate change and its impacts.		13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
13. Take urgent action to combat climate change and its impacts.		13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025
13. Take urgent action to combat climate change and its impacts.		13.b.1 Number of least developed countries and small island developing States with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.2.1 Number of countries using ecosystem-based approaches to managing marine areas
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.4.1 Proportion of fish stocks within biologically sustainable levels
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.5.1 Coverage of protected areas in relation to marine areas
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.7.1 Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.a.1 Proportion of total research budget allocated to research in the field of marine technology
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.b.1 Degree of application of a legal/regulatory/ policy/institutional framework which recognizes and protects access rights for small-scale fisheries
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.		14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.1.1 Forest area as a proportion of total land area

15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.2.1 Progress towards sustainable forest management
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.3.1 Proportion of land that is degraded over total land area
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.4.1 Coverage by protected areas of important sites for mountain biodiversity
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.4.2 Mountain Green Cover Index
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.5.1 Red List Index
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species

15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.b.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.		15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.1.2 Conflict-related deaths per 100,000 population, by sex, age and cause
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.1.4 Proportion of people that feel safe walking alone around the area they live
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.1.1 Number of victims of intentional homicide per 100,000 population, by sex and age
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.1.3 Proportion of population subjected to (a) physical violence, (b) psychological violence and (c) sexual violence in the previous 12 months
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.2.1 Percentage of children aged 1-17 years who experienced any physical punishment and/or psychological aggression by caregivers in the past month

16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.2.2 Number of victims of human trafficking per 100,000 population, by sex, age group and form of exploitation
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.2.3 Proportion of young women and men aged 18-29 years who experienced sexual violence by age 18
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.3.2 Unsentenced detainees as a proportion of overall prison population
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.3.1 Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.3.3 Proportion of the population who have experienced a dispute in the past two years and who accessed a formal or informal dispute resolution mechanism, by type of mechanism
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.4.2 Proportion of seized, found or surrendered arms whose illicit origin or context has been traced or established by a competent authority in line with international instruments
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.4.1 Total value of inward and outward illicit financial flows (in current United States dollars)
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.5.1 Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.6.1 Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar)

16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.6.2 Proportion of the population satisfied with their last experience of public services
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.7.1 Proportions of positions in national and local institutions, including (a) the legislatures; (b) the public service; and (c) the judiciary, compared to national distributions, by sex, age, persons with disabilities and population groups
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.7.2 Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.8.1 Proportion of members and voting rights of developing countries in international organizations
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.10.1 Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.10.2 Number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.a.1 Existence of independent national human rights institutions in compliance with the Paris Principles
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.		16.b.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.1.1 Total government revenue as a proportion of GDP, by source
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.1.2 Proportion of domestic budget funded by domestic taxes

17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.2.1 Net official development assistance, total and to least developed countries, as a proportion of the Organization for Economic Cooperation and Development (OECD) Development Assistance Committee donors’ gross national income (GNI)
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.3.2 Volume of remittances (in United States dollars) as a proportion of total GDP
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.3.1 Foreign direct investments (FDI), official development assistance and South-South Cooperation as a proportion of total domestic budget
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.4.1 Debt service as a proportion of exports of goods and services
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.5.1 Number of countries that adopt and implement investment promotion regimes for least developed countries
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.6.1 Fixed Internet broadband subscriptions per 100 inhabitants, by speed
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.7.1 Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.8.1 Proportion of individuals using the Internet
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.9.1 Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.10.1 Worldwide weighted tariff-average
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.11.1 Developing countries’ and least developed countries’ share of global exports
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.12.1 Weighted average tariffs faced by developing countries, least developed countries and small island developing States
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.13.1 Macroeconomic Dashboard
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.15.1 Extent of use of country-owned results frameworks and planning tools by providers of development cooperation

17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.17.1 Amount in United States dollars committed to public-private partnerships for infrastructure
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.18.3 Number of countries with a national statistical plan that is fully funded and under implementation, by source of funding
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.18.2 Number of countries that have national statistical legislation that complies with the Fundamental Principles of Official Statistics
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.19.1 Dollar value of all resources made available to strengthen statistical capacity in developing countries
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.		17.19.2 Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration

Global City Indicators Facility

CATEGORIES	SUB-CATEGORY	INDICATORS
City Services	Education	Student/teacher ratio
City Services	Education	% of children completing primary & secondary ed.
City Services	Education	% of students completing primary education
City Services	Education	% of students completing secondary education
City Services	Education	% of school-aged children enrolled in schools
City Services	Education	% of male children enrolled in schools
City Services	Education	% of female children enrolled in schools
City Services	Finance	Debt service ratio
City Services	Finance	Tax collected as percentage of tax billed
City Services	Finance	Own-source revenue as a % of total revenues
City Services	Finance	Capital spending as a % of total expenditures
City Services	Governance	Gross Operating Budget ($)
City Services	Governance	Gross Operating Budget per capita ($)
City Services	Governance	Gross Capital Budget ($)
City Services	Governance	Gross Capital Budget per capita ($)
City Services	Governance	Debt service ratio (%)
City Services	Governance	Tax collected as a % of tax billed
City Services	Governance	Capital spending as % of total expenditures
City Services	Governance	Own-source revenue as % of total revenues
City Services	Governance	% of women employed in the city government
City Services	Governance	Voter participation in last municipal election (%)
City Services	Governance	No. of local officials elected to office per 100,000
City Services	Governance	Type of government (e.g. Local, Regional, County)
City Services	Recreation	Square metres of public indoor recreation facility space per capita
City Services	Recreation	Square metres of public outdoor recreation facility space per capita
City Services	Transportation	Km of high capacity public transit per 100,000 pop.
City Services	Transportation	Km of light passenger transit per 100,000 pop.
City Services	Transportation	Number of personal automobiles per capita
City Services	Transportation	Annual number of public transit trips per capita
City Services	Transportation	Number of two-wheel motorized vehicles per capita
City Services	Transportation	Number of non-stop commercial air destinations
City Services	Transportation	Transportation fatalities per 100,000 population
City Services	Wastewater	Percentage of city population served by wastewater collection
City Services	Wastewater	Percentage of the city's wastewater that has received no treatment
City Services	Wastewater	Percentage of the city's wastewater receiving primary treatment
City Services	Wastewater	Percentage of the city's wastewater receiving secondary treatment
City Services	Wastewater	Percentage of the city's wastewater receiving tertiary treatment
City Services	Energy	Percentage of city population with authorized electrical service
City Services	Energy	Total residential electrical use per capita
City Services	Energy	Total electrical use per capita (kilowatt/hr)
City Services	Energy	The average number of electrical interruptions per customer per year
City Services	Energy	Average length of electrical interruptions (in hours)
City Services	Fire and Emergency Services	No. of firefighters per 100,000 population
City Services	Fire and Emergency Services	No. of fire related deaths per 100,000 population
City Services	Fire and Emergency Services	Response time for fire department (minutes)
City Services	Health	Average life expectancy
City Services	Health	Under age five mortality per 1,000 live births
City Services	Safety	No. of police officers per 100,000 population
City Services	Safety	No. of homicides per 100,000 population
City Services	Safety	Violent crime rate per 100,000 population

City Services	Solid waste	Percentage of city population with regular solid waste collection
City Services	Solid waste	Percentage of city's solid waste that is recycled
City Services	Solid waste	Percentage of the city's of solid waste that is disposed in an incinerator
City Services	Solid waste	Percentage of the city's solid waste that is burned openly
City Services	Solid waste	Percentage of the city's of solid waste that is disposed in an open dump
City Services	Solid waste	Percentage of the city's of solid waste that is disposed in an sanitary landfill
City Services	Solid waste	Percentage of the city's of solid waste that is disposed by other means
City Services	Urban Planning	Jobs/Housing ratio
City Services	Urban Planning	Areal size of informal settlements as a percent of city area
City Services	Urban Planning	Green area (hectares) per 100,000 population
City Services	Water	% of population with potable water supply service
City Services	Water	Domestic water consumption per capita (litres/day)
City Services	Water	% of pop. with sust. access to improved water source
City Services	Water	Total water consumption per ca pita (litres/day)
City Services	Water	% of water loss
City Services	Water	Water service interruption per household [avg. hrs/yr]
Quality of Life	Civic Engagement	Voter participation in last municipal election
Quality of Life	Civic Engagement	Citizens representation: # local officials elected to office per 100,000 population
Quality of Life	Economy	City Product per capita ($)
Quality of Life	Economy	GDP per capita ($)
Quality of Life	Economy	% of country's GDP
Quality of Life	Economy	% of country's population
Quality of Life	Economy	Average household income ($)
Quality of Life	Economy	Annual inflation rate (avg. of last 5 years) (%)
Quality of Life	Economy	Cost of living ($)
Quality of Life	Economy	Income distribution [GINI Coefficient]
Quality of Life	Economy	Total employment
Quality of Life	Economy	Annual avg. unemployment rate (%)
Quality of Life	Economy	Employment % change since base year
Quality of Life	Economy	City unemployment rate (%)
Quality of Life	Economy	% of persons in full time employment
Quality of Life	Economy	Commercial/Ind assessment as % of total assess't
Quality of Life	Economy	Number of businesses per 1,000 population
Quality of Life	Economy	% of city population living in poverty
Quality of Life	Shelter	Percentage of city population living in slums
Quality of Life	Shelter	Number of households that exist without registered legal titles
Quality of Life	Shelter	Number of homeless people per 100,000 population
Quality of Life	Culture	% of jobs in the cultural sector
Quality of Life	Environment	PM10 concentration
Quality of Life	Environment	Greenhouse gas emissions measured in tonnes per capita
Quality of Life	Social Equity	Percentage of city population living in poverty
Quality of Life	Technology and Innovation	No. of Internet connections per 100,0000 pop.
Quality of Life	Technology and Innovation	No. of new patents per 100,000 per year
Quality of Life	Technology and Innovation	% of jobs in the cultural sector
Quality of Life	Technology and Innovation	No. of higher education degrees per 100,000 pop.
Quality of Life	Technology and Innovation	No. of telephones (landlines & cell) per 100,000 pop.
Quality of Life	Technology and Innovation	No. of landline phone connections per 100,000 pop.
Quality of Life	Technology and Innovation	No. of cell phone connections per 100,000 pop.

European Green City Index

CATEGORIES	SUB-CATEGORY	INDICATORS
CO_2		CO_2 emissions
CO_2		CO_2 intensity
CO_2		CO_2 reduction strategy
Energy		Energy consumption
Energy		Energy intensity
Energy		Renewable energy consumption
Energy		Clean and efficient energy policies
Buildings		Energy consumption of residential buildings
Buildings		Energy-efficient buildings standards
Buildings		Energy-efficient buildings initiatives
Transport		Use of non-car transport
Transport		Size of non-car transport network
Transport		Green transport promotion
Transport		Congestion reduction policies
Water		Water consumption
Water		Water system leakage
Water		Waste water treatment
Water		Water efficiency and treatment policies
Waste and land use		Municipal waste production
Waste and land use		Waste recycling
Waste and land use		Waste reduction and policies
Waste and land use		Green land use policies
Air quality		Nitrogen dioxide
Air quality		Ozone
Air quality		Particulate matter
Air quality		Sulphur dioxide
Air quality		Clean air policies
Environmental governance		Green action plan
Environmental governance		Green management
Environmental governance		Public participation in green policy

European Common Indicators (ECI)

CATEGORIES	SUB-CATEGORY	INDICATORS
		Satisfaction with the local community
		Local contribution to global climate change – carbon footprint of the town
		Mobility and local transport of passengers
		Availability of public spaces and services
		Local air quality
		Paths for children to and from school
		Unemployment
		Environmental load of noise
		Sustainable land use
		Ecological footprint of the town

Environmental Performance Index (EPI)

CATEGORIES	SUB-CATEGORY	INDICATORS
Air Quality		PM2.5 exposure
Air Quality		Household solid fuels
Air Quality		Ozone exposure
Sanitation & Drinking Water		Unsafe drinking water
Sanitation & Drinking Water		Unsafe sanitation
Heavy Metals		Lead exposure
Waste Management		Controlled solid waste
Biodiversity		Terrestrial biomes (national)
Biodiversity		Terrestrial biomes (global)
Biodiversity		Marine protected areas
Biodiversity		Protected Areas Rep. Ind.
Biodiversity		Species Habitat Index
Biodiversity		Species Protection Index
Biodiversity		Biodiversity Habitat Index
Ecosystem Services		Tree cover loss
Ecosystem Services		Grassland loss
Ecosystem Services		Wetland loss
Fisheries		Fish Stock Status
Fisheries		Marine Trophic Index
Fisheries		Fish caught by trawling
Climate Change		CO2 growth rate
Climate Change		CH4 growth rate
Climate Change		F-gas growth rate
Climate Change		N2O growth rate
Climate Change		Black Carbon growth rate
Climate Change		CO2 from land cover
Climate Change		GHG intensity trend
Climate Change		GHG per capita
Pollution Emissions		SO2 growth rate
Pollution Emissions		NOx growth rate
Agriculture		Sustainable Nitrogen Mgmt Index
Water Resources		Wastewater treatment

The Urban Sustainability Index: Urban China Initiative

CATEGORIES	SUB-CATEGORIES	INDICATORS
Society	Social welfare	Urban employment rate (%)
Society	Social welfare	Number of doctors per capita (per thousand persons)
Society	Social welfare	Middle school students in young population (%)
Society	Social welfare	Pension security coverage (%)
Society	Social welfare	Health care security coverage (%)
Environment	Cleanliness	Concentration of SO2, NO2, PM10 (mg per cubic meter)
Environment	Cleanliness	Industrial SO2 discharged per unit GDP (tons per bn RMB)
Environment	Cleanliness	Days of air qualified equal or above level 111(%)
Environment	Cleanliness	Wastewater treatment rate (%)
Environment	Cleanliness	Domestic waste treated (%)
Environment	Built environment	Persons per square kilometer of urban area
Environment	Built environment	Passengers using public transit (per capita)
Environment	Built environment	Area of public green space (%)
Environment	Built environment	Public water supply coverage (%)
Environment	Built environment	Household access to Internet (%)
Economy	Economic development	Disposable income per capita
Economy	Economic development	GDP from service industry (%)
Economy	Economic development	Government investment in R&D (per capita)
Resources	Resource utilization	Total energy consumption (SCE per unit GDP)
Resources	Resource utilization	Residential power consumption (kwh per capita)
Resources	Resource utilization	Total water consumption (liters per unit GDP)

Annexure 3. Umgeni River plastic pollution in the media. List of media outlets

South African press

2013-04-25, IOL. *High cost of water pollution*

2013-06-07, IOL. *Umgeni River one of the dirtiest in SA*

2014-07-14, IOL. *Wave of fish deaths in eThekwini*

2015-06-14, National Geographic. *Durban into the Zulu Kingdom*

2016-05-20, Sunday Times. *Durban beaches reopen, but municipality urges caution*

2016-05-21, SA PEople. *Plastic pollution comes under the spotlight in South Africa*

2016-07-27, eNCA. *IN PICTURES, Storms leave trail of debris on Durban beaches*

2016-08-20, ECR. *Cleanup expected for Durban beaches this morning*

2016-09-01, Ground Work. *Newsletter*

2016-09-15, Northglen News. *Dumping spirals out of control*

2016-09-21, UKZN. *Microplastics research featured on Carte Blanche*

2017-04-12, Northglen News. *Lifter booms halts massive rubbish deluge*

2017-07-11, The 10th Province. *A global war on plastic waste may see an end, with South Africa playing a lead role in it: African Marine Waste Conference*

2017-11-06, Oricol Environmental Services. *Plastic waste clean-up*

2018-02-04, Sunday Tribune. *Eco+Hero+Ayanda*

2018-02-04, Sunday Tribune. *Water+Pollution*

2018-02-08, The Witness. *River's fouled flow*

2018-06-13, Plastics SA. *Plastics|SA raises awareness about keeping plastics pollution out of the environment sustainability week, world environment day, world oceans day*

2018-06-14, Infrastructures news. *Keep plastic pollution out of the environment. Plastics SA*

2018-10-25, Roving Reporters. *Durban date for fiery dung beetle*

2018-11-08, ZigZag Magazine. *Day 1: Umgeni River Bank Cleanup ft. The Litterboom Project*

2018-11-26, Highway Mail. *Quarry Road residents educated on waste management*

2018-12-02, IOL. *Illegal dumping threatens Durban, s Umgeni River*

2019-03-11, Zigzag Magazine. *The Umgeni Drops Its Guts.*

2019-03-14, East Coast Radio. *Help clean-up Umgeni River with the Litterboom Project and Wildlands*

2019-03-14, IOL. *Call to curb pollution in Umgeni River*

2019-03-19, Rising Sun Overport. *Plastic nightmare at Durban beach*

2019-03-31, Tunza Eco Generation. *[Ambassador report] Teams of Activists, Stakeholders and Local NGOs Team up for a Massive Durban Beach Clean Up*

2019-04-25, George Herald. *Month of cleaning expected in wake of Durban floods*

2019-04-25, The Citizen. *Month of cleaning expected in wake of Durban floods*

2019-04-29, The South African. *KZN floods: Blanket of plastic pollutes Durban beachfront [photos]*

2019-04-30, Times. *Her dress may have been trashy, but it surely made a statement*

2019-05-28, uShaka Marine World. *Plastic Pollution at an All-Time High*

2019-05-29, The green times. *Operation #Cleanup Durban a huge success*

2019-06-01, Noseweek. *236 Slew of free new condoms piles up after deluge in Durban*

2019-06-08, SABC. *South Africans celebrate World Oceans Day by cleaning up beaches*

2019-06-25, Yoco. *Green Corridors: Looking after Durban*

2019-06-28, IOL. *Major clean-up for Durban rivers*

2019-07-23, Mercury. *Call to end single-use plastic products*

2019-08-23, The Mail & Guardian. *Rivers die after oil, chemical spill*

2019-09-18, Infrastructure news. *Clean up and recycle SA week has kicked off*

2019-10-28, Umhlanga Rocks Tourism. *Sarah shines on tough North Coast swim*

2019-11-18, Zigzag Magazine. *Fighting the good fight against the ocean plastic problem*

2019-12-10, Berea Mail. *From waste to art*

2019-12-12, Business Insider. *Durban South Africa Umgeni River Plastic Pollution*

2019-12-13, SABC. *Tons of plastic churns through waves on South African beach*

2019-12-14, UKZN. *Waste to art: the Neptune Project to help tackle pollution*

2019-12-17, Business Insider. *Shocking footage caught tons of plastic crashing in the waves off Durban following heavy rains*

2019-12-19, SA peoples news. *WATCH Durban's plastic pollution makes world headlines (whilst voted greened city in the world)*

2019-12-21, Business Insider. *Durban just picked up an award as the Greenest City in the world. but when it rains the beaches look like plastic waste dumps*

2020-01-15, Mark Dittke Attorneys. *Durban Greenest City in the world*

2020-01-17, Vancouver Sun. *Plastic oceans: Unwanted trash and a popular but unproven plan to solve the problem*

2020-02-22, IOL. *Master of Umgeni River: Geytenbeek looks for solutions to polluted river*

2020-03-08, Northglen News. *Rife river pollution threatens water supply*

2020-03-08, Roving Reporters. *Green plan to turn dirty waste into walkways*

2020-03-09, Cape Town ETC. *Durban recycles river waste to make walkways*

2020-03-09, UKZN. *Neptune Project raises awareness of pollution in Umgeni River*

2020-03-10, Getaway. *Non-recyclable waste could pave Durban's walkways*

2020-06-03, New Frame. *You are what you eat, including plastic*

2020-09-02, Shepstone & Wylei. *Impacts of Plastic Pollution on our Marine Economy and Environment*

2020-09-04, South Coast Sun. *Task team to tackle polluted Amanzimtoti rivers*

2020-09-04, UN. *South Africa aims to stop marine litter at its source*

2020-11-27, Coast KZN. *Lend a helping hand at Durban beach clean-up events*

2020-12-07, Plastics SA. *SAFRIPOL signs OCS pledge to protect our environment*

2021-03-05, Good things guy. *Plastic industry pledge a plastic free environment in SA*

2021-03-12, Plastix Portal. *Safripol signs operation clean sweep pledge*

2021-04-09, PlasticOceans. *Breathe Ocean Conservation: a beacon of light*

International press

2018-06-05, Pressestelle des Senats. *Bürgermeisterin Linnert trifft Ocean Champs* (Germany)

2018-06-07, Leibniz-Zentrum für Marine Tropenforschung. *Bremen-Durban Netzwerk für Marine Umwel* (Germany)

2019-12-12, ABC. *Montañas de plásticos se acumulan en las playas de Sudáfrica* (Spain)

2019-12-12, Atlas Agencia. *Montañas de plásticos se acumulan en las playas de Durban (Sudáfrica)* (Spain)

2019-12-12, Cadena Ser. *Olas de plástico, el indignante video* (Spain)

2019-12-12, Marca. *Medio Ambiente, Montañas de plásticos* (Spain)

2019-12-12, Panamericana. *Sudáfrica, toneladas de basura invaden playas de Durban (video)* (Peru)

2019-12-12, Püblico TV. *Montañas de plásticos se acumulan en las playas de Sudáfrica* (Spain)

2019-12-12, Sky. *Inquinamento in Sudafrica: I'ondata di bottiglie di plastica sulla costa. VIDEO* (Italy)

2019-12-13, Foros Peru. *Sudáfrica, olas de plásticos invaden las playas de Durban* (Peru)

2019-12-13, Clam y Directo MX. *Olas de plástico azotan Ia Playa de Durban en Sudáfrica* (Mexico)

2019-12-13, Enfoque Noticias. *RIo brotante de plásticos en Sudàfrica* (Mexico)

2019-12-13, Euronews. *Olas de plásticos en Sudáfrica: Ia triste imagen del progreso* (EU)

2019-12-13, Planeta vivo. *Preocupación por Ia alarmante imagen de "olas de plásticos" en Sudáfrica* (Argentina)

2019-12-13, Tele Ambiente. *Inquinamento: l'ondata di bottiglie di plastica in Sudafrica VIDEO* (Italy)

2019-12-14, Passione vegano. *Sudafrica: I'onda di plastica che si infrange sulla costa è ii simbolo del nostro tempo* (Italy)

2019-12-14, Green me. *Sudafrica: l'onda di plastica che si infrange sulla costa è ii simbolo del nostro tempo* (Italy)

2019-12-15, Il secolo XIX. *Sudafrica, tonnellate di rifiuti in mare: le onde sono ricoperte da bottiglie di plastica* (Italy)

2019-12-16, Bio Pianeta. *Sudafrica, allarme plastica, Ia marea di bottiglie invade Ic spiagge* (ltaly)

2019-12-16, Il fatto quotidiano. *Tonnellate Tonnellate di rifiuti in mare: le onde in Sudafrica sono bottiglie di plastica* (Argentina)

2019-12-16, Noticias Oaxaca. *Captan olas de plástico en una playa de Sudáfrica* (Mexico)

2019-12-16, Rifiuti & Riciclo. *Piene di plastica, le onde di rifiuti del mare in Sud Africa* (Italy)

2019-12-17, DolarLido. *Olas de plásticos en Sudáfrica, miles de botellas flotan en el mar* (Venezuela)

2019-12-17, El nuevo diario. *(VIDEO) Vea cómo las olas de plástico arropan las playas de Sudáfrica* (Santo Domingo)

2019-12-17, El Pais. *Un mar de plásticos baña una de las principales ciudades costeras de Sudáfrica* (Spain)

2019-12-17, Kaos en Ia red. *Olas de plásticos en Sudáfrica: Ia triste imagen del progreso* (Spain)

2019-12-17, Life gate. *Sudafrica, le incredibili immagini del mare invaso da tonnellate di plastica* (Italy)

2019-12-19, Scienze notizie. *Durban: un'onda di bottiglie di plastica si infrange sulla spiaggia* (Italy)

2020-01-17, Aguas.org. *Olas de plásticos en Sudáfrica, Ia triste imagen del "progreso"* (Mexico)

2020-04-27, Redaktionsnetzwerk Deutchland. *Unterstützung aus dem All, Werden so in Zukunft die Ozeane gesaubert* (Germany)

Annexure 4. Abstract for the peer reviewed article in the Journal of South African Science

Accepted for publication in Journal of South African Science. Special issue. Waste as a Resource: South African perspectives on circularity

Development of measurement systems of urban sustainability applied to the waste sector: The case of plastic pollution in the Umgeni River estuary

Antonio Blanco-Montero, Cristina Trois
College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Durban, South Africa

Abstract

Durban represents a paradigm of the Southern African megacity. At the same time, it is a coastal city prone to natural disaster due to climate change. Therefore, social and environmental challenges meet together to conform an interesting breeding ground for the development and testing of creative solutions that are forced to look at problems from a holistic perspective.

This overarching vision typically clashes with a tight departmental organization at municipal level which together with a constraining lack of human and technical capacity, affect enormously the efficacy of service delivery. Moreover, despite efforts being done to increase the level of integration urban strategic planning, not much success has been accomplished. In this circumstance, this paper aims to explore opportunities to assist municipalities to measure the problem of mismanaged plastic waste in the South African urban context.

In addition, African cities do not locally develop indicator-based measurement frameworks but apply those developed in the so called 'global north'. The study addresses from the ground the problem of plastic in the Umgeni River, one of the most polluted in the WIO region.

In recent years, the national waste management strategy is facilitating the development of new sustainable approaches to waste management. However, the aforementioned circumstances at governance and social levels increase the failure risk of appropriate technologies implementation.

The study focuses on the development of a measurement framework to assist municipal governments and urban strategic planning in the solution of the problem of plastic pollution, with specific indicators across all 'fields of performance' of the city: governance, economy, people, environment, infrastructure and living, approaching the problem from a holistic perspective applied to the case study of Durban.

Keyword-: urban sustainability; plastic pollution; waste management; climate change

Annexure 5. List of outputs from the research

Annexure 5. List of outputs from the research

2022 Guest editor for the SAIA-KZN Journal. Monograph on Waste Architecture. Durban, South Africa.

2021-2023 Appointment as component coordinator for green infrastructures within the Umgeni Resilience Project. UN, South African National Biodiversity Institute (SANBI) and UKZN. Durban, South Africa.

2021 Landfill and waste treatment 2021 virtual seminar. Institute of waste management of southern Africa. Durban, South Africa.

2021 Development of measurement systems of urban sustainability applied to the waste sector: The case of plastic pollution in the Umgeni River estuary. Journal of South African Science. Special issue. Waste as a Resource: South African perspectives on circularity.

2021 Umgeni Research Project launch workshop. UKZN and TOC. Durban, South Africa.

2021 'Waste Architecture and urban waste in developing countries'. Coursework Master in Waste and Resources Management. University of KwaZulu-Natal. Durban, South Africa.

2020 'Introduction to Waste Architecture. A glimpse of the African city of the future'. REMTECH EXPO digital edition. Ferrara, Italy.

2020 Detritus Vol. 11. Monographic issue: Waste Architecture / Waste management in landscape and urban areas. CISA Publisher. Padova, Italy. ISSN: 2611-4135

2019 The 'African City of the future' is now. The Mercury 2019.01.08. Independent News & Media. Durban, South Africa.

2018 International architects practicing in Durban Talks Series. Phansi Museum. Durban, South Africa.

2016 'Smart… ma non troppo!' Science Forum of South Africa. Pretoria, South Africa.